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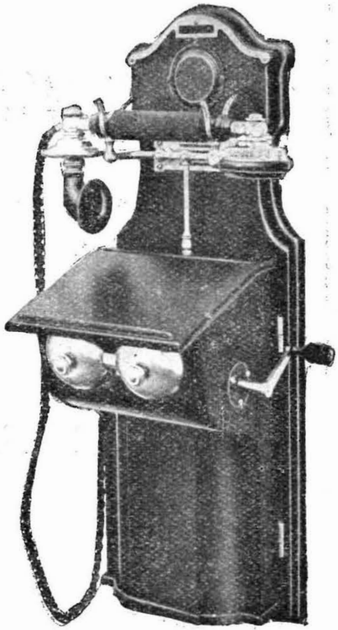

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THE Post Office Electrical Engineers' Journal

POST OFFICE TELEPHONE FINANCE.

In view of the frequent references in the public press regarding Telephone Finance and the prospect of increased rental charges, it may be of interest to readers of the Journal to examine the figures which have been published annually since the National Telephone Company's undertaking was transferred to the State in 1912.

In the first place it will be convenient to deal with the principal terms used in the accounts.

Capital.—The money for providing telephone plant is obtained by means of loans from the National Debt Commissioners. The loans are now generally repayable within a period of fifteen years.

Depreciation Fund for Repayment of Capital.—Plant has a limited period of life beyond which it is wasteful to keep it in use. The plant either wears out and thus becomes useless, or owing to new inventions or improvements, the time arrives when, after making due allowance for the residual value, it becomes profitable to scrap the old material and instal new plant which is less costly to operate or maintain or has greater earning capacity. The equated average life allowance in the case of telephone plant is twenty years. The depreciation allowance, which corresponds to the "Reserve Fund" accumulated by the late National Telephone Company, is calculated to repay the capital expended, less scrap value of recovered material within the period; and the sum required is set aside in annual instalments. In practice new plant is added to provide for growth year by year, and consequently the renewal of the entire system does not become due at any particular date, but is proper to be dealt with gradually.

Renewals and Displaced Plant.—Each year certain portions of the plant fall to be renewed, or plant which has become useless is recovered. The cost of this work is charged against the accumulated depreciation fund. The amount expended on renewals added to the value of plant permanently displaced is deducted from the amount provided for depreciation during the year, and the difference is carried to the total "balance at credit of depreciation fund."

Maintenance.—The cost of maintenance is the cost of looking after the plant, keeping it in running order, and effecting ordinary repairs but not renewals. As a matter of convenience minor renewals, such as the replacement of broken insulators, worn-out cords, broken plugs, etc., are charged against maintenance, but these items are regarded as proper to repairs rather than renewals, and due allowance has been made accordingly in calculating the equated average life of the plant.

In carrying out storm repairs such as the replacement of broken poles or wires, a certain amount of renewal work is necessarily effected by the provision of new plant. A proportion of the storm repairs expenditure is therefore regarded as proper to "renewals" and is paid for out of the depreciation fund.

Administrative and Operating Expenses are affected to some extent by the condition of the apparatus as regards obsolescence. With obsolete exchange equipment a larger staff of operators is required to handle a given volume of traffic than is necessary where better and more convenient facilities are afforded with the modern type of apparatus. As an example of this, when the Manchester old Central Exchange with 4045 lines was transferred to new central battery equipment in 1917 seventy operators were saved and made available for other duties, while at the same time the service was greatly improved by bringing into use over 300 additional long-distance lines for direct communication with neighbouring towns. The improvement of exchange equipment has been delayed in a great number of cases owing to restrictions due to the war.

In 1912 the National Telephone Company's undertaking was purchased at a cost of about 12½ millions sterling. Table 1 shows that after making due allowance for depreciation, the whole of the telephone plant, including trunks and local exchange systems previously owned by the Post Office, was estimated to have a value of £21,564,050 in March, 1913. In addition, stores and cash to the value of £1,429,700 were held. In March, 1919, the accumulated depreciation fund had risen to £12,540,100. The plant increased in value up to 1916. Since 1916, although the Table shows that the amount of plant has increased, the value has decreased, the latter result arising from the deferment of renewals owing to restrictions due to the war.

Maintenance costs have increased out of all proportion to the increased amount of plant, owing to the rise in rates of wages and cost of materials, the telephone service being affected in this respect in the same way as ordinary industrial undertakings.

It is interesting to note that wayleave charges have been reduced by £10,813 since 1914. Engineering officers will, no doubt, be glad to observe this very tangible result of their efforts to persuade property owners as to the desirability of affording wayleave facilities at reasonable cost in the general interests of the community.

Profit and Loss.—The revenue accounts are shown in Table 2. The general financial effect of the working is briefly summarised in the following extract from a statement made by the Postmaster General in Parliament in July, 1919:

"When the National Telephone Company were running the telephone system they had a capital of some £11,000,000. The average dividend on the whole capital for the five years before the transfer was 5·13 per cent. In 1913–14, after the services had been transferred to the State, they showed a profit of £239,000, in addition to interest charges of £692,000. These two figures, added together, represented a dividend of 4·29 per cent. on the total capital employed. Above this the National Telephone Company paid in royalties to the Post Office 10 per cent. on the gross receipts of the services. This with the last year's working of the Company amounted to £353,000, but the provisions of the Company in regard to pensions and wages were not what could be described as liberal. In their last year all that the Company provided for pensions was £13,000. This sum was increased in 1913–14, immediately the service was taken over by the State, to a sum of £243,000 per annum, whilst salaries and wages were immediately increased by £158,000. Although by the transfer to the Government office the undertaking had benefited by the extinction of £353,000 which was paid in respect of royalties, that was more than set off by additional wages and pensions, which amounted to £400,000 a year.

"The dividend which, had it been a commercial concern, the undertaking would have paid was only 1 per cent. less than had been paid by the National Telephone Company for the five years' average before the war, and the reduction was accounted for by the improved conditions and the pay of the staffs. If the situation had not been so drastically altered by the war, the undertaking would still have been making similar profits to what had been made before the war. On account of the war the cost of living had increased, and consequently the bonus paid to the telephone workers had also to be increased. This year £2,500,000 per annum more was paid in wages than when the Telephone Company was first taken over by the State. That meant that the wages bill had practically doubled since 1913–14."

It will be noticed that the gross interest paid on loans is not

Table I.—Telephone Trunk and Exchange Systems.

Extracts from Depreciation and Capital Accounts.

Cost of Maintenance and Increase of Plant.

	1912–13.	1913–14.	1914–15.	1915–16.	1916–17.	1917–18.	1918–19.
	£	£	£	£	£	£	£
Provision for depreciation during year	1,391,197	1,471,320	1,628,562(*a*)	1,730,526	1,753,241	1,781,891	1,845,544(*b*)
Deduct renewals and displaced plant	435,280	668,198	739,784	705,497	508,417	465,731	533,121
Net depreciation allowance for year	955,917	803,122	888,778	1,025,029	1,244,824	1,316,160	1,312,423
Depreciation fund brought forward	4,993,847	5,949,764	6,752,886	7,641,664	8,666,693	9,911,517	11,227,677
Balance carried to depreciation fund	5,949,764	6,752,886	7,641,664	8,666,693	9,911,517	11,227,677	12,540,100
Prime cost value of plant at beginning of year*	25,913,044	27,513,814	30,137,043	33,394,035	34,863,680	35,540,770	36,234,098
Net additions to plant during year	1,600,770	2,623,229	3,256,992	1,469,645	677,090	693,328	815,377
Prime cost value of plant at end of year	27,513,814	30,137,043	33,394,035	34,863,680	35,540,770	36,234,098	37,049,475
Deduct balance at credit of depreciation account	5,949,764	6,752,886	7,641,664	8,666,693	9,911,517	11,227,677	12,540,100
Present value of plant	21,564,050	23,384,157	25,752,371	26,196,987	25,629,253	25,006,421	24,509,375
Value of stores and cash	1,429,700	1,393,997	1,493,054	1,641,284	1,392,776	1,344,505	1,854,081
Maintenance :							
Supervision	420,206	526,894	565,506	523,420	459,995	495,145	562,677
Wages	478,424	517,522	616,183	580,790	684,688	740,555	913,744
Materials	135,417	108,023	116,508	80,158	156,424	139,571	175,357
Wayleaves	—	83,769	77,542	78,651	77,170	74,064	72,956
Other charges	345,333	231,637	243,934	253,664	281,385	245,820	269,586
Total	1,379,380	1,467,845	1,619,673	1,516,683	1,659,662	1,695,155	1,994,320
Maintenance per cent. on present value of plant	6·4	6·3	6·3	5·8	6·5	6·8	8·1
Plant :							
Approximate mileage of wire, overhead	718,000	769,000	837,000	865,000	866,000	870,000	865,000
,, ,, ,, ,, underground	1,600,000	1,755,000	1,955,000	2,122,000	2,225,000	2,311,000	2,400,000
,, ,, ,, ,, total	2,318,000	2,524,000	2,792,000	2,987,000	3,091,000	3,181,000	3,265,000
Telephone stations	730,763	774,821	796,347	786,991	774,264	778,901	797,218

The total stations amounted to 879,709 on September 30th, 1919—an increase of 82,491 in six months.

(*a*) Including £14,884, accrued depreciation on transferred plant.

(*b*) Including £17,238 ,, ,, ,, ,, ,,

* The figures include £1,992,044 prime cost value of plant constructed for war purposes up to March, 1919.

Table II.—Telephone Exchange and Trunk Systems Combined.

Revenue Account.

	1912–13.	1913–14.	1914–15.	1915–16.	1916–17.	1917–18.	1918–19.
	£	£	£	£	£	£	£
Administrative and operating expenses	1,472,656	1,509,089	1,602,056	1,718,351	1,750,485	2,021,850	2,429,422
Maintenance of system	1,379,380	1,467,845	1,619,673	1,516,683	1,659,662	1,695,155	1,994,320
Provision for depreciation	1,391,197	1,471,320	1,613,678	1,730,526	1,753,241	1,781,891	1,828,306
Pension liability	358,794	400,636	437,385	468,959	439,256	442,407	446,806
Engineering stores for war communications	—	—	8,085	242,571	1,120,078	2,230,778	2,109,056
Rent of premises, rates, repairs, etc.	161,680	366,286	397,107	404,950	394,936	406,785	436,142
Stationery, printing, etc.	82,932	42,576	36,078	23,228	48,741	55,904	71,807
Interest on loans, etc.*	697,428	691,833	812,412	873,564	811,718	884,826	903,793
Civil pay to staff with Forces	—	—	69,594	204,221	324,871	336,229	364,438
Adjustments, etc.	—	2,488	—	—	—	—	—
Total expenditure	5,544,067	5,952,073	6,596,068	7,183,053	8,302,988	9,855,825	10,584,090
Subscriptions and rentals	5,791,988	6,111,025	6,285,589	6,300,945	6,367,125	6,580,976	6,746,500
Services to other Government Departments	51,154	64,347	181,921	445,606	760,003	1,153,345	1,421,779
Engineering stores for war communications	—	—	8,085	242,571	1,163,022	2,296,296	2,173,368
Services to telegraph services	—	—	—	65,878	90,958	97,965	121,185
Royalties by telephone licensees	3,844	12,803	5,959	6,706	8,254	7,243	7,582
Interest on advance subscriptions	—	—	—	—	—	75,468	77,415
Adjustments, etc.	424	3,009	3,496	3,170	115,355	—	—
Total revenue	5,847,410	6,191,184	6,485,050	7,064,876	8,504,717	10,211,293	10,547,829
Revenue surplus over expenditure	303,343	239,111	—	—	201,729	355,468	—
Revenue deficiency	—	—	111,018	118,177	—	—	36,261

* Net interest shown, after allowing for interest received on current balance of advance subscriptions, up to, and including, 1916–17.

shown until 1917–18 (first published in the 1918–19 accounts). Had the interest on advanced subscriptions been allowed for in 1913–14, the return shown on the capital would probably have amounted to at least 4½ per cent. after placing £1,471,320 in the Reserve Fund.

Taking the whole period of seven years, the total surpluses amounted to £1,099,651, and the total deficits to £265,456, or a net surplus of £834,195 after paying off the interest due on the borrowed money and making appropriate additions to the depreciation fund each year. In addition, the revenue had to bear the cost of contributing £1,299,353 under the heading of "Civil pay to staff with Forces." It is true that the interest has not amounted to 5 per cent. on the capital, but as the Government can borrow at a lower rate than a private company, this is obviously to the advantage of the subscribers, who have to pay the bill in any case.

Since October, 1915, the trunk fees have been increased 33⅓ per cent. and the obsolete "unlimited rate" of £10 for an exchange line has been increased 20 per cent. The great bulk of the subscribers are charged at the "measured rate" of £5 for 300 calls or £6 for 500 calls, and these rates have not been increased. The figures, of course, compare very favourably with the increased cost of 80 per cent. to over 100 per cent. in the case of many public services or commodities provided by municipal corporations or private companies.

Since March, 1919, the running costs have further increased to a considerable extent, and it is now clear that these costs can only be met by increased rental charges. It is well to remember, however, that bearing in mind the present purchasing value of money as compared with 1914, the rates would have to be considerably more than doubled to represent any real increase in cost to the public. It is equally clear that no private company could have continued to provide the services without a very substantial increase in the pre-war rental rates.

W. J. MEDLYN.

[On page 115 we publish a complete list of the Telegraph and Telephone Plant in the United Kingdom on the 31st March of this year, arranged according to the Engineering Districts. With the kind co-operation of the Superintending Engineers we hope to keep this list up-to-date quarterly, and thus indicate the progress and development of the systems.

The rapid growth of the service is, in common with all industrial undertakings, hampered by the world-shortage of materials. Orders for vast quantities of telephone apparatus and line stores have been placed with the manufacturers, but deliveries are not being effected at a sufficiently rapid rate to enable the Department to meet promptly the applications from the public for additional telephone services. —EDITORS, POST OFFICE ELECTRICAL ENGINEERS' JOURNAL.]

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONE STATIONS AND SINGLE-WIRE MILEAGES AT 31ST MARCH, 1920.

Telephone Stations. (*a*)	Overhead Wires: Mileage.				Engineering District.	Underground Wires: Mileage.				Submarine Wires.
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.	Land Miles.
299,477	1,461	2,790	58,043	184	London	17,014	16,305	1,000,824	16,849	
43,727	6,357	15,486	44,944	1,826	S.E.	2,348	6,782	130,281	17,348	
37,615	8,505	17,231	35,806	1,208	S.W.	12,423	1,342	64,080	1,528	Telegraph: (*b*)
29,489	16,008	26,198	31,453	3,720	E.	8,220	13,136	34,284	16,570	
52,181	16,056	37,879	39,047	2,831	N. Mid.	6,825	12,319	86,574	9,014	14,452
39,523	11,369	23,854	44,943	4,755	S. Mid.	6,079	6,150	88,242	9,556	
32,982	8,076	22,797	36,423	3,465	S. Wales	4,262	8,913	57,303	13,642	Trunk:
48,020	12,441	19,555	32,049	5,029	N. Wales	11,494	16,317	84,661	10,046	1,261
88,293	4,655	16,343	44,484	3,719	S. Lancs.	9,495	29,302	217,612	28,228	
44,109	8,685	22,983	35,174	3,155	N.E.	3,740	11,460	96,608	17,214	Exchange:
42,474	6,879	26,593	38,578	2,004	N.W.	9,282	11,305	75,266	15,333	3,843
29,069	4,052	13,162	23,493	2,234	N.	3,042	4,022	43,301	6,884	
30,615	23,130	9,921	25,037	473	Ireland	827	100	50,231	443	Spare:
40,284	11,738	15,413	28,151	2,770	Scot. E.	1,428	4,729	70,712	3,413	296
60,047	10,927	19,965	40,543	460	Scot. W.	11,151	7,479	144,981	14,885	
917,905	150,339	290,170	558,168	37,833	—	107,630	149,661	2,244,960	180,953	19,852

NOTES.—(*a*) Telephone Stations: Exchange and Private Wire including Miscellaneous and Subscribers' Property and National Emergency.
(*b*) Including Atlantic Cable, 3985 land miles.

PLANT

HEATING OF SWITCHBOARD CABLES.

THIS article describes some of the results of tests made upon telephone switchboard cable of 23 S.W.G. wires, the individual wires of which were heated by relatively large currents of from 0·5 to 4·5 ampères. The investigation was undertaken to prove that no excessive heating could occur with the use of 23 S.W.G. wires in certain telephone circuits: arising out of the tests information upon the heat conductivities or resistivities of insulating materials was found. The following conclusions were arrived at after a scrutiny of the results: it is not possible in this short article to give the proofs.

Summary of Results.—(1) Switchboard cables cannot be set on fire by internal heating when *in sitû* in telephone exchanges. If any wire carries a current sufficient to fuse it (say 30 ampères or more), the wire will fuse in the fanning strip at the end of the cable where the covering is removed.

(2) The temperature rise of a wire is calculable by theory: such calculations are approximate when the heat qualities of the insulation are partially known, but may be quite reliable when the qualities of the insulating materials are known.

(3) For the insulating sheath of 21-wire cable, K, *the thermal resistivity* (this is the reciprocal of the thermal conductivity and is given as the Centigrade degrees required to drive 1 watt per second through a cm. cube of the material), = 1300 to 1600; k, the thermal conductivity, = 0·00077 to 0·00062 watts per 1° C. per cm. cube.

(4) For the sheath and the core taken together, of the 84-wire cable, K = 430 to 800, k = 0·0023 to 0·00125. A reasonable value to choose is K = 600.

(5) The *surface resistivity* (this is the temperature difference in Centigrade degrees between the sheath of a cable and the air, required to drive 1 watt per second per sq. cm. from the sheath to the air) for the 21-wire cable may be put as K' = 450. For the 84-wire switchboard cable, K' seemed to be 740: these are values when the sheath is at 40° C. and the air at 20° C. approximately.

(6) The temperature of a small wire carrying current may be reduced by covering the wire with insulation.

(7) The heat emitted by hot bodies *per unit area* decreases as the size of the hot body increases.

Tests were made on 21/9¼ and 84/9¼ cables; in some cases the cable was wound in a coil about 1 ft. in diameter; in other cases the cable was stretched in the air. The heating current was put through various numbers of wires in the 18 tests, as follows:

No. of "live" wires	1	2	6	8	12	18
No. of tests ...	2	1	5	3	5	2

Switchboard cables cannot be set on fire internally.—Consider a 23 S.W.G. wire (9¼ lb./mile : 0·6 mm.) in an 84-wire cable, brought out to a fanning strip at one end. As the current sent through the wire is raised from 1 ampère to 2, 3, 4 ampères, etc., the temperature of the wire increases, but until more than 10 ampères is put through it, the wire does not reach red heat. If 25 to 30 ampères are suddenly put through it, the wire will fuse where it is not surrounded by other wires, viz., where it is fanned out. The heat generated in the wire in the midst of the cable finds its way more easily out of the wire by heating up other wires and insulation than it can find its way from the surface of the single wire into the air. If one could suddenly put 10 to 16 ampères through all the 84 wires of the cable

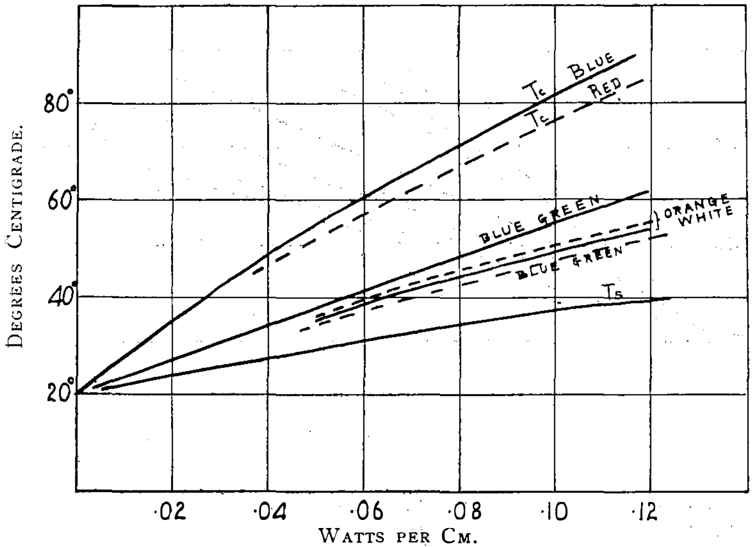

Fig. I.—Heat Generated. The Dotted Lines Refer to the Test when the "Red" Wire was Live.

it might then burst into flame, though even then the tendency would be for the wires outside the cable to fuse; but to pass 840 to 1300 ampères through an 84-wire cable *in sitû* is a practical impossibility. Air is a very bad conductor of heat: its thermal resistivity, K, is about 4000° C. per watt—unless there are considerable air currents—whereas insulating materials have resistivities about 700° to 1800° C. If one is considering methods of emitting heat from a small wire to the air, it may be worth while to cover the wire with insulation to increase the heat dissipation. The heat travels much more easily from the larger outside surface of the insulation after passing through the insulation, than from the small surface of the wire direct to the air.

Method of testing switchboard cables.—In order to test the cables, groups of wires were joined in series and currents up to 4·5 ampères from a 22-volt battery were passed through the series (the density at 4·5 ampères = 1540 amp/cm.^{2} = 9900 amp/in.^{2}). In some cases groups of wires were placed in parallel and currents up to 4·1 ampères were circulated in each group. In tests *L* and *R* currents up to 10 ampères were circulated in one wire. At first it had been assumed that the current would divide equally through each group —which were of practically the same resistance when cold—but it was found that the temperature rise of the groups differed considerably one from the other, so that it was necessary to read the current in each group. Parallel groups had to be used because the voltage was insufficient to send enough current through all the wires

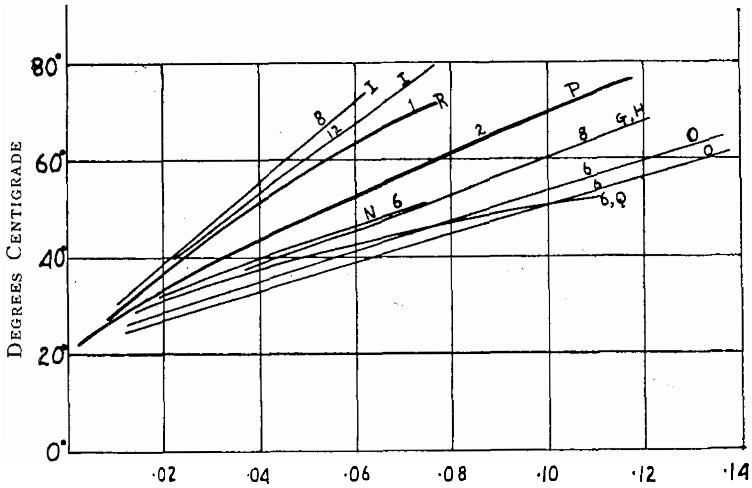

FIG. 2.—TEMPERATURE OF "LIVE" WIRES UNDER VARIOUS CONDITIONS. FIGURES AGAINST THE CURVES GIVE THE NUMBER OF "LIVE" WIRES. THE LETTERS REFER TO THE RELATIVE TESTS. POSITION OF 84/9½ CABLE: I, ON DRUM; R, P AND N, STRAIGHT IN AIR; O H, COILED UP IN AIR; O Q, STRAIGHT IN AIR.

in series in order to produce the large temperature rises desired. In all the tests the *temperatures* of the *wires* not carrying current were deduced from the rise of resistance; the temperatures of the sheath and of the air were measured by thermometers. The *resistances* of the wires were measured by a Wheatstone bridge.

Fig. 1 shows the results of a typical test on 21-wire cable. *Tc* is the temperature of the "live" wire carrying current, which in this particular instance amounted to 13 ampères when the watts/cm. = 0·12. *Ts* is the temperature of the outer surface of the cable. The temperature of some wires not carrying current is shown by the lines "blue-green" and "orange-white."

Summary of test results.—Fig. 2 shows the maximum temperature

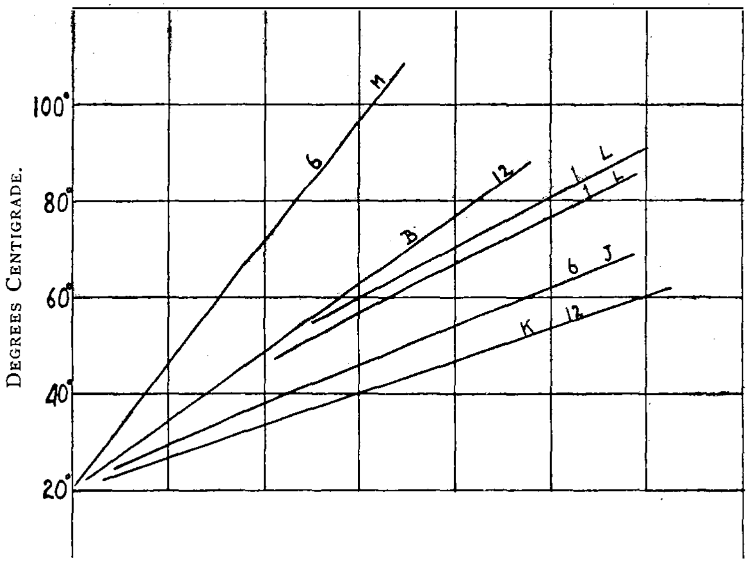

Fig. 3.—Position of 21/9¼ Cable: M on Drum, Covered by other Cable; B, on Drum; L, Straight in Air; J, Coiled up in Air; K, Straight in Air.

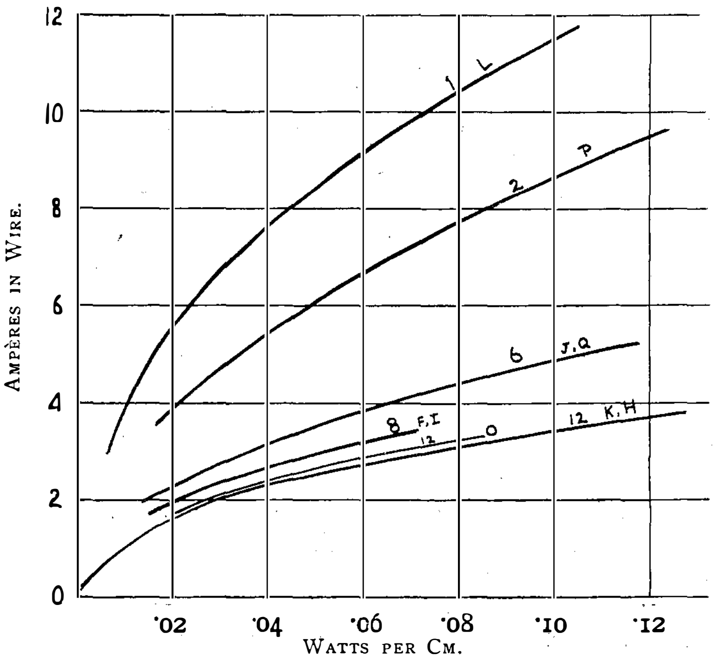

Fig. 4.—Currents Required to Give Various Amounts of Heat. Figures Give Number of "Live" Wires. Letters refer to Tests.

reached by the live wires under various conditions for the 84-wire cable, and Fig. 3 shows the same for the 21-wire cable. These figures are drawn up on a *watts per cm.* base; this is the most suitable method of comparison, as the currents circulating in the wires produce different amounts of energy depending upon how many wires are heated. The fewer the wires which are heated the greater will the temperature of these be if the same amount of energy is generated, as the generation of energy takes place in a smaller space and needs greater temperature gradients to carry it through the insulation. That is why the temperature when 1 wire is heated (see Fig. 2), test *R*, exceeds the temperature in test *P* where 2 wires were heated; again the temperatures in test *P* exceed those in test *O*. Fig. 4 gives the heat generated when various currents circulate in 1, 2, 6, 8, 12 wires. Fig. 4 is not very illuminating as it stands; when replotted on log-paper as in Fig. 5 interesting results are obtained. The law connecting watts generated with currents in switchboard cables becomes:

$$\text{Watts per cm.} = (\text{constant}) \times (\text{ampères})^{2 \cdot 25}.$$

We find the numerical values of the constant and of the index thus; the equations of the straight lines in Fig. 5 are,

$$\log\,(100 \text{ watts}) = (dy/dx)\ [\log\,(\text{amp.}) - \log P]$$

where *P is the point* in which the sloping lines cut the horizontal line where watts = 0·010, and dy/dx is the slope of the lines. This slope appears to be the same in every case, and is 2·25. Thus re-writing the equation,

$$100\ (\text{watts}) = \left(\frac{\text{amp.}}{P}\right)^{2.25} = \left(\frac{1}{P}\right)^{2.25} (\text{amp.})^{2.25} = 100\,A\ (\text{amp.})^{2.25}.$$

Then $A = 0{\cdot}01\,(1/P)^{2 \cdot 25} = n\,B$, where n = the number of the wires carrying current. Fig. 5 gives the values as follows:

No. of live wires.	P.	$P^{2 \cdot 25}$.	A.	$(10)^{-B^4}$.
12	1·2	1·49	0·00670	5·6
10	1·25	1·64	0·00610	5·5
8	1·45	2·29	0·00347	5·47
6	1·67	3·13	0·00320	5·33
4	2·06	5·00	0·00200	5·00
2	2·98	11·50	0·00087	4·35
1	4·10	22·60	0·00044	4·40

The values for the 10 and 4 wires are interpolated. When the number of wires heated exceeds 12, the value of the constant *B* is equal to the resistance per cm. of the individual wires and the increase of resistance due to rise in temperature is covered by the index, 2·25, of the current. Fig. 5 enables one to determine the watts generated per cm. when the currents flowing in the wires are known. Suppose 40 wires carry 2 ampères each, what are the watts/cm. generated?

Using the previous equation, watts/cm. $= 40\ (0{\cdot}00056)\ (2)^{2{\cdot}25}$ $= 0{\cdot}104$. The temperature of the hottest wires in the cable—if the cable were in still air—would be somewhat less than that given by tests *G*, *H* (Fig. 2), as 40 wires instead of only 8 are live. It is desired to emphasise the fact that the law, watts = (amp.)^2 resis-

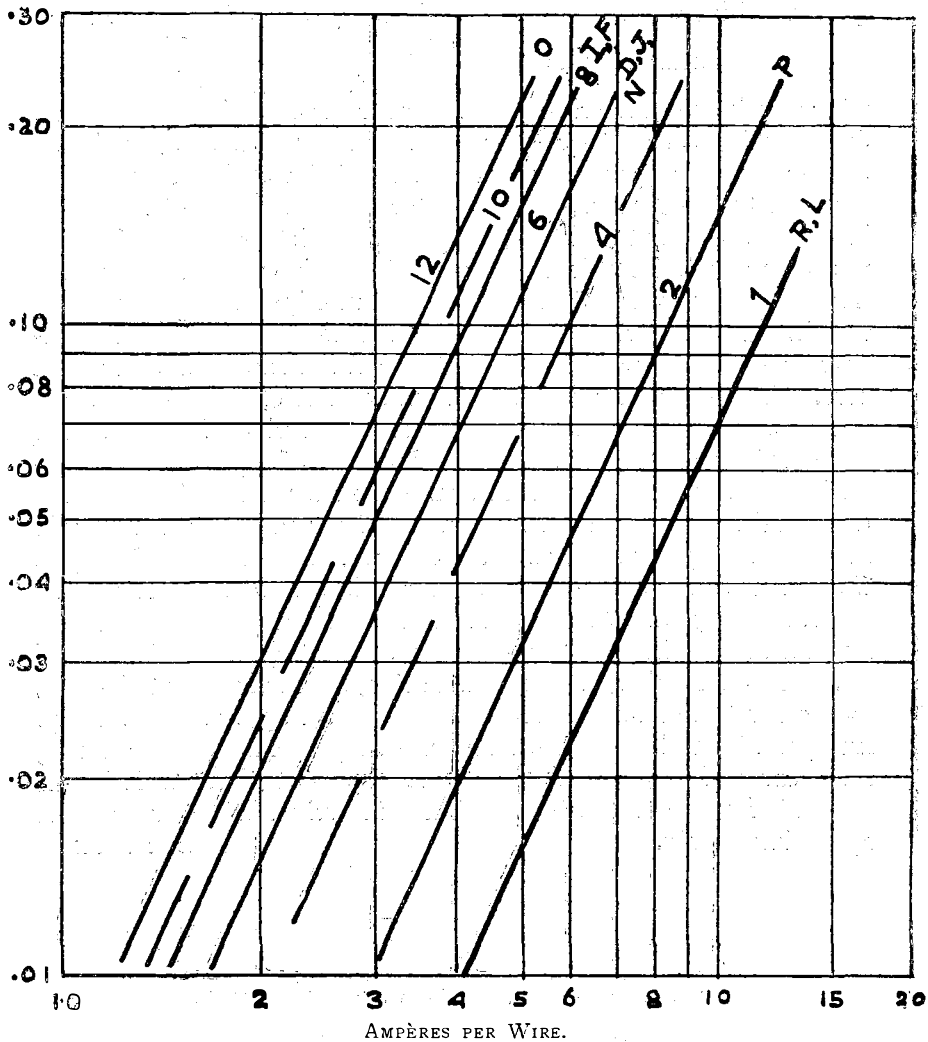

Fig. 5.

tance, is not abrogated by putting watts = *A* (amp.)$^{2{\cdot}25}$. The tests merely showed that the resistance of the wires when hot can be put equal to r (amp.)$^{0{\cdot}25}$; this enables one to evaluate the watts generated without assuming some value for the temperature of the wire in order to calculate the hot resistance with which the factor (amp.)^2 would be multiplied.

Laws of Heat Flow.—The laws of heat flow upon which the *calculations* of temperature can be made may be summarised (proofs are given in Appendix 2 of the original report); they can also be found in various technical papers.

Heat Flow through Insulation.—The rate of heat flow *through a cylinder* of insulating material is given by the following formula:

$$\text{watts per cm.} = \frac{(T1 - T2)}{K} \frac{1}{0{\cdot}365\, log_{10}\,(d_2/d_1)}$$

where $T1$ is the temperature of the inner surface of the cylinder of diameter d_2 (= the outer diameter of the hot core), and T_2 is the temperature of the outer surface of the cylinder of diameter, d_1. In the tests the writer attempted to determine the value of K for the insulation, and for the cable as a whole: this latter information was wanted so as to be able to form an idea of how much heat would travel from the inner cables of a batch of multiple cables on racks to the air. Owing to the unsymmetrical nature of the inside of switchboard cable it was not possible to know the diameter d_2 of the hot core. For instance, when the six inner wires of the 21-wire cable were heated, what would one choose as the outside diameter of the hot core? One might choose the diameter of the circle circumscribing the six copper surfaces, or the diameter of the circle passing through the centres of all the wires. In either case the heat flow will not be precisely the same as if the core were a solid mass of copper. The values of K have been given already in the summary of results.

Heat Flow from a Surface to the Air.—We also want to know how much heat is emitted from the surface of a hot cylinder lying in *still* air. The heat emitted is due to radiation, which varies as $T_s^4 - T_a^4$, and to conduction and convection currents set up by the hot body. An approximate law for the heat emitted per cm. length, covering these causes is watts/cm. $= 0{\cdot}0029\ D^{0{\cdot}6}\ (T_s - T_a)^{1{\cdot}18}$. This law is deduced from the results of other investigators' tests and is approximate only. A. B. EASON.

THE CARBON TRANSMITTER.

By H. J. GREGORY, B.Sc.,
Research Section.

IT is usual to consider the ordinary telephone transmitter as merely a varying resistance, which produces alternating current superimposed on a direct current by virtue of this variation in resistance in response to the speech waves impressed upon it. In the following simple theory the writer endeavours to show that the transmitter is similar in its mode of operation to that of an alternator, in that it has an output characteristic and internal impedance.

In order to simplify matters, take the simple case where the transmitter is connected in series with a primary battery and a non-inductive resistance, as in Fig. 1.

If r_1 = D.C. resistance of the transmitter,
r_2 = internal resistance of the primary battery,
r_3 = non-inductive resistance in series with r_1 and r_2,
then the total resistance of the circuit—

$$= R = r_1 + r_2 + r_3.$$

Suppose E = total E.M.F. of the primary battery. When the transmitter is spoken into its diaphragm will vibrate in response to the sound-waves, thus causing the resistance of the transmitter granules to vary. Suppose instead of a complex series of waves, as produced by speech, we have a sound of a single frequency ($w = 2\pi f$) impinging on the diaphragm, then the diaphragm will vibrate at the

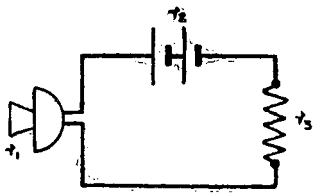

Fig. 1.

FIG. 1.—TRANSMITTER IN SERIES WITH PRIMARY BATTERY AND NON-INDUCTIVE RESISTANCE.

frequency f and produce a variation of r_0 sin wt in the resistance of the transmitter.

The primary circuit will therefore then contain a constant resistance R and a variable resistance r_0 sin wt, and by Ohm's law we have—

$$I = \frac{E}{R + r_0 \sin wt} = \frac{E}{R(1 + \frac{r_0}{R} \sin wt)} \quad . \quad . \quad (1)$$

The current I will be a direct current with a ripple superimposed upon it, but the shape of the ripple will be determined by the ratio $\frac{r_0}{R}$, *i. e.* although the change of resistance is simple harmonic, the ripple it produces in the current will not be a sine wave unless R is very great compared with r_0. This is shown by the curves on Fig. 2, which represent the shape of the current wave calculated from the above expression for I and assuming different values of r_0. The amplitude of the ripple increases as $\frac{r_0}{R}$ increases, but the distortion of the wave increases also. Incidentally, we see that the transmitter cannot faithfully produce an electric current to correspond exactly with the sound applied to it, but always introduces harmonics; apparently the second harmonic is the principal one.

The direct current in the primary circuit is $\frac{E}{R}$, so that from

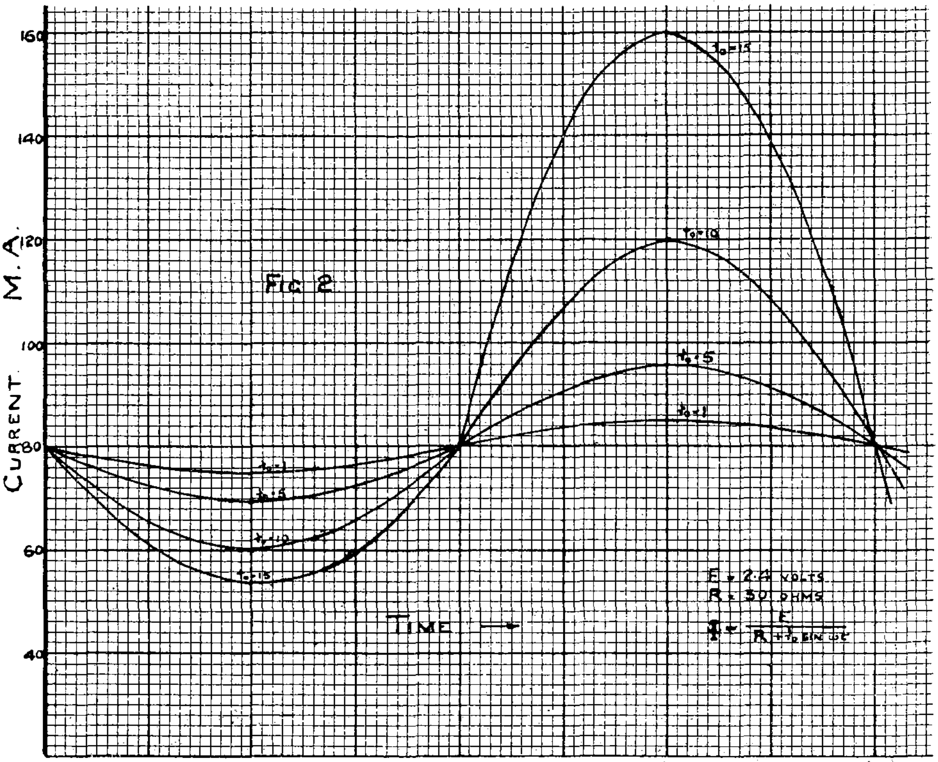

FIG. 2.—CURRENT CURVE FROM FIG. 1, WITH DIFFERENT VALUES OF r_0.

equation (1) the alternating, or rather the microphonic current produced will be—

$$I_A = \frac{E}{R} - \frac{E}{R + r_0 \sin wt}$$

$$= \frac{E}{R} \times \frac{r_0 \sin wt}{R + r_0 \sin wt}$$

If the D.C. feeding current $= I_D$ amps.

$$I_A = \frac{I_D \, r_0 \sin wt}{R + r_0 \sin wt} \quad . \quad . \quad . \quad (2)$$

This current I_A is therefore proportional to the feeding current to the transmitter, and the E.M.F. of the transmitter is evidently $I_D \, r_0 \sin wt$.

A curve showing the relationship between the feeding current to a transmitter and its E.M.F. is shown in Fig. 3. This curve was obtained by measuring the *a.c. P.D.* across a transmitter when "howled" into by a receiver at 1000 frequency. Direct current was supplied to the transmitter through a very high impedance retard. This curve shows that the E.M.F. is proportional to the feeding current up to 160 m.a., after which the increase in E.M.F. is smaller, and if it were carried further, a point would be reached where no further increase in E.M.F. would be obtained by increasing the feeding current. This departure from the straight line law is probably due to the excessive current causing a rise in temperature of the carbon granules and so reducing the value of r_0. The shape of this E.M.F. curve is the same for any frequency, but the magnitude of the E.M.F.

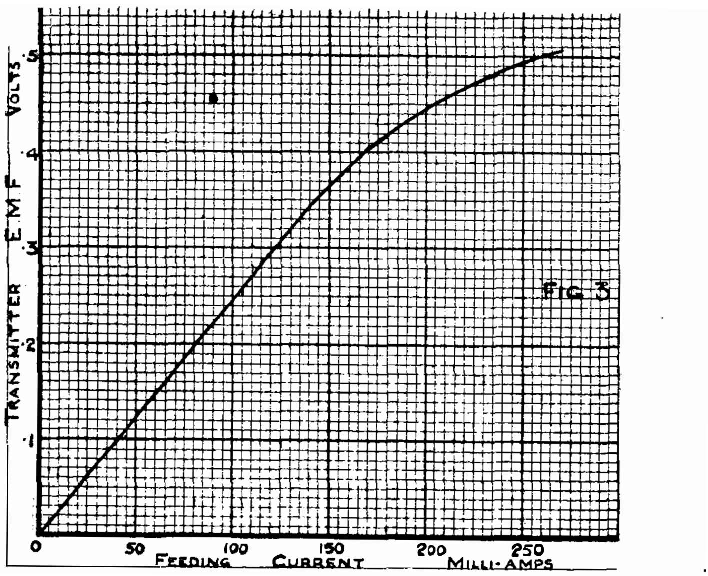

FIG. 3.—CURVE SHOWING RELATIONSHIP BETWEEN FEEDING CURRENT TO A TRANSMITTER AND ALTERNATING P.D. ACROSS IT.

is different for different frequencies, due to the resonance points of the transmitter. In fact, experiment seems to show that the only frequencies that are important are those near the resonance points in the transmitter, and that the output of the transmitter at frequencies other than these is negligible. A curve showing the resonance points of a C.B. transmitter is shown in Fig. 4. Fig. 5 was obtained from a L.B. inset transmitter.

The terminal *a.c.* P.D. across the transmitter will be from (2):

$$I_A (r_2 + r_3) = \frac{(r_2 + r_3)\, I_D\, r_0 \sin wt}{R + r_0 \sin wt}.$$

The internal impedance of the transmitter will be—

$$= r_1 + r_0 \sin wt.$$

Usually r_0 is small compared with R_1, so that in formula (2), r_0 sin wt may be neglected in the denominator. This amounts to neglecting the harmonics in the current introduced by the transmitter, as described above. The impedance of the transmitter will then be equal to r_1, *i. e.* equal to the *D.C.* resistance.

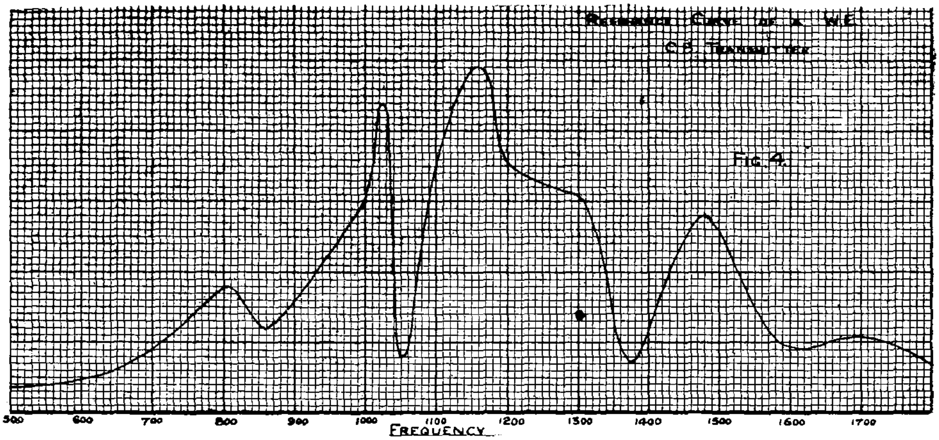

FIG. 4.—RESONANCE CURVE OF A WESTERN ELECTRIC C.B. TRANSMITTER.

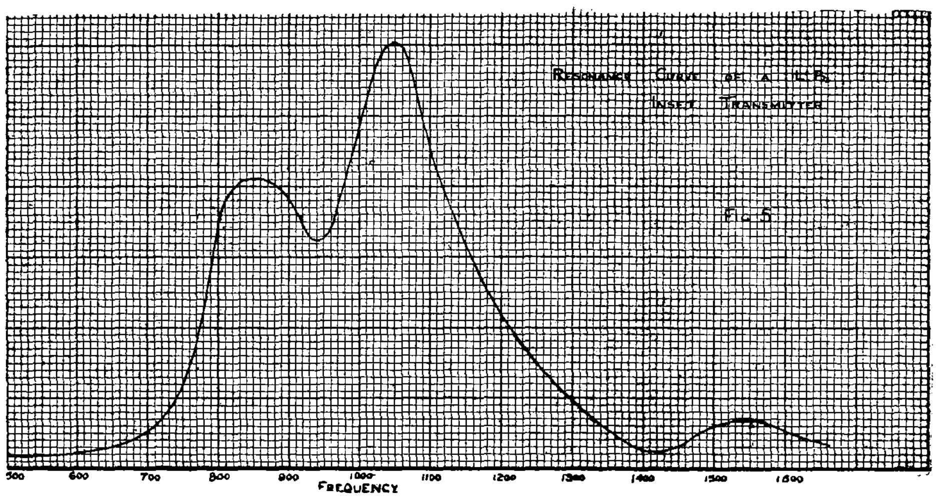

FIG. 5.—RESONANCE CURVE OF A LOCAL BATTERY "INSET" TRANSMITTER.

The transmitter will therefore have its internal impedance just the same as any other electrical machine producing *A.C.*, and it will be non-reactive.

It is consequently quite easy to construct the characteristic curve for a transmitter on a non-inductive load, as then its terminal *P.D.* and current will be in phase, and the drop in terminal *P.D.* will be proportional to the current taken from the transmitter. This is shown in Fig. **6**, where *oa* is the E.M.F. of the transmitter, and the straight line *ab* shows the relation between the current supplied by the transmitter and its terminal *P.D.* At the point *e* the internal drop *de* = current *oc* × resistance of transmitter.

From Fig. **6** another curve showing the relation between the output in watts and the resistance of the external circuit can be deduced. This is shown in Fig. 7, and shows that a maximum output occurs when this resistance is equal to the resistance of the transmitter.

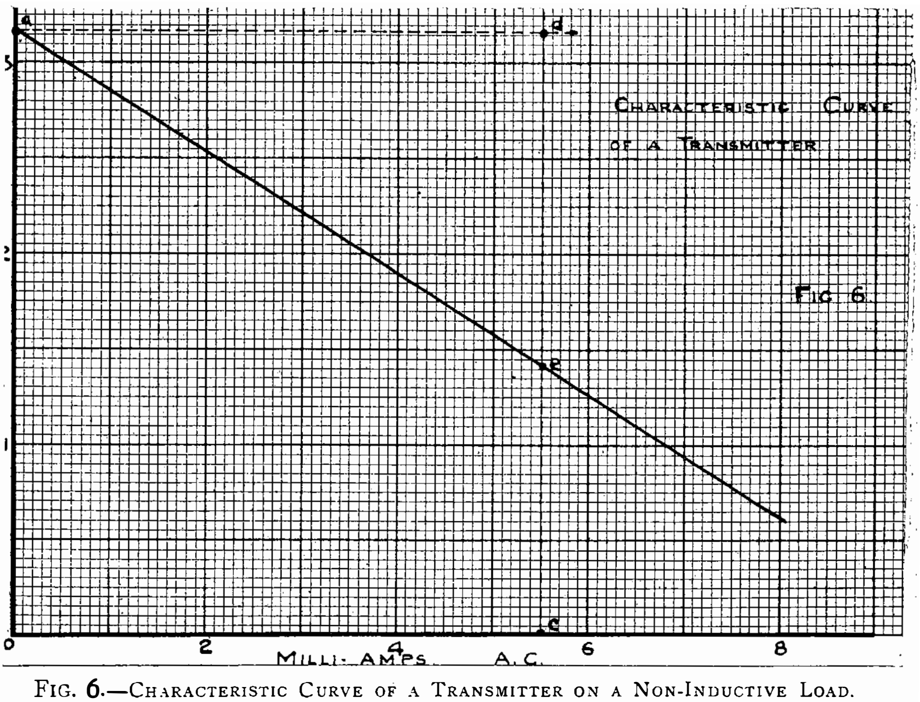

Fig. **6**.—Characteristic Curve of a Transmitter on a Non-Inductive Load.

The alternating microphonic current from a transmitter will not, however, necessarily be in phase with the terminal *P.D.*, but will usually lag behind it, as the load on the transmitter is practically always inductive. The approximate expression in this case for the current corresponding to equation (2) will be—

$$I_A = \frac{I_D \, r_0 \sin (wt - \phi)}{Z} \quad . \quad . \quad (3)$$

where $Z|\underline{\phi}$ is the total impedance of the circuit including the resistance of the transmitter. This is proved in G. D. Shepardson's book on 'Telephone Apparatus.'

Fig. **8** illustrates the operation of the transmitter under an inductive load of angle θ. *oa* is the terminal *P.D.*, which, of course, must have the same phase relation with respect to the current as the angle of the load impedance. It has been explained that the impedance of the transmitter is non-reactive, so the internal drop in volts must be in phase with the current *I*, and is represented by *ab*. The E.M.F. of the transmitter will therefore be represented by *ob*.

It is quite a simple matter to calculate the terminal *p.d.* across a transmitter for any load, provided the E.M.F. is known. Referring to Fig. 8, although *oa* and *ab* represent the terminal *p.d.* of the transmitter and its internal drop in *p.d.*, they also represent to another scale the impedances of the load and transmitter respectively, and *ob* represents the vector sum of these impedances. We may therefore write :

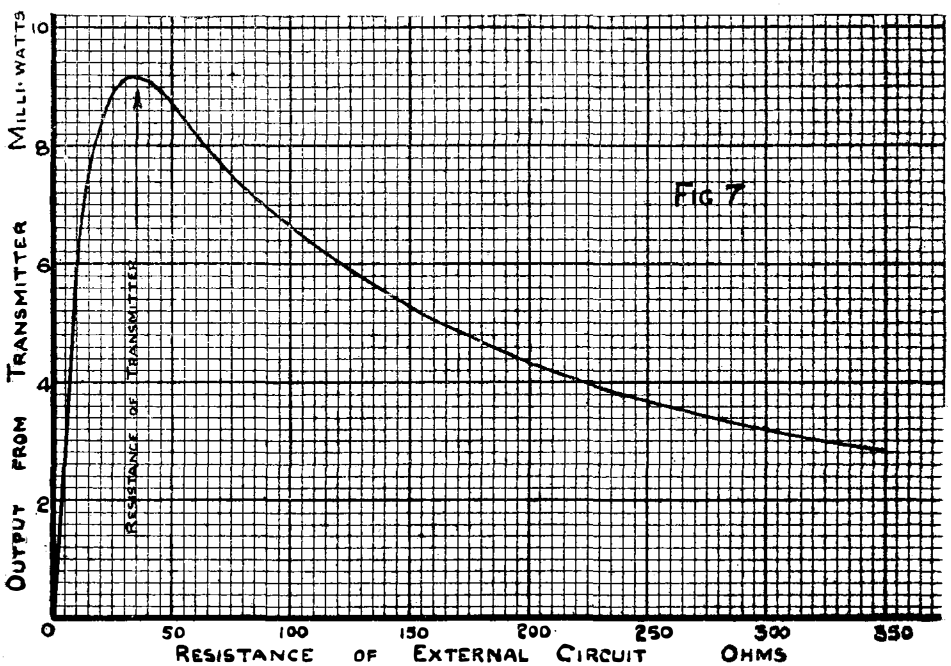

FIG. 7.—CURVE SHOWING RELATION BETWEEN OUTPUT IN MILLI-WATTS AND RESISTANCE OF EXTERNAL CIRCUIT.

$$\frac{\text{E.M.F. of transmitter}}{\text{Terminal } P.D.} = \frac{ob}{oa} = \frac{\text{vector sum of impedances of load + transmitter}}{\text{impedance of load}}.$$

Suppose the impedance of the load $= a + j\,b \quad = A|\underline{\theta}$

and the impedance of the *xmtr* $= \quad r_1$

Vector sum $= a + r_1 + jb = B|\underline{\phi}$

$$\text{but } \frac{ob}{oa} = \frac{B}{A},$$

$$\therefore \frac{\text{E.M.F. of transmitter}}{\text{Terminal } P.D.} = \frac{B}{A},$$

$$\text{i.e. Terminal } P.D. \text{ for load } A\underline{|\theta} = \frac{\text{E.M.F.} \times A}{B} \qquad . \quad . \quad (4)$$

Fig. 7 shows that a transmitter is giving its maximum power output when the resistance of the load is equal to the resistance of the transmitter. In the practical case, however, the load is inductive, but a relation between the resistance of the transmitter and the impedance of the load can be found which will give the maximum power output.

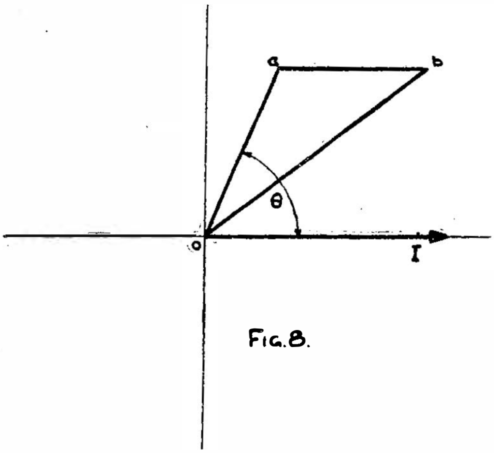

FIG. 8.—OPERATION OF A TRANSMITTER UNDER AN INDUCTIVE LOAD.

If E = E.M.F. of the transmitter,
r_1 = resistance of the transmitter,
$Z_1\underline{|\theta} = R + jwL$ = impedance of load on transmitter,

$$\text{the current produced} = I_A = \frac{E}{r_1 + R + jwL},$$

and from formula (4)

$$\text{the terminal P.D.} = \frac{E\,(R + jwL)}{r_1 + R + jwL}$$

and the power output from the transmitter = $P.D. \times I_A \times \text{Cos}\,\theta$

$$(\text{where } \theta = \tan^{-1}\frac{wL}{R})$$

$$= \frac{E^2\,(R + jwL)}{(r_1 + R + jwL)^2} \times \frac{R}{\sqrt{R^2 + w^2L^2}},$$

for a particular value of θ we may put $R = xL$, where x is a constant.

$$\therefore \text{Transmitter output} = \frac{E^2\,(xL + jwL)}{(xL + r_1 + jwL)^2} \times \frac{x}{\sqrt{x^2 + w^2}} = P.$$

$$\text{for a maximum output } \frac{dP}{dL} = O.$$

∴ differentiating P with regard to L and equating to zero we eventually find that—

$$r = R + jwL \quad . \quad . \quad . \quad . \qquad (5)$$

and equating the real quantities and the imaginary—

$$r_1 = R \text{ and } jwL = O.$$

This result may be interpreted as follows :

(1) We shall get a maximum output from the transmitter when the load is non-inductive and equal in resistance to r_1.

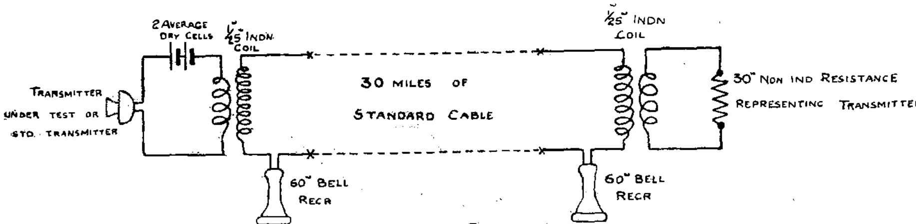

Fig. 9.

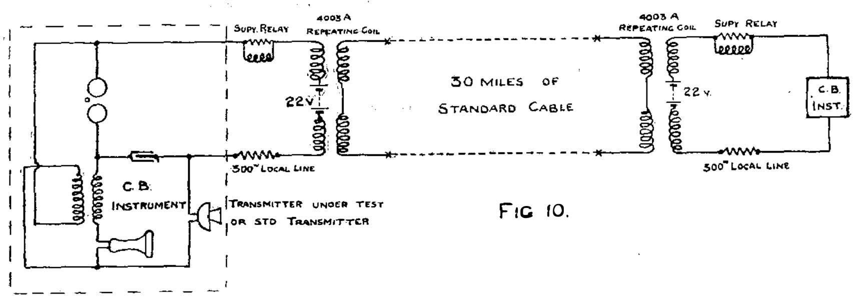

Fig. 9.—Local Battery Transmitter, Test Circuit.

Fig. 10.—Common Battery Transmitter, Test Circuit.

(2) But if the load is inductive, then we shall get the maximum output when the power supplied to the external circuit is equal to the power lost in the transmitter itself due to its resistance r_1,

$$i.\,e. \text{ when } R = r_1 \quad . \quad . \quad . \quad . \qquad (6)$$

The impedance of the load on the transmitter will depend, of course, on the type of instrument with which it is used.

L.B. Transmitter.

These transmitters are tested for volume efficiency by comparing them with a standard transmitter on a circuit shown in Fig. 9.

The impedance of the primary winding of a $1^{\omega}/25^{\omega}$ induction coil, when the secondary was connected to a 60^ω Bell receiver and a long length of standard cable as shown above, has been measured with 10 ma. and it was found to be :

$$\text{at 800 frequency. } 15 + j31 = 35 \angle 64^\circ,$$
$$\text{at 1000 frequency. } 23 + j44 = 50 \angle 63^\circ,$$

Evidently for any given type of transmitter there will be a best value for its resistance, which, when the transmitter is connected to the above testing circuit, will give the highest volume efficiency. It may be of interest to calculate this resistance by the aid of formula (3) as we know the circuit conditions.

The E.M.F. of the primary battery . . . . . $= 2{\cdot}4$ volts
Internal resistance of the primary battery . . . $= 5$ ohms.
D.C. resistance of primary winding of the induction coil $= 1^\omega$
Resistance of the transmitter . . . . . . $= r_1$

$\therefore$ Total D.C. resistance of primary circuit $= 6^\omega + r_1$ ohm and transmitter feeding current $= \dfrac{2{\cdot}4}{r_1 + 6^\omega}$ amps.

By formula (2) the E.M.F. of the transmitter $= I_D\ r_0 \sin wt$.

There does not appear to be any information as to the relation between the resistance of a transmitter and the variation in resistance (r_0 sin wt) caused by sound-waves impinging on the diaphragm It is evident that r_0 is a function of r_1, and for a sound of constant amplitude it will not be far wrong to assume that it produces a variation in resistance such that r_0 is proportional to r_1.

We may therefore put $r_0 = x\, r_1$ where x is constant. Taking the value $15 + j\,31$ for the impedance of the primary winding of the induction coil, we obtain from formula (3) that the alternating current produced in the primary circuit—

$$I_A = \frac{\dfrac{2{\cdot}4}{r_1 + 6}\, x\, r_1 \sin wt}{(r_1 + 5 + 15 + j31)} \text{ amps.}$$

For a maximum output from the transmitter this expression must be a maximum, and eliminating the constant quantities we wish to find the value of r_1, for which—

$$\frac{\dfrac{r_1}{r_1 + 6}}{(r_1 + 5 + 15 + j31)} = \frac{r_1}{(r_1 + 6)\,(r_1 + 20 + j31)} \text{ is a maximum.}$$

By differentiating with regard to r_1 and equating to zero we find the necessary condition is when—

$$r_1^2 = 120 + j186$$

but r_1 can only be a real quantity

$$\therefore\ r_1^2 = 120$$
$$\therefore\ r_1 = 11 \text{ ohms.}$$

Similarly, by taking the value of the impedance of the primary winding of the induction coil measured at 1000 frequency we find that the best value for r_1 is 13 ohms.

The minimum resistance for L.B. transmitters allowable for acceptance by the Department is 25 ohms. This minimum value is specified so as to limit the feeding current taken from the primary cells. It may be suggested that the increased talking efficiency obtained by using a lower resistance transmitter (the best value would be 12 ohms) might be sufficient to compensate for the decreased life of the cells due to the larger feeding current taken. An alternative would be to use a larger induction coil with a primary winding having a higher impedance than the $1^{\omega}/25^{\omega}$ coil; the most suitable transmitter would be of correspondingly higher resistance, thus reducing the current taken from the primary battery. The better arrangement could best be found by a practical test.

C.B. Transmitters.

The testing circuit for C.B. transmitters is shown in Fig. **10**.

The impedance of the load on the transmitter when connected to the above circuit is with 1 ma.—

at 800 cycles per second $248 \,\overline{|4{\cdot}4^\circ} = 247 - j19$.

(This is taken to be $250 \,\overline{|0^\circ}$ in the following calculations.)

at 1000 cycles per second $475 \,\overline{|27{\cdot}8^\circ} = 421 - j222$.

C.B. transmitters are usually compared with a standard transmitter on this circuit, so that the transmitter whose resistance is of such a value that its output is a maximum when connected to this circuit will, other things being equal, presumably give the best volume efficiency. We will therefore calculate the value of this resistance from formula (3) in a similar way to that of the L.B. transmitter.

The D.C. resistance of the circuit through which the feeding current to the transmitter flows is made up as follows:

	Resistance of transmitter .	$= r_1$ ohms
	Induction coil winding . .	$= 17^{\omega}$
	Local line	$= 300^{\omega}$
	Supervisory relay and shunt .	$= 21^{\omega}$
	Two repeater coil windings .	$= 46^{\omega}$
∴	Total resistance . . .	$= 384^{\omega} + r_1$
	E.M.F. of battery . . .	$=$ 22 volts

∴ Feeding current to the transmitter $= \dfrac{22}{384 + r_1}$ amps.

As before we put $r_o = x\, r_1$.

By formula (2) E.M.F. of the transmitter $= I_D\, v_o \sin wt$

$$= \frac{22\, x\, r_1 \sin wt}{384 + r_1}.$$

At 800 cycles per sec. the impedance of the circuit . . . . . $= r_1 + 250$.

$\therefore$ Alternating current produced $= I_A = \dfrac{22 \, x \, r_1 \sin wt}{(384 + r_1)(r_1 + 250)}$ and

for this to be a maximum $\dfrac{r_1}{(384 + r_1)(r_1 + 250)}$ must be a maximum.

$\therefore$ Differentiating with respect to r_1 and equating to zero, we find this to be a maximum when $r_1 = 310$ ohms. A similar calculation, taking the impedance of the load on the transmitter at 1000 cycles per sec. as $420 - j220$, gives the best value for r_1 as 400 ohms.

Therefore a C.B. transmitter of about 350^{w} resistance will give the maximum output on the standard C.B. testing circuit. This value has regard only to volume efficiency, and the usual resistance for C.B. transmitters, *i. e.* 30 or 40 ohms, may be the best value when other factors are included, such as articulation, frying, packing, and the effect of this resistance on signalling arrangements, which have to be considered in choosing a transmitter for general use. It is also evident that although a transmitter of 350 ohms' resistance may give the best volume efficiency on the standard C.B. testing circuit, it does not follow that it would give the same efficiency on another circuit—in fact, it is most unlikely. The above calculations refer only to the standard L.B. and C.B. testing circuits, as the volume efficiency of transmitters is usually judged by the results obtained on these circuits. Determining the best resistance for a transmitter on any given circuit is another problem which includes consideration of the performance of telephone induction coils. Testing arrangements would, however, not permit of dealing with all types of circuit in use, and if transmitters are to be selected for use on their most suitable circuits, some new method of testing them must be devised.

It has been shown that the resistance and the E.M.F. determine the operating characteristics of a transmitter, so that if these two quantities are known, we shall know how the transmitter is going to behave on any given circuit. The resistance is, of course, quite easy to measure, but before the E.M.F. can be measured, the conditions which produce it must be defined or specified. It has been shown that the E.M.F. of a transmitter will depend on the feeding current and on r_0, the change of resistance produced by sound-waves impressed on the diaphragm. Therefore the feeding current must be specified, and also, seeing that it is quite impossible to specify speech, a solution of the old problem of finding some mechanical substitute for the voice is required. This substitute should produce a constant standard sound of the same intensity as the average voice and contain the important frequencies of the voice, those frequencies being of the same relative amplitudes as occur in the voice. Some success in this direction has already been attained (see Capt. Cohen's paper on 'Telephonometry'). It is the opinion of the writer that when some such method of testing transmitters is devised, a great deal of the monotonous work entailed in standard cable measurements will be obviated.

It may also be found more satisfactory to have as the basis for the standard volume efficiency of transmitters a certain E.M.F. in volts, rather than basing it on the performance of a certain transmitter on the standard testing circuit a number of years ago, and then maintaining this standard by cross-checking a large number of other standard transmitters by means of standard cable measurements.

From the E.M.F. of a transmitter could be obtained its standard cable allowance, if desired, as there is a mathematical relationship between the two.

When making a transmission test a fixed length of 30 miles of standard cable is used and a shorter length for balancing is introduced in the standard circuit or the circuit under test, whichever happens to give the better transmission. In the case of transmitters better than the standard, the balancing length is in circuit with the transmitter under test. The current at the receiving end, when the balance is obtained, will always be equal to that produced by the standard circuit with 30 miles of standard cable as the junction line. This current may be calculated from the formula—

$$I_2 = \frac{V_1}{Zo \sinh \gamma l + Za \cosh \gamma l}$$

$$\text{or } I_2 = \frac{V_1}{(Zo + Za) \sinh \gamma l} \text{ approx.} \qquad (7)$$

Where V_1 = P.D. produced across the junction side of the sending end repeating coil;

Zo = characteristic impedance of the line,

and γ = its propagation constant;

Za = terminal impedance at the receiving end.

It has been found that for a standard transmitter of zero allowance on the standard testing circuit V_1 is about 0·5 volt for the average normal voice. I_2 may now be calculated from the following data, when l is 30 miles:

	At 800 frequency.	At 1000 frequency.
Zo =	$571 \angle 43{\cdot}26^\circ$	$510 \angle 42{\cdot}96^\circ$
j =	$\cdot 15427 \angle 46{\cdot}5^\circ$	$\cdot 1728 \angle 47{\cdot}04^\circ$
Za =	$720 \angle 26{\cdot}0^\circ$	$755 \angle 28{\cdot}0^\circ$
I_2 =	·0386 ma.	·0278 ma.

(By calculation.)

Now it is evident that V_1 will be proportional to the terminal

P.D. of the transmitter, and tests at 800 and 1000 periods per second showed that the *P.D.* impressed across the transmitter terminals of the standard C.B. circuit with 300^{ω} locals produced about an equal *P.D.* across the junction side of the repeating coil when connected to 30 miles of standard cable. The relation between the terminal *P.D.* and the allowance in terms of standard is therefore expressed by—

$$I_2 = \frac{v_1}{(Zo + Za)\sinh\gamma(l + L)}. \qquad (8)$$

Where v_1 = terminal *P.D.* of the transmitter,
L = allowance of the transmitter,
l = 30 s.m.

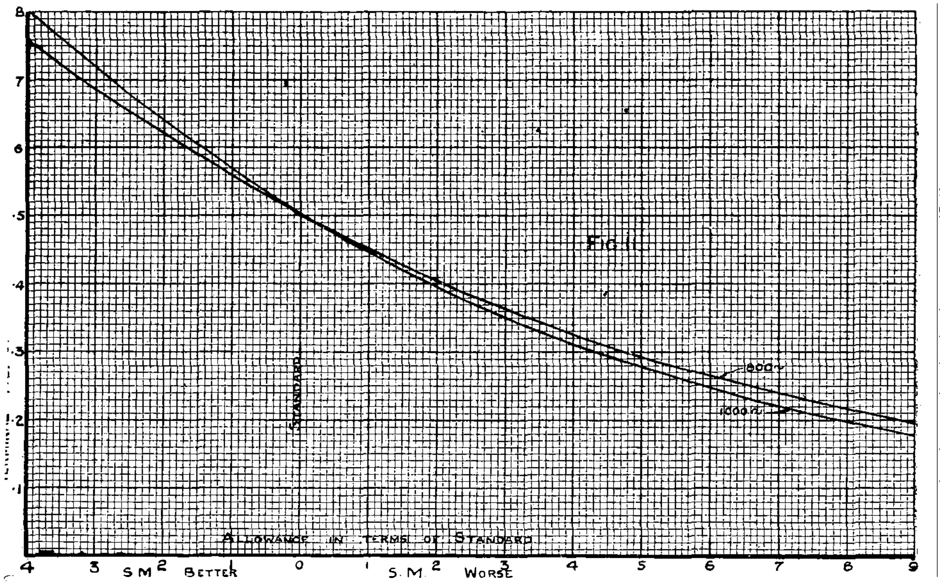

FIG. 11.—THE RELATION BETWEEN THE P.D. ACROSS A TRANSMITTER AND ITS ALLOWANCE IN STANDARD CABLE MILES COMPARED WITH STANDARD TRANSMITTER.

v_1 may therefore be calculated for any value of L. For transmitters worse than standard the balancing length is placed in the standard circuit, so that the received current, when the balance is obtained, will be—

$$I_2^1 = \frac{0{\cdot}5}{(Z_o + Z_a)\sinh\gamma(l + L^1)}. \qquad (9)$$

and the terminal *P.D.* of the transmitter—

$$v_1 = I_2^1 (Z_o + Z_a)\sinh\gamma l. \qquad (10)$$

By calculating v_1 for several positive and negative values of L, and plotting the results, a curve (Fig. 11) has been obtained which shows the relation between the terminal *P.D.* of a transmitter when spoken into with the average normal voice and its allowance in M.S.C., better or worse, than the standard transmitter. A curve calculated for 800 periods per second and another for 1000 periods per second are shown and the curve for the equivalent speech frequency is somewhere between these two. The impedance of the load on the transmitter at the equivalent speech frequency will also be somewhere between the values for the standard testing circuit given above for 800 and 1000 periods per second. The resistance of the transmitter being known, its E.M.F. may therefore be obtained from formula (4).

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THE AUTOMATIC TELEPHONE.

By B. O. ANSON.

THE telephone was invented by Alexander Graham Bell in 1876 and two years later a commercial telephone exchange was opened at New Haven, Conn. This exchange served eight subscribers, and the lines were connected to one another as required by means of radial switches similar in type of those used for altering the resistance of a rheostat. A modern telephone exchange serves up to 10,000 subscribers, but for obvious reasons the radial switch has long since been replaced by plug and cord connections. In a 10,000-line London exchange the staff required for the sole purpose of manipulating the plugs and cords is from 100 to 350 operators; the exact figure depends upon the traffic of the exchange.

As the telephone exchanges of a large city increase in number the junction traffic between them becomes more and more intricate; each new exchange entails the opening of "B" positions at other exchanges and probably the handling of a considerable block of junction traffic at a "junction lending" or "tandem" centre. The operating time occupied in establishing and disconnecting a call at a Central Battery manual exchange without any junction traffic is, approximately, fifteen seconds, whereas the operating time with 100 per cent. junction traffic rises to, approximately, forty seconds. The operator's errors or irregularities increase rapidly as the amount of junction traffic increases. As the average length of an operator's arm and the phonetic operating troubles that result from long numbers impose a practical limit of 10,000 lines upon a manual exchange, it follows that the mere development of the telephone system, by increasing the number of exchanges, produces junction traffic and thereby progressively degrades the service.

The efficiency of an operator is at its maximum when she has a full load of traffic *on her own position.* During slack times an operator must control several positions with a corresponding loss of efficiency, so that the service given by operators at night and on Sundays is poor and costly.

Owing to the trying nature of the work, operators are year by year more difficult to obtain, and in times of war, when the telephone is of prime importance, the supply of operators is likely to fail entirely. The average service of an operator is four years, several months of which are absorbed in training; an operator does not become really expert under eighteen months. The existence of a big operating *personnel* means, also, a large organising and administrative force concerned with the work of adjusting operators' loads, arranging duties, scheduling holidays, substituting sick absentees, providing meals, cleaning operators' quarters, providing transport facilities during emergencies, and, last but not least, paying wages and pensions.

A manual telephone exchange needs a long, narrow operating-room on one floor, in order that the duties of operating and supervision may be carried out efficiently. This in congested cities entails difficulties in procuring sites for new exchanges and thereby hampers development.

These factors, which are seriously detrimental to the progress of telephony, are the direct effect of human operating. For years past the organisation of the telephone system has been improved continually, but unfortunately the practical difficulties of affording service increase more rapidly than can the improvements in organisation, and as the system becomes more and more complex with lapse of time, it is clear to experienced telephone men that the best organisation will not provide a real solution of the problem. The only solution is to be found in the abolition, as far as practicable, of human effort in switching operations. In local telephone exchange areas this is achieved by the introduction of automatic exchanges, which are in fact switching machines.

It is no longer necessary to urge the practical efficiency of automatic exchanges. So many are now in use that their capabilities are well known. They operate on a numerical basis; the average time occupied in establishing a call depends on the number of digits that have to be called. This may be taken at 1·5 seconds per digit, which in a 5-figure exchange requires 7·5 seconds. The release of a connection occupies less than 0·5 second, making a total of 8 seconds' operating time. If the whole of the exchanges in the area are *automatic* the junction traffic adds nothing to the time of operating, but if some remain *manual* there is an additional time factor due to the intervention of the junction operator.

Automatic exchanges are at present more expensive as regards prime costs than manual equipments. They do not cost appreciably more to maintain, however, and the financial position resolves itself into one in which the saving of operating charges should at least repay the interest and depreciation on the excess capital. Manufacturing conditions for manual plant are now well organised, but those for automatic plant are still undeveloped. We can look forward, therefore, to reductions in the prime cost of automatic plant due to standardisation, mass production and other improvements in manufacture, whilst very little, if any, further economy can be expected as regards manual plant. It should be noted that the methods of mass production are specially applicable to automatic plant, as the parts used in the former are largely press products, whilst the amount of cabling is comparatively small.

In the larger towns and cities the advantage of the automatic system is obvious. The fact that, even in the largest cities, it can be expected to give a far quicker and more accurate service than the manual system without deterioration as the development of the area increases, places the future of automatic telephony in such centres upon a firm basis. In the smaller towns, where the operating conditions are simple and the services of operators are comparatively easy to obtain, the need for automatic plant is not so pronounced, but such equipment will nevertheless be desired by subscribers because of the rapid service afforded. In villages and outlying districts where very small exchanges exist, the capital cost per line of the automatic exchange plant is very high, but at such exchanges it is practically impossible to obtain efficient operating throughout the twenty-four hours, and therefore the automatic system is an advantage because it solves the problem of night and Sunday service and gives a good service at all times.

Briefly, the case for automatic plant rests on "service." The more extensive a manual system becomes the worse is the service afforded and the higher become the plant and operating charges, but with automatic plant it is easy to maintain through all stages of development a supreme service by day and night, on weekdays and Sundays. *If the telephone man's ideal of universal service is to be attained, it is clear that he must employ a machine for switching.*

AIRCRAFT OBSERVATION.

MUCH information has been published from time to time concerning the aërial defences of this country during the war. There may, however, be some who are not too surfeited with the subject to find interest in the accompanying two photographs.

Fig. 1 shows the map table on which the movements of hostile aircraft within the London defences were plotted. Telephone messages from the various observation stations were received over

FIG. 1.—AIRCRAFT OBSERVATION: MAP TABLE.

lines terminated in a group of silence cabinets in an adjoining room. In the earlier raids the messages were passed to a plotting room in memo. form. This was found to be too slow a process, especially as those at the distant ends of the lines were apt to be unnecessarily verbose in reporting their observations. The possibility of standardising the messages was considered, with the result that only essential information was transmitted. This led to an improvement in the speed with which the messages were docketed and passed into the plotting room. It also led to a message-indicating scheme being designed by the writer. Fig. 2 shows the transmitting apparatus and the telephonist's instrument in one of the silence cabinets. Similar sets were installed in each of the remaining cabinets. The indicator board is seen clearly in Fig. 1. The keys were of the order-wire non-locking type and the indicators of the drum type, wired so as to retain through the local contact.

As a telephonist received a spoken message in his receiver he

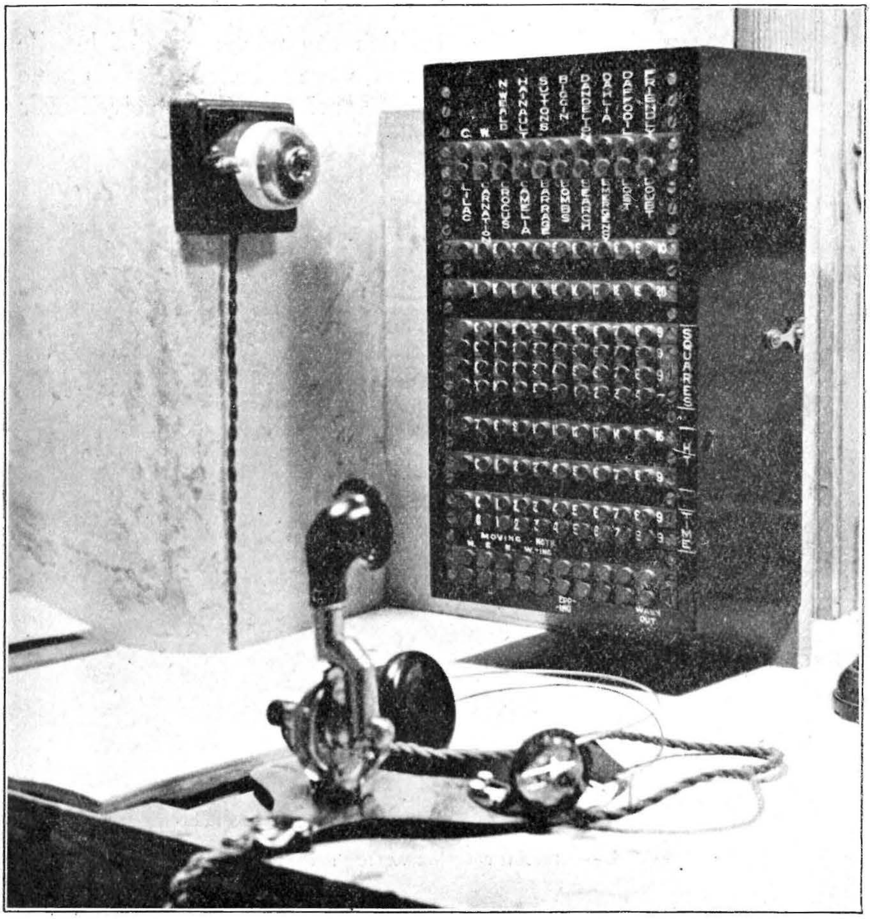


FIG. 2.—AIRCRAFT OBSERVATION: TRANSMITTING APPARATUS AND TELEPHONE IN SILENCE CABINET.

passed it on in visual form to the plotting table by pressing the appropriate keys. Messages would generally give the following information :

(1) Place of origin of message.
(2) Secret code word.
(3) Location of hostile aircraft by reference to a squared map.

(4) Height of aircraft.
(5) Time of observation.
(6) Direction of motion.

Such a message would only require nine keys to be pressed. In the case of "time" it was only necessary to press one key in the tens row and one in the units row to indicate the number of minutes past the hour. There was no necessity to transmit the hour itself. As soon as a message had been noted the officer at the map table responsible for that section of the indicator board pressed one key to break the retaining circuit of the indicators, and another to advise the telephonist by means of a buzzer that a fresh message could be set up. The arrangement worked admirably. The officers and men concerned after a little drilling were able to read and send the messages with great speed. It might be imagined that the plotting room during a raid was a scene of great excitement. As a matter of fact it was quite the reverse. Imagine a number of officers sitting round the table quietly placing counters on the map in conformity with the visual messages appearing one after another in front of them. In the early stages of a raid by several machines it might be difficult to follow clearly the course of each, but after a time as they became scattered it was generally possible to plot the movements accurately. As soon as the course of a machine was identified the plottings as indicated by the counters were transferred to the squared chart on the wall where the tracks were indicated by continuous lines. The only sound in the room was the voice of the officer whose duty it was to keep the local anti-aircraft command headquarters advised of the movements of the "birds."

G. F. GREENHAM.

POST OFFICE ENGINEERING DEPARTMENT: ANNUAL DINNER.

THE Eleventh Annual Dinner of the Engineering Department of the Post Office was held on Tuesday, April 27th, at the Café Monico, a numerous company being present.

Mr. Noble, the Engineer-in-Chief, presided, and among the guests present were the Rt. Hon. A. H. Illingworth, M.P. (Postmaster General), Sir Evelyn Murray, Mr. Roger T. Smith (President, I.E.E.), Mr. Raven, Sir A. M. Ogilvie, Sir W. Slingo, Mr. F. Gill, Dr. Kempster Miller, Mr. F. A. B. Lord, Sir R. Bruce, Mr. G. F. Preston, Mr. John Lee, Mr. C. C. Sanderson, Mr. W. H. Allen, Mr. G. Morgan, Mr. A. M. Sillar, and many others.

The Rt. Hon. ALBERT H. ILLINGWORTH, M.P., His Majesty's

Postmaster General, in proposing "The Post Office Engineering Department," said:

Mr. Chairman and Gentlemen, — I have been occupying the position of Postmaster General for some years, and this has been the first opportunity I have had of addressing you at one of your engineering dinners as, on account of the war, I understand you have not been able to hold them of recent years.

After this great upheaval, we ought to, and I am quite sure we all do, feel delighted that we can meet here to-night and rejoice over the great victory which we have achieved over all our enemies, tempered with sympathy for the relatives of those who were once our colleagues and who sacrificed their lives to achieve the great event that we have just celebrated—victory and peace. After this great upheaval, however, we now have to face in the Post Office, and especially in the Engineering Department, the great task of reconstruction: bringing things to their proper level and securing more efficient management than there was before the war. You have done enormous things in assisting the country to achieve the great victory. I think there were 13,000, or to be correct, 12,977—near enough to call it 13,000—of the engineering staff who joined the fighting forces in one form or another during the war. I regret to say that 997 have been killed, and some 2500 wounded, but there is, I think, a cheerful side to this. Your decorations have amounted to 637, and one gallant fellow received the Victoria Cross, I am told, for taking in Flanders a "pill-box," one of those concrete fortresses which were considered impregnable, single handed. (Cheers.) I am glad to say he returned safely and is now working in the Midlands at his old occupation.

The Post Office Engineers, gentlemen, not only did good service in the field, in the fighting line, but their inventive powers also gave wonderful assistance to the authorities in prosecuting the war from the scientific side. Some of you know of the Sound Range Finder, which was manufactured and mainly developed by one of the engineers of the Post Office. I remember when His Majesty was good enough to come around the Post Office during the war, he was so interested in the instrument that I could hardly get him out of the room. He tapped on the table and the light went out immediately. This may have been quite simple to the engineer, but it has always been a puzzle. I am told that, within a range of seven miles, a battery could be located to within a few yards by the aid of this instrument, and the result of the development of this extraordinary invention was that many batteries were silenced within a very short time of their opening fire on the British lines. (Cheers.) If the Post Office Engineers had done nothing but that, they would have done something to have been greatly proud of. But, during all this time, while these men have been away, we have put up with the complaints of the public in one way or another, for all of which I am blamed. (Laughter.) Fortunately, many of these complaints have a humorous aspect. Only a few weeks ago I got a letter from a gentleman who complained that something had gone wrong with a telegram of his. A word had been missed out, or something. I do not know whether an engineer was responsible, or whether the operator was, but this gentleman wrote to me and said that he was absolutely "fed up" with the whole country. He was paying his taxes, he had paid for his telegram, and he had decided that this country was no longer any good. He would sell out and go to a land where a blank, blank, Postmaster General knew his job. (Loud laughter.) This is only one instance of an attempt to send me down to the depths of despair, but I was cheerful for the whole afternoon. That man had no sense of humour.

The Press too, for many months, conducted a campaign against the Post Office, especially the work in which the Engineering Department is interested—the Telephone and Telegraph Departments. It was not, I think, seriously directed at the Post Office, but against the Government — using it as a stick to beat the Government with.

I think that everybody recognises and acknowledges that the greatest praise is due to the Post Office. It has worked under the greatest difficulties with substituted staff—anybody that could be got—and I think the result is a great tribute to the organising powers of the English race. I must be careful in saying "English" with a Scotsman in the chair. (Laughter.) I repeat, the organising powers of the British race which have come out in this war are extraordinary, and such as have never been shown before in the whole history of the country.

Then, a paper of what is known as the gutter press type sent out a man to America to examine their telephone system, and to write articles on what America could do in the way of telephones. He did not write anything. He undoubtedly had a very good time, but the fact remains he did not write any articles, because he had nothing to write about. The American service was much worse than our own. In two years of war their service had gone absolutely to pieces. I know we have a distinguished American here this evening, but I hope he will excuse me for what I believe the Americans describe as "flapping the eagle's wings," just for once.

But now we have to overtake the arrears, and it mainly rests on your shoulders to do this most important work. Since we took over the National Telephone system there has been very little opportunity of bringing the equipment up to date, but now we have to begin. We have, indeed, made a start, but it is only a start. The expenditure on renewals and extensions in 1918–1919 was £1,330,000. Then in 1920 this was increased to £7,500,000 and I think very much more than this would have been expended had it been possible for the manufacturers to deliver more material. I do not blame them for not being able to satisfy our requirements. They have their difficulties—shortage of material and labour—but they are gradually overtaking the arrears, and in the course of this year they will, I hope, be able to do better.

The contracts placed in 1918–19 amounted to £240,000, and in 1919–20 this was increased by nearly ten times—£2,375,000—and this, I hope, in the current year, will be very much exceeded. I hope that the supply of materials necessary to complete and start the necessary works will be forthcoming.

Exchanges have been increased by 25, making a total 3578, and the telephones have increased by 63,383.

Although that is, of course, a very considerable increase, it is not what the country demands and must have. I hope in future that this will be increased year by year by at least two, three, or even four times the amount. (Hear, hear.)

The damage done by storms to the overhead lines has been very great, and has caused the greatest inconvenience to the public, more especially round the constituency which I have the honour to represent—(laughter)—that is, between Lancashire and Yorkshire. Since I have been Postmaster General the storms have swept down the poles almost as soon as they were put up, and have caused such indignation among my constituents that I have shortly to receive a deputation in order to allow them to blow off steam.

There have been 500 miles of ducts placed underground, and 185 miles of new main cable, which I think contain 19,000 miles of wires. There, again, this would have been very much exceeded had the contractors been able to supply the cable, and had the duct makers been able to make more ducts, and had the railway companies been able to carry them.

New overhead circuits numbering 136, containing 6500 miles of wire, were completed. The underground wires were much greater—680 miles of ducts have been put down which have taken 148,400 miles of wire, and above this some 2400 miles of wire have been put up overground.

Now these are, to my mind, quite satisfactory considering what material we have had to work with, and under the difficulties we have had to contend with, but I do not think in future that I should say that—in a normal year—I should be quite satisfied with this. We must do better than that, and in future I hope that the increase will be very much greater.

We have not only these things, though, we are now getting on with the contracts for the completion of the tube railway which will take off the streets so many of the postal vans between the most important postal centres. During the present year we have a very large programme which I will not trouble to detail—it is so big that if I did I should be here all night, and I only hope it will all be carried out. I hope before long that repeaters, which have hitherto been used only on a small scale, will be used on a much larger scale. I am informed by the experts that only one-tenth of the weight of copper wire will be needed to take the place of what we have at present. One-tenth of the wire is what one might call a compound saving. You will not only save the cost of the wire, but you will also save the size of the ducts, getting many times more wires in the same space than you could with the old system. With the inauguration of the Dollis Hill Research Station, it will give great opportunities for those of an inventive brain of increasing the efficiency not only the present system of telegraphy and telephony and various electrical installations, but also wireless telegraphy and wireless telephony.

The staff of the Engineering Department of the Post Office has increased enormously. Fifty years ago, when the Government took over the telegraph systems, the staff only consisted of roughly 500 members. Before the war I think it was about 24,000. During the war the staff decreased until in March of last year there were about 10,000, but in March of this year the number had gone up to 26,000. That is a very great increase of staff, and I hope that the development will increase even more rapidly than the staff has done. There is much work to be done by you, Mr. Noble, in the future, and by the whole of your staff, in development, and arrears to catch up, and you will have to work hard. Unless you are going to have the House of Commons very much on my shoulders, you will have to hurry up and get a move on. (Laughter.) I get all the blows—not that I mind it, for I have a thick skin and I can give as good as I get. But still, I want to be able to appear before the House of Commons and prove to them that everything is being done that can be done—(applause)—and I have no fear that I shall not have your whole-hearted support. (Cheers.)

The three and a-half years during which I have been Postmaster General, have, I think, been the most strenuous years that either any Postmaster General or the staff, which has so ably supported me, have ever gone through ever since the Post Office has been in existence. We have had troublous times to go through—loss of staff who had gone to the war, the service to carry on as best we could; and now the reconstruction period comes along. Things are possibly more difficult than they were before. I am sure, though, that nobody could have been more loyal than the Post Office

Engineering Staff, and this is a source of great gratification to me. I hope this support will continue until things are in a normal and proper state again.

Well, Gentlemen, we are not met here to-night to make long and dreary speeches, and I think I could not do better than draw my remarks to a close with a little story.

Lord Palmerston was attending a white-bait dinner at the Old Ship Hotel, Greenwich—in the days before we had any mention of "Pussyfoot," in days of liberty when we could eat and drink what we wanted and when we liked. There was a new Cabinet Minister there who was very anxious that there should be some speeches. At these white-bait dinners, however, they did not worry much about speeches. Lord Palmerston made a few remarks, for about two or three minutes, and concluded by saying, playing with a fork upon which dangled a white-bait: "Gentlemen, I think we could not do better than follow the example of these little fishes, drink a hell of a lot and say nothing." (Loud applause.)

In replying to the toast, Mr. NOBLE, who was greeted with loud and sustained applause, said: Mr. Illingworth, Sir Evelyn Murray, Gentlemen,—The other day the Committee informed me that they had provided a very excellent programme, and judging from the samples we have already had, they were right. They consequently wished the speeches to be short. I did not tell Mr. Illingworth this, because the Annual Dinner is the only occasion when we can get our Parliamentary Chief to tell us what he thinks of us. Mr. Illingworth has told you this is the first occasion that he has had an opportunity of addressing us at a dinner, for the reason that during the war these functions did not take place. There was all the more reason why we should allow him some latitude as to time. A guest does not usually say anything very derogatory to his hosts. Mr. Illingworth, however, has a reputation for straight and blunt speaking, and I believe he believes all he said in favour of the Post Office Engineering Department. On your behalf we have to thank him for his commendation of what we have done in the past, and I can safely assure him, on your behalf, that, given adequate supplies of material, it is nothing to what we will do in the future. (Hear, hear.) Sir Robert Morant, whose lamented death occurred recently, gave an address at a Civil Service society a week or two before he died, and during that address he said that he always regarded men who work at all seriously at things as falling into two classes—those who leave no stone unturned to make a job a complete success, and those who turn only as many stones as will just do. I think I can tell Mr. Illingworth that the engineering staff generally belong to the former class, and that we will one and all leave no stone unturned to make the telegraph and telephone services of this country second to none.

Mr. Illingworth has told you some of the work we have done since the Armistice, but we could have done much more. We had the men, and we could get more; we had the officers, and we could get more; we had the money, and we could have got more, but the contractors could not deliver the goods, and therefore the work done was less than it would otherwise have been. It was not the fault of the contractors, it was the fact that they could not get raw material. The abundant supply of material appears to be in the lap of the gods, but when that trouble is overcome I can assure the Postmaster General that the work accomplished by this Department will be greatly increased.

I do not know whether you can satisfy the British Public—it is a hard taskmaster—but if there is any lack of development it will not be due to the Engineering Department. We are given every facility by the Administration to obtain the necessary staff and the money, and all we want at the present time is material. The manufacturers are doing their best, but are delayed, as I have said, by the shortage of raw material.

Mr. Illingworth referred to attacks on the Post Office telephone service in certain newspapers. I do not think I need tell this gathering that these attacks were unjustified. I do not, however, believe that the newspapers really wished to attack Post Office administration of the telephones so much as to use this as a weapon against the nationalisation of the coal mines. The *Evening News* was very unjust. It commenced, by means of the pen of its so-called telephone "expert," a campaign that it knew a Government Department could not reply to, as we are not allowed to go in for Press propaganda. Had it known we could have answered, many of the charges would never have been made, certainly not so exaggerated. The correspondent was no expert in telephone work—if we use the word "expert" as an adjective and add the noun "witness" he might have come within the scope of the saying of a certain Judge who said: "There are liars, damned liars and expert witnesses." (Laughter.) Had its correspondent really been an "expert," and a just one, he would have appreciated that all our trouble was due to war conditions. In one of his articles he was good enough to say he had no fault to find with the Engineering Department, but a few days later he asked, how could the Department manage the telephones when it followed the practice of engaging three men at £300 a year instead of one expert at £900 a year? On this point, at a recent meeting of the Rotary Club I issued a challenge to the *Evening News* to scour the country to find the best telephone expert outside the Post Office. I would give the *News* a list of twenty-four officers from my staff, and allow facilities for ascertaining the capabilities of these officers so that one could be selected by the newspaper. Then if a committee of three electrical engineers, after examining the two gentlemen, decided that the *Evening News* expert was better than my officer, I would pay £1000 to any charity. Mud-slinging, although unjustified, sometimes results in a little mud sticking, but I was surprised that an association which has been formed apparently to benefit the public should have sent out tens of thousands of post-cards asking the public to attack the Government so that they could have a private company to run the telephones. They have a private company in America—they are all private companies in America. Well, when I was in America I asked a high official in the telephone world there what he thought of their service, and he said it was rotten. "What is the cause of it?" I asked; and the reply came, "Why, the war." "By the way," said I, "how long were you in the war?" "Two years." "Well," said I, "what would it have been like had you been in it five years?" And the answer was, "Damned rotten!"

Under all the circumstances I think we have every reason to be proud of the service at the end of the war. Thirteen thousand of our staff joined the Forces, and of those left behind a large proportion was on war work building lines to camps, aerodromes, searchlight and anti-aircraft stations, munition factories, Government offices, etc. Also plant was supplied in large quantities to the Navy and the Army, and it is, I think, wonderful that we accomplished what we did. I venture to say that no private company could have done so well during the war, or since the war. During the war we could retain men that a private company could not have kept from the recruiting sergeant. We also got stores and material, being a Government Department, that no private company could have got. I admire the National Telephone Company for the way they managed their business, but had the Company been in existence during the war the telephone service would have deteriorated more than it did under the Post Office, for the reasons I have given.

One other point I should refer to. We get another form of attack from inside the Government service as well as from outside. A few weeks ago I read an advertisement in a certain journal asking men with experience of automatic telephones to apply for positions. I knew what the sequel would be. Last week one of the Superintending Engineers wrote saying that two of his experts in automatics had been successful in obtaining positions, but the firm had refused to engage them without the sanction of the Post Office. I knew I could not refuse. If I did Mr. Illingworth would have been asked in the House of Commons why permission was not given, I would just like to say this: if these manufacturers wish the department to develop automatic telephones they must leave our men alone. We have got to maintain the systems they instal. It is in their interest as well as ours to leave our trained staff alone. I will tell you what I said to one manufacturer who wrote saying he had engaged one of my engineers and hoped I did not object. I replied saying that I thought it rather late to object after he had engaged the man. I politely suggested that in future he should follow the practice of the Post Office, namely, engage his own young men and train them at his own expense.

Recently we have lost several officers to other Government Departments. The latest instance is this, and I am mentioning it in the hope that Mr. Illingworth will drop a hint in the right quarter and have it stopped: I was asked to give up an engineer with eight to ten years' experience of wireless telegraphy to the Road Department of the Transport Board! This officer knows wireless telegraphy from "A" to "*Z*"; he does not know the "A B C" of road-making.

There is another way to stop all that. (Loud and prolonged cheers, and a voice, "What do you mean?") What do I mean? Well, I will say this: I do not think there is a Government Department that requires more administrative ability, more knowledge, more diplomacy, to run than does the Post Office, and I cannot see any reason why it should not be on equal terms with any other Government Department in order that we may retain our staff. (Hear, hear.) At the present juncture it would be a serious matter if any other Government Department considered to be of a higher order than the Post Office were to take away Sir Evelyn Murray. I am speaking seriously, not only for myself, but I know I am expressing the views of other officers in my Department. Sir Evelyn Murray has taken a keen interest in the engineering work, and I know he does the same in regard to all other departments of the Post Office, and with so many important reconstruction questions on hand it would, as I have said, be a grave error to withdraw the Secretary at such a time. I hope Mr. Illingworth will drop a hint in the right quarter to get a remedy for the present state of affairs.

Well, I promised not to take more than a quarter of an hour, and my time is just up. I will only reiterate our appreciation of Mr. Illingworth's references to the Engineering Department, and thank those gentlemen who do not belong to the Engineering Department for the way they have received the toast. (Loud cheers.)

Mr. A. J. Stubbs, in proposing "The Visitors," said: Mr. Chairman and Gentlemen of the Engineering Department,—We have heard a good deal this evening on a very important subject—our noble selves—and we are grateful to the Postmaster General that he has assessed us this evening nearer our own valuation than he will probably get on any of the other of the 365 days of the year. It is my duty now to try to divert your thoughts to another important matter—our welcome guests.

We welcome respectfully and heartily Mr. Illingworth, our principal guest, the head and the political chief of our Department. We are very sorry that Mr. Pike Pease has not been able to come, but we have with us Sir Evelyn Murray—(applause)—who, I suppose, has the toughest job of any civil servant in the country. (Hear, hear.)

We welcome Mr. Raven, the Second Secretary, and a host of other official friends. One sees Mr. Morgan sitting beside his successor looking practically as youthful as he. (Hear, hear.) We had hoped that Sir John Snell would be present with us—a man who now holds, I suppose, the highest official position in our profession in the country—until quite lately almost one of ourselves.

We have Mr. Roger Smith—(applause)—the President of the Institute of Electrical Engineers. One cannot refrain from mentioning Dr. Kempster Miller—(applause)—whose name is a household word among telephone men all over the world. I cannot forget—although I am almost tempted to leave out—Sir William Slingo—(applause): it seems almost unreasonable to think of him as a "guest." Mr. Martin Roberts had hoped to be with us, but was prevented at the last moment.

These are only some of our official guests, those who are our friends in an official sense—official as well as private. We have also a good many equally dear, equally welcome, who are not associated with us in our official life. It would be obviously difficult for me to mention names; it would probably be unwise, because those whose friends' names were omitted would probably not let me get out of the cloak-room with a whole coat. (Laughter.) I must, however, associate with the toast the name of Mr. Lane Mitchell. Mr. Lane Mitchell, I understand, is rather a peculiar man. He is a Scotchman. (Laughter.) Nothing strange about that—most important people are! But he is a Tory. (Shame.) He is also a friend of Mr. Noble. (Shame.) Do not condemn Mr. Noble too hurriedly. When I heard that I thought there must be some extenuating circumstance. I sought for it, and found that some time ago Mr. Lane Mitchell had the good fortune to be born in Aberdeen. (Laughter.) Now, Mr. Noble loves an Aberdonian. Had I been so fortunate as to be born in Aberdeen, the Engineer-in-Chief might have refused his appointment in my favour. (Loud laughter.) A card has just been placed in my hand which tells I have been speaking of the absent—Mr. Lane Mitchell is not here! I must leave out the rest of my speech that refers to Mr. Mitchell and mention a new name—a name I ought to have mentioned, and indeed intended to mention, among the official guests. I am sure Mr. Gill—(loud cheers)—this evening accepted at its true value the very sincere expression that Mr. Noble gave to our appreciation of the high ability with which the National Telephone Company was run when Mr. Gill was one of its ruling triumvirate, and we are very glad indeed that he has been able to come this evening to see some of those who served under him in times past, and to see those who are attempting, not much to the satisfaction of the newspaper public, to carry on his good work in the present.

I want now, therefore, to associate the name of Mr. Gill with this toast. Gentlemen, the toast is, "Our Welcome Guests."

Mr. GILL replied as follows: Mr. Stubbs, Mr. Noble and Gentlemen of the Post Office Engineering Department,—I feel rather embarrassed at having been asked only a few minutes ago to reply to the very kind toast proposed by Mr. Stubbs. I feel that there are so many in the Post Office who might have undertaken this duty. I think Mr. Kempster B. Miller might have replied to the Postmaster General's remarks about the "flapping of the eagle's wings," or Mr. Smith might have induced some of the members of the Post Office Engineers to become members of the Institute of Electrical Engineers. (Laughter.)

However, I am inclined to fulfil my duty as best I can in the name of the visitors. We thank you very sincerely for your generous hospitality and for a very pleasant evening.

I am speaking as an outsider, and as an outsider I would like to say this. A good many of us outside do really recognise the splendid work which has been done by the Post Office engineers during the war and at other times. Personally I have a great admiration for a new departure which has just cropped up, that is, the publication of books by the Post Office Engineering Department. I think the first one is really excellent. You are very much to be congratulated in the possession of Mr. Hill.

I would like to say something else. During the war I was with the Ministry of Munitions and I had a number of Post Office men working with me. Every one of them made good and did well, one of them especially, who was sent by Mr. Moir, and has, I think, now gone to the Ministry of Pensions.

The Postmaster General threw out a kind of challenge about the old National. We used to hear that the naughty National filled up all the cables, etc. Of course they did, and the conditions were such that they couldn't do anything else—(hear, hear)—and now we have it that the naughty Post Office has done the same. Yes, of course, the conditions were such that nothing else could be done. I do think that the service the Post Office has taken over—the telephone service—is a very difficult service, one in which you are brought into actual touch with the public. My feeling is, however, that I would not worry very much about what some of the irresponsible people say, because I put it down to their ignorance—(hear, hear); in very many cases the public complains without knowledge. You all know about the man who thought a telephone exchange was a long room with rows of instruments set up straight all around the room and with operators running up and down trying to answer all the calls—of course you all know the story. The ordinary member of the public does not appreciate the service one little bit.

There is just one other thing. I think Mr. Noble referred to the American service. The American service did suffer seriously in the war. I think it is fair to say this—the American service, the British service and every other service suffered during the war, but the American and British services are common in this respect—the authorities have determined that nothing will stand in the way of reconstruction. I understand the British Government has determined that nothing whatever in the way of money shall stand in the way of complete reconstruction. Whatever is necessary is going to be done. I cannot see why the British should be content with a second-rate service. (Hear, hear.) I do know this—I am not wrong in saying that I can speak with authority—the British nation has got the engineering ability; there is no question about it. I think there is one point, though, where the Americans can score over you a little bit: they are a little more flexible in getting engineers as they want them—in drawing men. If I may humbly suggest that if they can ease the Engineering Department by getting more men when they want them, of the right kind, I think it will go a long way towards producing the service that the Postmaster General is aiming at. Mr. Noble's occupancy of the chair reminds me of a tale I once heard—probably from Mr. Noble. A Scotchman had a son who was coming up to London on a visit. When he got back his father asked him what he thought of the English people. "Well," said the son, "I didn't see any—I only saw the heads of departments." (Laughter and cheers.)

Sir EVELYN MURRAY, K.C.B., in proposing "The Chairman," said: Gentlemen,—After an excellent dinner and an equally excellent entertainment, it is a pleasant task to propose the toast of "The Chairman," and it is even more agreeable when the Chairman happens to be, as he is to-night, a distinguished member of our own household.

We have been promised during the war in many quarters a new heaven and a new earth. How far that has at present materialised, I will leave you to judge. But a large section of the community have evidently decided that one of the essential conditions of the new Utopia is a telephone. Whether they will hold to that view when they have got it is, perhaps, more doubtful. (Laughter.) In saying that, I cast no reflection either upon the plant which you, gentlemen, provide or upon that much-abused, and in the main unjustly abused, class of public servant—the telephone operator. The telephone enables us to communicate with those we want to speak with, but it also enables those who wish to speak to us to do so, and unfortunately they are not always the same person. (Laughter.) But it is clear that we are faced with a large development of telephone business, and, as the Postmaster General has said, in the next few years the limiting factor will be not demand, but supply. There are great fields of possibility for the Engineering Department, and the responsibility of the Engineer-in-Chief will be even heavier than it has been in the past. Added to the management of the telephones he has other matters, such as wireless, cables, and so on. If he has any leisure after that, he can devote it to exploring the possibility of communication with other planets. (Laughter.) We are told by that fountain of truth—the halfpenny press—that this will sooner or later be possible. Personally, I confess I hope that it will not be so. It opens an unlimited vista of inter-planetary conventions which is not comforting.

The Post Office, at the moment, is to be congratulated in having in charge of the Engineering Department a man like Mr. Noble. In these days such a man requires not only technical knowledge and experience, but also capacity for organisation, and, above all, driving power. Personally, I think I can congratulate the Engineering Department on its performance in the past year. I notice with some satisfaction that the only complaint the Postmaster-General had to make was that poles erected in his constituency had been blown down. No doubt if he will guarantee a degree of permanency in his present relations with that neighbourhood the Engineering Department will have the foresight to put up super-poles of unassailable strength.

Mr. Noble possesses the qualifications which are required at this time, and he wants your co-operation and support, which I am certain he will receive. Mr. Illingworth has said that one of our main troubles in the war was the absence of the staff. I have found by experience that when the staff came home the troubles were not always diminished. (Laughter.) But whatever views you may hold on certain other matters which have been referred to but not mentioned, I am sure that we can count on the loyal assistance of the staff in the Engineering Department, and with that assistance Mr. Noble will prove himself, as, indeed, he has already proved, a worthy successor of the distinguished engineers who have occupied the chair before him.

Gentlemen, I give you the toast of "Our Chairman." (Loud applause.)

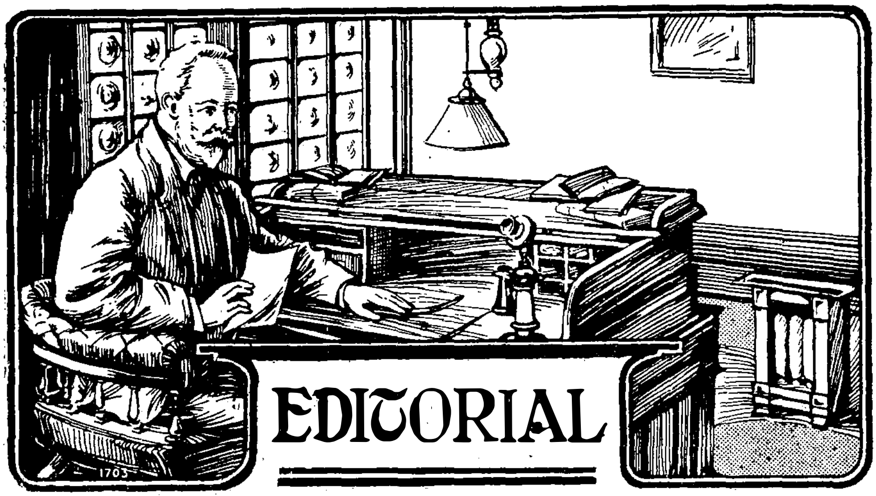
Mr. NOBLE, in replying, said: Sir Evelyn and Gentlemen,—Mr. Stubbs has referred to the fact that Scotsmen come to London. Apparently one occasionally does not come of his own accord. Last Friday, at the Willesden Police Court, a Scotsman was charged with travelling from Scotland to Willesden Junction without a ticket. His excuse was drink, and he said he recollected nothing from the time he left Glasgow until he was awakened at Willesden Junction, and he addressed the magistrate thus: "Do you believe, sir, that I would have come from a place like Glasgow to a place like London if I had been in my right senses?" (Laughter.) A short time before another Scotchman appeared at the same Court, strange to say, charged with being drunk and disorderly. He said it was due to the fact that he had been in bad company—he had travelled in a railway compartment having two bottles of whisky and with only one other passenger who was a "Pussyfoot." (Laughter.)

Some twenty-two years ago I was asked to come from a better town than Glasgow—(laughter)—to London. I was in my right senses when I accepted, but if I had ventured to prophesy that I should occupy this position to-night, I would have forgiven anyone who said that I was either not in my right senses or that I had been in bad company. I feel it to be a great honour to preside at this gathering, and it is certainly a great pleasure to occupy the position. I am indebted to Sir Evelyn Murray for his commendatory remarks, but I take it that those remarks apply also to my staff. I will say this: That if, during the comparatively short period which I shall occupy the position of Engineer-in-Chief, I achieve any measure of success it will be largely due to the most excellent staff I have under me. (Hear, hear.) They are able and willing workers, and I have faith in their loyalty.

I have only to thank Sir Evelyn Murray for his kind words, and you, gentlemen, for the way in which you have received the toast. (Loud cheers.)

The Chairman then moved a hearty vote of thanks to the Dinner Committee for providing the excellent dinner and entertainment, and this was carried with loud applause.

During the evening an excellent musical entertainment was contributed to by Miss Annie Coxen, Miss Nance Haines, Mr. Alfred Read, Mr. Fred Gibson and Mr. Edward Shakespeare.



EDITORIAL NOTES AND COMMENTS.

ONE of the most significant features of the period that has elapsed since the declaration of peace has been the greatly increased demand for education. The universities, technical and secondary schools are full, and the demand for further accommodation still grows. It would be interesting to investigate the reasons for this new keenness in matters educational, which is one promising development in an epoch that has not come up to expectation in many other ways. No doubt the speeches of men like Lord Haldane and the present Minister of Education have influenced parents and done much towards the realisation of the necessity for improving the mental capacity and technical skill of the nation, but the main reason, it appears to us, has been the recognition under the dire force of circumstances that we had been lagging behind our chief rivals, America and Germany, and that sooner or later we should have to pay the penalty of neglect.

It is true that to a certain extent the demand for improved technical education had arisen before the war, and far-seeing men had long pleaded for a closer relationship between the schools and the big manufacturing firms, and had urged the Government to adopt a more liberal attitude towards the encouragement of research and to increase the grants in aid of institutions such as the National Physical Laboratory. Unfortunately, however, the awards in the fields of scientific research and engineering work generally have not been in the past so opulent as to offer inducement to young men to follow these pursuits ; the buying and selling of materials, not always useful commodities either, and the " wangling " of finances on paper have paid better than messing about with test-tubes and spanners. It is seldom the man who can read an indicator diagram or grind a valve seating that rides in the limousine.

In spite of this, however, this country of ours has always produced "lads o' pairts" with a bent for mechanics, who could use their hands and reason out problems with their heads, and who chose their calling even although there were no glittering allurements dangling in front of them. If the war has proved anything at all it has surely shown that the most important individuals in the State are the men behind the tools and those who direct, control and foster their energies to the best advantage of the community. The present demand for education opens a vista that should never be closed, and it is the duty of the State to see that the desire for knowledge is fostered and encouraged, and that the products of the training are utilised efficiently and rewarded according to their value.

The series of Workmen's Training Pamphlets is growing healthily, and the sets should be complete before the classes start for next winter's session. They will form valuable text-books for the young men, and are not unworthy to rank as works of reference to the older and even the higher-placed officers of the Department. It is doubtful whether any skilled trade or industry in the Kingdom is possessed of a better or more complete set of manuals. The question of workmen's training is intimately associated with the more vexed one of promotion and the recruitment of the higher classes. There is the danger—and it is a very real one—that unless the promising young men are watched and encouraged they will succumb to temptations from outside, and the cost of their training will become but gifts to private firms. The whole subject is now under investigation by the Department and by the men's societies, and it is likely that the problem will appear among the first items of business to be considered by the Engineering Department Whitley Council.

Mr. W. J. Hilyer, of the Telephone Transmission Section of the Engineer-in-Chief's Office, has been appointed Projects Engineer to the Egyptian Telegraph and Telephone Administration. Before leaving he was presented by the Engineer-in-Chief, on behalf of the staff, with an album bearing the signatures and friendly sentiments of many of his *confrères*. Mr. Hilyer has been a steady contributor to the pages of the JOURNAL, and we hope to hear from him again. A comparison between the results obtained and those calculated from the attenuation constant based on the physical characteristics of the Cape-to-Cairo trunk would be interesting!

It is regretted that in the report of the experimental trials on combined telephone and telegraph cables which were summarised in our last issue the name of Mr. F. Lock was inadvertently omitted. He was associated with Messrs. Roberts and Hilyer throughout the tests, and it was only by a *lapsus pennæ* that his name was not mentioned.

Mr. Powell, Plant Engineer to the Western Union Telegraph-Cable Company, has pointed out to us that the speed on the London–Paris duplex triple multiplex of Western Union pattern was raised in July, 1919, to 184 revolutions, at which speed it has worked ever since. In our summary of Mr. Mercy's article in 'Les Annales' in last issue we quoted the speed as 155, but pointed out that the system will work at a much higher rate, and that it has reached over 300 per minute. We are pleased to announce so early a confirmation of our contributor's statement.

THE AMERICAN T. AND T. COMPANY'S GRAND OLD MAN.

THEODORE N. VAIL, Chairman of the Board of Directors of the American Telephone and Telegraph Company and chief executive of the Bell system for some twenty years, died at the Johns Hopkins Hospital in Baltimore, Md., the morning of April 16th. On the day of his funeral, as a mark of respect for the head of the Company, service on all Bell telephones, approximately 12,000,000 stations, was suspended for one minute. Mr. Vail was 31 years old when Alexander Graham Bell invented the telephone, and he was filling the responsible post of general superintendent of the railway mail service. Still earlier, however, he had been a telegraph operator, and, interested in the possibilities of electrical communication, he had visions that Bell's "toy" would some day be a great factor in American life. Bell and his associates had equal faith in Mr. Vail's organising genius, and he was easily induced to resign his government post to become the general manager, in 1878, of the first American Bell Telephone Company.

It was not an easy task that Mr. Vail had before him. When Alexander Graham Bell and his chief sponsor, Gardiner G. Hubbard, his father-in-law, exhibited the telephone at the Philadelphia Centennial, it had afforded novel amusement. But when they sought to introduce it commercially they were ridiculed. The *Times* called it "the latest American humbug." To make matters worse, the Western Union Telegraph Company, then one of the most powerful organisations in the country, began to thwart them at every turn. Theodore N. Vail, however, was a fighter and stayed by the Bell Company until it had overcome all obstacles, established confidence in itself, and could command capital on reasonable terms for expansion from city to city. In 1885 he became the first president of the newly formed American Telephone and Telegraph Company, which at first made a speciality of long-distance communication, but which, in 1900, acquired the property of the American Bell Company.

Having fought and won, Mr. Vail retired for a time to a farm he had purchased in Northern Vermont and introduced scientific methods to agriculture with much success. His energies could not be confined to such a narrow sphere, however, and he turned his attention to electric traction in Buenos Ayres, where, largely by the aid of British capital, he developed an elaborate system. Things did not go over-well with the American Telephone and Telegraph Company, and a deputation of directors went to Vermont, in 1907, to appeal to Mr. Vail to return. Like the Roman Cincinnatus he responded to the call from the wider sphere, and resumed his old post at the head of the company.

The first thing Mr. Vail did was to raise $21,000,000 new capital, and in the succeeding six years he raised a quarter of a billion as skilfully as ever a banker or capitalist financed a corporation. Through his timely action the corporation weathered the panic of October-November, 1907, without a tremor. In 1910 the American Telephone and Telegraph Company purchased the Western Union Telegraph Company, and for several years Mr. Vail served as president of both companies. Among the innovations supplied the public during his incumbency of the office of president of the Western Union was the institution of day and night letter telegraph service. Several years later, however, the telephone-telegraph combine was held by the Attorney General of the United States to be unlawful and was ordered dissolved. Thereupon, in April, 1914, Mr. Vail resigned as president of the telegraph company. In the summer of last year Mr. Vail resigned from the presidency of the American Telephone and Telegraph Company, but continued to direct its affairs as chairman of the board of directors.

We had hoped to be able to publish an article in this issue on "Submarine Cable Speeds," but unfortunately complete details are not yet available. We have to thank the Pacific Cable Board, the Great Northern Telegraph Company, the Eastern Telegraph Company, and the High Commissioner of Australia, for information supplied regarding their systems.

HEADQUARTERS NOTES.

OUR readers will have observed that in the last Birthday List His Majesty has been pleased to confer the honour of knighthood upon the Engineer-in-Chief of the Post Office, Mr. W. Noble.

We congratulate Sir William upon the distinction awarded to him so early in his career as Engineer-in-Chief, and assure him that the announcement has been received by the whole staff with a keen sense of pleasure and satisfaction, tempered by the firm conviction that the honour is well deserved. It is a remarkable fact, and one that speaks volumes for the universal regard and respect in which the present Chief is held, that amongst the hundreds of messages which bore down upon him were notes of congratulation from the officials of every union and society in the service. A portrait and sketch of his career appeared in Part 2, Vol. XII of the JOURNAL, at the time of his appointment to the post of Engineer-in-Chief.

Our congratulations, although now rather belated but none the less sincere—these honours will come out just after we have gone to press—are extended to Messrs. J. Sinnott, S. A. Pollock and C. Crompton, who have been appointed Officers of the Most Excellent Order of the British Empire, and to Mr. A. H. Roberts, Telegraph Section, who has been made a Member of the Order. Amongst the names of other officers in the list we are very pleased to see that of Mr. Frank Gill, who rendered valuable services during the war at the Ministry of Munitions.

Post Office men will observe with satisfaction that Sir William Noble has been elected a member of Council of the Institution of Electrical Engineers.

Mr. E. H. Shaughnessy, O.B.E., in charge of the Wireless Section of the Engineer-in-Chief's Office, has been appointed Examiner in Telegraphy by the City and Guilds of London Institute, and Mr. J. Fraser, executive engineer, Aberdeen, Examiner in Magnetism and Electricity for the examinations held by that body for the Department.

TELEPHONE DEVELOPMENTS.

Orders have been placed for new exchanges at—

Birmingham (E.)	(No. 1)	1000 lines.
Eccles	(,, 10)	1040 ,,
Fleetwood	(Relay Auto)	480 ,,
Guildford	(No. 10)	1000 ,,
Ilkley	(,, 10)	640 ,,
Malvern	(,, 10)	580 ,,
Northwich	(,, 10)	400 ,,
Scarborough	(,, 10)	1060 ,,
Stroud	(,, 10)	340 ,,
Wallasey	(,, 1)	2880 ,,

Orders have been placed for extending the equipment at the following exchanges:

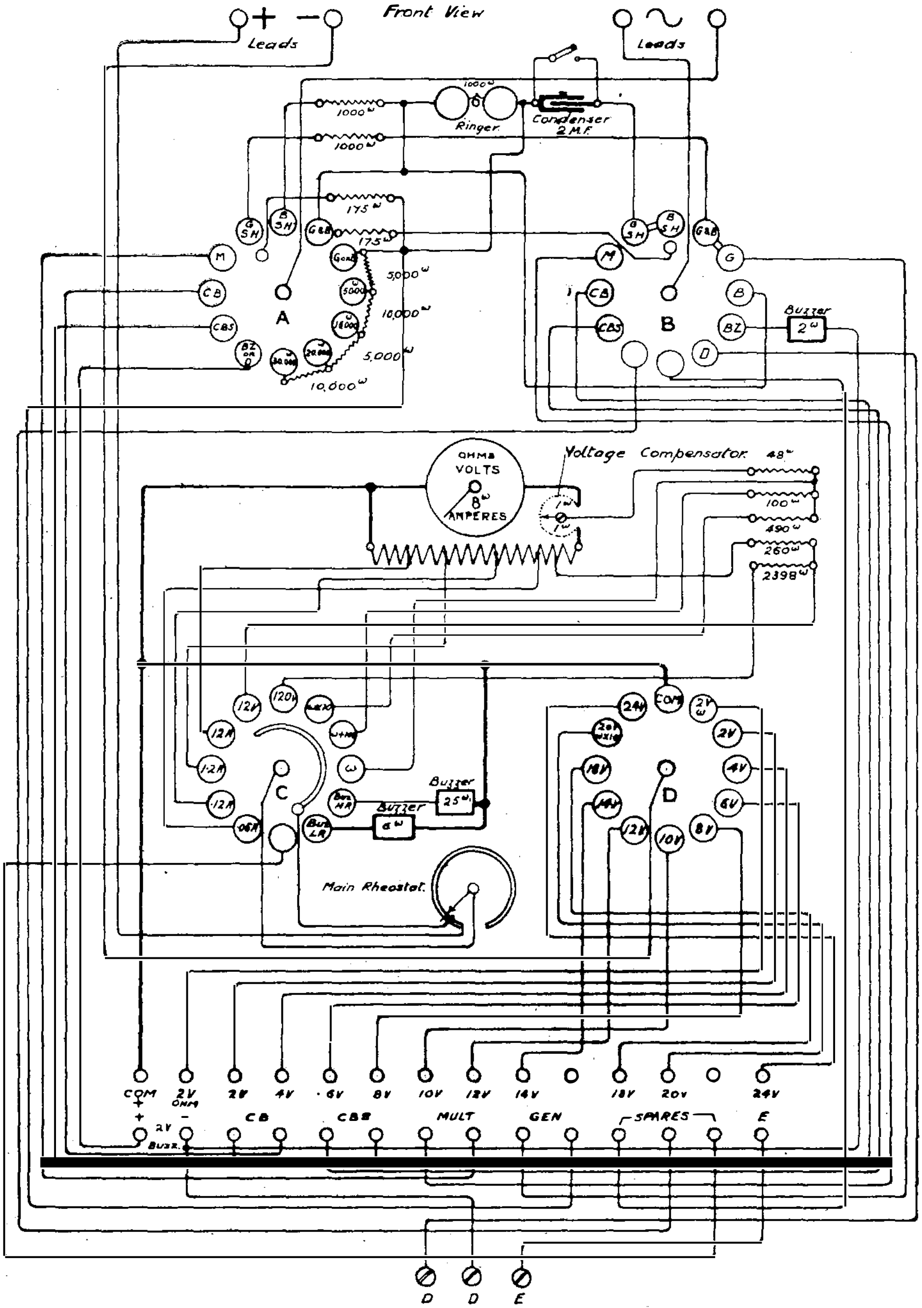
Bradford	(No. 1)	1140 lines.
Cardiff	(,, 1)	800 ,,
Crosby	(,, 10)	240 ,,
Hornsey	(,, 1)	1440 ,,
Hove	(,, 1)	340 ,,
Leith	(,, 1)	120 ,,
New Cross	(,, 1)	720 ,,
Port Talbot	(,, 12)	120 ,,
Trafford Park	(,, 1)	480 ,,
Willesden	(,, 1)	960 ,,

The Combination Testing Set for dealing with a large variety of telephone apparatus has recently been re-arranged and otherwise slightly modified. The up-to-date arrangement is shown in the diagram opposite.

The apparatus is contained in a walnut case 11 inches high, 9 inches wide and 7 inches deep (internal measurements) the case being arranged to fix on the wall above the test bench. The front panel of the case accommodates—

1. A moving coil measuring instrument.
2. Four switches, A, B, C and D, each switch having a moveable arm which is connected to one of the test leads and which sweeps over 12 contact studs giving connections for various tests.
3. An ebonite knob marked "Zero" which mechanically sets the indicator of the moving coil instrument to zero.
4. An ebonite knob marked "Zero" which forms part of a 2-ohm compensating rheostat, the function of which is to correct any variation in the voltage of the ohm-meter battery.

Two pairs of flexible testing leads are provided, one pair being in connection with the two top switches A and B and the other in connection with the two bottom switches C and D. In order that the resistance of the flexible testing leads connected to switches C and D shall not have to be deducted from the indicated resistance measurement, the instrument is calibrated to allow of a fixed value (2 ohms) for the leads. An adjustable zero stop in the main rheostat enables the resistance of the leads to be brought up to exactly two ohms. As the main rheostat will not be required when resistance and voltage tests are to be made, and when the buzzers are in use, a semi-circular metal disc is fitted which short-circuits the rheostat when the studs associated with these tests are corrected. Generator and magneto bell tests are made between switches A and B. A short-circuiting switch is provided for the 2 mf.



THE COMBINATION TESTING SET: DIAGRAM OF CONNECTIONS.

condensers on the testing set to enable the condenser on the telephone set under test to be used if required. A buzzer and a detector with two dry cells are also provided, together with arrangements for working tests on "C.B.," "C.B.S." and magneto apparatus. Between switches C and D, voltage, resistance and current tests may be made, and a high- and low-resistance buzzer is provided for continuity testing.

The following tests can be made with the set:

1. Switches A and B.
   (*a*) Standard bell and generator test. Testing of bells and generators through 5,000, 15,000, 20,000 or 30,000 ohms.
   (*b*) Working tests on C.B., C.B.S. or magneto instruments.
   (*c*) Continuity tests with buzzer or detector.
2. Switches C and D.
   (*a*) Measurement of current, voltage and resistance. Figure of merit tests.
   (*b*) Continuity testing with 6-ohm or 25-ohm buzzer.
3. Switches A, B, C and D.
   (*a*) Figure of merit tests where local contacts are required to function. The buzzer associated with switches A and B is put in the local circuit.

"The New Postal Telegraph Carriage."

In view of the development of mobile signal offices during the war, and the close association between them and many of our readers, it is thought the accompanying description and illustration, reproduced from the *Graphic* of September 14th, 1872, of the first Travelling Telegraph Office, may be of interest. It will be noted that the cable could be paid out and drawn in with the greatest ease in the world! In those days W. H. Preece had not reached the status of the 1872 "Who's Who," and his name, not being in the paper's pigeonholes, has regrettably been mis-spelt by the author of the par.

"The new Postal Telegraph Carriage, or Travelling Telegraph Office, of which we here give a sketch, is of quite recent origin, having been used for the first time in connection with the Universities Boat Race in March last. The idea is to have a moveable office, carrying its own cable, apparatus and batteries, which can be transported from place to place, either by road or rail, at the shortest notice, and which can be taken to the wires when the wires cannot be taken to it. This, which is the only carriage of the kind in use for similar purposes, is constructed to carry one of each of the different forms of instrument (six in all) in use in the Postal system, and can comfortably accommodate as many as eight clerks in full work. It carries, also, nearly 150 battery cells, and so skilfully is the accommodation designed that these are all stowed away out of sight in odd corners, so that not a single atom of space is lost. Half a-mile of three-wire iron-sheathed cable is stowed away as snugly as possible in the 'boot,' and can be paid out and drawn in with the greatest ease in the world. In addition to the occasion to which we have referred, the Telegraph Carriage has been used at the Windsor Agricultural Show and Races, Henley Regatta, the International Boat Race, and the Eton and Harrow Cricket Match at Lord's. But its most important 'engagement' was at Goodwood Races, when it was connected with the line at

Postal Telegraph Carriage: Reproduced from a Woodcut in the 'Graphic' of September 14th, 1872.

Drayton Station by means of five miles of four-wire cable, laid through the fields, and in the hedges and trees right up to the stand enclosure. On this occasion it was universally admired and inspected by numerous distinguished persons, including H.R.H. Prince Arthur and several members of the Ducal party from Goodwood House. Our sketch, which is from a photograph by Brooks of Salisbury, shows the carriage in the act of being prepared for the work of the Autumn Manœuvres; and among the portraits in the foreground are those of Mr. W. H. Preese, the Postal Divisional Engineer for the district embraced by the military operations, and Mr. R. W. Johnstone, the Controller of Special Arrangements, by whom the carriage was designed."—*The Graphic*, September 14th, 1872.

Visitors to London are always interested in the escalators in use on the various underground railways. So far they form one more link in serving the traffic problem in congested areas; their use is, however, restricted to comparatively shallow tunnels on account of the fact that they require a direct incline, and cannot be used in the usual lift-wells. A recent invention by Mr. H. North, of this office, promises to overcome this latter difficulty, as in the proposed idea the steps revolve round the lift-well, both on the upward and downward journeys, and so provide a moving spiral staircase, which of course can be fitted into any public or private building irrespective of its height. Moving spiral staircases are not new, but hitherto their design has rendered them of little practical value. In the proposed form an entirely novel method is employed, and from a study of the specification it should be a comparatively simple matter to construct this type of escalator.

Provision is made for one or two staircases to revolve in the same well-shaft, thus doubling the carrying capacity, whilst for positions where power is costly an ingenious automatic arrangement is provided for utilising water to assist in driving the staircase.

The general principle of the revolving staircase consists of a continuous chain, to which is attached a special type of platform forming the steps; these are caused to revolve in their upward and downward journey, but cease to revolve whilst passing over the driving-drums at the top and bottom of the wells. Two lift-wells are necessary—one for the upward travel and one for the downward journey. Passengers arriving at the lowest platform are protected from accident by finding themselves standing on a stationary step formed by a projecting grid on the basement platform, which intersects grooves in each step as they arrive at the bottom, whilst facilities for alighting at the top platform are provided for by a number of stationary steps with hand-posts, so that passengers may alight at any step. If he should fail to alight before reaching the last position the moving hand-rail would guide him, or the automatic device for stopping the machinery would be operated until the platform is cleared.

In private buildings, hotels, etc., provision is made for stopping the staircase at intermediate landings or stepping on and off as indicated above.

 CORRESPONDENCE

CORRESPONDENCE.

DISTANCE TESTING.

The Editor, THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL.

DEAR SIR,—One or two notes in your kindly Editorial reference to my recent article leave me with the impression that one or two points might, with advantage, have been developed more fully.

From experience it seems quite practicable that testing officers might embody distance testing as an everyday part of their work, so affording regularly improved facilities for the linemen, instead of distance tests having to be specially arranged by an inspector or senior lineman.

On circuits extending into other districts or sections the plan followed is to quote the resistance from the nearest testing-point. Thus in the typical example given below, a balancing resistance of 132 ohms would have the locality expressed as "8 ohms North of Snape Rake" rather than "268 ohms (from M. R.) to fault." (The use of loop-circuit values would simplify matters somewhat.)

With the knowledge that with the co-operation of a lineman sublocalisations can be made with ease to any pole, irrespective of whether the wires are terminated or not, the subject was treated as if a maximum distance error of, say, 6 per cent., would still leave distance testing a commercial success on routes not over 120 miles in length. On this account I do not quite agree that the differences due to insulation or unequal conductance value, are sufficiently material to warrant a reversion to the older methods of sublocalising.

The difficulties associated with the compilation of suitable records are more apparent than real; tests can be made with practically no loss of time whenever a lineman is faulting near a test-pole, or an intermediate office is asked to loop owing to the existence of a fault.

I would urge that the interest in technical matters which even moderately fair distance test results engender would bring out and tend to concentrate on the weak points those ideas which in other sections ally science so closely with everyday work.

Circuit.	Loop values from Barrow to :	
M.R.—B.B.Z.	Manchester 400^{ω}	Snape Rake Bdy. Pole 160^{ω}.
	N.W. Dst. Boundary.	Lancaster 120^{ω}.
	Bolton 320^{ω} .	Newton 80^{ω}.
	Heapey . .	Dalton 40^{ω}.
	Blackburn 240^{ω} .	Barrow —
	Langridge 200^{ω}.	

And remain, Yours faithfully,

BLACKBURN; W. WHEELER.

March 22nd, 1920.

DISTRICT NOTES.

LONDON DISTRICT.

INTERNAL CONSTRUCTION.

Telephone Lines and Stations.—During the thirteen weeks ended March 27th, 1920, 5865 exchange lines, 7391 internal extensions and 488 external extensions were provided. In the same period 1369 exchange lines, 4093 internal extensions and 612 external extensions were recovered, making net increases of 4496 exchange lines and 3298 internal extensions, and a net decrease of 124 external extensions.

New Electrophone Exchange.—The opening of the new electrophone exchange took place on March 29th. This exchange provides accommodation for 1500 subscribers to the electrophone service, and includes provision for connections to all the important theatres and also to a number of churches and music-halls in London.

A service is given every evening of the week, on Saturday afternoons and three times on Sunday. The problem to be met was to provide with the minimum of equipment an installation which would deal with calls from any subscriber to any place of entertainment, and yet not overburden the music line from a transmission point of view by connecting subscribers from different suburban exchanges of differing distances. In the old exchange this was accomplished by means of two boards. On one of these, the junction board, all the junctions from distant exchanges terminated; on the other, the music board, the music lines terminated. Each board was equipped with plugs directly connected to similar plugs on the other board; one for picking up the junction on the junction board, the other for connecting to the theatre on the music board. Every call had to be handled twice, and the equipment was not therefore on economical lines. A trial was given while extending the old exchange of a new method of connection. All the junctions from a certain exchange—fifty in number—were terminated on a position on the music board, and wired on the method of signal junctions in a C.B. exchange. Calls could thus be put through directly. The experiment was so satisfactory that it was taken as a basis for the new exchange, with the modification that instead of the junction lines terminating on plugs they terminated on jacks, and connection was made by means of a double-ended plug.

Calls are now received over the order wire associated with a group of junctions and the desired connection is made between the selected junction and the desired place of entertainment. Each operator deals only with the particular exchange group of lines connected to her board, and it is therefore easy to arrange that junction lines of approximately equivalent resistance are connected on any music line.

Clerkenwell Temporary Exchange.—This exchange was opened at 2 p.m. on March 27th with 766 subscribers' lines, transferred mainly from London Wall and Holborn Exchanges. A second batch of subscribers' lines numbering 514 circuits was transferred from London Wall Exchange a fortnight later. The full number of junctions, 284 outgoing and 281 incoming, were opened with the first batch of subscribers' lines. The sections with multiple and "A" position equipment were recovered from the Hotel Cecil, vacated by the Air Ministry, and were taken direct from the Hotel Cecil to Clerkenwell Exchange. Nine of the forty "A" positions were converted for keyless junction working, and two positions for jack-ended junctions. The conversion of the switchboard sections and the wiring of the power board was undertaken by the factory staff, but with this exception the work was carried out by the District staff. Tests on the equipment and subscribers' lines subsequent to the transfer showed the exchange to be practically free from faults.

Avenue Exchange Extension.—The contractors have completed twenty additional "A" positions which have been brought into service and have served to relieve the pressure on the other "A" positions.

Private Branch Exchanges.—Three position No. 9 private branch exchanges have been installed at the offices of the Metropolitan Water Board and the *Times*.

The Metropolitan Water Board Office is a most finished building and the whole of the lighting and telephone services are provided in concealed tubing.

The installation for the *Times* has been fitted to replace a two-position switchboard which was overloaded and the opportunity has been taken to block-wire the building completely. A new switch-room was erected on the roof of the Queen Victoria Street building and every possible comfort has been provided for the operating staff by the *Times* authorities.

External Construction.

For the three months ended 30th April, 1920, the net increase in telephone exchange wire mileage in the London Engineering District was 24,436 miles, 24,545 miles of underground and 141 miles of open wire having been added and 250 miles in aërial cable having been recovered.

During the same period telephone trunk wire mileage increased by 250 miles—154 miles of underground and 96 miles of open.

Wire in use for public telegraphs increased by 152 miles—148 miles of underground and 4 miles of open.

The aggregate mileages of pole and pipe line in the district at the same date were 2768 and 3643, showing increases of 49 and 28 miles respectively.

The length of underground cable increased by 76 miles to 7297. This includes a section of 1635 yards of 300 pr./20 cable laid on small concrete piers in the subway beneath the Thames Tunnel.

The total single wire mileages, exclusive of wires on railways maintained by companies, now stand at—

Telegraphs	17,473 miles.
Telephone (exchange) . .	1,068,106 ,,
,, (trunks) . . .	18,578 ,,
Spare wires	16,682 ,,

Line Mileage.

The aggregate pole and pipe line mileages increased by 49 and 28 miles respectively, the totals now being:

Pole line	2,768 miles.
Pipe line	3,643 ,,

The Annual Clerical Supper was held in the refreshment room at Denman Street, S.E. 1, on Tuesday, March 23rd. This was the ninth of the series, the last one being in 1914. Two hundred and fifty members of the staff from the Headquarters and Sectional Offices, etc., attended. A. E. Cooke, Esq., principal clerk, presided, and the superintending engineer, A. Moir, Esq., O.B.E., was "The Guest of the Evening."

Mr. Cooke, before proposing the toast "The Guest of the Evening," welcomed the presence of former colleagues now serving in the Engineer-in-Chief's office, Accountant General's office, Ministry of Pensions, Air Ministry, etc.

He spoke with feeling regarding the 300 clerks of the District who had joined the Colours, and made special reference to the 39 clerks who had lost their lives in the great war.

As to the reconstruction scheme he could well understand that the staff were on the tiptoe of expectation. The Post Office clerks were naturally anxious to learn how they would be graded in the new scheme. The clerks in the District had proved themselves thoroughly competent and would continue to do their utmost in carrying out their clerical and accounting duties in a highly efficient manner. He believed in awarding good pay and favourable conditions, and in return the staff would give of their best. The one would follow the other. The grading of the staff, however, was "on the knees of the gods" and they must wait patiently for the result to be announced.

Mr. Cooke, in proposing Mr. Moir's health, congratulated him, on behalf of the staff, on receiving the honour of O.B.E., and he also referred in a complimentary manner to the interest Mr. Moir had taken in the function of the evening.

Mr. Moir, in responding to the toast, stated that he hoped that all the good things Mr. Cooke desired for them might be realised and that in the interests of the work of the office the attractions of the Treasury Pool might be correspondingly diminished. He made special reference to the beautiful illuminated scroll exhibited in the Hall at Denman Street as a tribute to the memory of those who had fallen in the war. The scroll was a labour of love on the part of their colleague Mr. Brockett, who had succeeded in achieving a most artistic result.

In conclusion he stated that although O.B.E.'s were pretty plentiful he still regarded his own decoration with much satisfaction: not so much on personal grounds as because it was a token of appreciation from those in authority as to the excellent and efficient manner in which the work of the London District was at all times carried out.

The supper was followed by an excellent musical programme under the direction of Mr. J. W. Kimber. Among those who contributed were: Miss Pitfield, Messrs. S. L. Bickerton, J. Cordineer, C. W. Cornwell, J. J. French, S. G. Frost, J. J. Gerke, H. Gilbert, E. F. Griffiths, Chas. Harris, J. W. Kimber, F. G. A. Terrill, H. H. Thorne, R. W. Turk and A. A. Turner. Messrs. T. H. Ayre, E. W. Casserley and H. Curtis accompanied on the piano. The L.E.D. Orchestra, led by Mr. H. W. Gardener, proved the instrumental accomplishments existing in the District. Praise is also due to the Committee, who, with the aid of the Refreshment Club staff, transformed the prosaic dining-room into something resembling a west-end restaurant and provided a supper in keeping with the surroundings.

All concerned are to be congratulated on the success of the function.

NORTH MIDLAND DISTRICT.

T.S.–MR. Underground Progress to May, 1920.

Old Stratford to Newhaven, 96 *miles.*

The duct work has now been completed in this district, with the exception of the town work in Leicester and Derby, which is proceeding.

Contracts have been placed for cabling and jointing, and work has been started on the southernmost section of the route.

ANNUAL MEETING OF THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

LONDON CENTRE.

The last meeting of the Session 1919–20 of the London Centre of the Institution of Post Office Electrical Engineers was held on the evening of May 5th, in the Lecture Hall of the Society of Arts. The President of the Institution, Mr. William Noble, Engineer-in-Chief, presided, and was accompanied on the platform by the Chairman of Council, Mr. A. J. Stubbs, M.I.C.E., Assistant Engineer-in-Chief, and by the Chairman of the Local Centre, Mr. J. Sinnott, O.B.E.

Before the ordinary Centre business took place the meeting constituted itself by rule into the annual meeting of the Institution. Mr. T. Smerdon, Secretary, and Mr. A. O. Gibbon, Treasurer, submitted their reports on the year's work and the financial position respectively. Although the last twelve months had been a period of abnormal stress the Institution had carried out a very successful session and the members and associates had increased in number. A noteworthy feature was the steady growth in the number of Colonial members, who looked more and more towards the home country for guidance in regard to telegraph and telephone practice. The funds were in a satisfactory condition; arrears due from members on war service had been paid up almost completely, and the Council was able to assist the JOURNAL of the Institution.

In moving the adoption of the report Major Purves congratulated the Institution on the work done during the past year, and expressed regret at having recommended at the beginning of the war to abandon the publication of the JOURNAL. It had been carried on during a very trying period, and the Board of Editors deserved the thanks of the members for preserving the continuity of issue in face of many adverse circumstances. It formed a link between the home and colonial administrations which had proved of considerable service and had justified the Board in their policy.

The Chairman expressed gratification at the position, and proceeded to present the Institution Medals to writers of papers contributed during the sessions 1915 and 1916. It had not been possible to obtain these medals earlier owing to war conditions. The awards were as follows:

Senior Silver Medal to Mr. J. G. Hill for his paper, "Phantom Working on Telephone Circuits."

Senior Bronze Medal to Capt. B. S. Cohen for his paper on "Telephonometry."

Junior Silver Medal to Mr. J. Hedley for his paper on "The Western Electric Semi-automatic System."

Junior Bronze Medal to Mr. S. C. Bartholomew for his paper on "Power Interferences."

The Council of the Institution for the year 1920–21 is composed of the following representative members:

President of the Institution: The Engineer-in-Chief.

Chairman of Council: Mr. A. J. Stubbs.

Executive Engineers: London, Capt. J. G. Hines; Provinces, Mr. H. Kitchen.

Assistant Engineers: London, Mr. F. E. Mitton; Provinces, Mr. A. W. Gardiner.

Chief Inspectors: London, Mr. J. H. Hart; Provinces, Mr. G. Bailey.

Clerical Classes: London, Mr. W. J. A. Payne; Provinces, Mr. F. McMullen and Mr. W. Miller.

Treasurer: Mr. A. O. Gibbon.

Secretary: Mr. T. Smerdon.

A vote of thanks to the retiring members was passed unanimously.

Mr. A. C. Greening, London District, then read a valuable paper on "Some Notes and Views upon Telephone Fitting Work." He commenced by quoting figures indicating the magnitude of the work, and then reviewed the organisation of a fitting office and discussed the work and methods of the fitting staff, which are extraordinarily varied in character. Some 150,000 fitting works had been carried out in the London District during the twelve months ended December 31st, 1919. An experimental trial of delivery of apparatus by motor transport had not been quite so successful as anticipated, but the last has not been heard of this scheme, which has been operating satisfactorily in America for some time.

He pointed out the necessity for the thorough training of the fitting staff, and pleaded for better accommodation for the men engaged in the work, not only in the fitting stores but in the exchanges.

An interesting discussion followed, in which Messrs. Moir, Medlyn, Greenham, Wright and others took part.

The provincial Districts were represented by several Chairmen and Vice-Chairmen of the several centres, including Messrs. Medlyn, Gomersall, Taylor, Eldridge, Lamb, Turner and Weaver, as well as by the Members of Council.

LOCAL CENTRE NOTES.

NORTH MIDLAND CENTRE.

After the enforced suspension of the meetings due to the prevailing war conditions this Centre has had a very successful

Session. We had the advantage of an auspicious opening by the visit of Mr. A. J. Stubbs (Assistant Engineer-in-Chief) in November last, when he read to a good gathering of members and associates his " Notes on Accidents in the Post Office Engineering Department," conveying much valuable information and statistics on the problem of minimising the risks and consequences of accidents in the industry. A lengthy and varied discussion followed Mr. Stubbs' deliverance.

In December we had a visit from Mr. E. H. Farrand, Sectional Engineer at Leeds, who read his paper, already presented to the North-Eastern Centre, on "The External Preparations for the Transfer to Automatic Telephone Working at Leeds."

Mr. Farrand's paper presented a very lucid and interesting account of the great and unique undertaking at Leeds, dealing in excellent detail with the difficulties encountered, and the subject-matter should prove to be of great advantage to any engineering officers who may, as the development of the telephone system proceeds, be called upon to deal with the installation of similar automatic exchanges.

In January an interesting illustrated paper was contributed by Mr. C. A. Carpenter (Third Class Clerk) on "Wireless in the War."

Mr. Carpenter served on the Wireless Headquarters Staff in France and so had the advantage of speaking from first-hand knowledge. The subject was of absorbing interest and was very creditably presented by Mr. Carpenter.

In March Mr. J. R. Milnes contributed a paper on " Scientific Illumination " and supplemented very valuable information with illustrations by lime-light views. Mr. Milnes covered a wide field and his paper was much appreciated.

It was intended to wind up the Session in April with a paper on " Call-Office Circuits " by Mr. W. Platt, but owing to the severe pressure caused by the gale breakdown the meeting had regretfully to be abandoned and the paper was reserved for the next Session.

The meetings were held in the Theosophical Hall, so it will readily be understood that " good spirits " prevailed throughout.

E. W. M. B.

NORTHERN CENTRE.

THE meeting on March 10th, being the last of the Session, the the Chairman, Mr. Baldwin, made reference to the successful season and the excellent series of papers read during the year. He further remarked that the members were to be congratulated on the healthy state of the Society and the results attained, and suggestions were proffered in respect of notes, papers and discussions in preparation for the next winter session.

The main business of the evening was the reading of a paper by Mr. E. D. Wilkie on "Telephone Testing Equipment," which was fully illustrated by a series of lantern slides dealing with each subject; these were explained in detail. The subjects covered by the paper were: (*a*) A general description of operators, testing and plugging-up positions, with particulars of typical circuits; (*b*) general description of engineers' test-desk, with its typical circuits; (*c*) fault procedure and traffic staff tests.

The discussion which followed was opened by Mr. J. W. Hastings, and Messrs. Whillis, Bellwood, Tait, Longmore, Armstrong and Peel also took part.

E. E. GREGORY,
Local Hon. Sec.

EASTERN CENTRE.

THE fourth meeting of the 1919–20 Session took place at Cambridge on March 24th, 1920, when a paper was read by Mr. C. F. Freeman, entitled "Telephone Relay Station at Fenny Stratford." Mr. J. F. Lamb presided, and there was a good attendance, including Mr. Ashby, District Manager, Norwich.

The minutes of the previous meeting having been read and passed, the Chairman called upon Mr. Freeman to read his paper.

Mr. Freeman commenced his remarks by explaining that the essential part of telephone-repeating apparatus is the thermionic valve. He described fully the evolution of the valve and its theory, the description being assisted by the curves and diagrams that were exhibited. The arrangement of the repeating portion of the apparatus at a telephone-repeater station was then explained, including both the single-valve and the double-valve systems. Details of the other plant required at the station were given, with particulars of accommodation for, and the general lay-out of the whole plant at Fenny Stratford. Allusion was made to the need on relayed telephone lines of very high insulation and the importance of preserving the balance of the circuits, especially in connection with the leading in of the cables. The paper closed with a reference to the important changes in telephone practice that are made possible by the use of the thermionic valve, particularly in the direction of a very great reduction in the gauge of long-distance lines.

The full discussion which followed was taken part in by Messrs. Lamb, Crocker, Cain, Carr, Moody, Ashby, Andrews, Calveley, Nunn, and Major Batchelor. Several interesting points emerged from the discussion, amongst others that the probable spacing of telephone relay stations would be fifteen standard cable miles apart, and that the magnification resulting from the inclusion in the circuit of a relay was from 15 to 25 standard cable miles.

A hearty vote of thanks to Mr. Freeman brought the meeting to a close.

The fifth (and final) meeting of the 1919–20 Session was held at Cambridge on April 21st, 1920. The chair was taken by Major Batchelor, and there was a good attendance.

The minutes of the previous meeting having been read and passed, the Chairman called upon Mr. H. M. Cowles to read a paper, entitled "The Utilisation of Mechanical Transport and Power for Line Construction."

Mr. Cowles, after noting the fact that the present-day methods of line construction are fundamentally those of a quarter of a century or more ago, adverted to the possibility of development in line-construction practice now that motor transport has been introduced into the service. He suggested that, apart from the conveyance of men and stores, the motor lorry might be adapted to serve the purpose of a tower-waggon—for use in wiring, tree-cutting, etc.—and that the engine might be used to drive an electric generator, thus giving a power supply for such work as tree-cutting and soldering operations. Mr. Cowles next mentioned the question of pole-hole excavation, and advocated the adoption of a power-driven mechanical drill. Another suggestion was that a crane—of a type described—might be fitted to the motor lorry for handling poles and other stores, and also for lowering poles into position. The paper, which was illustrated by photographs and diagrams, closed with a reference to the possibility of utilising a motor vehicle for charging secondary cells at the small C.B. Exchanges which might under such a system become a practicable proposition. After a reply by Mr. Cowles on points raised by members, the Chairman called on Mr. Lamb to read a paper on "The Importance of Sketches Accompanying Reports."

Mr. Lamb pointed out that a sketch, however simply drawn, provided it gave the *essential* information, often saved a long description, and was more readily understood. From experience he found that the sketches furnished to illustrate reports frequently did not fulfil their function. Sometimes a sketch would contain a lot of superfluous information and omit the essential particulars. Mr. Lamb gave some illustrations of cases in point, and explained the essentials of a sketch intended to accompany a report.

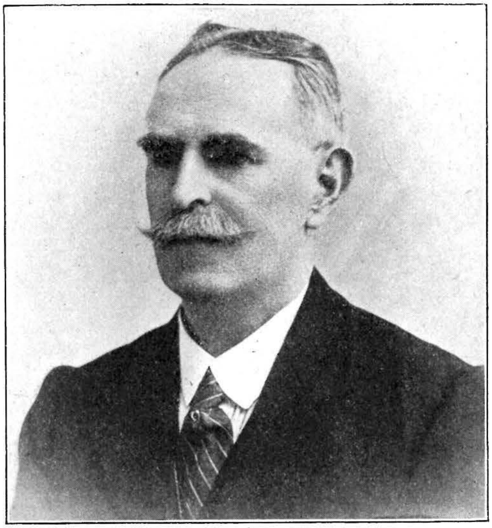
The discussion which followed was taken part in by Messrs. Whitehead, Gardner and others. There was general unanimity as to the desirability of an extension of the practice of furnishing sketches with reports.

The meeting closed with a hearty of thanks to Messrs. Cowles and Lamb for their interesting papers.

RETIREMENT OF J. W. SULLIVAN.

On May 31st, 1920, Mr. John William Sullivan, the senior Assistant Superintendent Engineer of the North-Western District, retired from the service under the age regulation. Those of his colleagues in London and elsewhere who have lost touch with him in recent years will readily recognise the photograph we publish, and will rejoice to know that the hand of time has touched him but lightly. In all essentials he remains the genial J. W. S. who won the hearts of all he came in contact with throughout his career.

Mr. Sullivan commenced his service in the Post Office as a telegraphist at Waterford at the age of fifteen, and was soon after



Mr. J. W. Sullivan.

transferred to Cork. In 1877 he joined the "K" Company of the Royal Engineers, in which he went through the Egyptian Campaign of 1880–2.

Resuming civil life in 1889, Mr. Sullivan took duty in the Central Telegraph Office, London, where his technical qualifications were quickly recognised. At the trunk transfer he was selected with others for joining up switch sections and the training of operators in the provinces.

In December, 1896, Mr. Sullivan was offered and accepted a Second-Class Engineership at Bolton. In 1901 he was promoted to First Class Engineer and transferred to London, where he was one of the pioneers of the Post Office telephone service. He was promoted to Assistant Superintending Engineer at Birmingham in May, 1910, but was transferred to Preston in the following year on the formation of the present North-Western District, where he remained until his retirement.

Mr. Sullivan has been vice-chairman of the North-Western centre of the Institution of Post Office Engineers from its inception in 1911, and throughout has taken a lively interest in its proceedings.

A typical son of the Emerald Isle, kindly and loveable, generous to a fault, fluent of speech and versatile of thought, ever ready to advise the less experienced and to give practical help to those in difficulty, Mr. Sullivan leaves a gap in the service which will take long in filling. That he may live long and continue to brighten the lives of his fellow-men is the wish of all who have come under his influence in the North-Western District.

At a well-attended smoking concert held on May 17th, with Mr. T. E. P. Stretche, Superintending Engineer, in the chair, supported by the Engineer-in-Chief, Mr. Sullivan was presented with a gold watch and chain subscribed for by the district staff. Mr. Stretche spoke feelingly of the unique qualifications of Mr. Sullivan and the loss to the district occasioned by his retirement, at the same time congratulating him upon reaching the age of sixty in the full enjoyment of health and vigour, sound in wind and limb. Other speakers voiced similar sentiments, and their hearty reception was indicative of the approval of all present.

Mr. Noble, in making the presentation on behalf of the staff, stated that he was present at some personal inconvenience, but that he would gladly have suffered greater inconvenience rather than miss the opportunity of saying farewell to his old friend Sullivan. In a happy speech, interspersed with anecdote and advice, he referred to Mr. Sullivan's many good qualities in terms of the highest appreciation.

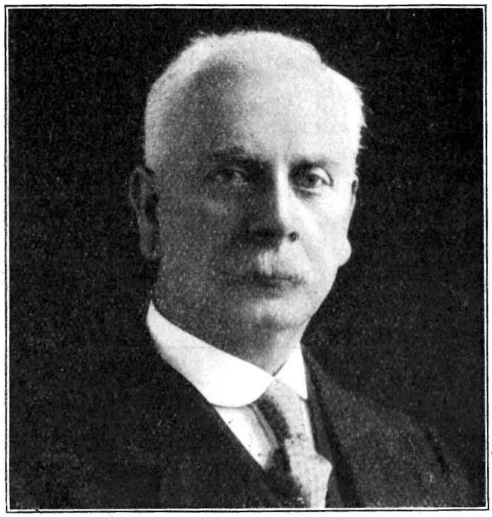
Mr. Sullivan, in a charmingly characteristic reply, which was marked by those felicitous turns of expression and quotations which those who heard him have learned to expect from one whom Mr. Stretche aptly described as "our official Demosthenes," thanked the members of the staff for their assistance during the years he had been with them and for their handsome present, which would always remind him of the happy time they had worked together.

Mr. Sullivan was also presented personally by the Superintending Engineer with a pearl and gold tie-pin and by the clerical staff with a beautifully illustrated edition-de-luxe of the 'Rubaiyat' of Omar Khayyam, containing autographs of the subscribers, while the mechanics expressed their good wishes by a separate presentation which will doubtless afford him some solace during the time of his retirement. He intends to reside at Eastbourne.

W. J. R.

RETIREMENT OF JOHN WALKER BARBER.

PRELIMINARY to the April meeting of the South Lancashire Branch of the I.P.O.E.E. the opportunity was taken of presenting a pair of binoculars and a silver cake-basket to Mr. J. W. Barber, Assistant Superintending Engineer, on his retirement after forty-two years' service, twenty-nine of which were spent in the Engineering Department. Mr. Medlyn made the presentation, and in a brief speech referred to the valuable work carried out by Mr. Barber and the loss the service sustained by reason of his retirement. In the evening Mr. Barber was given a joyful send-off at a smoking concert held in his honour at the Exchange Hotel at Manchester. A



MR. J. W. BARBER.

crowded meeting of officers from all centres of the District enthusiastically greeted references to the unfailing kindnesses and efficient work of Mr. Barber in appreciative speeches by Mr. Medlyn, Mr. Parkinson, Mr. Magnall and Mr. Hart. The musical programme, provided principally by Mr. Barber's official friends, was thoroughly enjoyed, and a most happy evening was spent.

Mr. Barber's career has been a very varied one. Commencing at Stockton-on-Tees in 1878 he passed to Newcastle 1891, Leeds 1896, Doncaster 1898, Hull 1904, and finally finished his travels at Manchester on his appointment as Assistant Superintending Engineer in 1913. His work on the Inventory of the late National Telephone Company's plant probably made him one of the best-known officers of the Engineering Department, and the value of that work was fully recognised by those responsible for the presentation of the Department's case before the Courts. He represented the Postmaster-General on the purchase of the late National Telephone Company's plant by the Hull Corporation, and in that connection received special commendation, and no doubt he will be able to look back in his retirement with a considerable degree of satisfaction to a career of usefulness and thoroughly good work. Thoroughness and accuracy in all details were his outstanding qualifications, and if genius may be correctly described as an infinite capacity for taking pains, without doubt Mr. Barber was a genius. To those of us who were most intimately associated with him it was an education to watch the patience, application and assiduity which were manifested in all his official duties, and to know that Barber was on the job was a preliminary certificate of its successful completion.

As a man his personality appealed to every one; genial, even-tempered, and of unfailing good humour, it was a pleasure to be associated with him, and when he reaches Whitby, where he hopes to settle down, and the sea he loved so well, one can only wish that the fish will bite freely, and that in the intervals, when he is not busy putting on the bait, his recollections of old official friends will be as satisfactory to him as the recollection of his valued friendship will be to those he has left behind. F. S. P.

BOOK REVIEWS.

'The Practical Electrician's Pocket-Book and Diary, 1920.' (S. Rentell & Co., 36, Maiden Lane, Strand, London, W.C. 2*s.* 6*d.*)

This handy pocket-book has been again carefully revised and brought up to date as far as is practicable. It contains 520 pages of valuable information and a well-arranged index to its contents, which, besides dealing with the usual electrical matters from bells to vehicles, also contains information on electric welding and electric furnaces, steam boilers, and Diesel engines.

'The *Practical Engineer* Electrical Pocket-Book and Diary, 1920.' (The Technical Publishing Co., 1, Gough Square, Fleet Street, London, E.C. 1*s.* 6*d.* in cloth; 2*s.* in best binding. Postage 6*d.*)

This very useful pocket-book has been thoroughly revised with the addition of extra tables and notes, totalling 592 pages of information divided into thirty-six sections, and an appendix of one page on steam production. It deals with mathematical tables, units testing, lifts, motors, traction, mining, and wireless telegraphy, among other subjects. An excellent index is provided, and there is a list of items with their French, Spanish, and Russian equivalents.

'Alternating Current Work.' By A. Shore, A.M.I.E.E. (London: The Wireless Press. 163 + ix pp. 3*s.* 6*d.* net.)

There are many wireless operators and students of wireless telegraphy who have a fair knowledge of the elements of magnetism and electricity, but whose knowledge is confined to direct current phenomena. They are not familiar with the effects produced by capacity and inductance in a circuit and the factors governing the power expended in an alternating current system; to them power factor conveys no meaning. To such this volume should appeal: with only such mathematics as are essential it deals in simple language with the elements of alternating current work.

The type and diagrams are clear. Chapters on Resonance, Transformers and Electrical Measuring Instruments will be of special interest and help to the student.

We would suggest that in future editions the matter of Chapters V and VI, dealing with inductance and capacity, precede that of Chapter IV, which deals with power in an alternating current circuit; this appears to us to be the natural sequence of the matter.

'The Baudot Printing Telegraph System.' By H. W. Pendry. (Sir Isaac Pitman & Sons, Ltd. 6*s.*)

This is one of a very limited number of descriptions in English of this highly successful multiplex telegraph system. It is cheap, and should be in fairly good demand considering the greatly extended use of this apparatus in English-speaking countries.

The first edition has been improved by the addition of new diagrams and amplification of the information previously given, including some of the later improvements and modifications that have been made by the engineering branch of the Post Office.

The author commences with a very brief reference to the history of development of printing telegraphs.

The Baudot code is given in alphabetical order; it is a distinct loss that no reference is made to the very easy way of learning this code by first learning the vowel signals and then the consonants in their alphabetical order. This is the basis of the Baudot code, and the recognised way for teaching it in France—the birthplace of the system.

The distributor is fully illustrated and explanations given of both the weight-driven and phonic-wheel types. On p. 16 reference is made to segments 23 and 24 of the distributor plate being *in contact* with the positive and negative poles of the line battery. This has no reference to a fault, but is intended to convey the meaning that the line battery is permanently connected to the segments mentioned. A similar remark is applicable to the last line on p. 17, where it is stated that Ring V is *in contact* with the line.

The author gets rather out of his depth on p. 19 regarding "Duplex." The want of success of the earlier duplex multiplex telegraph systems was not due to aërial line difficulties, nor was the success of the Baudot duplex due to the use of underground cables. The failure of the earlier duplex multiplex systems was due to the large number of signals per letter and the lack of aërial (not underground) lines of sufficient speed to carry those signals. The success of the Baudot duplex is due to the small number of signals per letter which can readily be passed over long underground lines as well as over difficult aërial circuits. The first successful Baudot duplex installed in this country was not on an underground line, but on a long aërial line working through two repeaters and a long submarine cable, viz. the London–Berlin double duplex. There was no reason whatever for not having the quadruple duplex Baudot on aërial lines, and there was not the least intention, either in 1910 or at any other period, to confine such working to underground cables. The cable happened to be available, and it would have been merely stupid not to have used it.

A full description with good illustrations of Murray's phonic-wheel design is given, but we must confess our inability to understand what is intended by the following sentence on p. 31: "and synchronism is maintained over a wider range of differential speed."

The keyboard is dealt with in Chapter 3 and the keys are referred to as "double-current keys." It is true that they deal with positive and negative currents, but as the system can be worked "single current" and the keys are essentially of the "single-current" type, it would be better to avoid this description, more especially as double-current keys were actually in use at the time prior to the introduction of secondary cells. These keys were similar in their electrical arrangement to the well-known telegraph double-current key.

On p. 41 the author asks for a good firm pressure on the keys. Seeing that connection is made by a thin flat spring, there is no necessity to use any more pressure than twice the equivalent of that exerted by the retractile spring. The essential point is that the keys must be depressed below the locking-point, where they will remain until released by the next cadence signal. As a matter of fact a momentary tap is quite sufficient, *i.e.* a staccato action, but operating is easier by making the action legato. Pressure is not a factor.

A serious mistake has been made in fig. 23, the contact springs of the switch-bar having been drawn the wrong way round. No explanation is given of the use of the arrangement, and not even by tracing the connections can the reader ascertain the purpose of the switch-bar. The function of the tablet, etc., is fully described and illustrated in the POST OFFICE ELECTRICAL ENGINEERS' JOURNAL, vol. vi, part 4, January, 1914.

On p. 66 the following sentence occurs: "Upon the end of the fly-wheel W a brass block M is fixed." This becomes more intelligible if "axle" were inserted after "fly-wheel."

The Baudot printer is dealt with very fully in Chapter 4, but the illustrations of the weight-driven apparatus in figs. 24 and 25 were out of date some years before the war so far as the Post Office is concerned. The "rapide" type of receiver is illustrated and described, as well as the equally speedy type designed by officers of the French Administration, and known, because of its simplicity, as "Le squelette."

Chapter 5 is devoted to "relays," especially the Baudot relay, but as any good relay is quite as serviceable on the Baudot system this chapter need not have appeared. We cannot resist quoting the following gem, commencing at the foot of p. 81: "With two bobbins, as in this instrument, the *finishing ends* of one are joined to the *beginning ends* of the other, making two continuous paths, each consisting of *one wire on both bobbins*." The italics are ours.

On p. 83 the author suggests the use of a long-handled screw-driver, with its tip resting on the contact of the relay, for listening to the beats of the relay tongue. If this action does not permanently damage the relay, more especially if the screw-driver slips, it will almost certainly short-circuit the closely set contacts. We have heard of 14-in. files being used for cleaning the platinum contacts of relays, but that was long, long ago; also we thought the use of a 14-in. screw-driver with business end on a delicate contact of a relay was dead before the end of last century, and are therefore very grieved to see its use advocated in a modern telegraph book intended for practical men.

Chapter 6 brings us to the electrical connections of simplex sets dealt with theoretically; then in Chapter 7 the double simplex is explained, and a full diagram of connections as used with the French method of motor driving is provided.

Chapter 8 deals with the quadruple simplex, single-plate and double-plate types, but the statement that in the latter the distortion of line signals can be rectified to a much greater degree is rather wide of the mark. The real reason was that the duration of the current impulse through the receiver magnets was not long enough in the early days when primary cells were in use. The currents from the line relay were therefore passed through another relay, which in turn passed currents through a full-length segment to the receiver magnets. It had nothing whatever to do with additional rectification, but was due to the need for an increase in rapidity and sensitivity of action, which is now obtainable without this second relay and its additional complications.

Chapter 9 deals with duplex Baudot, both from the theoretical aspect of bridge and differential, as well as the full connections for quadruple and double duplex. It is to be regretted that only fifteen pages, including full-page diagrams, have been allocated to this most important development of the Baudot system—a development which in ten years has increased the use of the Baudot system and its variations some five times as much as the simplex Baudot was extended in fifty years. Its use will undoubtedly increase much more rapidly in the next few years, and there is probably room for quite an extensive work on this phase of the subject.

We think enough has been said to show that the work requires serious and careful revision if it is to take its proper place in the literature of a subject that well deserves able treatment.

We would suggest the use of "unison" instead of "synchronism" and "isochronism," neither of which is applicable in actual practice; the use of "channel" instead of "arm" for the "working operator position," because "arm" is used sometimes to indicate one channel, at others to indicate two channels, *i.e.* one in each direction, and again in reference to the brush carriers of the distributor. There are several instances of words omitted, wrong spelling and loose phraseology giving wrong impressions of what is intended, and these should not have been allowed to appear in a second edition.

We can still trace nearly forty illustrations from Mr. Booth's Institution of Post Office Electrical Engineers' paper of 1907 on this subject, from which much of the information was originally obtained excluding the accent over the "o" in Baudot. This surely is an altogether unjustifiable levy on the work of another author without special acknowledgment, and there is no acknowledgment whatever either in the text or preface of the second edition, although a reprint of the preface of the first edition does give a very short reference to the author's indebtedness.

'Questions and Solutions in Telegraphy and Telephony.' By H. P. Few. Fifth Edition. (S. Rentell & Co., Ltd., 36, Maiden Lane, W.C. 5*s.* 6*d.* net.)

In the instrument rooms and linemen's quarters throughout the country the name of Mr. Few is a household word, and his "questions and answers" lies inside many a sounder screen to be glanced at when the traffic slows down. To this edition the solutions to the City and Guilds examination papers from 1915 to 1919 have been added, and the book now comprises a complete set from 1904 to date, in addition to a specimen overseer's written examination paper and forty-eight oral questions. To those studying for these examinations the book is invaluable and we can thoroughly recommend it. The answers if anything are of a higher standard than the examiner has a right to expect in the time and circumstances, but this is a failing which is really a virtue. A brief model answer might not convey the amount of information on the question which the author does in his method. Detailed information on the subject is furnished, and parrot-like reiteration is avoided.

In our review of 'The Telegraphist's Guide' by Bell and Wilson (S. Rentell & Co.), which appeared in last issue, it was stated that the chapters appeared originally in the *Telegraph Chronicle.* This was a mistake; they appeared in the pages of *Electricity.* Our reviewer admits that he acquired a good deal of his earlier knowledge of telegraphy from these two papers, and in this case he regrets that he crossed the two sources.

We are requested to announce that the Western Electric Company, Ltd., North Woolwich, have found it necessary to acquire an additional building at 60 and 62, Finsbury Pavement, London, E.C. (Telephone Nos.: London Wall 7608 and 7609). The Export Sales Department have removed from Oswaldestre House, and the Supply Sales Department from Norfolk House to the new address, and all Sales business will be carried on from Finsbury Pavement in future, where they now have extensive show-rooms.

The registered offices of the Company will continue at Norfolk House.

THE IMPERIAL WIRELESS PROPOSALS.

THE COMMITTEE'S REPORT.

Appended are the Committee's findings and recommendations

We recommend:

(1) That a scheme of Imperial wireless communications be established connecting the communities of the Empire by geographical steps of about 2,000 miles each, as indicated on the accompanying map.

(2) That the wireless system employed be that involving the generation of radio-telegraphic energy by thermionic valves.

(3) That the service of communication between Leafield and Cairo by Poulsen arcs, shortly to be in operation by the Post Office, be the first link in the chain of communication with the British communities in Africa, and that this communication be continued by a valve station near Nairobi, in East Africa, and by the alteration of the ex-German station at Windhuk to a valve station, to complete the connection with the Union of South Africa.

(4) That for communication with India, the far East, and Australia, valve stations be erected in England, near Cairo, at Poona (or other Indian station), at Singapore, at Hong Kong, and in Australia at Port Darwin or Perth.

(5) That similar communication be established by valve stations between England and Canada, subject to decision in conference between the Imperial and Canadian Governments.

(6) That the stations be planned by a Wireless Commission of about four members, as herein described, whose functions would probably cease with the completion of the stations, and that the construction of the stations be entrusted to the Engineering Department of the General Post Office and the corresponding Dominion and Indian authorities, according to the plans furnished by the Wireless Commission.

We find:

(1) That an Imperial wireless scheme established in this manner would afford reliable, expeditious and economical communication for commercial, social and press purposes throughout the Empire, and that it would meet essential Imperial strategic requirements.

(2) That estimates of revenue and expenditure indicate an initial annual loss, after paying interest at 6½ per cent. on capital, and allowing for complete amortisation of buildings and plant within a proper period, of about £100,000, divided as shown between the Imperial Government and the other Governments concerned, but that (*a*) this loss, which was to be expected, may reasonably be regarded as likely to decrease annually, until after ten years the services will show a profit; (*b*) the system recommended is probably the most economical that will produce the results required, and at the same time be in accord with present wireless science and future wireless developments; and (*c*) the small temporary loss is negligible in comparison with the Imperial benefits to be conferred.

The Committee rejected the proposals of the Marconi Company as being too vague to admit of detailed comment, but so far as they could judge they appeared to be of a scope so great and involving such heavy capital and annual expense, that even if it carried the whole of the traffic handled to-day by all the cable companies serving the same regions it could only be remunerative, if at all, by duplicating the Postmaster-General's system of inland and continental telegraphy and by competing with the State telegraph systems of the various overseas Governments. They were further of opinion that if fully carried out the scheme would be prejudicial to the interests of free wireless research and independent development.

The terms of reference were as follows:

(*a*) To consider what high-power wireless stations it is desirable on commercial and strategic grounds the Empire should ultimately possess.

(*b*) To prepare estimates of the capital and annual cost of such stations and the life of plant and buildings.

(*c*) To examine the probable amount of traffic and revenue that may be expected from each station.

(*d*) To recommend the order in which such stations will be built.

The Committee consisted of: The Rt. Hon. Sir Henry Norman, M.P. (Chairman), Sir John Snell, Rear-Admiral F. L. Field, Prof. J. E. Peltavel, Dr. W. H. Eccles, Mr. James Swinburne, Mr. F. J. Brown, Mr. L. B. Turner; Secretary, Brigadier-General S. H. Wilson; Assistant Secretary, Lieut.-Col. C. G. Crawley.

The Committee estimated that the cost of the scheme outlined, to be apportioned between the Mother Country and the Dominions concerned, would be approximately as follows:

	Total.	Britain's share.
Capital cost	£1,243,000 .	£853,000
Annual charges . . .	425,000 .	268,000

It is further estimated that the annual traffic for the whole service would be about 10,000,000 words, producing a revenue of £325,000, and that in the opening years an annual loss of about £100,000 may be expected, of which £63,000 would fall on the Imperial Government. The Committee's anticipation is that in ten years' time the loss would be turned into a profit.

In view of the Committee's recommendations the opinion of the Marconi Company, as expressed by their Managing Director, Mr. Godfrey Isaacs, at the annual meeting of the Company on the day following that on which the report was issued, is of considerable interest. After criticising the estimated capital costs and annual charges and the anticipated revenue of the Committee's scheme Mr. Isaacs proceeded:

"Let him, however, assume for a moment that the stations were going to be built by the State and worked and owned by the State. What was their position? They must have the thermionic valves—the Committee said so.

The thermionic valve was controlled by a number of important master patents, some of the most important of which were taken out by gentlemen in the Marconi Company. He did not care which form they used, whether American, German or English, for every one of those master patents was the property in the whole of the British Empire of the Marconi Company. (Loud cheers.) That being so, where in this report and the estimate of cost did the Committee deal with the 10 per cent. of gross receipts to which the Marconi Company were entitled? How were they going to pay that if they carried out their own recommendation? If they did not build these stations they would be entitled to a very substantial royalty. He did not fear anything at all from the report. They might be perfectly certain they would not sit still, and the last word had not been said upon it."

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

Promotions.

Name.	District.	From.	To.	Date.
Statters, J. E.	E. in C.O. (Telephone)	Asst. Engr.	Exec. Engr.	1 : 4 : 20
Fletcher, J. F.	South Lancs	,,	,,	30 : 3 : 20
Blight, W. O.	E. in C.O. (Equipment)	,,	,,	1 : 4 : 20
Robinson, C.	E. in C.O. (Research)	,,	,,	31 : 3 : 20
Horner, F. H.	Scotland West	,,	,,	12 : 4 : 20
Lucas, J. G.	E. in C.O. (Telephone)	,,	,,	16 : 4 : 20
Angwin, A. S.	E. in C.O. (Wireless)	,,	,,	16 : 4 : 20
Hardie, J. J.	E. in C.O. (Designs)	Unestab. Asst. Engr.	Unestab. Exec. Engr.	29 : 4 : 20
Lampard, F. P.	E. in C.O.	Junior Engr.	Asst. Engr.	To be fixed later
Baldwin, D. Z.	,,	,,	,,	
Buckland, F. H.	,,	,,	,,	
Brentini, J.	,,	,,	,,	
Dell, L. J.	South-Eastern	2nd Cl. Engr.	,,	
Rees, V. W.	Testing Branch	Test Clerk, 1st Class	,,	
Peel, J.	Northern	2nd Cl. Engr.	,,	
Stevenson, B. J.	E. in C.O.	,,	,,	
Day, T. F.	,,	Chief Inspector	,,	
Halton, E.	North Wales	,,	,,	
Noyes, H. S.	Eastern	,,	,,	
Pollock, C. E.	Northern	2nd Cl. Engr.	,,	
Jones, T. V.	London	Chief Inspector	,,	
Atkins, F.	Scotland East	,,	,,	
Robinson, F. W.	Ireland	,,	,,	
Albry, W. H.	South-Eastern	,,	,,	
White, A. E.	North Midland	2nd Cl. Engr.	,,	

PROMOTIONS—*continued*.

Name.	District.	From.	To.	Date.
Elliott, A.	South Wales	Chief Inspector	Asst. Engr.	To be fixed later
Gear, W. J.	London	,,	,,	
Wynne-Jones, A.	North-Eastern	2nd Cl. Engr.	,,	
Couch, J. M.	North Wales	Chief Inspector	,,	
Herbert, C. M.	South Lancs	,,	,,	
Pooley, R. E.	E. in C.O.	,,	,,	
Wootton, G. A. H.	,,	,,	,,	
Land, A. E.	South Wales	,,	,,	
Tissington, H. G.	,,	,,	,,	
Lancaster, T. S.	London	,,	,,	
Tanner, G. F.	,,	,,	,,	
Lewis, E. A.	North Wales	,,	,,	
McIntyre, J.	Scotland East	,,	,,	
Struthers, G. A.	E. in C.O.	,,	,,	
Eves, W. J.	North Wales	,,	,,	
Cleaver, J.	South Lancs	,,	,,	
Barralet, F. O.	E. in C.O.	,,	,,	
Greenstreet, R.	,,	,,	,,	
Hill, G. J. W.	,,	,,	,,	
Bell, A. J.	,,	,,	,,	
Jupp, J.	,,	,,	,,	
Callis, H. J.	North-Western	,,	,,	
Brown, F. G.	London	,,	,,	
Frost, G. H.	North-Western	,,	,,	
Hodgetts, W. J.	South Wales	,,	,,	
Chambers, H. M.	London	,,	,,	
MacMillan, F. S.	,,	,,	,,	
Morgan, C. E.	South-Western	,,	,,	
Cheetham, W. B.	North-Western	,,	,,	
Beattie, W.	,,	,,	,,	
Paddon, A. F.	London	,,	,,	
Lewis, T.	,,	,,	,,	
Jeary, L. G.	Scotland West	,,	,,	
Whetton, S. F.	South Wales	,,	,,	
Salmon, J. B.	North Wales	,,	,,	
Morrell, E. J.	London	,,	,,	
Morice, L. F.	South Midland	,,	,,	
Sadler, H.	London	,,	,,	
Pinnock, A. E.	North-Eastern	,,	,,	
Hay, P. G.	London	,,	,,	
Lloyd, H. P.	North Wales	,,	,,	
Richardson, T.	,,	,,	,,	
Dipple, H. W.	E. in C.O.	,,	,,	
McGregor, A.	London	,,	,,	
Radford, J.	South Wales	,,	,,	
Mobbs, H. J.	E. in C.O.	1st Class Draughtsman	,,	

Mr. C. P. Kay, Chief Inspector, has cancelled his promotion to the rank of Assistant Engineer.

RESIGNATIONS.

Name.	District.	Rank.	Date.
Hilyer, W. J.	E. in C.O. (Telephone)	Assistant Engineer	27 : 5 : 20 (to Egyptian Govt.)
Perrin, E. S.	E. in C.O. (Wireless)	,,	30 : 4 : 20
Ward, W. G.	Northern	,,	12 : 6 : 20

SUPERANNUATIONS.

Name.	District.	Rank.	Date.
Barber, J. W. . . .	South Lancs	Asst. Suptg. Engr.	25 : 4 : 20
Sullivan, J. W. . .	North-Western	,,	31 : 5 : 20

TRANSFERS.

Name.	Rank.	Transferred.		Date.
		From	To	
Allen, F. J.	Asst. Engr.	E. in C.O.	London	29 : 3 : 20
Eaton, G. J.	,,	N. Wales	Scot. E.	14 : 4 : 20
Jones, E. P.	,,	E. in C.O.	Metn. Power	1 : 5 : 20
Coxon, J.	,,	Met.Power	E. in C.O.	
McKichan, J. J . .	,,	S.-Eastern	E. in C.O.	12 : 4 : 20
Herbert, T. E. . . .	Asst. Suptg. Engr.	Scot. W.	S. Lancs.	17 : 4 : 20

COMMUNICATIONS.

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

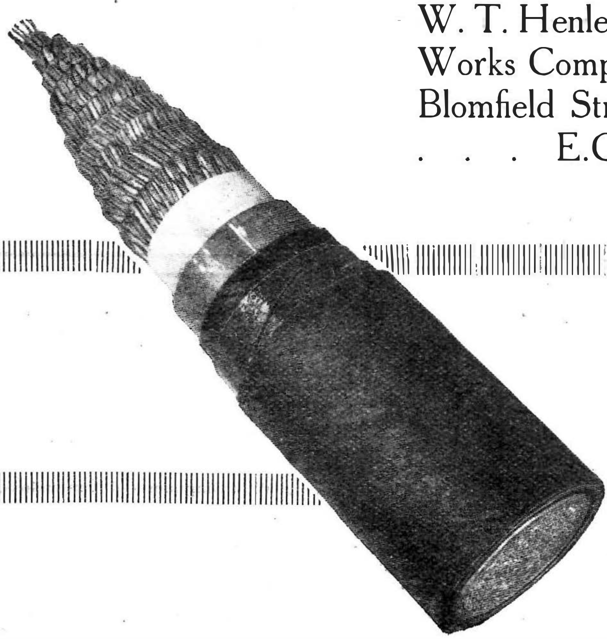
Binding covers and copies of the Contents Index for Vol. 3 to 12 are available, and may be obtained from the local agents for 1*s.* 6*d.* and 3*d.* respectively. Subscribers can have their copies of Vol. 12 bound, with index included, at a cost of 3*s.* by sending the JOURNALS to the local agents. Orders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

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

The Council of the Institution of Post Office Electrical Engineers has decided to raise the price of the JOURNAL to 2*s.* (2*s.* 3*d.* post free) per copy. This price applies also to annual subscribers, the subscription being 9*s.* per annum, post free. All back numbers 2*s.* each. The Board of Editors is anxious to repurchase copies of the following parts: Vol. 1, Part 1; Vol. 5, Part 2; Vol. 7, Part 1; Vol. 9, Part 1; Vol. 12, Parts 1 and 2. Two shillings each part will be paid for clean copies in good condition.

A paper on "The Relationship between Efficiency and Working Costs for Small D.C. Motors and Dynamos," by Mr. E. G. Kennard, has been unavoidably held over.

INDEX TO ADVERTISERS.



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