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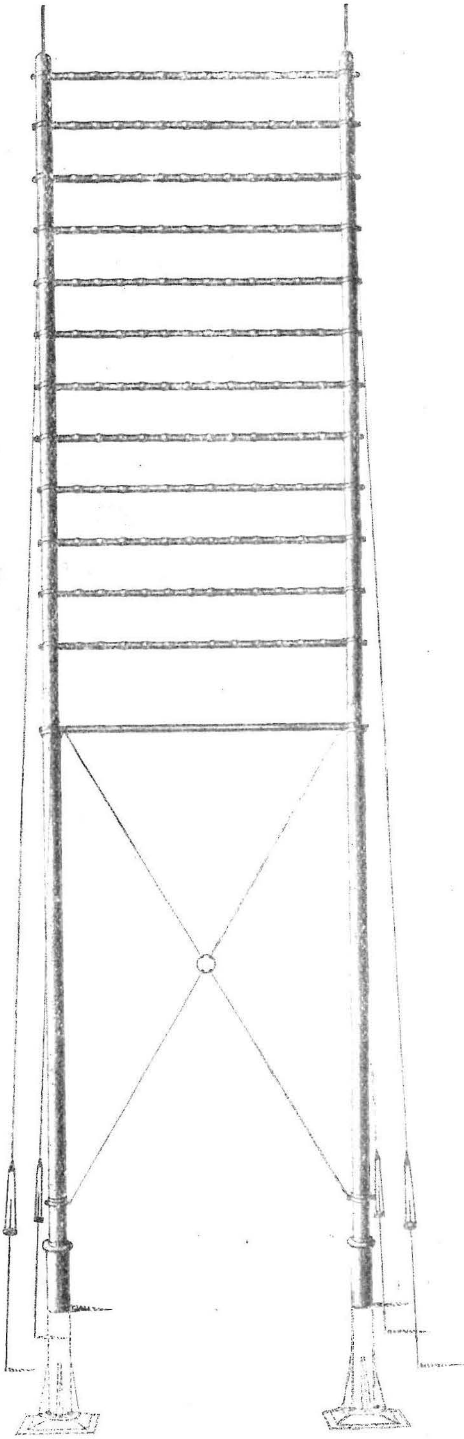
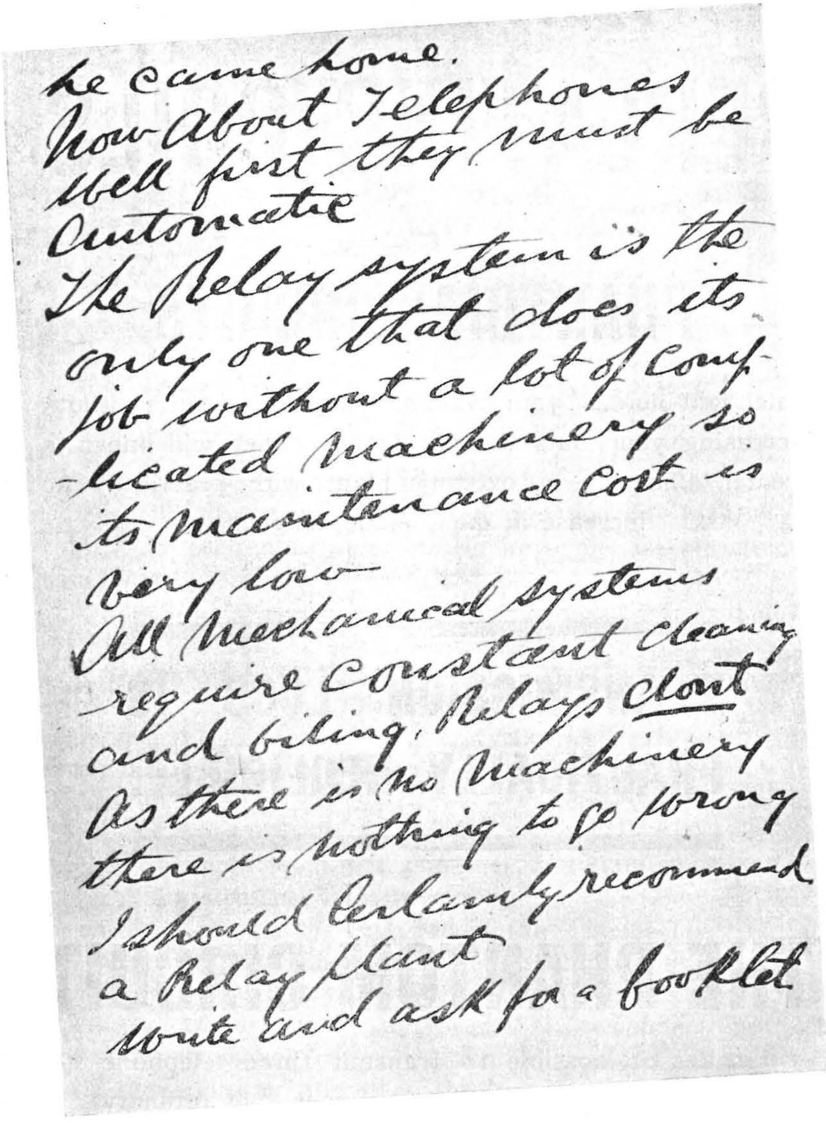




he came home.
Now About Telephones
well first they must be
automatic
The Relay system is the
only one that does its
job without a lot of comp-
-licated machinery so
its maintenance cost is
very low
All mechanical systems
require constant cleaning
and oiling. Relays dont
As there is no machinery
there is nothing to go wrong
I should certainly recommend
a Relay plant
write and ask for a booklet

THE Post Office Electrical Engineers' Journal

THE TELEPHONE REPEATER.

(*Continued from p.* 75.)

IT is sometimes required to insert a telephone repeater into a circuit, each wire of which is used (composited) for telegraph working. In such cases none of the repeater circuits described previously is suitable.

The requirement is met by the use of a repeater circuit devised by Messrs. Robinson & Chamney of the Engineer-in-Chief's Staff (patent specification 11709/1918 refers). This circuit is generally known as the "Series-Tee." **19** illustrates the circuit arrangement.

The output transformer, valve and batteries have been omitted from the diagram, the connections to this apparatus being identical with those of **10** (*b*).

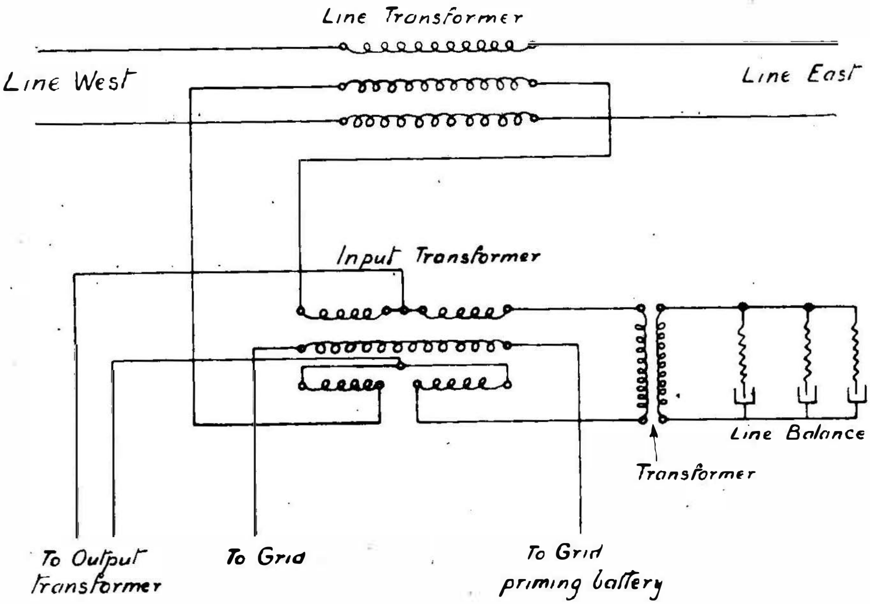
The line transformer should preferably be of the Department's No. 4006A type with equal ratio windings, and a transformer of the same type is inserted between the repeater and the line balance.

It will be seen that the insertion of the "Series-Tee" repeater into a telephone circuit does not interfere with the continuity of the wires of the loop, which may therefore be tested between terminal offices in the ordinary way. Moreover, if the telephone repeater be out of service from any cause, *e.g.* fault in repeater apparatus, or inattention of repeater attendant, the loop is not rendered useless for telephone or telegraph purposes. The loss in the telephone circuit due to the presence of the inactive repeater is negligible. So far as the superposed telegraph circuits are concerned, there is only the resistance of a half primary winding of the line transformer (about 16 ohms) to be taken into account.

The "Series-Tee" system has proved to be particularly suitable for emergency services where moderate improvements in transmission (of the order of 10 standard miles) are required. It has been extensively used by the British Army in France on long aërial lines.

Two or more repeaters of this type may be used in series in a line provided that the distance between repeaters measured electrically, and the distance between a repeater and a terminal station, are not greater than the improvement obtained from any one repeater.

Lieut.-Col. Edgeworth, D.S.O., M.C., R.E., who has had considerable experience of this system in actual service, has very kindly supplied the author with some useful notes on the construction of artificial line-circuits and has given permission to include them in this article.



19—The "Series-Tee" Repeater Circuit.

Col. Edgeworth has also devised a very ingenious development of the " Series-Tee " system which provides for the introduction of a telephone repeater in a phantom circuit, formed on two physical circuits, the arrangement being such that the two physical circuits are not interfered with, and the continuity of the four conductors forming the circuits is not interrupted.

Notes on Artificial Lines for Telephone Repeaters.

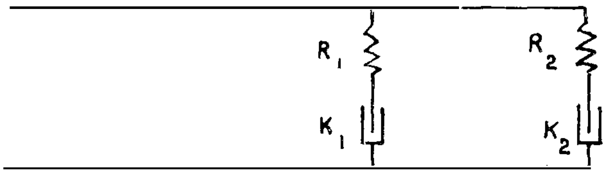
"A telephone circuit has a terminal impedance which can be represented at any frequency by a resistance and a condenser in series. The correct values of the resistance and capacity are different for each frequency, although they tend to reach a constant value for frequencies exceeding a certain figure.

"To obtain freedom from distortion of speech and accurate balancing, it is desirable that an artificial line should have approximately the correct values for frequencies between 100 and 1600 per second.

UNIFORM LINES OF INFINITE LENGTH.

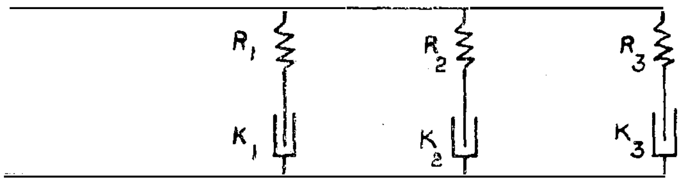
"The simplest case is that in which the line to be balanced is of infinite length and possesses uniform characteristics throughout. In such a case the terminal resistance and terminal capacity plotted against the frequency give smooth curves without waves or other irregularities.

"Open copper wires can be represented by two resistances and two capacities arranged thus:



20.

"Underground circuits show a greater range of variation, and require three resistances and three capacities arranged thus:



21.

"The values of the resistances and capacities for certain standard types of line are shown in the attached table.

"A circuit having uniform characteristics for a length equivalent to from 8 to 15 miles of standard cable differs only slightly from an infinite length, and the balances given in the table are therefore suitable.

"The lower figure may be used for repeaters giving an improvement of 10 to 12 miles standard cable.

"The above rule applies when the change in the characteristics of the circuit are considerable, such as might occur at the junction between cable and open wires. When the change is from one gauge of open wire to another, or from one gauge of cable to another, 4 to 8 standard miles of uniform composition is probably sufficient.

"It should be noted that the table gives the balance for a single loop. For two loops in series capacities should be halved and resistances doubled. If the two loops on either side of the repeater are different mean values of the resistances and capacities must be used.

Lines which are not Uniform.

"The commonest case is that in which the circuits are on open wires, but allowance has to be made for leading-in cables adjoining the office. If the length of the leading-in cables exceeds about 100 yards, a balance must be made representing the whole length of cable in addition to the normal balance for the open wires beyond. The following rules may be used as a guide:

(1) The inductance of lengths of underground not exceeding 2 miles may be ignored.

(2) The total capacity of the balance for either side must be within ·005 of the capacity of the portion of the line which is being balanced.

(3) Individual condensers should not exceed ·1 mf.

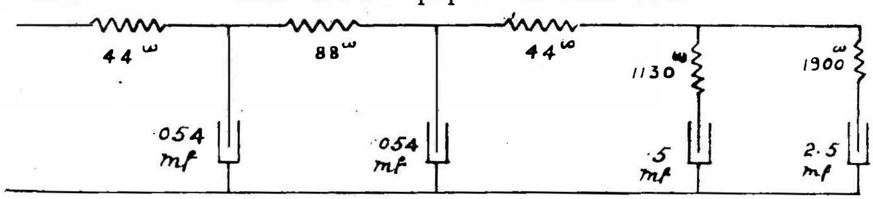
(4) The total resistance of the balance for either side must be within 30 ohms of the resistance of the portion of the line which is being balanced.

(5) Individual resistances should not exceed 100 ohms.

(6) When two resistances are used they should be of equal magnitude, and the condenser should be placed between them.

(7) When more than two resistances are used, the two terminal resistances should each be equal to one-half an intermediate resistance.

"*Example.*—The balance for a single loop of 200 lb. copper open wires led in on 2 miles of 20-lb. paper-core cable would be—



22.

"For two similar loops in series the capacities should be halved and the resistances doubled.

"When the two loops have different lengths of leading-in cable it is better to balance each loop separately.

Repeating Coils.

"When it is desired to balance a superimposed circuit, it is necessary to take account of the repeating coil in making up the artificial line. Usually the inductance of the coil can be ignored, and a resistance inserted in the artificial line equal to the resistance of the repeating coil. Note that the total resistance of primary and secondary must be taken."

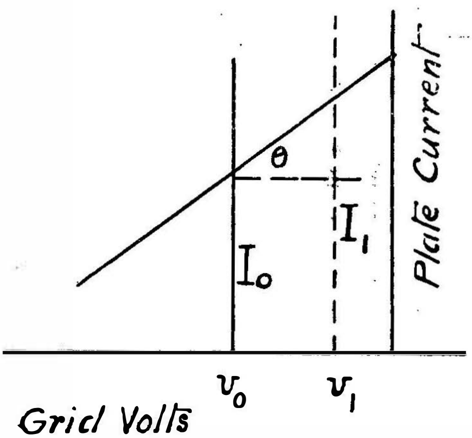
ARTIFICIAL LINES FOR USE WITH TELEPHONE REPEATERS.

Description of circuit.	Capacity per mile.	Inductance per mile.	Resistance per mile.	Leakance per mile.	k_1.	r_1.	k_2.	r_2.	k_3.	r_3.
	mf.	henries.	ohms.	ohms.	mf.	ohms.	mf.	ohms.	mf.	ohms.
Open wires, 200-lb. copper, 17 in. spacing .	·0078	·0038	9·0	—	0·5	1130	2·5	1900	—	—
Open wires, 200-lb. copper, phantom 12 in. square.	·0178	·0018	4·5	—	1·1	510	5·5	880	—	—
Open wires, 100-lb. copper, 17 in. spacing .	·0074	·0040	18·0	—	0·33	1070	1·5	2550	—	—
Standard paper-core cable	·054	·001	88·0	5×10^{-6}	0·19	270	0·33	1500	3	2270
Q.P. paper core-cable 100-lb conductors .	·050	·002	17·6	5×10^{-6}	0·33	430	0·8	620	8	1100

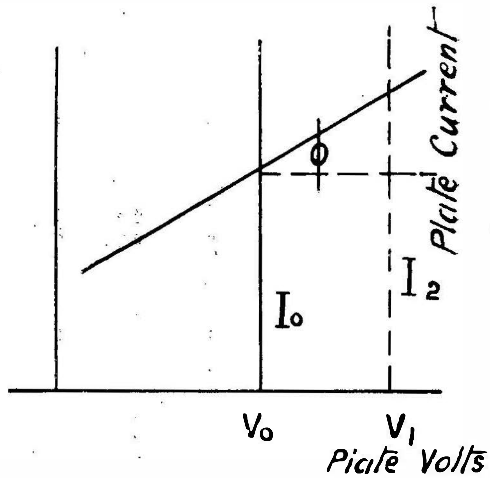
A SIMPLIFIED THEORY OF THE VALVE AMPLIFIER.

By E. Mallett, Capt., R.E.(T.), B.Sc., A.M.I.C.E.

In the valves now in general use for telephone repeaters, described in the April number of the Journal, it may be taken with a sufficient degree of approximation that over the range used in telephony the curves showing the variation of plate current with grid potential, and of plate current with plate potential, are straight lines. On this assumption the equations for the amplification given by the valve can be arrived at in a very simple manner.



1.



2.

1 shows the straight line connecting the plate current with the grid volts, the plate volts remaining constant at V_0; and 2 the straight line connecting the plate current with the plate volts, the grid volts remaining constant at v_0.

V_0 = steady value of plate voltage as determined by value of plate battery.

v_0 = steady value of grid voltage as determined by value of grid battery.

I_0 = steady value of plate current under plate voltage V_0 and grid voltage v_0.

θ = angle which $I-v$ curve makes with axis of x.

ϕ = angle which $I-V$ curve makes with axis of x.

Considering 1, if the grid volts are increased from v_0 to v_1, we have by simple geometry—

$$\frac{I_1 - I_0}{v_1 - v_0} = \tan\theta.$$

Where I_1 is the new value of the plate current and due regard is paid to the sign of v_0 and v_1 (both are, of course, negative)—

$$\therefore\ I_1 = I_0 + (v_1 - v_0)\tan\theta \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

i.e. if plate voltage is kept constant at V_0, an increase of grid volts to v_1 results in an increase of the plate current by $(v_1 - v_0)\tan\theta$.

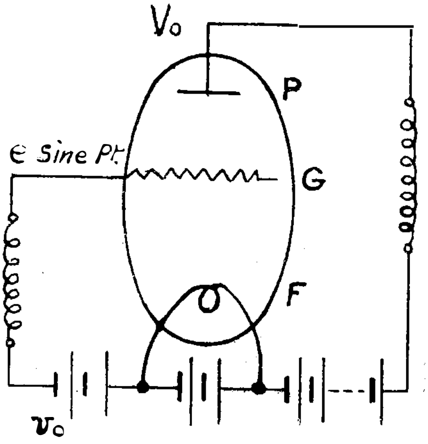
Similarly, considering **2**, if the plate voltage is increased to V_1, the new value of the plate current I_2 is given by—

$$I_2 = I_0 + (V_1 - V_0)\tan\phi \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

i.e. if grid voltage is kept constant at v_0, an increase of plate volts to V_1 results in an increase of the plate current by $(V_1 - V_0)\tan\phi$.

If now the two alterations are made together, the alteration of the grid volts to v produces an increase of plate current of $(v - v_0)\tan\theta$, and an increase of plate volts to V produces an increase of plate current to $(V - V_0)\tan\phi$. The total increase is the sum of these two, and we may write—

$$I = I_0 + (v - v_0)\tan\theta + (V - V_0)\tan\phi \quad . \quad . \quad . \quad (3)$$



3.

Consider now the effect of superposing on the grid an alternating e.m.f. $e \sin pt$.

The grid voltage at any instant will be $v_0 + e \sin pt$. The plate current will in consequence be varying about its normal value I_0, and further, the plate voltage will also be varying owing to the volt drop in the impedance Z of the valve winding of the output transformer (**3**). Writing the plate current $= I_0 + J$, where J is the alternating current superposed on the steady current, it is easy to see that the plate voltage drop is JZ, or the increase of plate voltage is $-JZ$, and the plate voltage becomes $V_0 - JZ$. Substituting these values, viz.—

$$I = I_0 + J$$
$$v = v_0 + e \sin pt$$
$$V = V_0 - JZ$$

in (3) we have—

$$I_0 + J = I_0 + (v_0 + e \sin pt - v_0) \tan \theta + (V_0 - JZ - V_0) \tan \phi.$$
$$\therefore\ J = e \sin pt \tan \theta - JZ \tan \phi \quad . \quad . \quad . \quad . \quad (4)$$

Now write—

$$R_0 = \frac{1}{\tan \phi} \text{ and } \frac{\tan \theta}{\tan \phi} = \mu$$

so that—

$$\tan \phi = \frac{1}{R_0},\ \tan \theta = \frac{\mu}{R_0} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

R_0 and μ are constants depending on the construction of the valve—

$$R_0 = \frac{1}{\tan \phi} = \frac{V_1 - V_0}{I_1 - I_0},$$

i. e. R_0 is the internal impedance of the valve to alterations of plate current. Its value is of the order of 50,000 ohms.

μ is the maximum voltage amplification that can be obtained (as will be seen later), is of the order of 10, and is called the amplification constant of the valve.

Substituting (5) in (4)—

$$J = e \sin pt \frac{\mu}{R_0} - JZ \frac{1}{R_0}$$
$$J\left(1 + \frac{Z}{R_0}\right) = e \sin pt \frac{\mu}{R_0}$$
$$\therefore\ J = \frac{\mu\, e \sin pt}{R_0 + Z_1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

That is to say, the effect of impressing a voltage $e \sin pt$ on the grid of a valve of amplification constant μ, internal impedance R_0 and external impedance Z, is equivalent to inserting a voltage $\mu\, e \sin pt$ in a circuit of impedance $R_0 + Z$.*

From this result all the usual amplification expressions can be derived. For instance, a voltage available across the impedance Z is—

$$JZ = \frac{\mu Z}{R_0 + Z} e \sin pt,$$

and so the voltage amplification is obviously—

$$\frac{\mu Z}{R_0 + Z}.$$

This is a maximum when $Z = \infty$ and is then $= \mu$.

To obtain an expression for the power amplification, let the grid be shunted by a resistance R. Then—

* This result is given by J. R. Carson in 'Proc. Inst. Radio-Engineers,' April, 1919.

$$\text{power input} = \frac{(e \sin pt)^2}{R}$$

$$\text{power output} = J^2 Z = \frac{\mu^2 e^2 \sin^2 pt}{(R_0 + Z)^2} \cdot Z$$

$$\text{power amplification} = \frac{\mu^2 \cdot ZR}{(R_0 + Z)^2}.$$

This is a maximum when $R_0 = Z$, and is then equal to—

$$\frac{R\mu^2}{4R_0} = \frac{R}{4} \cdot \frac{\tan^2\theta \tan\phi}{\tan^2\phi}$$

$$= \frac{R}{4} \cdot \frac{\tan^2\theta}{\tan\phi},$$

i.e. the maximum power amplification is proportional to the square of the slope of the $I-v$ curve divided by the slope of the $I-V$ curve.

ELECTRIC CURRENT RECTIFIERS.

ONE may classify the ordinary forms of rectifier under one of the following five types: (1) Mercury arc, (2) electrolytic, (3) vibrating tongue or relay, (4) thermionic, (5) mechanical, with rotating parts and commutator. For these types one finds usual current outputs as follows: 3 to 40 ampères for mercury arcs using glass bulbs; 200 to 800 ampères for mercury arcs in steel containers. Vibrating tongue rectifiers may give 1 to 6 ampères; thermionic valves anything up to about 6 ampères. Mechanical rectifiers, including motor generators, may give anything up to 1000 ampères and more. This article contains some notes concerning the life and efficiencies of glass bulb rectifiers and references to types 2 and 3; the "Tungar" rectifier, type 4, was described in the POST OFFICE ELECTRICAL ENGINEERS' JOURNAL, vol. xi, p. 84, 1918, and elsewhere*; high power rectifiers of type 1 and rectifiers of type 5 are not discussed.

In the British Post Office rectifiers are in use for charging small telephone exchange batteries at the following towns:—Clydebank (two 30-ampère bulbs in parallel); Coventry, Uxbridge, Darlaston (30-ampère); Shettleston, Portobello, Neath (20-ampère); Redditch, Redhill, Southport, Hebburn, Headingley, Leicester, Hoylake, Cheltenham (10-ampère); Harrogate (5-ampère). The currents refer to bulb rating; the ordinary load may differ appreciably from the rating.

* 'Gen. Elec. Rev.,' vol. xx, p. 209, 1917; 'Elec. World,' vol. lxviii, p. 1258, 1916; 'Telephony,' vol. lxxiv, p. 34, 1918.

Life of Rectifier Bulbs.

The life of bulbs in the British Post Office varies between 1100 and 4000 hours, particular values being, 1340, 2000, 2340, 2580, 3000, 3000, 4000, the average life being 2420 hours. At the same time other bulbs were still in use after 4770, 5800 hours, 4 years, 6 years, so that the real average was greater than 2420. All figures for life must be accepted with caution as the records of time during which the bulbs are actually in use are not absolutely accurate; there appeared to be no rule connecting life and rated capacity.

In the 'Electrical World' (vol. lxx, p. 297, 1917) some figures for the life of bulbs are given. Clifford, of Harvard University, had stated that the life ranged from 2500 to 3000 hours, but Elder, of the Edison Company, disputed this. The company's records showed that the life of a 4-ampère bulb on a 6000-volt supply was 2500 hours, and a much smaller life for the 6·6 ampère bulb: the makers would only guarantee a 400-hour life on the average for the 6·6-ampère bulb. Some bulbs, however, lasted from 8000 to 10,000 hours; all the bulbs were given a rest of from one to thirteen weeks to keep them in good condition. The records of lava-tipped bulbs used by this company for the two and a-half years up to 1913 showed an average life of 2000 hours, but by December, 1914, the life had fallen to 1330 hours, as good glass was unobtainable. In order to operate bulbs under the best conditions the temperature should be within the limits 10° to 27° C. (50°—80° F.); when the temperature exceeded 30° C. the bulbs leaked and the vacuum was gradually destroyed, whereas with temperatures below 10° C. the arc tended to fail and satisfactory operation was unobtainable. Moss ('Journ. I.E.E.,' vol. xxxix, p. 692, 1907) states that the life to be expected is 4500, 2500, 1400 hours for 10-, 20-, 30-ampère bulbs. Hopfner ('Archiv für Post und Teleg.,' vol. xviii, p. 525, 1912) furnishes a report on the mercury arc rectifiers used in the German Post Offices; the 5- to 20-ampère bulbs were worked from single-phase supplies and were all satisfactory, but the 20- to 30-ampère bulbs, which worked off polyphase systems, proved troublesome to maintain. The working life amounted to 800, 3600, 5000 hours for the 5-ampère size, to 2000 hours for the 10-ampère size, to 1600 for the 20-ampère size; some, however, failed even to reach the 600 hours guaranteed by the makers. The failures were due to the overheating of the graphite anodes.

The 'Electrician' (vol. lvi, p. 743, 1911) states that the B.T.H. or G.E.C. bulbs reached a life of 3000 hours, though in Germany the average life for all bulbs was only 1000 hours. A new type of bulb with a calcium oxide anode, such that a life of 1000 hours is claimed, is described in the 'Electrical World,' vol. lxvii, p. 500, 1916.

The life to be expected will evidently depend upon the rated capacity of the bulb and upon the load. Assuming that the bulbs mentioned above have been fully loaded, the probable *ampère-hour* life appears to be:

—	Authority.		
	Elder.	Moss.	Hopfner.
Nominal rating in ampères . .	4·0, 6·6	10, 20, 30	5, 10, 20, 30
Ampère hour life in 1000 hours .	10, 8	45, 50, 42	4–25, 20, 32, 27–45

The probable life would then be about 20,000 to 30,000 ampère-hours at full load, and perhaps 30,000 to 40,000 ampère-hours if run at half load. If one knew what point could be considered as the termination of the life of a bulb and its physical cause, *i.e.*, loss of vacuum, deposit on the anode, etc., one might determine theoretically how the life depended on the load, as the load would heat the bulb and affect the leakage. Such theoretical treatment would neglect the chance of mechanical damage, but in most situations this should not be a cause of failure.

Efficiencies of Rectifier Outputs.

The efficiency of the rectifier system depends on (*a*) transformer efficiency, (*b*) bulb efficiency, and in general *decreases* for a particular bulb as the load *increases*. To keep the arc alight requires a certain minimum current; to provide this current a reactance coil is used. The following losses exist in the rectifier:

(1) Copper and iron losses in the transformer.

(2) Copper and iron losses in the reactance coil.

(3) Voltage drop in arc; about 14 to 18 volts.

(4) Leakage loss from anode to anode.

Tschudy ('Elec. World,' vol. lxxi, p. 403, 1918) proved fairly conclusively that bulb losses vary with the frequency of supply, but the amount of variation was small until the output exceeded 800 watts. Schulz ('Archiv für Elek.,' vol. xi, p. 491, 1913) had maintained that the losses in the bulb were quite independent of frequency. Tschudy ('Elec. World,' vol. lxvii, p. 1409, 1916) showed that the bulb losses were 123 watts at 26 cycles, increasing to 249 watts at 100 cycles with a constant output of 1050 watts, and proved that the bulb loss $= Ai^2 + Bi^3$, where A and B are constants depending upon the frequency and i is the output current. The transformer losses appear to be least when the frequency lies between 30 and 40 (Tschudy, 'Schweiz. Elek. Ver. Bull.,' vol. iii, p. 85, 1912).

Figures for efficiencies have been found in various tests as follows:

Ampère output.	Volts D.C.	Supply volts.	Cycles.	Efficiency per cent.	Authority and reference.
3–10	120	—	—	80–90	Moss, 'Journ. I.E.E.,' vol. xxxix, p. 692, 1907.
16–34	120	—	—	75–80	
3·8	—	1,000	—	80	
4·0	—	11,800	—	92	
—	20	—	—	44	Leblanc, 'Soc. Int. Elec. Bull.,' vol. iii, p. 11, 1913.
—	50	—	—	67	
—	80	—	—	76	
—	110	—	—	81	
—	150	—	—	86	
—	220	—	—	90	
10	110	110	50	78·3	Tschudy, 'Schweiz. Elek. Ver. Bull.,' vol. iii, p. 85, 1912.
5	110	110	50	82·5	
500 watts	—	110	50	82	Tschudy, 'Elec. World,' vol. lxxi, p. 403, 1918.
1,200 ,,	—	110	50	70	
0–60 ,,	6–8	100	25	0–50*	'Gen. Elec. Rev.,' vol. xix, p. 806, 1916.
0–80 ,,	12–16	100	60	0–50	
10	120	—	—	60	'Elec. World,' vol. lxvii, p. 500, 1916.
16	24	230	50	43–46	At Clydebank Exchange.
23	24	230	50	45–49	
30	24	230	50	48	
27–60	24	230	50	50	
3–10	24	—	—	40	Efficiencies which may be expected.
10–30	24	—	—	45	
3–10	46	—	—	60	
3–10	120	—	—	80	

Costs.

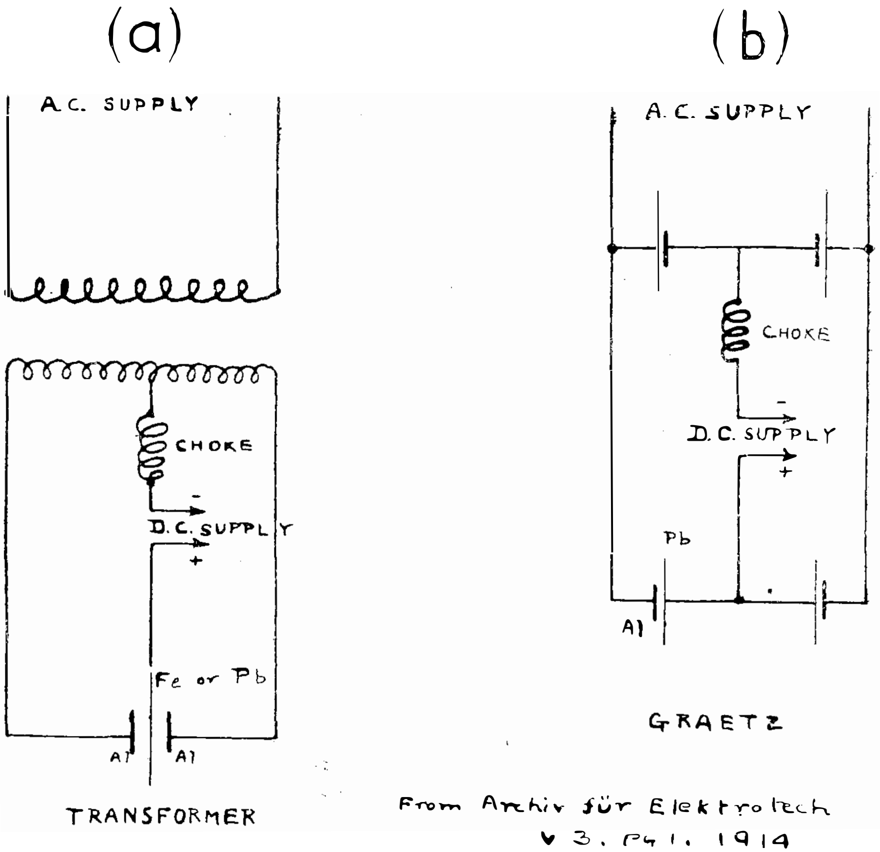
No accurate figures can yet be given for the relative costs of rectifiers and motor generators. Bulbs cost between £5 and £12, depending upon the size, but the life is still uncertain, and the war conditions have made it more uncertain than ever. The efficiencies of small sets when charging batteries at low rates and the alteration of efficiency with life are not known; the efficiencies of small motor generators or dynamotors are only known in some particular cases. The quantities of energy used are very small, and therefore if the bulb breaks its replacement cost may outweigh the total cost for current for the year whether a charging generator or rectifier is installed.

Electrolytic Rectifiers.

An aluminium-iron rectifying cell was installed at Chelmsford Telephone Exchange in order to supply a charging current of

* Increasing proportionately to output.

3 ampères, but it did not give satisfaction. The aluminium rods wore away too quickly. The electrolyte was bicarbonate of soda and distilled water. It seems that an aluminium-lead cell using ammonium phosphate ('Elec. Rev. and W. E.,' vol. lxvii, p. 669, 1915) would have been more satisfactory, the amount of phosphate required being 2 lb. per gallon of distilled water ('Elec. Rev. and W. E.,' vol. lxx, p. 168, 1917). The temperature of the cell should



I.—Electrolytic Rectifiers.

be kept below 50° C. (122° F.) according to Meares ('Elec. Eng. Practice') if it is to work, and below 30° C. (86° F.) if it is to be efficient (Moss, 'Journ. I.E.E.,' vol. xxxix, p. 692, 1907). Moss gives the efficiency as about 65 to 75 per cent. when giving 2 to 10 ampères at 140 volts, but this decreases as the temperature rises beyond 40° C., and is only 35 per cent. at 51° C. In order to get satisfactory cooling some makers utilise a lead pipe conveying cooling water as the lead anode (Pingriff, 'Eng. Mech.,' vol. ciii, p. 401, 1916, and Nodon, 'Electrician,' vol. liii, p. 1037, 1904). Schulze ('Elec. World,' vol. lxv, p. 1552, 1915, and 'Archiv für Electrotech.,' vol. iii, p. 1, 1914) has determined from first principles the maximum possible efficiencies for cells when connected as shown in **1**; in the transformer system the maximum efficiency is 80 to 85 per cent. at 60 to 80 volts, falling to 40 per cent. at 5 volts; for the Graetz system the efficiency is 80 to 85 per cent. at 100 to 150 volts, dropping to 25 per cent. at 5 volts. In working the cell the current density at the bottom of the aluminium electrode should be about 0·05 to 0·10 amp./cm.^{2} Fitch ('Phys. Rev.,' vol. ix, p. 15, 1917) discusses fully the counter E.M.F. of such cells. When used as a rectifier the deposit on the aluminium electrode increases every time the aluminium is an anode. The oxide is not decomposed until a high temperature is reached, and thus the film increases as time goes on, and increases the internal resistance. The heat developed then increases, and after a period of time becomes so great that the rise of temperature allows the reverse current to decompose the oxide. The rectification then fails and the efficiency falls to zero.

Vibrating Tongue or Relay Rectifier.

The author knows of no present commercial form of rectifier using a vibrating armature to make contacts in unison with the current alternations. Such rectifiers made to Falkenthal's design were in use in Germany in 1911 ('Elek. Tech. Zeit.,' vol. xxix, p. 715, 1911). This was made by the Deutsche Telephone Works, Berlin, to give D.C. supplies from 12 to 220 volts. The current output is not stated, but it is said to be sufficient to work a telephone exchange for 500 subscribers. The no-load input is given as 2 to 6 watts.

A form of rectifier called the "Premier Ampèro" was tested by the late National Telephone Company at Dalston Exchange in 1910. The efficiency of the transformer was about 96 per cent.; the efficiency of the complete set with vibrator was about 88 per cent. at loads 5 to 8 ampères. The vibrator took a constant load of 12 watts. The addition of a reactance coil sufficed to make the rectifier silent when charging a battery directly connected to the telephone exchange, but naturally reduced the efficiency.

Tests carried out at Princeton, New Jersey, in 1910 gave an efficiency of only 76 per cent. at loads from 4–6 ampères; the tests giving this figure seem to have been conducted more accurately than those giving the higher value.

Messrs. Johnson & Phillips will be bringing out a commercial form of rectifier in accordance with Mr. S. A. Pollock's patent, No. 119081 of 1918. The no-load is very small in this rectifier, and the efficiency is likely to be high, but no published reports of tests are yet available.

Messrs. Koch & Sterzel, of Dresden, made a commercial form of relay for giving up to 7 ampères at 30 volts in 1914, but no particulars of this instrument are available.

A description of a magnetic rectifier for charging either 6- or 8-volt. batteries at 10–15 ampères is given in the 'Wireless World,' vol. vi, p. 271, 1918. It is sold by Clarence E. Edson, 1276, West Third Street, Cleveland. No figures for efficiency are given. Those who wish to make such rectifiers at home would find full details of size of windings, etc., in the 'Scientific American' Supplement, vol. lxxx, p. 108, 1915, and vol. lxxxvii, p. 76, 1919. One method of joining up such rectifiers is given by Sutton in this Journal, vol. iv, p. 169, 1911.

THE CHEMICAL ACTION OF THE LEAD ACCUMULATOR.

"INVESTIGATIONS OF THE CHEMICAL ACTIONS OF THE LEAD ACCUMULATOR," by CH. FÉRY. ('Bulletin de la Société Française des Electriciens,' February, 1919, p. 85.)

Translated by E. Lack, M.B.E.

M. Ch. Féry discusses in the first instance the double sulphation theory. This theory, although allowing the E.M.F. obtained by experiment to be calculated, is not in accordance with the general laws of electrolysis.

Further, M. Féry draws attention to some features which do not appear to support the double sulphation theory:

(1) The variations of weight of the positive are practically *nil* both during charge and during discharge, whereas they ought to be of the same order as those of the negative.

(2) After discharge the positive is not white, as the theory would indicate.

(3) The colour of the negative darkens during discharge, whereas it should get lighter.

(4) The reduction of lead sulphate on the negative is slow and difficult; the peroxidisation of the sulphate formed on the positive is still more difficult, because it is of high resistance and almost insoluble.

These considerations led M. Féry to make a close study of the phenomena which take place in the lead accumulator.

STUDY OF THE POSITIVE.

After having fully charged a positive plate, M. Féry detached the active material, washed it in distilled water and dried it in a drying stove at 35° C. This substance is of a beautiful black colour which has nothing in common with the brown tint of PbO_2. Placed in a bulbous tube through which a current of dry hydrogen is passed, the material is reduced with a disengagement of heat and formation of H_2O, until its colour becomes like that of PbO_2.

M. Féry also made up a battery consisting of a sheet of platinum surrounded with the positive material and placed in a porous pot, and a plate of amalgamated zinc, the whole placed in water acidulated with H_2SO_4; the difference of potential between the terminals of this cell was 2·4 volts. After replacing the positive material by PbO_2, he obtained only 0·7 volts.

When the porous pot with its platinum plate and its depolariser is replaced by a positive plate from an accumulator, a voltage of 2·4 volts lasting some time is first obtained, and then after the final charge a second stable period is obtained commencing at 0·7 volts. The capacity represented by this second period is considerable. The discharge at 2·4 volts lasted for a few hours only, whereas the discharge at 0·7 volts lasted several days, and terminated only when the positive plate had been brought to a state of metallic lead.

Lastly, M. Féry observed that the black material taken from the charged positive plates and left to itself, sheltered from all reducing dust, finished by taking the colour of lead dioxide.

From these experiments it is seen that at the beginning of the discharge the positive material is formed of a substance richer in oxygen than PbO_2, and which passes to the state of PbO_2 after the normal discharge of the accumulator. The chemical analysis effected by weighing before and after the complete reduction by the hydrogen has brought M. Féry to the formula Pb_3O_7 or $Pb_2O_{4 \cdot 7}$.

Another reduction made by the use of oxalic acid and treating with permanganate has given the same result.

It might be feared that the charged positive material would reduce itself spontaneously during the washing with distilled water and drying in the oven, and thus lose some of its oxygen.

In order to obtain a correct determination of the formula of the positive material, M. Féry formed a small positive containing 22 gr. of material only, and two large negatives of a capacity of 40 ampère-hours. The discharge was thus limited by the exhaustion of the positive. Admitting that it passed to the state of PbO_2, the amount of oxygen could be calculated. This method brought M. Féry to the formula $Pb_2O_{5 \cdot 2}$, or about 4 per cent. more than the formula Pb_2O_5 indicated by M. Drezeviecki as representing the positive material. This substance would be the anhydride of perplombic acid, $Pb_2O_6H_2$.

The chemical analysis thus gives a faulty result on account of the spontaneous de-oxydisation of this peroxide, and the electrolytic analysis an excess result on account of the formation of bodies very susceptible to oxidation during electrolysis, such as oxygenated water, ozone, and possibly per-sulphuric acid.

Finally, if 1 represents the resistance of PbO_2 that of Pb_2O_5 is represented by 22.

Study of the Negative.

It is generally stated that the reduced lead which constitutes the active matter of the charged negative is transformed after discharge into $PbSO_4$. The discharged material is, however, a dark grey, while the normal sulphate of lead is white.

M. Féry tried to ascertain if the change of colour was superficial or affected all the mass.

In order to do this he poured and pressed into the bottom of a glass tube, carrying a strip of lead passing through it like an electrode, a paste of litharge and acid such as is used on negative plates. After hardening the paste, the tube was filled with acidulated water, and the negative formed in the usual way by employing a positive placed upright in the liquid. After the formation of the negative it was discharged. A zone of dark grey nearly black in colour was seen to be formed on the surface, which gradually affected the mass. The element was then recharged; the reduction took place commencing on the surface, and the colour was brought back to a light grey.

The material exhausted by the discharge thus retains a certain conductibility. The discharged negative whitened rapidly when exposed to the air.

On the other hand, the variation of the weight of the negative is strictly proportional to the ampère-hours given out, but the number of ampère-hours does not correspond to the weight of reduced lead contained in the plate.

Theoretically, one ampère-hour should be produced by 3·86 gr. of Pb, whereas in practice 11 to 12 gr. of reduced lead was necessary. A piece of negative exhausted by discharge, washed in distilled water and crushed, does not show in the breaking, when examined by microscope, any metallic part, but in breaking it with the blade of a pocket-knife small particles of lead flattened by the steel are perceived.

From these various observations M. Féry has concluded that the discharged negative material is a sub-sulphate of lead, or plumbous sulphate of the formula Pb_2SO_4, corresponding to the plumbous oxide Pb_2O of a black colour.

In admitting the production of plumbous sulphate, 7·72 gr. of lead are necessary to produce an ampère-hour, which is far from what is observed in practice, but it is necessary to take into consideration that during discharge there is a local action of the acid on the lead which does not produce current. M. Féry has by suitable trials determined the proportion of acid fixed in excess of that calculated by the ampère-hours given out.

Resumé and Conclusions.

The result of M. Féry's trials is that the action of an accumulator is analogous to that of an ordinary battery: 11 gr. of lead are necessary for the practical production of an ampère-hour in a Planté pair (twenty hours' discharge); these 11 gr. are divided thus:

Lead furnishing the current	7·72 gr.
Lead attacked by local action	0·77 gr.
Lead not attacked	2·51 gr.

Depolarisation is due to the reduction of a peroxide, Pb_2O_5, to PbO_2. At the negative, it forms during the discharge plumbous sulphate, Pb_2SO_4, which has a certain conductibility, whereas $PbSO_4$ is an insulator.

After having made the thermo-chemical study of Pb_2O_5 and of Pb_2SO_4, M. Féry has given the following formula, which according to his studies represents exactly the functioning of the lead accumulator:

Charge. *Discharge.*

$$Pb_2 + H_2SO_4 + Pb_2O_5 \rightleftarrows Pb_2SO_4 + H_2O + 2PbO_2.$$

According to this reaction the weight of lead employed on each electrode is the same. In practice, for the discharge of 20 hours there is about 70 per cent. of lead usefully attacked. The percentage of lead unattacked depends on the size of the lead crystals forming the negative, which augments with the number of charges; this explains the loss of capacity in the old elements.

The local actions are very active during the early part of the discharge, and seem to vary according to an exponential law.

From M. Féry's trials it appears that in the normal action of the cell sulphate of lead ($PbSO_4$) is never formed during discharge; this substance can only be formed after the final stage at the negative by sulphation of the plumbous sulphate, or at the positive only when the excessive reduction of the active material can give rise to oxides lower than PbO_2. In the last case these oxides can, indeed, by the later effect of the electrolyte, pass to the state of normal sulphate; these two cases of sulphation of the electrodes are to be avoided, as is well known.

The new theory of the lead accumulator expounded by M. Féry is more in accordance with practical results than the ordinary theory of double sulphation, and it seems to be actually that which best corresponds to the reality.—*Revue Générale de l'Electricité*, April 26th, 1919.

TELEGRAPH TRANSMISSION ON AËRIAL TELEGRAPH CIRCUITS WITH EARTH RETURNS.

THE following notes are based on a technical instruction on the above subject, a copy of which has been courteously sent to the Editors of this Journal by the Chief Electrician of Posts and Telegraphs, Alipore, Calcutta.

It is clearly recognised at the outset that the modern tendency is to replace hand-worked Morse systems by the Baudot or other multiplex systems, and consequently that the line must be adapted to the system. In order to facilitate calculations the efficiencies of lines are expressed in terms of a "standard line," which for telegraph purposes is in India an aërial line one mile in length of 300 lb. copper, and having an earth return. The length in miles of any line giving equal transmission to that of the standard line is termed the transmission equivalent of the line.

In the following tables (I and II) are given the transmission equivalents for various aërial lines and cables.

TABLE I.—*Telegraph Transmission Equivalents of Aërial Wires with Earth Returns.*

Line.	Transmission equivalents.
800 lb. per mile H.D. copper wire	1·75 miles.
600 lb. ,, ,, ...	1·49 ,,
400 lb. ,, ,, ...	1·18 ,,
300 lb. ,, ,, ...	1·00 ,,
200 lb. ,, ,, ...	0·80 ,,
100 lb. ,, ,, ...	0·56 ,,
No. 7, S.W.G. high-conductivity H.D. copper wire	1·36 ,,
,, 8 ,, ,, ,,	1·22 ,,
,, 9 ,, ,, ,,	1·09 ,,
,, 10 ,, ,, ,,	0·95 ,,
,, 11 ,, ,, ,,	0·85 ,,
,, 12 ,, ,, ,,	0·75 ,,
150 lb. per mile bronze wire	0·48 ,,
70 lb. ,, ,, ...	0·32 ,,
40 lb. ,, ,, ...	0·24 ,,
51 lb. per mile superior bronze wire . . .	0·31 ,,
600 lb. per mile iron wire	0·57 ,,
450 lb. ,, ,, ...	0·50 ,,
300 lb. ,, ,, ...	0·40 ,,

TABLE II.—*Telegraph Transmission Equivalents of Various Cables in Use in India.*

Speed or systems.	G.P. cores A, ALS and G.	Henley 20-conductor paper-insulated telegraph cable.
Morse simplex hand-speed	0·42 miles	0·22 miles
Morse duplex hand-speed	0·35 ,,	0·18 ,,
Quadruplex	0·26 ,,	0·135 ,,
Baudot 2-arm S x (180 revs. p.m.)	0·31 ,,	0·16 ,,
Baudot 2-arm D x (,,)	0·22 ,,	0·12 ,,
Baudot 3-arm S x (,,)	0·28 ,,	0·14 ,,
Baudot 4-arm S x (,,)	0·24 ,,	0·125 ,,
Wheatstone, 40 words p.m.	0·35 ,,	0·18 ,,
Wheatstone, 60 ,,	0·29 ,,	0·15 ,,
Wheatstone, 80 ,,	0·26 ,,	0·14 ,,
Wheatstone, 100 ,,	0·24 ,,	0·13 ,,
Wheatstone, 120 ,,	0·22 ,,	0·12 ,,
Wheatstone, 140 ,,	0·20 ,,	0·11 ,,

The length of a standard line having a transmission value equal to that of any given circuit entirely of one type of conductor is obtained from the formula—

$$\text{Equivalent length} = \frac{\text{Length of circuit}}{\text{Transmission equivalent}}.$$

If the circuit consists of several sections of different types of line the equivalent length is the algebraic sum of the equivalent lengths of the several sections.

The systems of working are divided into two main classes, the first embracing those in which the speed is fixed, and the second those in which it is variable.

In Class I the limiting length which will admit of satisfactory working all the year round is calculated on the bad weather conditions, and the following table gives the lengths for various systems of direct working between terminal offices.

TABLE III.—*Limiting Lengths for Various Systems of Working in India.*

System.	Limiting length in miles of standard line.
Morse D.C. simplex hand-speed	870
Morse D.C. duplex hand-speed	670
Morse quadruplex hand-speed	560

*Baudot 2-arm simplex	730
Baudot 2-arm simplex through a Morse repeater	660
Baudot 2-arm duplex	610
*Baudot 3-arm simplex	680
*Baudot 4-arm simplex	620

If repeaters are in circuit the values apply to each of the sections terminal to the repeater.

In Class II, which deals with Wheatstone and Wheatstone Creed working, the speed depends *inter alia* on the insulation of the line.

TABLE IV.—*Wheatstone Simplex Speeds in Circuits of Various Equivalent Lengths.*

Equivalent lengths in miles of standard line.	Wheatstone simplex speeds in words per minute. Good weather.	Bad weather.
540, 580	over 160	137, 124
620	158	112
660	144	100
700	134	87
740	126	75
780	118	62
820	110	46
860	104	27
900	98	—
940	91	—
980	85	—
1020	79	—
1060	74	—
1100	68	—

Table IV gives the Wheatstone (simplex) speeds on lines of various lengths in good and bad weather. With Wheatstone Creed simplex the values will be about nine-tenths of the above figures.

In Wheatstone duplex the speeds either way will be about half of those values, and with Wheatstone Creed duplex the speed will be about half that for Wheatstone Creed simplex.

Part II of the instruction deals with the theoretical aspect of transmission from the alternating current point of view, double-current working being regarded as a form of alternating current transmission. The Heaviside equation for evaluating the attenuation

* These lengths apply to Baudot worked (1) between two terminal sets direct, or (2) between a terminal set and either a Baudot translation or a Baudot retransmitter set, or (3) between two retransmitter sets or a retransmitter and a Baudot translation set.

constant α is given, and a table of effective resistances of 450- and 600-lb. iron wire at speeds varying from 25 w.p.m. to 150 w.p.m., the variation being from 12^{ω} to $12{\cdot}48^{\omega}$ in the case of the 450^{ω}, and from 9^{ω} to $9{\cdot}81^{\omega}$ in the case of the 600-lb.

The inductance values for single wire, earth return, are:

Copper-bronze and aluminium aërial	·005	henry	per mile	approximately
Iron and steel aërial . .	·015	„	„	„
Wires in cables . . .	·002	„	„	„

With regard to leakance, the insulation of aërial lines in good weather is 5 Ω or more per mile, and in bad weather ½ Ω per mile. These figures are the true I.R., and not the value obtained by multiplying the measured I.R. by the mileage, which might easily be 100 per cent. out.

The capacity of an aërial line with an earth return is $\cdot 015 \times 10^{-6}$ farads per mile, while the capacities of wires in cables vary considerably. In G.P. Core A, $K = \cdot 25 \times 10^{-6}$ farads per mile. In Henley 20 conductor LS paper cable $K = \cdot 095 \times 10^{-6}$ farads per mile.

In calculating the frequency for any particular speed of working there are three types to be considered, viz. the "dot frequency" when signalling an "h" or a "5," the "dash frequency" when signalling a series of "t's" separated by spaces, and lastly, various combinations of these two.

As the value of α increases with the frequency, only the question of dots need be considered, and for calculation purposes that frequency is selected. The following table gives the relation between w.p.m. in Wheatstone working, the frequency n, and $p = 2\pi n$.

TABLE VI.

Wheatstone speed.	Frequency n.	$P=2\pi n$.
50 words per minute	20 .	125·7
75 „ „	30 .	188·5
100 „ „	40 .	251·4
150 „ „ . . .	60 .	377·0

The calculations are based on the assumption that one foot of perforated slip is equal to 5 words. As one foot of perforated slip corresponds to 120 reversals, it follows that one word corresponds to 24. Thus, a speed of 50 w.p.m. will be equivalent to $\frac{50 \times 24}{60} = 20$ reversals per second, or a frequency of 20.

In multiplex working the frequency is calculated by dividing the number of segments in the transmitting ring by 2, and multiplying by the number of revolutions per second of the distributor, thus:

$$\text{Frequency} = \frac{\text{No. of segments}}{2} \times \text{revolutions per second.}$$

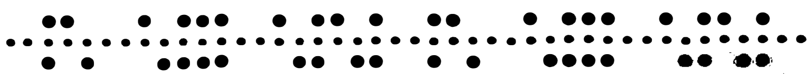
Reference is made in the concluding section of the instruction to possible disturbances due to high resistance in the battery leads common to several circuits worked off accumulators, and the need for eliminating it by ensuring that all leads to the battery distribution board, those between the centre of the battery and earth, and between the point from which the earth leads radiate to the sets and earth, are of sufficient size, by "tip burning" all cells and so ensuring the resistance of the battery is a minimum, and by reducing the earth resistance to the very lowest obtainable by laying the earths radially. A. F.

WHEATSTONE SPEEDS.

By A. C. Booth.

Everyone who has dealt with speed-trials of Wheatstone apparatus on long lines or cables must have been impressed with the serious waste of time and slip that is involved in the cumbrous method of running "old slip," then measuring a 10-foot slip, timing it through the transmitter and calculating the speed. It is hard to get a change made in old-fashioned methods, but the following method is well worth a serious trial by all those that have occasion to test Wheatstone speeds:

(1) Punch a slip about 3 or 4 feet long with the three letters A, B, C repeated, having two letter spaces between each letter, thus:



(2) Gum the ends together accurately so that the slip forms a loop and can run continuously and accurately.

(3) The speed of working in words per minute is the number of groups of A, B, C which are received in 50 seconds, or obviously twice the number received in 25 seconds.

This method obviates all reference to the sending station for measuring speed. It gives the actual speed of the running slip, and avoids that often noticeable variation of speed immediately a slip is put in the transmitter, due to the star-wheel not engaging correctly at the start.

Another most important point is that when the speed of working is approaching the limit, the dot of the A is the first signal to show signs of shortening, due to the long preceding space signal. The speed-slip has the dot, dash, short-space and long-space signals and is therefore a perfect test-slip. It also takes much less time to examine than the usual "old slip."

I devised this in 1910 for prolonged tests of the Anglo-German cables, and although I have often mentioned it to those interested in Wheatstone working its use has not been extended.

THE BAUDOT ON ITALIAN SUBMARINE CABLES.

In 'Les Annales Des Postes, Télégraphes et Téléphones,' June, 1919, a description is given by M. Cesare Albanese of the arrangements used to work quadruple Baudot simplex over two Italian submarine cables.

The details of the circuits are as follows:

Circuit.	Length of cable in kilometres.	K. in mf.	Res.	Land line km.	Res.
Naples to Palermo .	345	75	2100	23	Not given.
Rome to Sassari .	255	41	1190	168	"

In the first case it was found necessary to use the relay devised by M. Picard for the Marseilles-Algiers service. This relay is very delicate and is additional to the ordinary Baudot equipment. It was found necessary to take a separate earth return to the sheathing of the cable, owing to interference from other circuits when the common earth connection was used.

In the second case a shunted condenser at each end of the line is used; details are given of the arrangements for extending the circuit to form a Rome–Sassari–Cagliari service.

Our comment is that double Baudot duplex with ordinary apparatus should give the required four channels without the slightest difficulty, and that probably triple duplex Baudot would also be obtainable, giving three channels in each direction on each circuit. It may be remembered that double duplex Baudot worked on all four wires of a four-wire submarine cable between England and Germany. This cable was 436 km. long, and had a capacity of about 80 mf. and a resistance of about 1600 ohms. The inductive interference between wire and wire was fairly strong, but was neutralised to a considerable extent, with the result that triple duplex experiments were being undertaken just before the cables were cut.

The rate of signalling for double duplex Baudot is equivalent to a Wheatstone speed of forty-five words per minute, while the triple duplex is equivalent to sixty-four words per minute.

The electrical data of the cables indicate that both should easily work at a much higher speed than sixty-four; but if the land line in the Rome circuit is of high resistance it would reduce the speed of working considerably.

A WIRELESS SYSTEM ON A TELEGRAPH WIRE.

[THE following paper, published in the 'Journal of the Franklin Institute' for July by Lieut.-Col. J. O. Mauborgne, gives an account of experiments recently conducted on a Postal Telegraph-Cable Company circuit between Baltimore and Washington, employing the Squier high-frequency system of signalling over wires.]

Attention was first directed, in 1911, to the practical utility of employing high-frequency electric waves for transmission of energy along wires by Major (now Major-General) George O. Squier. The discussion following the publication of his results indicated that, in the minds of many, the opinion prevailed that because of the excessive attenuation obtaining at the "ultra audio" frequencies, the system would be inoperative over great distances. This was thought to be particularly the case if frequencies greater than 100,000 cycles per second were employed.

Recently this subject has assumed an important aspect from a military standpoint, and it was decided to conduct further experiments with the object of examining the possibility of adapting certain existing types of radio-telephone and telegraph apparatus to multiplex operation. The results of the few preliminary tests which have been made recently by First Lieut. R. D. Duncan, jun, and Radio-Engineer Samuel Isler, of the Engineering and Research Division, Signal Corps, Washington, D.C., are of interest because they have shown that not only is it possible to transmit energy, at least in sufficient amounts to actuate standard "radio" receiving apparatus, over comparatively long lengths of wire circuits, but that frequencies considerably in excess of the value hitherto named as the upper limit could be employed.

The apparatus used in these tests is known as the SCR-67, which is the ground set of the standard ground-airplane radio-telephone equipment. It comprises two three-electrode vacuum tubes, of the transmitting type (Type VT-2—one oscillator and one modulator) and connected circuit, a receiving-tube (Type VT-1) and circuit, and a two-stage audio-frequency amplifier. The method of modulation, that devised by Heising, is based on the fact that, to a very close approximation, the amplitude of the high-frequency current is directly proportional to that of the E.M.F. applied between the plate and the common filament terminal of the oscillating tube; any variation or the E.M.F., for example, at an audio frequency, will modulate or mould the continuous flow or high-frequency energy in a corresponding manner, which, when received by a tuned receiving circuit and rectified, manifests itself as an audible sound in a telephone-receiver. The means by which the modulation is accomplished is by a second tube, whose plate filament path-resistance is varied in accordance with the speech frequencies applied to its input terminals. By properly inter-connecting the plate or output circuits of the oscillating and modulating tubes, and by further converting the high-voltage plate power supply to the two tubes from a constant potential to a constant current system, the variation in amplitude of the high-frequency current may be made to follow out faithfully the variations impressed by the modulating source. This system is advantageous since the completeness and purity of modulation is practically independent of the frequency of the oscillating system.

The line may be connected to the source of oscillations in a number of ways, of which probably the most convenient is by inductive coupling.

To provide a practical means for carrying out of the tests, a wire, running from Washington, D.C., to New York City, was placed at the disposal of the Signal Corps by the Postal Telegraph Company. This line was duplexed, and was in continuous operation by the Postal Company. In the first series of tests one multiplex station was established at the Signal Corps Radio Laboratory, Bureau of Standards, Washington, D.C., and a second at Dixon's Park, Curtis' Bay, Md.—approximately three miles from the postal office in Baltimore, the total wire distance between the two approximating sixty miles. The multiplex apparatus was connected to the line at these two points.

Satisfactory two-way communication was obtained; speech was received at both stations, loud, and with exceptional clearness, the distortion common and inherent to long-distance wire telephony being completely absent. The tuning at the receiving stations was quite definite, comparable in every respect to that when receiving signals of a "sharply" tuned radio-station. This last fact permits of the operation of a number of multiplex units, each tuned to a different frequency and without the use of filter circuits on the same wire line. The carrier-frequency employed in these tests was 600,000 cycles per second (wave-length 500 metres); the effective line current, measured at each of the transmitting stations, averaged 60 milliampères. Throughout the test the operation of the multiplex apparatus in no way interfered with that of the wire telegraph apparatus nor was interference experienced from the latter.

The satisfactory range of an SCR-67, when operating as a ground "radio-telephone" set in communication with a corresponding SCR-67, is, under ordinary conditions, ten miles. Thus by confining and directing the flow of energy to a definite direction the range is materially increased.

The advantages of multiplex telephony and telegraphy are many. From a military standpoint alone it is obvious that in time of war any means of increasing the traffic-handling capacity of already overburdened telephone and telegraph lines will be of inestimable value. There is a further advantage from an economical standpoint, in that certain of the existing types of Signal Corps radio-telephone and telegraph apparatus, large quantities of which were purchased during the war and which are now idle, with only slight changes in construction, may be adapted to either radio or multiplex operation. The increased range obtained makes possible the connection of outlying military posts and establishments with low-power units where ordinarily comparatively high power and consequently heavier apparatus would be required if strictly radio-communications were solely relied upon.

THE WIRELESS EQUIPMENT OF EX-GERMAN SUBMARINES.

By Lieut. E. Harper, R.N.V.R.,

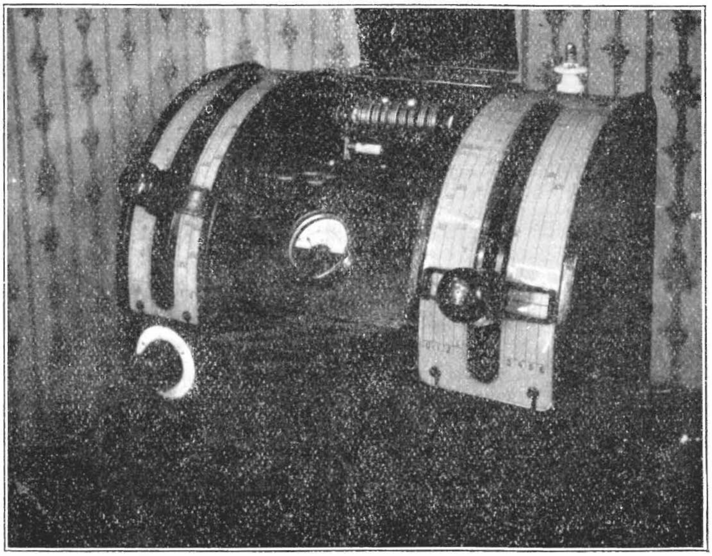
Assistant Engineer, Bristol.

When the German naval authorities, at the height of the submarine campaign, entertained an admiring home public with boasts and threats of what their "U boats" would accomplish, little did they imagine what would be the ultimate result of their challenge to the British Navy. Few more dramatic events have occurred in the course of the war than the surrender of the German submarine flotillas to the British Navy at Harwich in November last. To those who were privileged to take an active part in it, it was an experience not likely to be forgotten.

It was subsequently the writer's duty to investigate in detail the electrical equipment of these boats, which contained many things of interest to Post Office engineers, and as only a very few of the readers of this Journal would have the opportunity of seeing them, it is thought that a description of the wireless equipment may be of interest.

The system used throughout was the "Telefunken," which, as is well known, is a quenched spark system. The apparatus appears to have been standardised about 1915–16, and differs only in minor details in those boats commissioned during the second half of the war. The particulars given hereafter refer to a standard set.

The power was supplied by a motor alternator run from the main battery. This alternator was usually placed abaft the main motors, while in some of the latest boats of the larger types a duplicate machine was fitted in or near the control room. The rest of the apparatus, including the starter and regulator for the machine, was placed in a silence cabinet situated in the control room.



I.—Transmitting Apparatus.

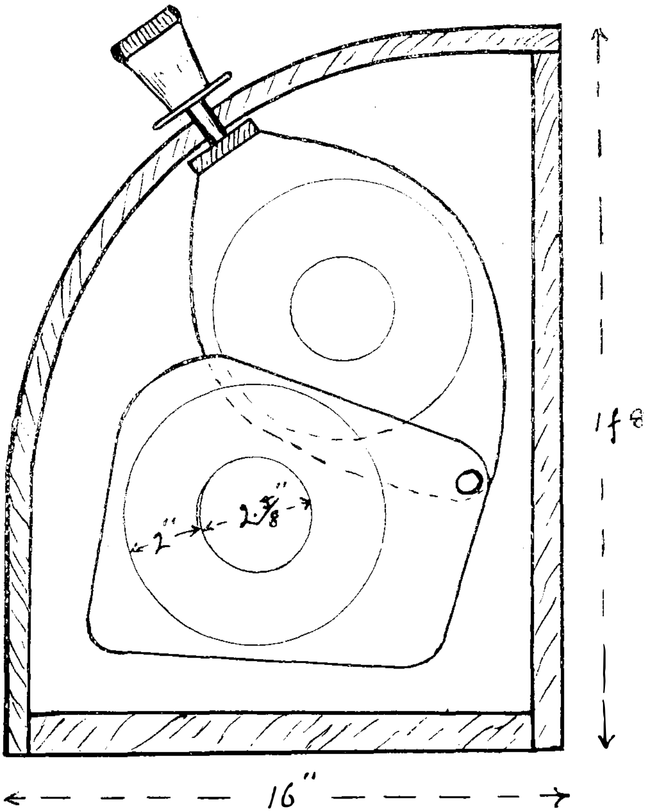
The rated output from the alternator is 15·5 ampères at 160 volts with a frequency of 470–600 per second, the speed varying from 2900 to 3600 r.p.m.

An interesting feature is the method of measuring the frequency of the A.C. supply. Instead of the frequency meter being shunted off the main A.C. circuit, a steel disc is fitted eccentrically on the end of the alternator shaft, and immediately over this is a permanent magnet fitted with coils over the pole-pieces, resembling in shape and size a double pole-bell telephone receiver minus the diaphragm. As the shaft revolves, the eccentric disc varies the magnetic field and generates currents in the coils, which actuate a frequency meter connected to them.

Transmitting Circuit.

The whole of the apparatus in the transmitting circuit, excepting the key and an oil condenser in the aërial circuit, is arranged together as shown in 1.

On each side of the central position are arranged variable inductances, the one on the left being in the primary oscillating circuit, across which is the spark-gap, while the one on the right is in the

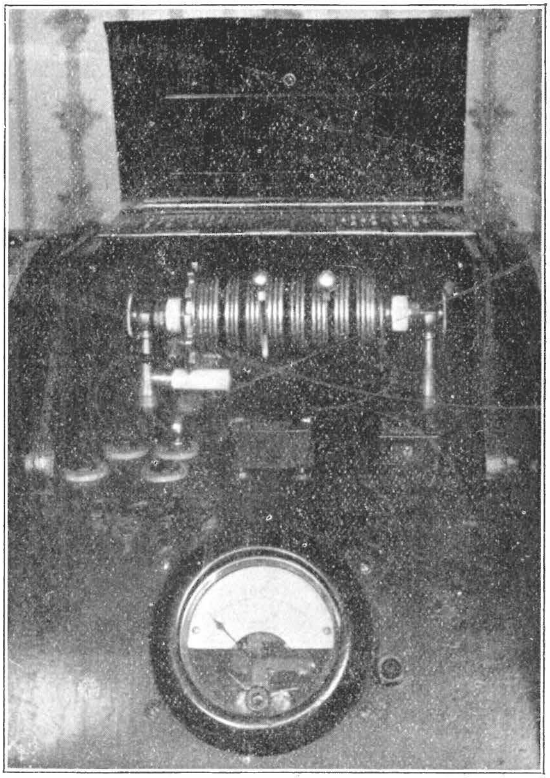


2.—Adjustable Inductance.

aërial circuit. These inductances consist of flat helices, each of eight turns, mounted between sheets of leatheroid. The aërial inductance is built up of ten of these, five of them fixed and the other five pivoted and attached to a movable handle for adjustment, as shown in 2, these five interleaving with the fixed ones and capable of moving through 90°. The central compartment contains the h.t. transformer, condensers and aërial ammeter. On the top is mounted the spark-gap, the construction of which is shown in 3.

The efficiency of the Telefunken system depends on the rapid extinction of the spark by cooling, and the spark-gap is designed to this end. The sparking discs in the later type are shaped as in 4 (*b*). The sparking takes place round the periphery, the discs being separated by mica washers ·2 mm. in thickness.

The discs are composed of an alloy, consisting of 80 per cent.

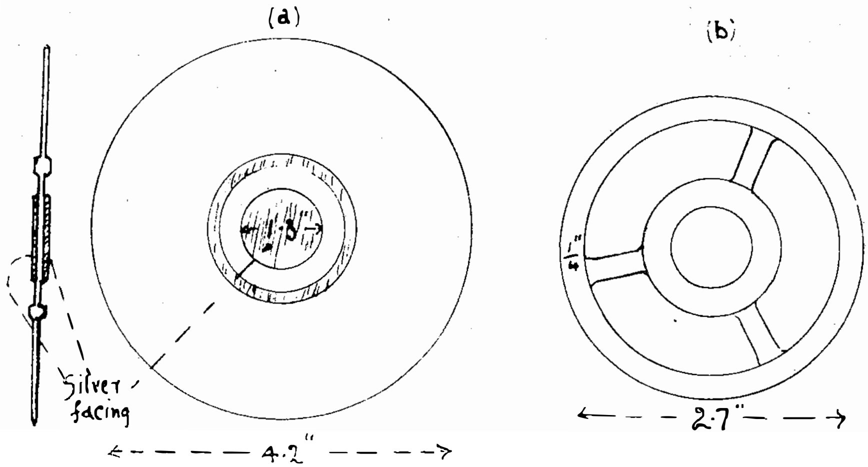


3.—Spark Gap.

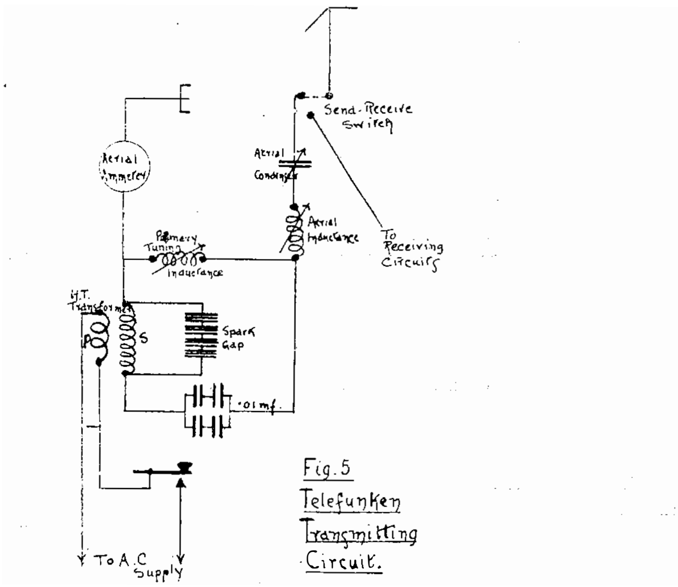
silver and 20 per cent. copper. An older type is shown in 4 (*a*); in this case the sparking takes place in the centre, which consists of copper faced with silver, the outer solid copper disc merely serving to radiate the heat. The later type is distinctly better from this point of view. Whichever type is used, a small fan motor with $4\frac{1}{2}$-in. impeller is provided to blow a current of air against the spark-gap while sending, and thus further assist in keeping the sparking-discs cool.

The complete transmitting circuit is shown in 5.

The wave-length organisation provided for transmitting on the following waves: 360, 400, 450, 500, 530, 600, 740, 820 and 900 mètres.



4.—Sparking discs.



5.

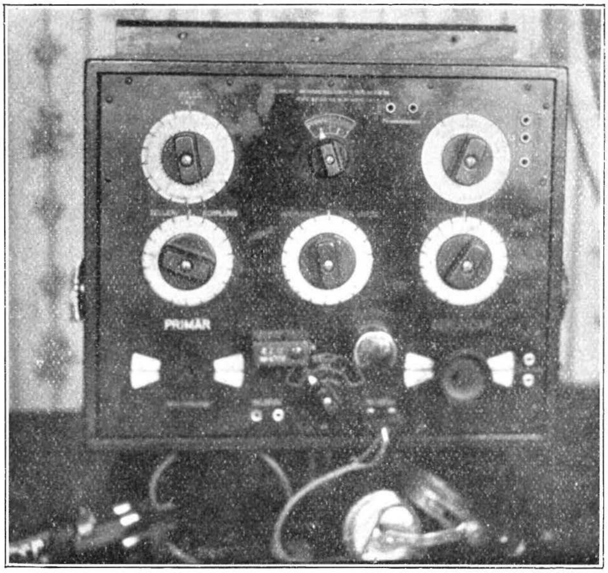
Receiving Apparatus.

Normally, crystal detectors were used for reception, the crystals being principally zincite-bornite.

The necessary inductances and capacities, with the switches for adjusting the former, are mounted together in a box as shown in **6.** The dimensions of this box are 14 in. by 18 in. by 9 in.

The box is designed for a wave-length range of 170–6000 mètres, this range being covered by 17 steps on the primary inductances.

The actual wiring of this box is given in 7 A. 7 B and C show in simplified form the arrangement for various tunings.



6.—ADJUSTABLE INDUCTANCES AND CAPACITIES.

NOTES ON 7 A.—SWITCH (*a*).

Contact No. 1 closed when switch in position No. 5.
" " 2 " " " " 8.
" " 3 " " " " 14.
" " 6 " " " " 2.

Contacts Nos. 4 and 5 operate when switch makes on No. 11 contact of primary induction switch.

SWITCH (*b*).

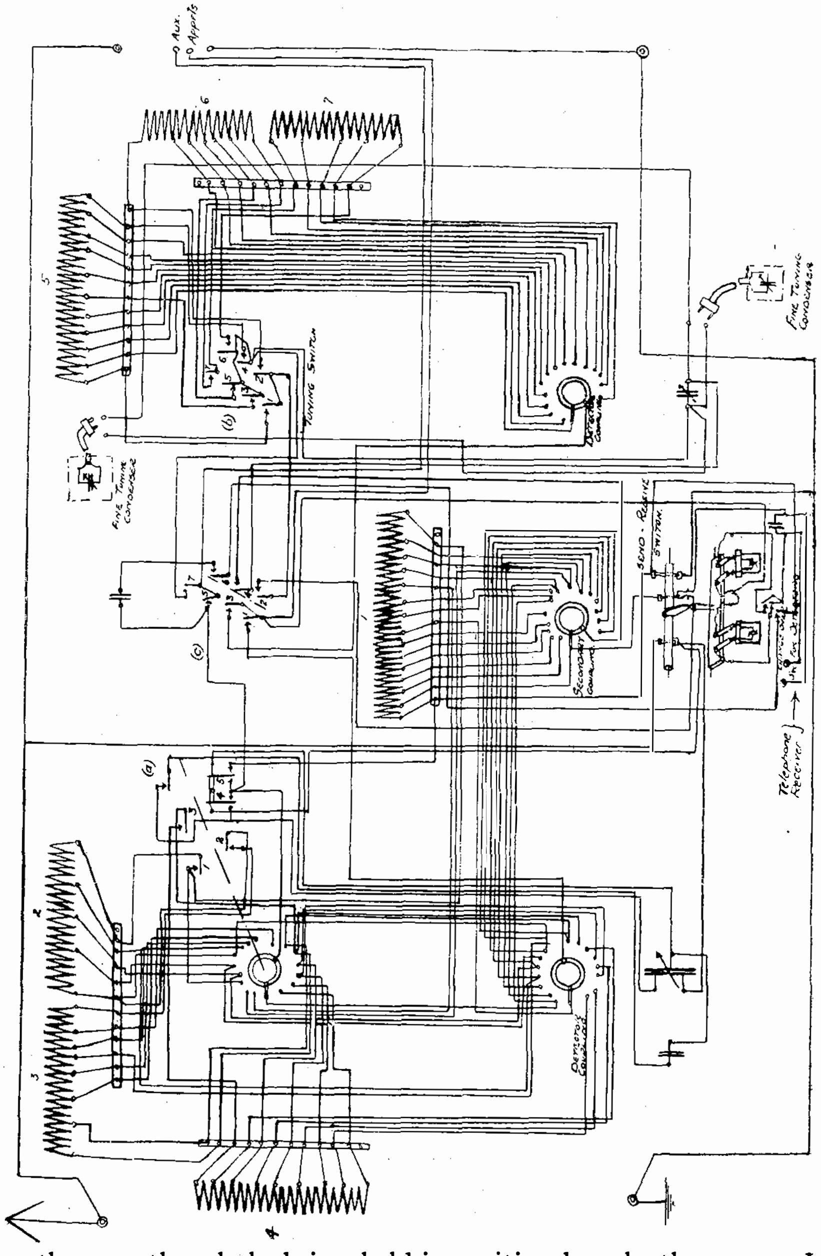
Position 1, contacts 1 and 3 closed.
" 2 " 1 " 4 "
" 3 " 2 " 5 "
" 4 " 2, 6 and 7 "

SWITCH (*c*).

Position 1, contacts 1 and 5 closed.
" 2 " 2, 3, 4, 6 and 7 closed.

The telephone used with this box was usually a single head receiver of 1000^{ω} resistance, a leather pad being provided to cover

FIG. 7A



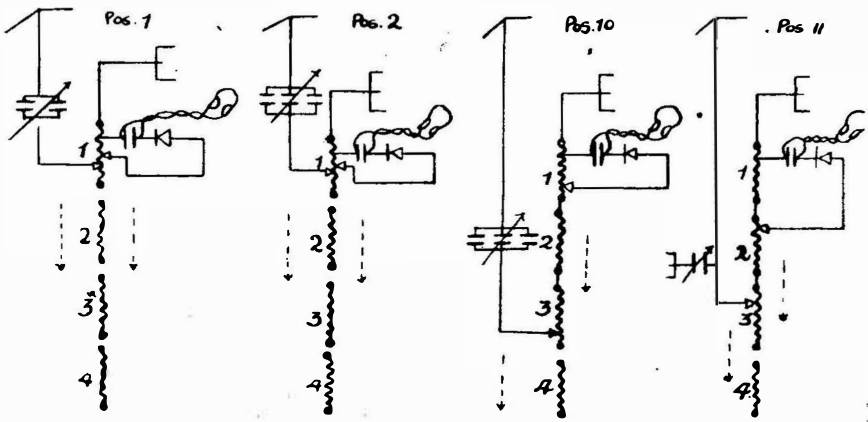
7A.—Wiring Diagram of Receiving Apparatus.

the other ear, the whole being held in position by a leather-covered spring band in the usual manner. In one case, in lieu of the leather pad, a dummy telephone was provided. Occasionally a double head-receiver was provided, having a total resistance of 4000^{ω}.

From the point of view of simplicity in manipulating by the operator, the design of this receiving apparatus is good, but the switch contacts are difficult of access, and it would be by no means an easy matter to remedy any defect which developed while at sea.

Low-frequency amplification by means of valves was used to extend the range of these sets, and a description of the amplifier is given in the following paragraphs. The amplifier was connected to the telephone-jack in the usual manner, the telephone being transferred to the output side of the amplifier.

FIG. 7B



RECEIVING BOX.—SKELETON DIAGRAMS.
LISTENING ON PRIMARY SIDE ONLY.
THE CRYSTAL COUPLING IS OF COURSE INDEPENDENT OF THE AERIAL TUNING ADJUSTMENT.
POS. NOS. REFER TO POSITION OF PRIMARY TUNING SWITCH.

AMPLIFYING SETS.

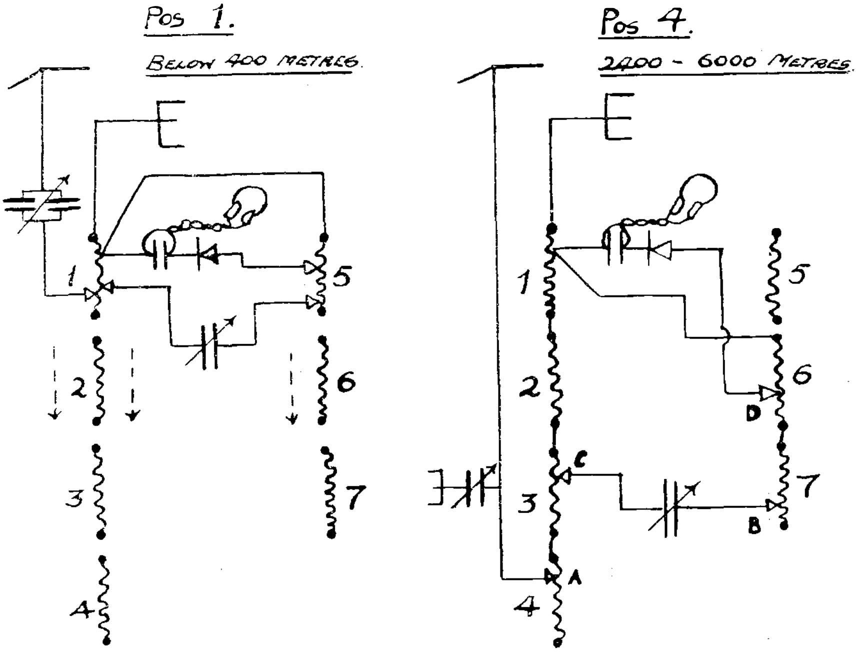
The older types consisted of two-valve amplifiers fitted with separate rheostats to adjust the filament current in each valve.

The later types are three-valve amplifiers, the component parts being mounted in an oak box 11 in. by 11 in. by 3½ in. The upper part of this box is hinged to provide ready access to the valves, the hinged part being fitted with small mica windows, so that the operator could see at a glance whether his valves were burning all right. The box was fixed to the cabinet-wall by means of flat spiral springs to absorb vibration, the valve-sockets also being on a felt seating for the same purpose.

In these amplifiers iron wire resistances in vacuum tubes are fitted to protect the valve-filaments from excessive current.

The current-resistance curves of these resistances show a very pronounced bend at the normal valve-filament current strength,

FIG. 7c



LISTENING ON SECONDARY SIDE.

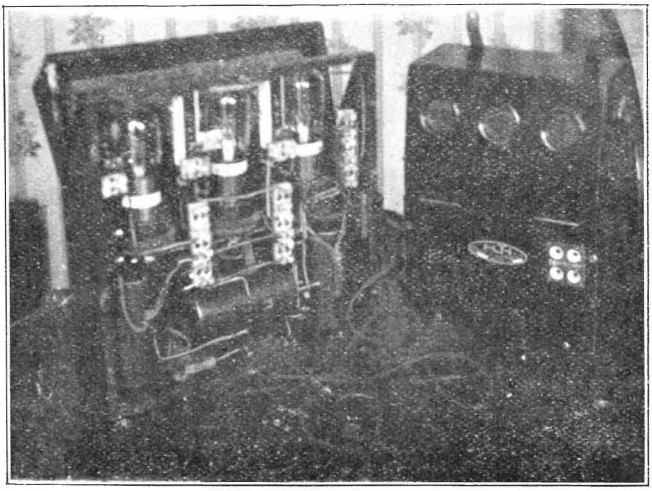
POSITION NOS. REFER TO POSITION OF SECONDARY TUNING SWITCH.
CONTACT (A) = PRIMARY TUNING ADJUSTMENT.
—„— (B) = SECONDARY —DO— —DO—
—„— (C) —DO— COUPLING.
—„— (D) CRYSTAL —DO—

i.e. 0·56 ampère, which ensures that the latter is kept fairly constant within the limits of the usual voltage variation of a 6-volt accumulator which is used to provide the heating current.

The circuit arrangements, which otherwise are of the usual type, are shown in 9.

In designing a compact amplifying set of this type, it is a matter of some difficulty to eliminate cross-coupling between one valve circuit and another. This stray coupling has a tendency to set up, by interaction, continuous oscillations of an audible frequency, which cause the telephones to "howl" and thus completely to drown the incoming signals.

In the case under discussion the centre transformer is fixed at right angles to the others (*vide* 8), and all are metal cased in order to reduce any stray action to a minimum. In addition, a small condenser of 1000 cm. capacity is connected between the grid and the negative side of filament circuit, to assist in damping out these unwanted



8.—Amplifying Sets. Left: Back View, showing Valves and Transformers. Right: Front View.

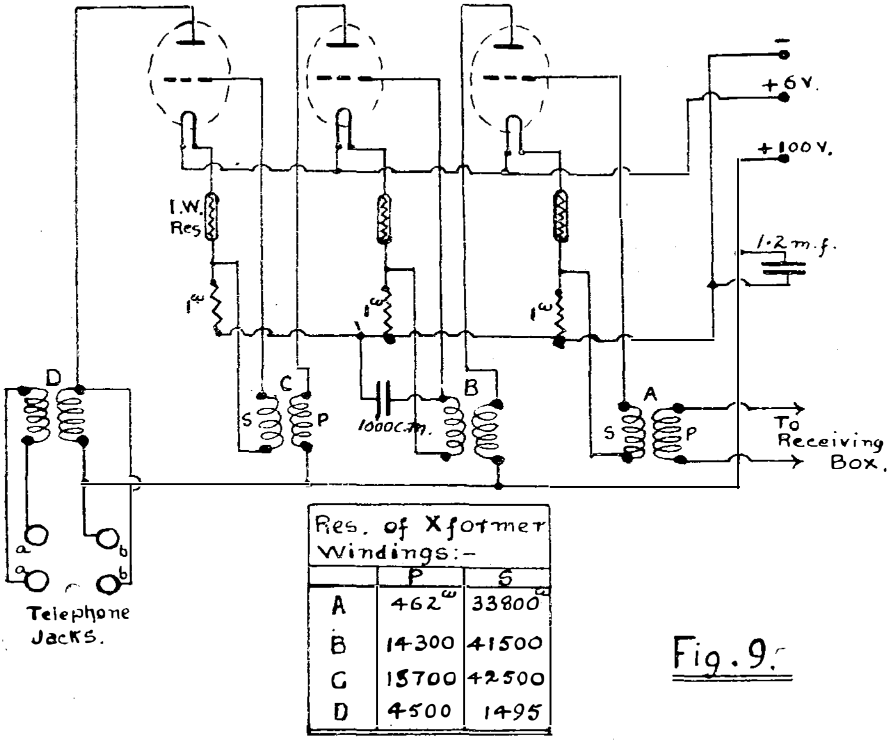
oscillations. Notwithstanding these precautions, however, the majority of these amplifiers were found to howl pretty badly until the filament current was appreciably reduced, with corresponding reduction in amplification.

Three types of valves were used for amplifying purposes—the "Seddig" and two made by the Telefunken Co. One Telefunken valve, an older type, had a flat disc as anode; the grid consisted of a small flat spiral, and the heating filament was a short loop. The newer types of "Telefunken" and also the "Seddig" followed the more general practice of having a cylindrical anode, with helical wire grid and straight filament. 11 shows the construction of a "Seddig" valve (middle one), and this photograph also shows the approximate dimensions.

The latter was decidedly the more efficient of the three, and some characteristic curves of a typical one are given in **10** and **10 A**.

C. W. Reception.

The apparatus already described is not designed for the reception of continuous waves, and the absence of such gear in the majority of the boats was the subject of comment. It was found that only in

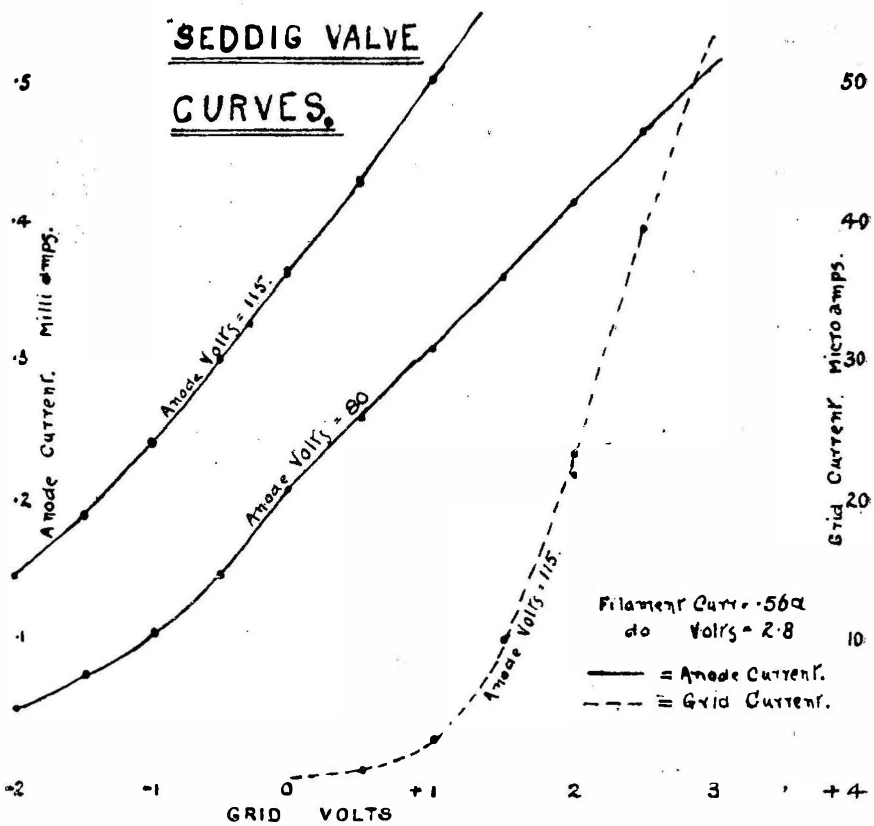


Res. of Xformer Windings:-	P	S
A	462ω	33800ω
B	14300	41500
C	15700	42500
D	4500	1495

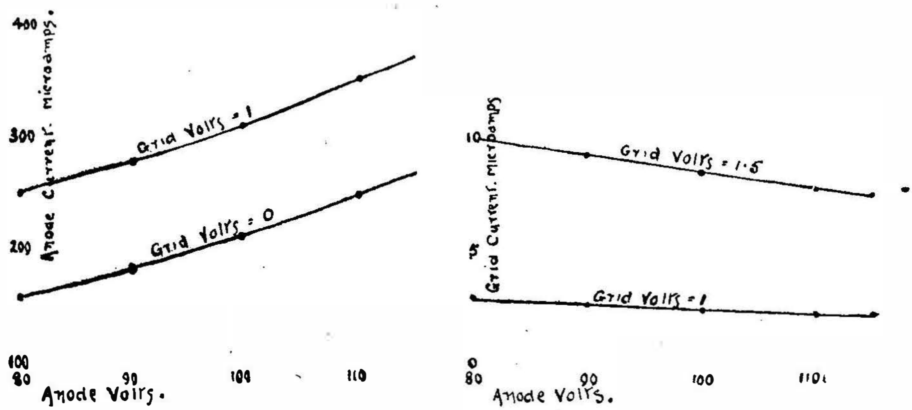
9.—Amplifier Circuit.

a comparatively small number of submarines was this provided for. In these cases it was clearly a later addition, the inference being that the Germans were distinctly behind other belligerents in the development of valve sets capable of generating continuous waves of small amplitude.

In the design of the gear under discussion the 3-valve amplifying box already described has been followed as closely as possible. Two valves were used, made by the Schutt Co., of Jena, these being mounted in a box similar to and about the same size as the amplifying



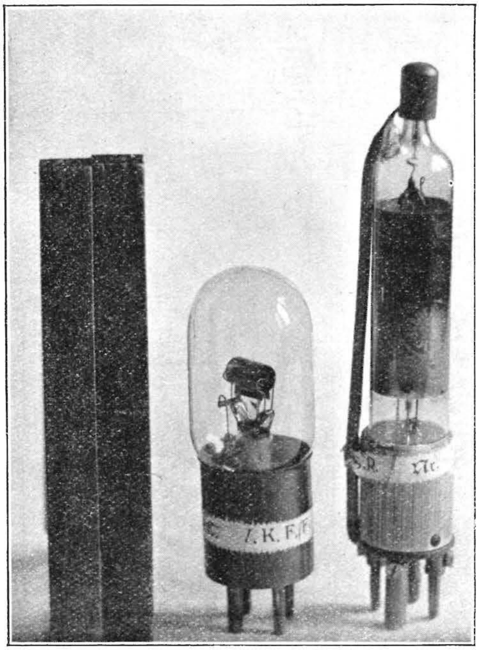
10.—SEDDIG VALVE CURVES.



10A.—SEDDIG VALVE CURVES.

box. These valves, one of which is shown in **11**, have a heavy copper cylindrical anode, approximately 2 in. long and $\frac{5}{8}$ in. diameter. The grid, or control electrode, consists of wire wound on a rectangular frame, the filament being straight and capable of carrying a current of about 1·2 ampères. The method of connecting up these valves is shown in **12**.

A "send-receive" switch is provided, with two exactly similar filament rheostats, one on each side. This arrangement of rheostats

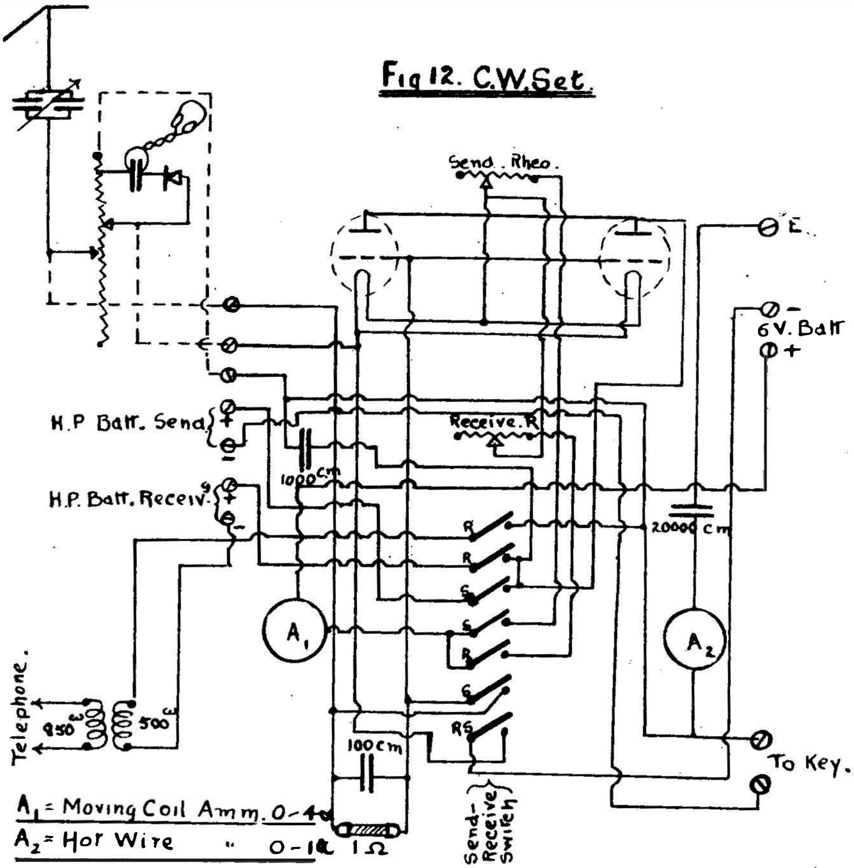


11.—Seddig Amplifying Valve in Middle.

makes it unnecessary to readjust every time the switch is changed from "send" to "receive," and *vice versâ*.

With this switch on the "receive" side a condenser of 100 cm. capacity is inserted in the grid circuit, shunted by a grid leak of one megohm, and the arrangement then permits, when connected to the main receiving box, of the reception of spark signals on the valves instead of on the crystals. With the switch on the "send" side, by suitably adjusting the filament current and the coupling on the main box, continuous oscillation would be generated for the reception of continuous waves by the heterodyne method.

A third object appears also to have been kept in view. Two terminals were provided and labelled for connecting up a key. With the valves working at their full capacity, an aërial current of about one oscillating ampère could be generated, and the set then becomes a short-range continuous wave transmitting set, no doubt for use when the submarines were working in flotillas for communication

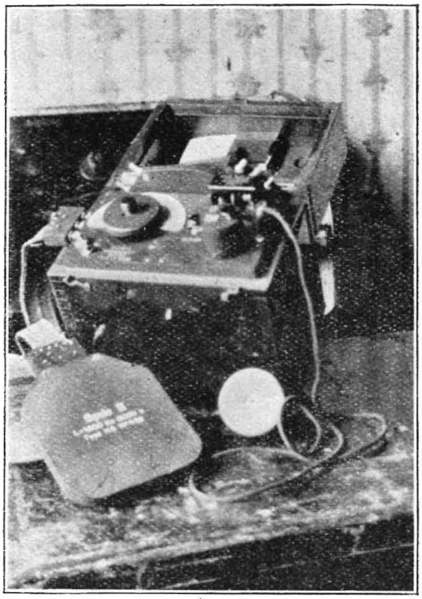


between boats. Such an arrangement would be much less likely to be detected than an ordinary spark set, whether quenched or otherwise, the average merchant ships not being able to pick up continuous waves.

Wavemeters.

Each set was provided with a neatly designed wavemeter (13). Mounted in the box are an adjustable air condenser, a crystal detector, buzzer and switch.

With the switch on one side the detector was in circuit and the set available for tuning the transmitting circuit. By throwing over the switch the buzzer replaced the detector, and by generating waves of a definite known length, enabled the tuning of the receiving circuit to be carried out.



13.—Wavemeter.

Three detachable inductances are provided, giving a range in the oscillating circuit of 100 to 6200 mètres.

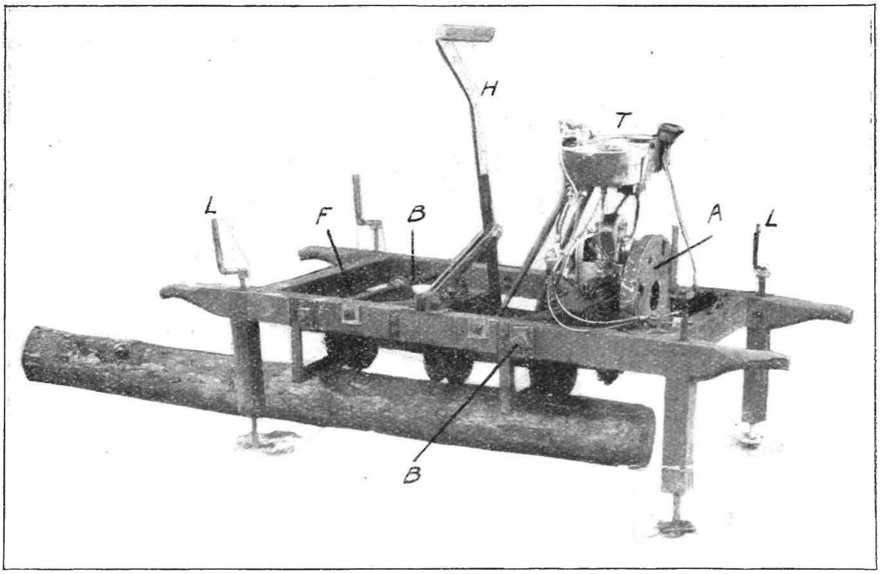
A telephone receiver, cells for working the buzzer, and a set of calibration curves for the three inductances completed this instrument.

AN IMPROVISED POLE-SLOTTING MACHINE.

By Capt. P. Dunsheath, O.B.E.

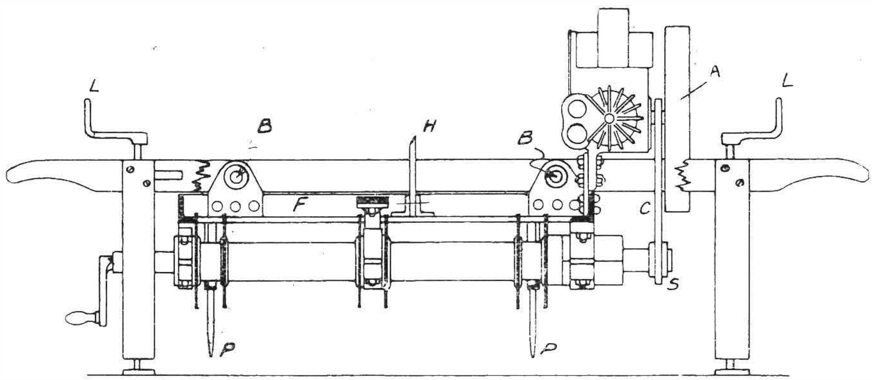
During the summer of 1917 the writer was faced with the problem of increasing the output of a pole-preparing depôt behind the lines in France. Large numbers of roughly trimmed trees varying in length from 22 ft. to 30 ft., and in butt diameter from 5 or 6 in. upwards, were received from the Forestry Companies. After being barked, bored, slotted for arms, and earth-wired, they were despatched to various parts of the line for use by Telegraph Construction Units.

The personnel of the yard at the time consisted of about 150 sappers and pioneers, assisted by 100 or more German prisoners, and at first the boring and slotting was done by hand, the best fitters being chosen from the British for the purpose.



AN IMPROVISED POLE-SLOTTING MACHINE.

In order to deal with the ever-increasing stacks of timber the machine illustrated was devised. A wooden frame, with handle and legs, has two 1-inch parallel and polished bolts (B), on which slides



AN IMPROVISED POLE-SLOTTING MACHINE.

an angle-iron frame (F), carrying the saws and motor. The saws, arranged in three pairs for cutting three slots, are assembled on a shaft running in bearings clamped to the underside of the angle-iron frame. A $2\frac{3}{4}$ h.p. Douglas motor-cycle engine, riding on an extension of the frame, drives the saws by means of a chain (C) and sprocket wheel (S) on the end of the saw spindle.

The poles to be cut are laid out side by side and bored for bolt-holes with auger and template. The machine party then follows, and three German prisoners very successfully carried out this duty. The machine, with engine and saws running, is lifted on to a pole with the taper pins (P) slipped into the first and third bolt holes, so fixing the depth and squareness of the slots. The leg adjusters (L) are then run down by the two men carrying the machine, to take up the unevenness of the ground, and the third man, manipulating the handle (H), feeds the saws across the pole against the pull of a spring, which normally keeps the carriage to one side.

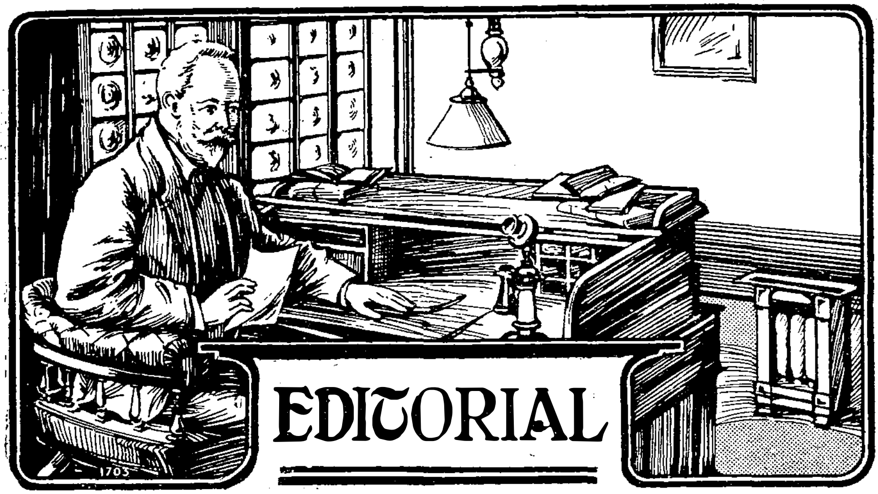
The whole operation occupies less than half a minute, and by fitting a fan (A) made from a petrol tin it was found possible to keep the engine running for several hours at a stretch.

The design and construction of the machine were carried out very much under active service conditions, with few facilities for such work. The M.T.,A.S.C. were induced to turn up the saw spindle and guide bolts, the engine was borrowed from the D.R. Letter Service, some parts were purchased from French shops; but most of the machine was made from "nothing" by two very handy men in the company, who much preferred to exercise their skill in this direction than in digging pole-holes.

MULTIPLEX TELEPHONY IN CANADA.

RECENTLY the Canadian Independent Telephone Company carried out an interesting experiment over the Toronto–Dundas telephone line of the Ontario Hydro-electric Power Commission. Due to the operating conditions in this district the ordinary metallic system has become very indistinct and frequently quite useless. The experiment was in charge of Dr. Lee de Forest, with Prof. C. A. Culver and his staff.

The demonstration was carried on over a pair of telephone wires extending from the power-station at Toronto to that at Dundas, near Hamilton, a distance of over forty miles. The apparatus was arranged at the power stations, and tests were made over the three miles of cable extending from the power-station at Toronto to the central office of the Hydro-electrical Commission. These tests show that the presence of the three miles of cable caused no appreciable attenuation to the service. Two complete transmitters and receivers were installed at each end of the line. Four distinct wave-lengths were employed, ranging from 16,000 to 12,000 metres. Additional tests were made, using wave-lengths of 600, 1000 and 1600 metres. Contrary to all expectations, the results obtained with the higher frequencies (the highest being 500,000 per second) were even better than those one-twentieth as great. The demonstration showed by actual trial that at least seven simultaneous conversations could be carried on without interference of one with any other, and without in any way disturbing the physical circuit. The existing conditions of the line were not disturbed in any way except by momentary interruption while choking coils were being introduced. It was found later that these choking coils were not necessary. The quality and loudness of the speech left nothing to be desired. Simultaneous talking and listening was carried on the same as over an ordinary telephone circuit, no switch-over device being employed. The success of the demonstration using these high frequencies, so new to the wired telephone art, upsets a good many preconceived and orthodox notions of the limitations of telephone operation and engineering. Thus with two pairs of wires sixty independent telephone conversations can be carried on without using the earth, and with earth connections six additional circuits can be provided which should be suitable for telegraph purposes. Over each of these latter circuits it would be possible to carry on ten additional telegraph communications suitable for high-speed work. It has been demonstrated that for this form of telephone communication galvanised iron wires answer admirably. There is no question but that most power-transmission conductors can be used for telephone purposes as well.—*Telegraph and Telephone Age.*



EDITORIAL NOTES AND COMMENTS.

THE elaborate press campaign against the administration and operation of the telephone service has been so full of deliberate misrepresentation that we cannot allow it to pass without comment. It is one of the privileges of the free-born Briton to write to the papers on the short-comings of public services; it is one of the distinctions of the British Civil Service that it remains silent and leaves its defence to the official head of the Department in the House of Commons. The main disadvantage of this procedure lies in the fact that for every hundred persons that read the attack only about one reads the defence, and the particular department lies discredited in the eyes of the ninety and nine. Were the present occasion an ordinary one, we should have preferred to allow the artificially-fostered storm to spend itself, even at the risk of our own depreciation by the multitude. But the times are not ordinary; the last five years have drained the resources of the State almost to the limit, thousands of millions of pounds have been spent on destruction and comparatively little on construction, and now we are face to face with entirely new conditions. One's ideas of the political sanity of the British public and of its notions of fair play are severely tested when it tolerates—and a portion of it at least supports—a virulent attack on a public department, which has not only maintained its own service uninterrupted, but provided the means of communication to and among the vast armies of the Empire operating on three continents throughout the war.

The Engineering Staff of the Post Office consisted of some 24,000 members in August, 1914; of this number it supplied the active services with 12,000 skilled men, who were indispensable to the Army, and who formed the backbone of the signal services. The demand for the return of key or pivotal men for the commencement of reconstructional work at home could not be applied to signal service men, who, by the nature of things, formed the "pivots" of the forces abroad. Since the Armistice the signal service has been busier than any other unit, with the result that our men were retained while others were being demobilised. The older men who stayed at home were called upon to "scorn delights and live laborious days." The provision of new army circuits to innumerable camps and outposts, circuits between searchlights and anti-aircraft guns, cable circuits and apparatus to outlying naval stations—Scapa Flow, Cromarty, and the Murman coast—the diversion of main underground cables to meet the extraordinary demand for telephones by munition and control departments, training the men of the new armies in Morse working and in the use and care of apparatus are but a few of the many extra duties thrust upon the depleted staff. It should be remembered also that even now the war bonus amounts to less than 40 per cent. of the pre-war wages, and it is to their everlasting credit that the men remained steadfast and loyal while wages were soaring outside.

Before the war the signal equipment of the Army was simple and primitive, and the quantities in stock on the outbreak of hostilities were insignificant. After the Marne and the Aisne, when General French and the German Army Commanders echeloned to the North Sea and fought the first battle of Ypres, the fronts settled down to the long dreary spell of trench warfare. An enormous demand for telephone material then came forward; G.H.Q. had to be joined to Army headquarters, armies to corps, corps to divisions, divisions to brigades, and brigades to battalions. The extraordinary artillery development called for a complete system of telephone control, from the "O Pips" to the batteries, and from the artillery brigades and areas to the front lines and supports. Main open lines had to be built in the back areas, and lateral communication circuits had to be provided and maintained between the various British armies and their allies. The whole of the battle-fronts became an intricate network of wires, each centre of operations having as many lines radiating from it as from any exchange in a provincial city. The telephone scheme laid down in the sewers and environs of Arras during the Somme fighting in July, 1916, was on a scale unprecedented, and undreamed of even in December, 1915, and demands for similar and greater facilities came from all parts of the line for the next two years. Nor was France and Flanders the only area requiring wire, cable and apparatus. In Mesopotamia and Palestine the lines of communication were long and the operating armies were entirely dependent upon them; the conditions on the Salonika front were similar to the western, although perhaps less elaborate. The extraordinary demand overwhelmed the ordinary sources of army supply and the Post Office had to come to the rescue. Manufacture for home service use practically ceased; the entire resources of the Departmental factories were devoted to the production of war material. Commercial firms, whose best customer was the State telephone service, and who had built up a telephone industry in the United Kingdom, were now fortunately in a position to manufacture on a large scale and were permitted to divert their plants from munition production—" Shells and still more shells" was the first cry—and produce telephone equipment for the army, and several factories were taken over entirely by the War Office for the same purpose. Wire, cable, telephones, switchboards and signalling apparatus of new and varied types poured across the Channel in ever-increasing quantities. Preparations for a grand assault in the spring of this year were in full swing when the Germans collapsed. Then came the reaction.

While hostilities were in progress no serious complaint came from the public, although the service given was admittedly not up to pre-war standard. Much of the plant was old (it would have been largely replaced if the war had not happened), and maintenance was difficult with the largely reduced staff, who were being called upon to perform many additional duties. The man in the street knew this and appreciated it in a general sort of way; he did not know that the entire telephone manufacturing plant of the country was producing special cables and apparatus at feverish speed for consumption by the armies in the field. He who asks, " Where are the wires to join up my telephone to-morrow, and why are they not available?" will receive the answer he would have received had he asked, " Where are the men of the old Contemptible Army." "They lie buried in the soil of France and Flanders." The professional pressmen know this, however, or ought to know, but do not publish it under sensational headlines.

This is the second time that a certain section of the daily press has attempted to throw discredit upon the staff and administration of the public telephone service; the first was in 1912, and began practically on the day the State took over the plant and *personnel* of the N.T. Company. We were told then that the highly efficient staff of the Company had become infected suddenly by the bacillus of slackness, and that the service was going to the proverbial dogs. We shall perhaps be told that it is because we suffer from the same disease that we are unable to trace any loss of efficiency in the said staff, who have borne their share of a very strenuous seven years with the same ungrudging devotion to duty as the old-time P.O. men.

It is in no wise remarkable that the second assault coincides with the miners' demand for the nationalisation of the mines. With the arguments for and against nationalising that industry we have nothing to do in our present capacity. What we do wish to express here is to protest against the administration and staff of the Post Office engineering service being used as a scapegoat for ulterior and political motives. We have endeavoured to indicate in the foregoing how the energies of the Department have been diverted during the last few years, and why the system has not been improved to the extent we confidently hoped for in 1912. We should be obliged if one of the enterprising and imaginative young men in the "Street" would present us with his ideas as to what would have happened had the telephone service been in private hands on August 4th, 1914.

As mentioned by the Postmaster-General in the House, the value of the plant supplied through the Post Office to the Army amounted to nearly seven million pounds—a sum more than half the total paid-up capital of the Company raised during its thirty years' existence. Unfortunately the great proportion of this plant is of special design to meet the military requirements, and would be of little use for civilian service if recoverable to-morrow.

We have heard a great deal about the deterioration in the service that set in immediately the Government took over the control of the telegraph and telephone services in the United States, but judging from a letter which Mr. Theodore N. Vail, chairman of the American Telegraph and Telephone Company, has circulated to the shareholders, a copy of which appeared in the 'Electrical World' on July 26th, there does not appear to have been much ground for complaint beyond the dislocation produced in her industries generally by the entry of America as a belligerent nation.

Mr. Vail remarks: "There has been no policy adopted by the Postmaster-General during the period of federal control which was not in the interest of the service, and with which your organisation has not been in full accord. This co-operation has resulted in the maintenance of the service at the highest standard possible under the extremely arduous conditions. Your property has been maintained and will be returned in as good physical condition as though it had never been out of your possession."

And again, "During the period of federal control the work of development and research made gratifying progress and many notable advances in construction, equipment and methods were brought to completion." Among the improvements he mentions the following:

Radio-transmission over unlimited distances has become an accomplished fact.

The amount of copper required per circuit has been reduced to a small fraction of the weight formerly used, and the capacity of one circuit increased from one to a number of simultaneous conversations. The capacity and value of underground ducts and conduits has been correspondingly increased.

Underground transmission distance has been increased.

Telephonic machine switching and machine telegraphy have been developed, and improvements have been effected in submarine cable transmission.

Our readers interested in telegraph problems will be sorry to hear of the death of one of our esteemed foreign contributors, Señor José Maria Fernandez Lamothe. "A Friend" in Rosario, in announcing his death, gives the following particulars of his service:

He commenced his career as Clerk in the Telegraph Superintendent's office of the Buenos Aires and Rosario Central Argentine Railway in September, 1898, and remained there till February, 1905. From February, 1905, till November, 1910, he was with the Pacific Railway Company as Assistant Telegraph Engineer. Afterwards Señor Lamothe occupied the post of Telegraph Inspector on the Central Argentine Railway from June 20th, 1911, until December 31st, 1912, when he was appointed Assistant Telegraph Superintendent, which post he held until his death.

When the JOURNAL was founded some twelve years ago the Council of the Institution of Post Office Electrical Engineers decided that it should be self-supporting, and the selling price was fixed accordingly. During the last three years there has been a continuous rise in wages and in the cost of materials, with the result that the expense of production has nearly doubled, and the original price of the magazine will have to be raised to meet the increased charges. The Council, at its June meeting, fully considered the position, and decided to sell copies of the October and January issues of the present volume at two shillings each, and to raise the price for subscribers to the new volume, commencing in April next, to the same figure. The postage charge will remain unaltered.

Owing mainly to the shortage and consequent dearness of paper we have been compelled to reduce the size of the JOURNAL, and have thereby been enabled to maintain, at least, the continuity of issue. The market is now easier, and at the increased price we hope to be able to produce a magazine equal in size and quality to that of former years. We regret that the depreciation in the purchasing value of the shilling has not been met by a corresponding increase in salary, but we feel confident that the staff will support us in the future as they have done in the past. The years ahead will be busy years, full of promise and pregnant with possibilities in every direction, and it shall be our duty and aim to keep abreast of development, and to keep our readers in touch with the progress achieved, not only in the home service, but in the colonies and abroad.

INSTITUTION MEDALS.

THE Council of the Institution has awarded the following medals for papers read before the Institution:

Senior Silver Medal.—Mr. J. G. Hill: "The Loading of Underground Telephone Cables for Phantom Working."

Senior Bronze Medal.—Mr. B. S. Cohen: "Telephonometry."

Junior Silver Medal.—Mr. J. Hedley: "The Western Electric Company's Semi-automatic System."

Junior Bronze Medal.—Mr. S. C. Bartholomew: "Power Circuit Interference with Telegraphs and Telephones."

HEADQUARTERS NOTES.

TELEPHONE EXCHANGE DEVELOPMENTS. C.B. MANUAL EXCHANGES.

ORDERS have been placed for new exchanges at—

Carlisle (No. 10), 880 lines.

Clerkenwell (No. 1), 7200 lines.

West Bromwich (No. 10), 600 lines.

Orders have been placed for the extension of the following exchanges:

Avenue (No. 1), extension 960 lines.

Barry (No. 9), rearrangement of junctions.

Lincoln (No. 10), 260 lines.

AUTOMATIC EXCHANGES.

Stockport Automatic Exchange opened on August 23rd. The contract for this equipment was placed with Messrs. Siemens Bros. & Co., Ltd., Woolwich, as long ago as September, 1913, but owing to early difficulties in manufacture, and subsequently to the existence of war conditions, very little progress was possible until recently.

The new exchange provides accommodation for 950 direct lines, and 781 subscribers' circuits with 1193 stations, and 78 junctions were transferred thereto. A special feature of the new system is the key-ended, order-wire junction service from Manchester to Stockport.

Local Line Development.

Little progress has been possible during the past four years, and every effort is now being made by means of the provision of underground work in congested areas to meet the telephonic requirements, both present and prospective. The following statistics have reference only to schemes which are being carried out by contractors under the Territorial Contracts. In addition, a considerable amount of work is being undertaken under ordinary contracts and by the Department's workmen. The period covered by the summary is April 1st to August 31st of the current year.

Number of separate development schemes approved, 257.

Number of separate development schemes for which orders have been placed with contractors, 90.

Approximate total value of schemes approved, £1,360,000.

Approximate total value of orders placed with contractors, £586,000.

Length of duct laid, 155 miles.

LONDON DISTRICT NOTES.

Internal Construction.

Telephone Lines and Stations.—During the thirteen weeks ended July 22nd, 1919, 4065 exchange lines, 4880 internal extensions and 292 external extensions were provided. During the same period 1261 exchange lines, 3163 internal extensions and 429 external extensions were recovered, making net increases of 2804 exchange lines, 1717 internal extensions and a net decrease of 137 external extensions.

External Construction.

For the three months ended July 31st, 1919, a net increase of 1142 miles occurred in telephone exchange wire mileage within the London Engineering District, the increase under the heading of underground being 1299 miles. Open wire (bare wire) and aërial cable decreased by 50 miles and 107 miles respectively.

Telephone Trunk open wire mileage remains unaltered, but underground increased by 55 miles.

Telegraphs (underground) increased by 170 miles; telegraphs (aërial) unaltered.

Pole line mileage increased by 15 miles, whilst pipe line mileage increased by 5 miles.

The aggregate mileage in the District at the end of July, 1919, was as follows:

Line Mileage.

Pole line	2589 miles.
Pipe line	3580 ,,

Single Wire Mileage.

Telegraphs	18,120 miles	Exclusive of wires maintained by railway companies.
Telephone exchange .	1,011,619 ,,	
,, trunks . .	17,464 ,,	
Spare wires	18,068 ,,	

The total length of underground cable is 7152 miles.

Central Telegraph Office.

The staff of the Censor's Department have departed from the Central Telegraph Office and accommodation is now available for the return of the apparatus temporarily removed during the war. Hughes and Baudot instruments are gradually being reinstated, and it is anticipated that all the dismantled apparatus will be working again by the time these notes appear in print.

It is anticipated that big developments will take place, and already a second Western Electric Multiplex set has been installed. Although the new set is not of the same pattern as the original, it is hoped that it will be possible, ultimately, to make the two sets interchangeable.

Private Branch Exchanges.

The work of providing new Private Branch Exchanges proceeds apace and at the present time three new boards are in course of construction; one of these comprises fifteen positions.

Progress is also being made with the recovery of some of the multiple type P.B.X.'s, which were provided for Government Departments in connection with the war.

RETIREMENT OF MR. F. W. HEATH.

His many friends in the Service will learn with great regret the news of the retirement, under the age regulations, of Mr. F. W. Heath, First Class Clerk in the London Engineering District, which took place on June 30th last.

Mr. Heath first joined the Engineering Department on March 3rd, 1877, under the late Mr. E. Shipp, Engineer. He was transferred to the Superintending Engineer's Office in 1885, and was promoted to Junior Clerk, First Class, in 1887.

In 1891 he became Correspondence Clerk, and continued to serve in this capacity under Mr. C. Fleetwood, Mr. Eaton's successor, being promoted to a Senior Clerkship in 1895.

Mr. Heath left Mount Pleasant in 1901 for Moorgate Street Buildings to take charge of the clerical staff of the newly-created Metropolitan South District under Mr. T. Harrison. In 1903 the removal of the Headquarters of the Metropolitan South District from the City to Wandsworth Common took place; the Metropolitan Central District and Metropolitan South District were amalgamated in 1912

MR. F. W. HEATH.

(the Metropolitan North District having ceased to exist upon the retirement of its Superintending Engineer in 1911) with Headquarters at London Bridge, and Mr. Heath had charge of the clerical staff who remained at Wandsworth Common until the closing of that office in 1916, consequent upon the completion of the new building at Denman Street and the transfer of the staff from Wandsworth there. His career, therefore, is virtually a history of the London Engineering District.

As a matter of interest, it is probably a fact that Mr. Heath is the only First Class Clerk who has had charge of the clerical staffs of two districts simultaneously. From 1909 to 1911 he was responsible for the staff of the South-Eastern District, which was also stationed at Wandsworth during that period.

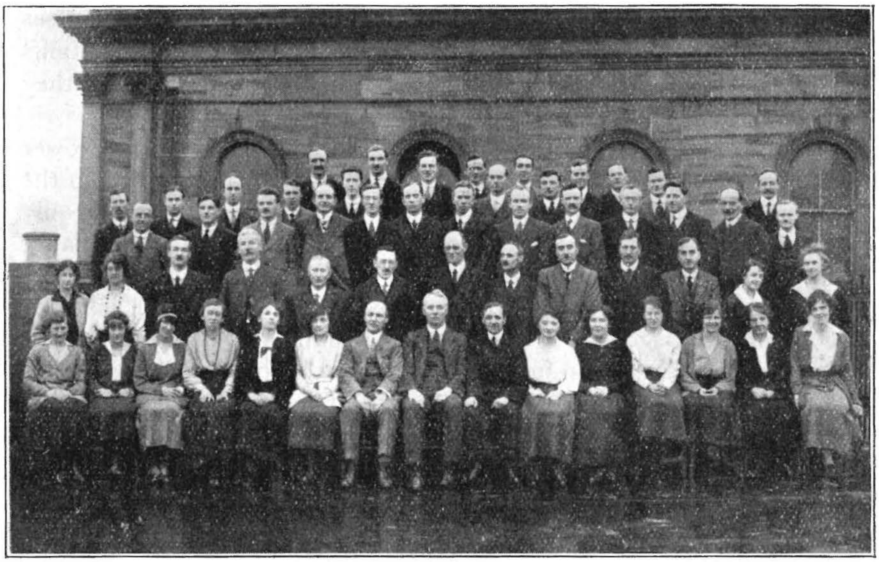
Considerations of space prevent us from giving more than a brief sketch of the career of a genial and interesting personality, who has made a host of friends for himself. It may readily be imagined that his retirement was marked by an event worthy of the occasion. On June 11th a farewell concert was given at Denman Street, Mr. Moir presiding over a large and representative company who had come to say good-bye to Mr. Heath. The affection and esteem in which he was held by all grades of the staff were well expressed by various speakers, and a tribute paid to his wide acquaintance with men and matters, his unique knowledge of London, past and present, and to his almost phenomenal memory. Mr. Moir, in presenting him with an illuminated address, referred in feeling terms to the loyal support he had received from him, both at Wandsworth and Denman Street. In addition to the address Mr. Heath was also presented with a china cabinet, combination book-case and writing-desk, a case of pipes and a cigar-case subscribed to by his many friends and admirers in the Engineering Department.

In him the District loses an officer who, by his tact, sympathy, and charm of manner, has won the affection and respect of the staff in no small degree.

For ourselves we wish him many years of happy, contented retirement.

SCOTLAND EAST DISTRICT HEADQUARTERS.

A GROUP taken on March 15th, 1919, to commemorate the return of some of "our boys" from H.M. Forces, and the presence with us of thirteen of the temporary Lady Clerks who helped to "carry on" during the war period.



SCOTLAND EAST DISTRICT HEADQUARTERS GROUP.

There are twenty-one demobilised engineering and clerical officers in the group.

Photograph by Mr. J. Tyson of our staff.

BOOK REVIEWS.

'The Strowger Automatic Telephone Exchange.' By R. Mordin. (London: E. & F. N. Spon, Ltd. Pp. viii + 186. With 32 plates and 82 illustrations. Price 21s. net.)

This book is a welcome addition to the Library of Telephone Engineers, as it includes an excellent collection of diagrams illustrative of the Strowger Automatic System as supplied by the Automatic Telephone Manufacturing Company, Liverpool, and installed in many of the Post Office Exchanges in this country.

The general principles do not seem to be quite so satisfactorily dealt with, but probably this is unavoidable in a book which deals only with one system. The Post Office Engineer will need to study also the automatic systems manufactured by the Western Electric Company and Messrs. Siemens Bros. & Co., taking the three systems together and then studying the general principles. Amongst the usual claims in favour of the automatic system the author repeats the well-worn claim of secrecy. As telephone engineers we ought not to make any such claim, as the replacement of operators by workmen which is involved in the introduction of an automatic system does not mean that the latter cannot overhear telephone conversations that are in progress. In the ordinary course of their work they occasionally must do so.

We do not know upon what ground the author can claim lower maintenance charges and comparative immunity from faults in the automatic system. The apparatus is more complex, and it is only reasonable to expect that, other things being equal, the maintenance charges will be somewhat higher and the faults somewhat more numerous than in the manual plant, even when allowance is made for faulty cords on the latter type of plant. The advantages of automatic working are sufficiently definite without making claims that cannot be sustained. The strength of the automatic policy lies in the fact that such plant tends to reduce the personnel of the telephone administrations, and to abolish or reduce the duties of organisation and administration which accompany personnel. Further, that automatic plant economises building space and can be housed in places that would be quite unsuitable for manual equipment. We agree that it is right to claim advantages in respect of the fact that there is no practical limit to the size of an automatic exchange, and also that the depreciation charges should be lower for an automatic equipment owing to its greater adaptability and its relatively longer life as a result of the absence of the subscribers' multiple, which is characteristic of a large manual plant and is not renewable.

B. O. A.

'The Principles of Electric Wave Telegraphy and Telephony.' By J. A. Fleming, M.A., D.Sc., F.R.S. (London: Longmans Green & Co. Fourth Edition. Pp. xv + 707. Price 42s. net.)

The name of Fleming has been intimately associated with the evolution of the principles governing the art of wireless telegraphy from the earliest days of its history; his 'Principles of Electric Wave Telegraphy' held an almost essential place in the bookshelf of every student of the art; whenever problems arose for consideration, especially those in which principles and calculations were involved, "Fleming" was instinctively turned to for guidance, and seldom was the expectation disappointed of finding some clear indication or food for thought in its pages. The welcome accorded to this the fourth edition will therefore, we anticipate, be no less cordial than was accorded to previous editions.

New matter has necessitated a material enlargement of the work; in order to keep the book within manageable proportions, a somewhat smaller type and a more compact style of setting have been adopted in the new edition; these we consider are improvements, and in nowise detract from the clearness of the reading. Certain historical matter and description of apparatus were removed when the third edition was issued; we are glad that the zeal for excision in this direction has not been carried too far in the fourth edition. In a new art, which is necessarily in a state of flux, history and description of apparatus, which have been tried and by process of evolution have given place to others, are important elements in development, and the fourth edition retains much of its former value in this direction. The general contents of the work are too well known to require any detailed exposition; the sections dealing with the subject theoretically and mathematically remain substantially the same as in previous editions; it may be added, however, that additional information has been added dealing with the "High-frequency Resistance of Multiple Stranded Insulated Wire," and where the development of the art has necessitated it the chapters have been rearranged to incorporate new information in its proper sequence. It is a matter for regret that some larger space has not been devoted to the latest developments in continuous wave working and the use of valves both for transmission and reception. No book purporting "to give a comprehensive view of the subject" can now be considered complete unless it deals comprehensively with these subjects. With this reservation it may be said that as a text-book of the principles of the art, particularly from the mathematical point of view, the work retains its position in the front rank of books on the subject, and will, we are sure, be given a hearty welcome.

Where practical application of the principles in the art, as distinct from the science of the subject, however, is concerned, the work leaves much to be desired; many errors have crept in or have been allowed to remain from former editions. To give a few examples: On p. 527 it is stated that the studs of the disc discharger make grazing contact as they pass the fixed electrodes. A wireless engineer who adopted this adjustment would soon receive his marching orders! On p. 555 it is stated that at coast stations the stay insulators are connected by well-tarred or paraffined rope. We imagine this practice was abandoned years ago; certainly the practice was abandoned, so far as the Post Office is concerned, in 1910, and we doubt whether it is adopted anywhere at the present time. On p. 558 a description of the Post Office Bolt Head Wireless Station is given as "a good illustration of a short-distance station on the latest model." The station was erected in 1908! and has not been used as a coast station for some long time, the St. Just Station taking its place. We should blush to present it as of the latest model; the more correct term would be "antiquated"; things move rather fast in the wireless world. On p. 564 it is stated that of the two masts at the Post Office St. Just Wireless Station, one mast carries "a 600-feet wave and the other a 300-feet wave antenna." The facts are that the two masts carry one T antenna which is used primarily for 600-metre wave transmission; 300-metre wave transmission is obtained on the same antenna by inserting a condenser in series. It is also stated that signalling is carried out by an electro-magnetic key worked from the receiving room, whereas the key in the receiving room is inserted directly in the low-tension side of the step-up transformer.

It is with keen regret that we find it in our duty to call attention to blemishes of this kind in a standard work. Theory and practice, if not shown to be divorced, certainly seem to be in a state of strained relationship. Fortunately the scientist and engineer rely on the technical periodicals for accurate details of practice, so no great harm will be done to those to whom the work would generally appeal. If such details appear in books such as that under review let them be accurate; for our part we should prefer to see them omitted.

F. W. D.

'The Practical Telephone Handbook and Guide to the Telephone Exchange.' By Joseph Poole, A.M.I.E.E. (Wh. Sc.). (London: Sir Isaac Pitman & Sons, Ltd. Sixth Edition. Pp. xxiii + 725. Price 12*s.* 6*d.* net.)

Published originally in 1895, this most valuable text-book has increased in size to meet the ever-growing development of the art, and the present issue runs to some 750 pages, few of which could be cut out without doing harm to the volume, either from the historical standpoint or from the point of view of modern practice. The progress in telephony has been so extensive in late years that an accurate knowledge of all detail is almost beyond the capabilities of any one man, and Mr. Poole has done well to secure the services of specialists in the various branches, and is thereby enabled to describe the latest methods in exchanges and in line construction. It is to be regretted, however, that very little is said about the application of repeaters to lines in this country. This is probably due to the existence of war conditions and to the controversy over patent rights concerning the thermonic valve. In this respect the book is not quite up-to-date. The reduction in copper gauge required on underground circuits and the corresponding increased capacity of pipe and duct lines by the use of the repeater is one of the most promising developments in recent years.

Otherwise very little fault can be found. The loading of underground and submarine cables, the superposing of phantom circuits on physical lines, traffic problems, manual exchanges and the various automatic exchange systems are all well described and the diagrams are clear. The last chapter in the volume gives an account of the 'Relay Automatic Telephone Coy.'s System,' which is claimed to be the first full description published. The book is recommended to students of telephony in all stages, and should be available for reference in the files of every telephone engineer.

MILITARY HONOURS.

THE Board of Editors has great pleasure in publishing the further list of honours awarded to members of the Engineering Department:

Temporary Major (Acting Lieut.-Col.) A. Evans, O.B.E., M.C., R.E. (Assistant Engineer, North Midland District). Mentioned in Despatches.

Captain R. J. S. Gold, Civil Service Rifles (Second Class Clerk E.-in-C.'s Office). Mentioned in Despatches.

Temporary Lieut. (Acting Captain) F. Bate, R.E. (Third Class Clerk, North Midland District). Mentioned in Despatches.

Staff-Sergeant A. E. Brown, R.A.S.C. (Clerical Assistant, North Eastern District). Awarded the Meritorious Service Medal.

Sapper P. W. Castle, R.E. Signal Service (Unestablished Skilled Workman, Eastern District). Awarded the Military Medal.

Corporal (Acting Coy. Qmr.-Sergeant) C. Connell, R.E. Signal Service (Skilled Workman, Class II, Eastern District). Awarded the Meritorious Service Medal.

Second Corpl. A. S. Deboise, R.E. Signal Service (Skilled Workman, Class I, London District). Awarded the Meritorious Service Medal.

Sergeant W. E. Mattison, R.E. Signal Service (Unestablished Skilled Workman, London District). Awarded the Meritorious Service Medal.

Second Corpl. F. J. May, R.E. Signal Service (Clerical Assistant, South Western District). Mentioned in Despatches.

Sergeant R. A. T. Monk, King's R. R. Corps (Tradesman, London District). Awarded the Military Medal.

Lance-Corporal A. Mortimore, R.E. Signal Service (Clerical Assistant, South-Western District). Mentioned in Despatches.

Corporal A. W. Rance, R.E. Signal Service (Skilled Workman, Class II, Eastern District). Awarded the Meritorious Service Medal.

Company Sergt.-Major D. H. Shepherd, Hussars (Third Class Clerk, Eastern District). Awarded the Meritorious Service Medal.

Sapper E. A. Weidhoft, R.E. Signal Service (Youth, London District). Awarded the Military Medal.

Sergeant F. W. Burton, R.E. Signal Service (Skilled Workman, Class I, London District). Awarded the Médaille Militaire (French) and the Meritorious Service Medal.

Sergeant H. J. Dowsett, R.E. Signal Service (Unestablished Skilled Workman, London District). Awarded the Military Medal and Mentioned in Despatches.

Sergeant A. G. Sheppard, R.A.F. (Clerical Assistant, Testing Branch, E.-in-C.'s Office). Mentioned in Despatches.

Private R. Fairbairn, Highland Light Infantry (Unestablished Skilled Workmen, Scotland East). Awarded the Distinguished Conduct Medal.

Acting Major F. Penfold, R.E. Signal Service (Third Class Clerk, South-Eastern District). Mentioned in Despatches.

Corporal E. J. Abbott, R.E. Signal Service (Skilled Workman, Class II, London District). Awarded the Croix de Guerre.

Private G. F. Badcock, Wiltshire Regiment (Unestablished Skilled Workman, London District). Awarded the Distinguished Conduct Medal.

Acting Corporal F. J. Baxter, R.A.F. (Skilled Workmen, Class II, North Wales District). Mentioned in Despatches.

Lance-Corporal T. M. Berry, R.E. Signal Service (Skilled Workman, Class II, North-Western District). Awarded the Meritorious Service Medal.

Corporal S. Cooper, Machine Gun Corps (Labourer, North Wales District). Awarded the Military Medal.

Sergeant T. Cripps, R.E. Signal Service (Unestablished Skilled Workman, London District). Awarded the Meritorious Service Medal.

Corporal J. Dick, R.E. Signal Service (Third Class Clerk, Scotland West District). Awarded the Meritorious Service Medal.

Acting Sergt.-Major J. Hart, Middlesex Regt. (Labourer, London District). Awarded the Military Medal.

Gunner W. Kelly, R.F.A. (Assistant Clerk, London District). Mentioned in Despatches.

Corporal G. E. Morison, R.E. Signal Service (Unestablished Skilled Workman, Scotland West District). Awarded the Meritorious Service Medal.

Lance-Sergeant G. Nimmo, A. & S. Highdrs. (Third Class Clerk, Scotland West District). Awarded the Military Medal.

Flight-Sergeant H. W. Powell, R.A.F. (Inspector North Wales District). Mentioned in Despatches.

Corporal (Acting-Sergt.) F. Shipperbottom, R.A.F. (Skilled Workman, Class II, North-Western District). Awarded the Meritorious Service Medal.

Corporal A. R. Wallworth, R.E. Signal Service (Skilled Workman, Class II, North Wales District). Awarded the Meritorious Service Medal.

Lieutenant R. Gauld, R.E. Signal Service (Skilled Workman, Class II, Scotland East District). Mentioned in Despatches.

Second Lieut. (Acting Captain) F. Bate, R.E. Signal Service (Third Class Clerk, North Midland District). Mentioned in Despatches.

Second Lieutenant L. A. Bird, R.F.A. (Assistant Clerk, London District). Awarded the Military Cross.

Sergeant H. Brown, R.E. Signal Service (Third Class Clerk, South Midland District). Awarded the Meritorious Service Medal and Mentioned in Despatches.

Sergeant W. Clark, R.E. Signal Service (Unestablished Skilled Workman, Ireland District). Awarded the Military Medal.

Corporal L. A. Edwards, R.G.A. (Shorthand Typist, North Wales District). Awarded the Military Medal.

Sapper W. E. Evans, R.E. (Unestablished Skilled Workman, South Wales District). Awarded the Military Medal.

Corporal W. Hansford, R.E. Signal Service (Third Class Clerk, South Wales District). Awarded the Gold Medal (Serbian).

Sergeant J. J. James, R.E. (Unestablished Skilled Workman, North Midland District). Awarded the Distinguished Conduct and Military Medals.

Sapper W. T. Jones, R.E. Signal Service (Unestablished Skilled Workman, North Wales District). Mentioned in Despatches.

Corporal W. A. Middlemiss, R.E. Signal Service (Skilled Workman, Class II, Scotland East District). Mentioned in Despatches.

Sapper (Acting Company Sergt-Major) L. Taylor, R.E. (Skilled Workman, Class II, North-Western District). Awarded the Croce di Guerra, Italian, and Mentioned in Despatches.

Corporal (Acting Sergeant) H. Temple, R.E. Signal Service (Labourer, London District). Awarded the Distinguished Conduct and Military Medals, and mentioned in Despatches.

Major A. S. Angwin, D.S.O., M.C., R.E. Signal Service (Assistant Engineer, E.-in-C.'s Office). Mentioned in Despatches.

Temporary Major W. M. Batchelor, D.S.O., M.C., R.E. Signal Service (Assistant Superintending Engineer, Eastern District). Mentioned in Despatches.

Major H. Brown, O.B.E., R.E. Signal Service (Assistant Staff Engineer, E.-in-C.'s Office). Mentioned in Despatches.

Major E. A. Lewis, D.S.O., R.E. Signal Service (Chief Inspector, North Wales District). Mentioned in Despatches.

Temporary Lieutenant (Acting Captain) T. Campbell, R.E. (Third Class Clerk, Scotland East District). Mentioned in Despatches.

Temporary Lieutenant (Acting Captain) E. E. Fenn, R.E. Signal Service (Testing Branch, E.-in-C.'s Office). Mentioned in Despatches.

Lance-Corporal (Acting Sergeant) F. W. E. Fletcher, Tank Corps (Clerical Assistant, South-Western District). Mentioned in Despatches.

Sergeant J. A. Gladman, R.A.O.C. (Clerical Assistant, South-Eastern District). Awarded the Meritorious Service Medal.

Acting Company Sergeant-Major W. H. Zanazi, R.E. Signal Service (Unestablished Skilled Workman, South-Western District). Awarded the Distinguished Conduct Medal.

Lieutenant G. E. Appleton, R.E. Signal Service (Third Class Clerk, South-Eastern District). Mentioned in Despatches.

Second Lieutenant S. Hanford, R.E. Signal Service (Assistant Engineer, E.-in-C.'s Office). Mentioned in Despatches.

Sapper F. J. R. Dixon, R.E. Signal Service (Unestablished Skilled Workman, Northern District). Awarded the Military Medal.

Sapper (Acting Corporal) W. Hamilton, R.E. Signal Service, attached to R.F.A (Unestablished Skilled Workman, North Midland District). Awarded the Military Medal.

Sergeant W. D. Johnson, R.E. Signal Service (Skilled Workman, Class II, South Midland District). Awarded the Meritorious Service Medal.

Sapper J. W. Joseph, R.E. Signal Service (Third Class Clerk, London District). Mentioned in Despatches.

Company Qmr.-Sergeant J. V. B. Mosdell, R.E. Signal Service (Clerical Assistant, South Midland District). Mentioned in Despatches.

Sergeant J. F. Ryan, R.E. (Skilled Workman, Class II, South Western District). Awarded the Distinguished Conduct Medal.

Sergeant C. H. Reed, London Regiment (Skilled Workman, Class II, London District). Awarded the Distinguished Conduct Medal).

Sergeant F. G. Ainsworth, R.E. Signal Service (Skilled Workman, Class I, South Midland District). Awarded the Meritorious Service Medal.

Sergeant W. H. Siddle, R.E. Signal Service (Inspector, North-Eastern District). Awarded the Meritorious Service Medal.

ROLL OF HONOUR.

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

Name.	Rank.	District.
R. Conlon	Unest. Skilled Workman	S. Lancs.
A. J. Gardner	,, ,, ,,	S. Wales.
E. E. Jenkins	Labourer	,,
G. H. Ronald	Skilled Workman, Cl. II	Scot. W.
D. Saunders	Labourer	S.E.
L. H. Shadforth	Inspector	N.
A. J. Sheppard	Youth	S. Mid.
F. E. Stapley	Labourer	,,
G. J. Tooke	,,	London.
P. D. Vanhinsbergh	,,	,,

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	District.	From.	To.	Date.
Freeman, F.	London.	2nd Cl. Clk.	1st Cl. Clerk.	13 : 4 : 19
Payne, W. J. A.	,,	,,	,,	15 : 7 : 19
Bliss, C. H. D.	,,	3rd Cl. Clerk	2nd Cl. Clerk.	13 : 4 : 19
Hilton, J. E. T. S.	,,	,,	,,	,,
Lock, F. J.	,,	,,	,,	,,
MacNalty, G. T.	,,	,,	,,	20 : 7 : 19
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Rankin, W. H.	Ire. to N. Mid.	,,	,,	1 : 6 : 19
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RETIREMENTS AND RESIGNATIONS.

Name.	District.	Rank.	Date of retirement or resignation.
Heath, F. W. . . .	London	1st Cl. Clerk	30 : 6 : 19
Hatfield, W. A.. . .	,,	Asst. Engr.	24 : 7 : 19
Rowe, R. S. . . .	E. in C.O.	3rd Cl. Clerk	1 : 9 : 19 (Resigned)

TRANSFERS.

Name.	Rank.	Transferred.		Date.
		From	To	
Angwin, A. S. . .	Asst. Engr.	Scot. W.	E. in C.O.	14 : 7 : 19
Hansford, R. V. . .	,,	Scot. E.	,,	9 : 8 : 19
Ireland, W. . . .	,,	London	,,	3 : 9 : 19
Lucas, W. C.. . .	3rd Cl. Clerk	E. in C.O.	Ministry of Pensions	8 : 7 : 19
Bence, W. R.. . .	,,	London	S.W.	16 : 5 : 19
Warren, A. . . .	,,	Submarine	Ministry of Labour	21 : 7 : 19

COMMUNICATIONS.

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