THE
Post Office Electrical Engineers' Journal

MICHAEL FARADAY.

THIS year is a notable one in the history of electrical engineering, inasmuch as it marks the centenary of the discovery of electro-magnetic induction—one of the greatest events in the annals of science. This momentous discovery was made by Michael Faraday on August 29th, 1831, after years of patient research in the laboratory of the Royal Institution in Albemarle Street, London.

It may be said of Faraday that he is one of the great figures in history, one of a small and select company of philosophers who have contributed much for the benefit of mankind. Faraday's epoch-making discoveries in chemistry and electricity form the basis of manifold applications of science in the modern world. Electric lighting and power, telegraphy, telephony and radio on the electrical side, trace their development from his fundamental discoveries.

There was an amazing and diversified genius in Michael Faraday. Many examples could be quoted in support of this statement in the realms of Chemistry, Optics, and Magnetism. Space will not permit of more than a passing reference to two of these. He succeeded in separating the solvent known as Benzine or Benzol, which is now the basis of a great industry. His fundamental research work in alloying iron with minute quantities of nickel, silver, and platinum, pointed the way to the discovery of stainless steel.

Faraday spent 50 years of his life in the service of the Royal Institution, which was founded in 1800 for the advancement of natural knowledge. In general, the objects of the Royal Institution are to prosecute scientific and literary research, to illustrate and diffuse the principles of inductive and experimental science, to give opportunities for social intercourse among those who are attached to science, and to afford them the means of collective and individual study. It is fitting in every way therefore that the "Royal" should take the lead, and be seconded by the Institution of Electrical Engineers, in arranging a series of centenary celebrations in London, which will do honour to the work of an Englishman whose memory is held in love and respect in every part of the world.

Michael Faraday started life from humble beginnings; he was born in Newington Butts in 1791, the son of a blacksmith. He became an errand boy at a newspaper shop at the age of 13 and a year later was apprenticed to a bookbinder in Blandford Street, Marylebone. The bookbinder's shop stood near the rear of Hertford House, Manchester Square, the home of the famous Wallace Collection. A tablet on the wall of the shop records the fact that Faraday worked there for nine years.

Scientific books which came into his hands for binding purposes gave him opportunities to increase his store of knowledge. He bound books as a duty, he read them as a joy. It has been recorded by Magrath, Secretary of the Athanæum, that, entering the bookbinder's shop on one occasion, he found one of the young apprentices absorbed in the study of a book when he ought to have been binding it. The

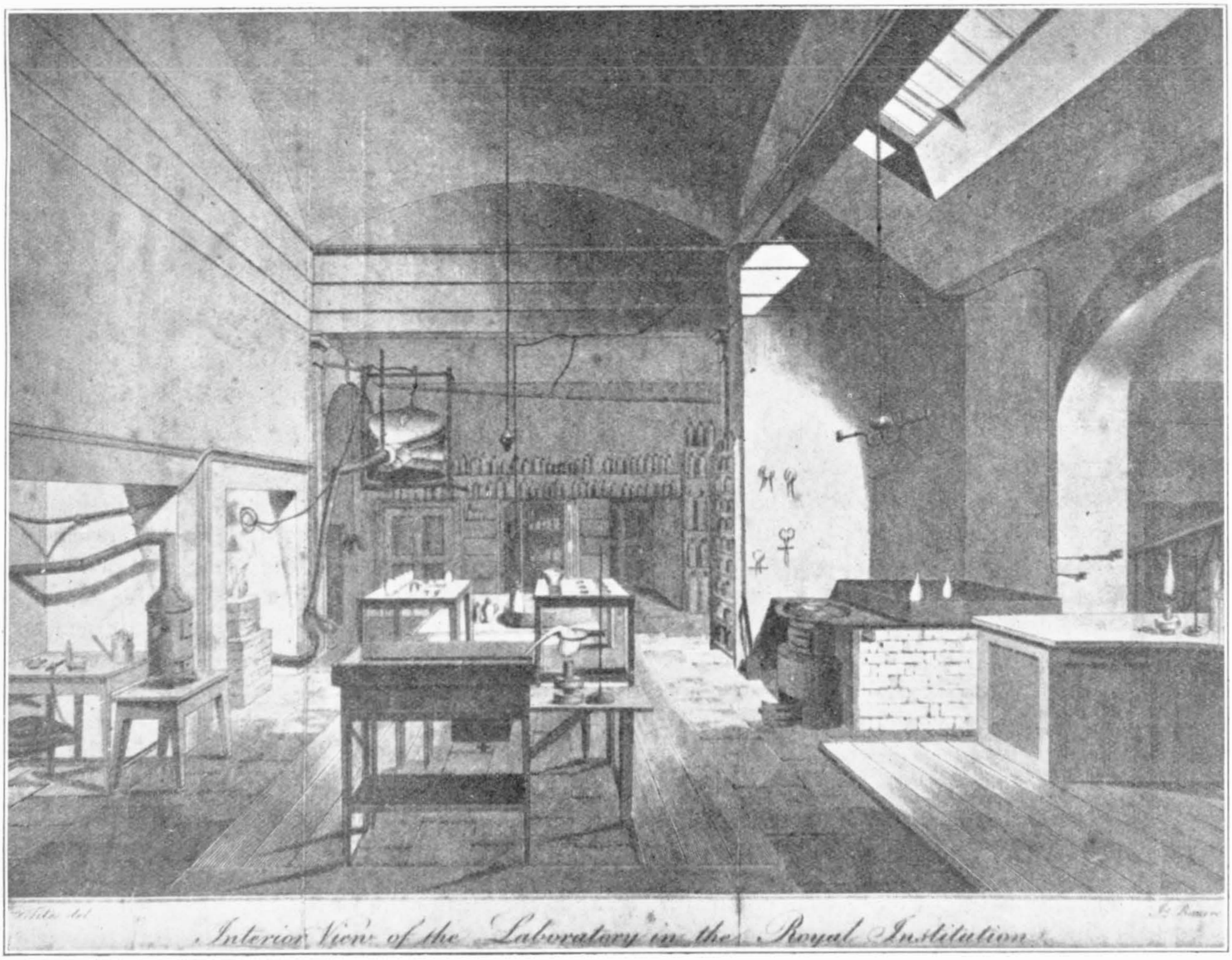


FIG. 1.

From a drawing by W. Tite.

two entered into conversation and Magrath was astonished to find that he was speaking with " a self-taught chemist of no slender proportions."

Faraday as a youth was particularly interested in chemistry and electricity and all the books on these subjects that came into his hands, whether for binding or as loans from friends, or finally, as purchases from his own slender means, were studied with the deepest interest and also made the basis of careful notes.

At this period in his life, he wrote to one of his friends " I loved to read the scientific books which were under my hand, ... I made simple experiments in chemistry as could be defrayed in their expense by a few pence per week and also constructed an electrical machine, first with a glass phial and afterwards with a real cylinder, as well as other electrical apparatus of a corresponding kind."

In 1812 Faraday was able, by borrowing a shilling from his brother,—a plumber—to attend one of Sir Humphrey Davy's lectures at the Royal Institution. This and the succeeding lectures made a great impression on Faraday's mind;—he compiled careful notes, made a fair copy and bound the beautifully written pages into a volume which he sent to Davy. This book is now in the Royal Institution and is one of its most cherished possessions. Faraday was fired with a desire to become a scientific assistant and the sending of his notes to Davy was accompanied by a request that some form of employment might be found for him. By a fortunate circumstance, both to Faraday and to the world in general, a vacancy occurred which enabled the youth to be employed as a laboratory servant at the Royal Institution at a weekly wage of 25/-, the position also including two rooms in the Institution building. This was the beginning of Faraday's career as a philosopher and scientist and, in the quiet laboratories in Albemarle Street, he helped Davy to continue his investigations in chemistry.

Through the courtesy of the officers of the Royal Institution, permission has been given to the writer to reproduce several interesting pictures bearing directly on Faraday and his work. Fig. **1** is a view of the interior of the Institution laboratory as it appeared in 1816, from a drawing by W. Tite. It will be noticed that the room is very sparsely equipped and the arrangement of the bellows and furnace is reminiscent of the blacksmith's forge.

FIG. 2. FARADAY IN 1831.
From a painting by H. W. Pickersgill, R.A.

Fig. **2** is a reproduction of a painting by H. W. Pickersgill, R.A., of Faraday as he appeared in 1831, the year which probably marked the zenith of his career as a discoverer.

Fig. **3** is a copy of an actual photograph from life, taken when Faraday was about 60 years old.

There is a special interest associated with the picture of one of the Juvenile Christmas lectures in December, 1855, painted by Alexander Blaikley, Fig. 4. This shews Michael Faraday lecturing on "The Metals." The Prince Consort is in the chair and the Prince of Wales, (the late King Edward VII.) is sitting on the left side of his father, with Prince Alfred (Duke of Edinburgh) on the right. Among the young people present at this lecture was Alfred Yarrow, now Sir Alfred Yarrow, the famous shipbuilder, who, together with Sir James Crichton-Browne, are probably the last remaining links with that historic meeting. Sir Alfred, in an interview granted to the writer of these notes, states that as a boy of 13 he attended the Juvenile lectures and was present on the occasion when the Prince Consort was in the chair. After each of the lectures, Faraday usually invited a number of the boys to join him in the laboratory, where he would carry out experiments and give demonstrations for the benefit of the youngsters, and also allow the boys to share in the general delight of experimental work. Alfred Yarrow attended these and other lectures at the Royal Institution during a period of ten years and had many opportunities of conversing with the eminent philosopher.

The Post Office has an association with Michael Faraday's life which may also be regarded as unique in Service annals. It is true that the link was forged originally by colleagues in the National Telephone Company, prior to the transfer of that undertaking to the State. The link remains to this day as a memorial and is a source of special pride to members of the electrical engineering profession. In 1899, the N.T. Coy. purchased a building in Barnsbury which had hitherto been used as a place of worship and, in due course, the building became known as the North telephone exchange. In Sylvanus Thompson's admirably written "Life of Faraday" there is a reference to a Sandemanian Meeting House in North London which Faraday attended. Careful investigations were made and it was ascertained beyond doubt that the North exchange and the old chapel were one and the same building. One of the trustees of the chapel was also able to supply information

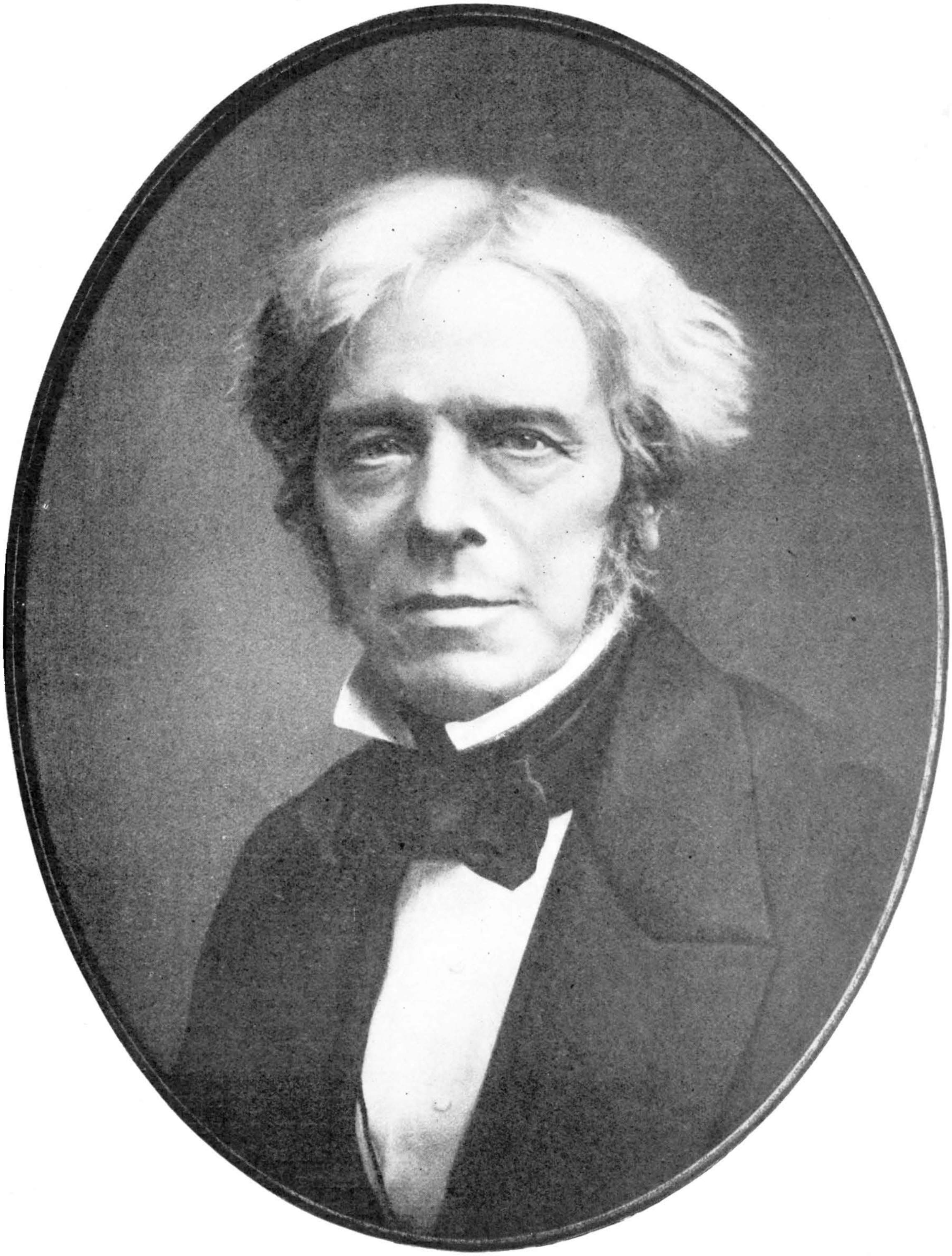


FIG. 3.—MICHAEL FARADAY, FROM A PHOTOGRAPH WHEN HE WAS ABOUT 60 YEARS OLD.

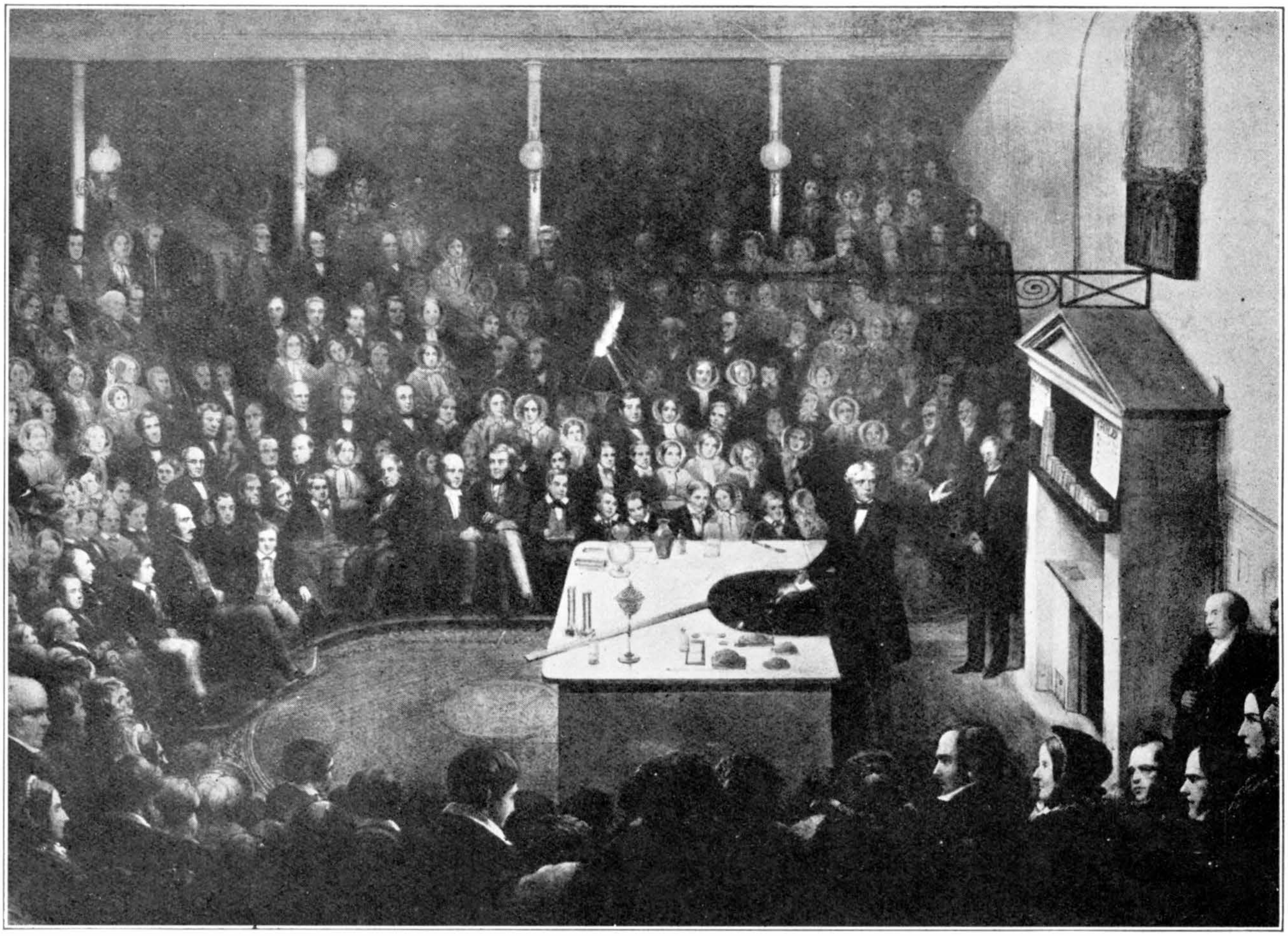


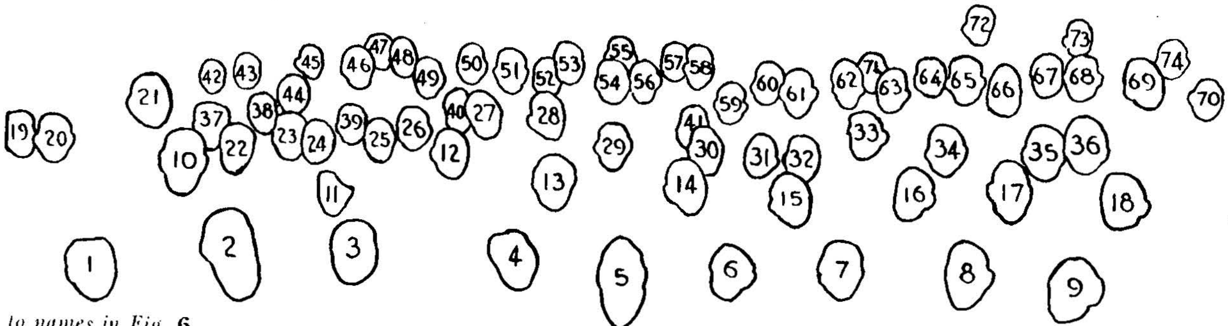
FIG. 4.—FARADAY LECTURING AT THE ROYAL INSTITUTION ON 27TH DECEMBER, 1855.
From a painting by Alexander Blaikley.

concerning Faraday's seat on the platform whilst serving as an Elder, also the position of his pew in the body of the hall.

Young Alfred Yarrow lived at that time in Arundel Square, Barnsbury, within a stone's throw of the chapel. Faraday was one of Yarrow's heroes and it was customary for he and a boy friend to way-lay Professor and Mrs. Faraday as they were walking to chapel along the Caledonian Road, doff their caps and say "Good afternoon, Professor." Faraday had always a kindly word for the boys. Not content with one greeting, the boys would then find their way to the chapel by another route and repeat the salutation! Yarrow and his friend attended service on several occasions and heard the Professor read the portion from the Scrip-

FIG. 5.—FARADAY MEMORIAL TABLET FITTED IN WALL OF SWITCHROOM OF NORTH TELEPHONE EXCHANGE, LONDON.

FIG. 6.—UNVEILING OF THE FARADAY MEMORIAL AT NORTH TELEPHONE EXCHANGE BY LORD KELVIN, 24TH NOVEMBER, 1906. (Photograph reproduced from the National Telephone Journal, January, 1907).



Key to names in Fig. **6.**

1 Miss K. Barnard (Niece of Faraday).
2 Sir Joseph Swan.
3 Sir A. K. Rollit.
4 Lady Kelvin.
5 Lord Kelvin.
6 Miss Barnard (Niece of Faraday).
7 H. Faraday (Nephew of Faraday).
8 Sir R. T. Glazewood.
9 Dr. Sylvanus P. Thompson.
10 C. J. Phillips.
11 Miss Swan.
12 A. F. Blaikley.
13 J. Barnard (Nephew of Faraday).
14 Dr. Walmsley.
15 H. E. Harrison.
16 S. J. Goddard.
17 F. Gill.
18 C. Elliott.
19 H. Honor.
20 J. Sandell.
21 C. B. Clay.
22 F. C. Raphael.
23 I. H. Jenkins.
24 T. Mather.
25 F. Francis.
26 H. Comer.
27 W. Guy.
28 A. P. Trotter.
29 J. E. Kingsbury.
30 A. Coleman.
31 W. M. Mordey.
32 E. Laidlaw.
33 W. W. Cood.
34 J. F. Edmonds.
35 S. J. Smith.
36 H. Davis.
37 T. Fletcher.
38 H. C. Gray.
39 Dudley Stuart.
40 P. T. Wood.
41 W. Judd.
42 Miss Hughes.
43 Miss Ashmead.
44 W. H. U. Napier.
45 W. D. Stewart.
46 W. M. France.
47 A. J. Aldridge.
48 O. S. Stiles.
49 R. H. Williams.
50 J. R. Gall.
51 H. Bines.
52 B. S. Cohen.
53 W. Ireland.
54 A. Warner.
55 W. U. Lonner.
55 J. H. Watkins.
56 W. U. Lonnon.
57 N. McLeod.
58 G. F. Greenham.
59 C. T. Peacock.
60 F. Woollard.
61 J. Poole.
62 G. H. Bryant.
63 J. Ashton.
64 G. Maddock.
65 J. Wolff.
66 H. S. Thompson.
67 P. Prentice.
68 P. H. Cole.
69 H. Bruce.
70 T. W. Woodman.
71 J. Ashton, junior.
72 G. H. Bush.
73 J. Teeboon.
74 G. McGregor.

tures or give the short address. The order of service was very similar to that conducted by the Society of Friends.

To mark the association of the North exchange building with Michael Faraday, the staff of the National Telephone Company subscribed to a fund for the provision of a memorial. This consists of a bronze plate fitted into the wall, also a small octagonal bronze plate fixed on the floor. The first marks the position Faraday occupied when on the platform, and the latter, which bears the initials " M.F.," the position of his pew. The memorial was unveiled by Lord Kelvin on Saturday, 24th November, 1906, in the presence of a distinguished and representative company. A full account of the proceedings is published in the National Telephone Journal for January, 1907. The event has historical interest, not only because of the honour paid to a great man by other eminent scientists and engineers, but because relatives of the Faraday family were present. An illustration of the memorial tablet is shewn in Fig. **5**, whilst a photograph of the group attending the unveiling ceremony is shewn in Fig. **6**. A key giving the names in the group accompanies Fig. **6**, but even without this guide it is easy to pick out faces that are recognizable and well known, even after the passage of a quarter of a century!

As an indication of Sir Alfred Yarrow's great regard for Michael Faraday, it is of interest to record that the commemorative tablets at the North exchange are being reproduced in bronze and will be presented to the Council of the Royal Institution.

Sir William Bragg who, as Fullerian Professor of Chemistry at the Royal Institution, and Director of the Davy-Faraday Research Laboratory, holds two of the posts which Michael Faraday once filled, has, in a recent address, expressed in eloquent language the debt we owe to the great experimental philosopher:—

" It is Faraday's public life that belongs to us: it is one of the possessions of the nation, one of the great treasures. It is not only that his work has had such far-reaching consequences that all the world is affected by what he did, not only that he made plain the intricate connection between electricity and magnetism so that we are in daily dependence upon these forces of Nature for the transfer of power and intelligence; it is not only that on his discoveries are now resting great British industries which are alive and are helping us through these difficult times. All these things are marvels so that we are proud of our famous countryman. But we all love the man himself for his simplicity of faith and purpose, for the breadth of his vision and the humility of his thought, for his kindly generosity and for the light which he shed around him. He thought first of the quality of that which he gave, and only in the second place of that which he received in return. Could there be a nobler leading? Could there be any following more certain to bring us through times of depression and doubt to a triumphant ending? "

ANDREW GIBBON.

AN ALL-MAINS TELEPRINTER DUPLEX SET.

Capt. A. ARNOLD and A. E. DENMAN.

MOST readers will be familiar with the " All-Mains " wireless set. The main feature of such set is that the whole of the power required for the operation of the set is switched on or off by means of a single switch. This article describes a Teleprinter Duplex Set, developed by the Post Office Research Section, for which the power required for the Teleprinter motor, the line circuit, local circuit and auxiliary circuit is derived from the public alternating current mains and all batteries are eliminated.

The alternating current from the mains must of course be rectified and the introduction of the copper-oxide metal rectifier has provided a very suitable means. The use of these rectifiers has already become so general for radio work and the important and exacting work of railway signalling that it is not considered necessary to deal here with the interesting but lengthy subject of the characteristics of this type of rectifier.

The power-supply requirements of a Teleprinter duplex circuit may be divided into two parts: (1) the power for driving the motor, (2) the power for line, local and auxiliary circuits.

The rectifier unit used was manufactured by the Westinghouse Brake and Saxby Signal Co., Ltd., to a specification designed to meet certain requirements indicated by preliminary experiments. The unit has a rated output of 110 volts, 0.75 ampere (D.C. mean). A schematic diagram of the unit is shown in Fig. **1**. Alternating current is supplied to the unit *via* the transformer. The rectifying elements are arranged in the Grätz bridge manner and each element, made in the form of a washer $1\frac{1}{2}$ inches in diameter, has a cooling fin. Since the voltages of the public supplies differ throughout the country, the turns ratio of the primary and secondary windings of the transformer must be such as to give a fixed voltage across the secondary winding on normal load, whatever the mains voltage may be. A secondary voltage of 153 has been fixed in the present case. Two types of unit are made, one for 100-120 v. mains and the other for 200-240 v. mains, with tappings on the primary windings of the transformers to provide for adjustment within the ranges. The output voltage and current values of a typical unit are shown in Fig. **2**. More detailed values are shown in the following table for an output range of from 100 to 600 milliamperes (D.C. mean), the circuit of Fig. **3** referring. The schematic diagram of a

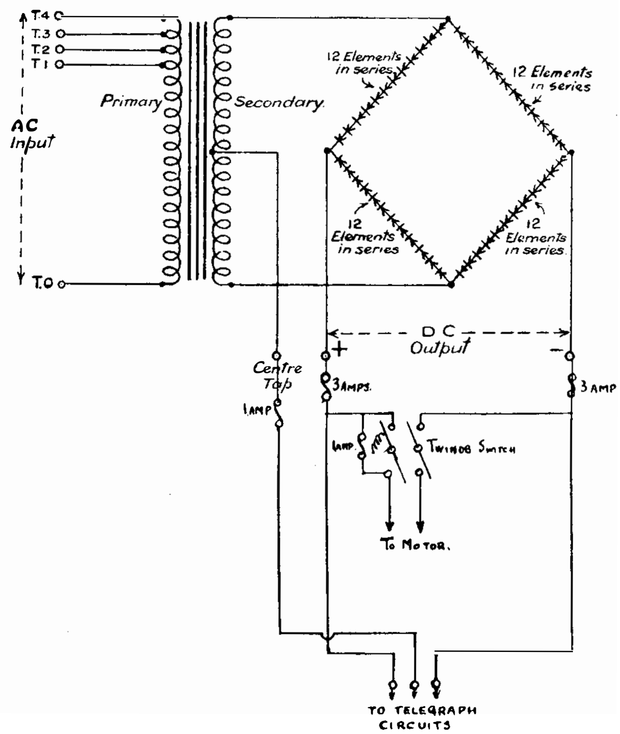


Fig. **1**.—Rectifier Unit.

Teleprinter 3A motor circuit is shown in Fig. **4**. The initial current at starting is much greater than the normal running current. When rectifiers are used the initial current is not so great as with secondary cell supply because the internal resistance of the rectifiers enters into the

A.C. Input.				D.C. Output.			Ratio	Ratio
Primary.		Secondary.		Volts	Current (m.a.'s)		7/6	4/7
Volts Vp	Current mAs. Cp	Volts Vs	Current mAs. Cs	(mean) Vo	Mean Co	R.M.S. Co		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
220	140	147	145	117	100	112.5	1.125	1.28
,,	170	147	210	116	150	170	1.133	1.23
,,	205	147	265	114	200	240	1.2	1.1
,,	245	147	320	113	250	300	1.2	1.066
,,	275	147	375	112	300	345	1.15	1.08
,,	310	146	437	111	350	420	1.2	1.04
,,	345	146	480	109.5	400	480	1.2	1.0
,,	380	146	550	109	450	550	1.22	1.0
,,	401.5	146	610	107.5	500	610	1.2	1.0
,,	490	146	750	105.5	600	750	1.25	1.0

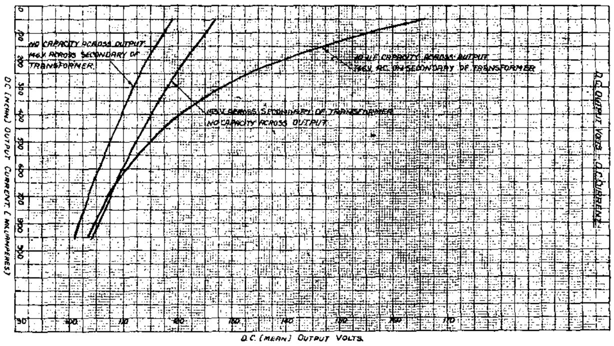


Fig. 2.—Output Voltage and Current from a Typical Unit.

circuit. In the case of the Teleprinter No. 3A the starting current on switching on is about five amperes with secondary cells, and about three amperes with rectifiers. The motor attains its normal speed almost instantly in the secondary cell supply case, but not in the rectifier case. However, with a transformer secondary voltage of 153 volts and the field circuit resistance A, Fig. **4**, not greater than 250 ohms, no difficulty is experienced in cold weather, after the machine has been stopped for 12 hours, in obtaining normal speed within 4 seconds of switching on. With the same conditions regarding secondary voltage and field circuit resistance, no difficulty is found in adjusting the motor to the standard speed within the range of adjustment of the governor, and the teleprinters are interchangeable on the same unit, on different units, and on circuits driven from secondary cell supplies, without readjustment of speed.

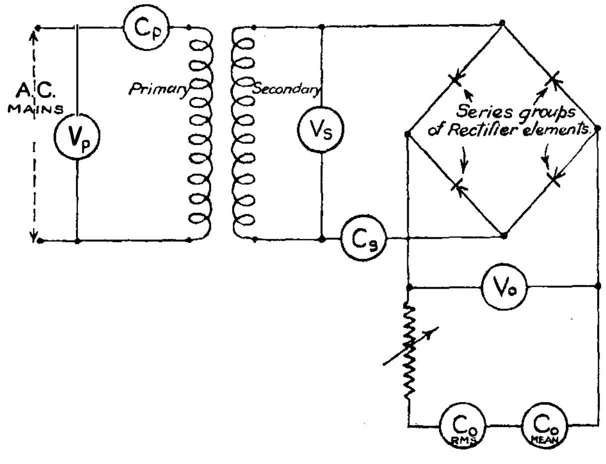


Fig. 3.—Circuit of Fig. 2.

A characteristic in connection with the driving of a shunt-wound motor from the rectifier is that the voltage across the output terminals is considerably greater than with an equivalent pure resistance load. The motor is a 110 v. D.C. motor and takes a current of from 0.4 to 0.6 amperes. The D.C. mean voltage output of the rectifier for 0.5 amperes, on a pure resistance load, is shown in Fig. **2** to be 107.5 volts. The D.C. mean voltage across the rectifier output terminals with the motor running is about 130 volts. This may lead to some confusion in practice and so a 10 μF condenser is connected across the output terminals. This reduces the voltage to 115 v. approximately. This condenser has other advantages described later. A

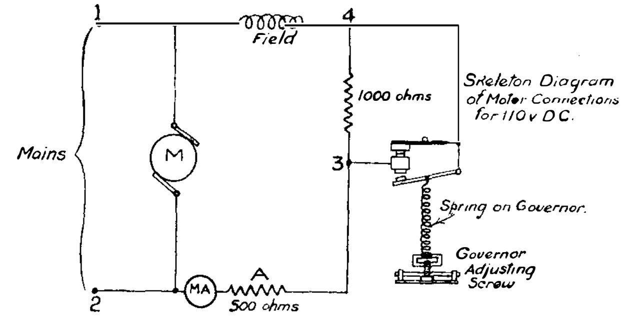


Fig. 4.—Teleprinter No. 3A, Skeleton Diagram.

further point of interest is that if there be any unsteadiness in the speed of the motor when supplied from secondary cells the speed is much steadier when driven from the rectified supply. This may be seen very easily if a tachometer be used for measuring the speed. It may be added that the use of a tachometer for testing and checking Teleprinter motor speeds is a very ready and reliable means. The speeds of the various spindles in a Teleprinter 3A are shown in Fig. **5**. Further, if a slot or hole be made in the cover opposite the centre of the governor disc, the speed may be checked without opening up the machine and removing the message tray, etc.

If the above conditions regarding the resistance in the field circuit is observed, the mains voltage in a certain typical case was varied from 200 v. to 230 v. without any change in the speeds of six machines. The legal requirements imposed on Supply Undertakings ensure that these

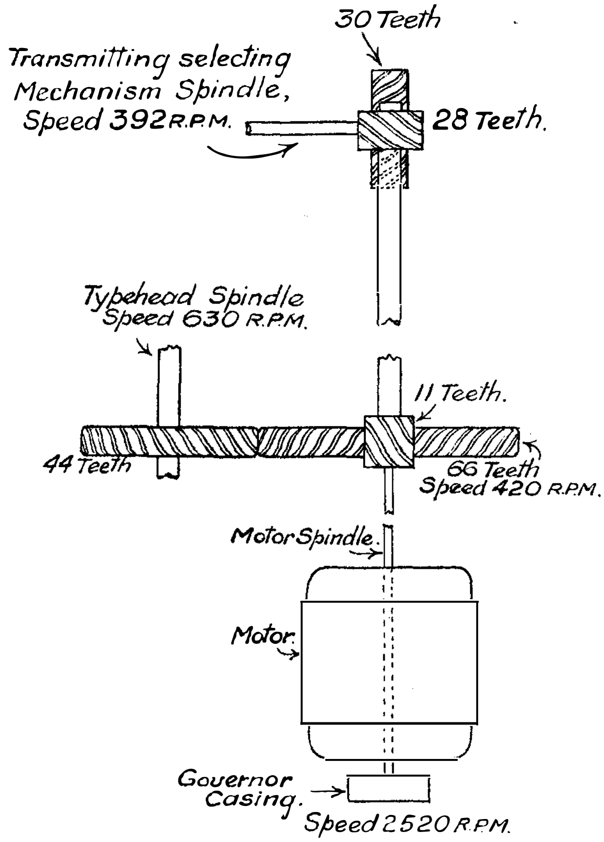


FIG. 5.—SPEEDS OF MAIN SPINDLES.

variations will normally be within small limits and a variation of 5% from a mean value is the maximum observed during trials at various offices.

The motors do not heat up more on rectified A.C. supply than with D.C. supply and no difference in commutator sparking is seen.

Where the public mains supply is A.C. it has been decided to use rectifiers and D.C. motors, the advantages being :—

(1) A.C. motors require considerable maintenance and in some cases are totally unsatisfactory.

(2) Considerable economy due to standardisation of one type of D.C. motor for all machines. This is a very important factor.

Supply of Line and Local Currents.—The maximum voltage available is that across the output terminals when the motor is running. To provide for double current working two equal voltages are obtained for the rectifier by the method, patented by Mr. Stevens, of the Westinghouse, Brake and Saxby Signal Co. This method is shown in Fig. 1 and will be seen to consist of using the Grätz Bridge and taking a tapping from the centre points of the transformer secondary. It will be seen that the voltage obtained will be half the full voltage across the output terminals.

Wave form of output current.—The wave form of the output current of copper oxide rectifiers is nearly a perfectly rectified input wave, neglecting any distortion of wave form due to the presence of the rectifiers. The resulting rectified wave form from a sine wave input is therefore a pulsating, unidirectional wave, having a number of loops or phases equal to twice the frequency of the input wave. It can be shown by analysis that such a pulsating wave may be made up from the following components:

(1) A steady current of 63.6% of the maximum value.

(2) A sinusoidal wave of frequency $2f$ and amplitude equal to 42.4% of the maximum value.

(3) A sinusoidal wave of frequency $4f$ and amplitude equal to 8.5% of the maximum value.

(4) A sinusoidal wave of frequency $6f$ and amplitude 3.6% of the maximum value.

Where f is the frequency of the input sine wave. The component frequencies higher than $6f$ have such small amplitudes that for the present case they may be neglected. In the present case the output wave is also affected to some extent by the motor circuit.

It is desirable to smooth such an output current for the following reasons :—

(1) Liability of causing interference in neighbouring telegraph and telephone circuits.

(2) With unsmoothed current, there is a liability to experience difficulty in obtaining a telegraph duplex balance. This would be increased if the supply frequencies at the terminals were different.

(3) A pulsating line current would be unsuitable for " G " relay reception.

The desirable features of a smoothing circuit for a duplex circuit are :—

(1) Minimum D.C. resistance.

(2) Absence of disturbing effect on the duplex balance.
(3) Economy in apparatus and space.
(4) Minimum reduction in the telegraph transmission efficiency of the circuit.

Various types of smoothing circuits have been tried, each possessing certain advantages. The required smoothing is obtained, with the least cost and amount of apparatus, if the filter be made so that the higher frequencies are eliminated and the remaining ripple reduced in magnitude as far a possible with a reasonable amount of apparatus consistent with the retention of good telegraph transmission. An important consideration is that in most cases in practice a smoother (or filter) would be inserted in the telegraph circuit to reduce or eliminate interference in adjacent circuits, and also a spark quenching device. If such a filter and spark quench circuit were provided, in addition to the rectifier and smoother, a considerable amount of apparatus would be needed. It appears desirable therefore to combine in the apparatus necessary for smoothing the rectifier supply, the functions of—

(1) A smoother for the rectified current.
(2) A line filter.
(3) Spark quench circuits.

The type of smoother adopted and the manner in which it is inserted in the telegraph circuit is shown in Fig. 6. The inductance coil has a D.C. resistance of 20 ohms and an inductance of 2 Henrys.

This was tested in underground circuits for interference on adjacent telephone and telegraph circuits under conditions much more severe than would arise in practice and was found very satisfactory.

Local Circuits.—No smoothing is required for the local current, whether the Teleprinter relay coil or the Sounder is in circuit. To ensure safe operation of the Teleprinter relay under all conditions, however, it is desirable to use " E " type relay coils (100 + 100 ohms resistance, 6 H. inductance) with one magnet instead of the " C " type coils (25 + 25 ohms, 2 H.) because of the greater magnetic effect and the smoothing effect of the higher inductance.

Auxiliary Circuit.—Where a " G " relay is used as a line relay, it is necessary to ensure an adequate degree of smoothing through the

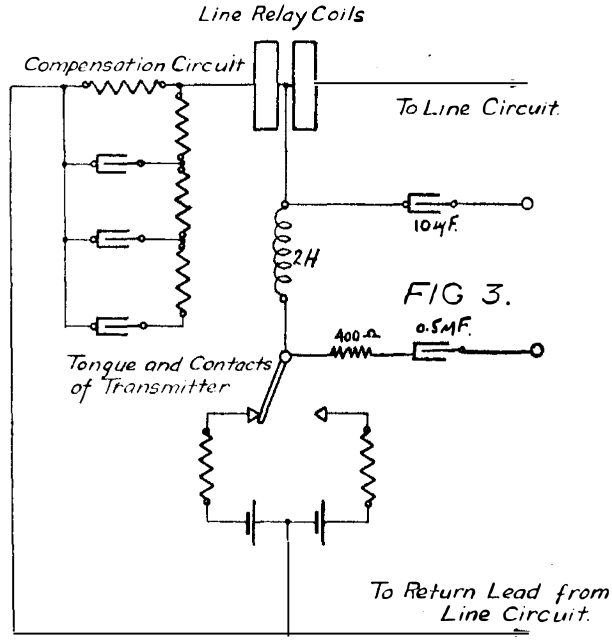


FIG. 6.—SMOOTHER ARRANGEMENT.

auxiliary circuit. This is very conveniently achieved without any extra apparatus by arranging the circuit as shown in Fig. 7. It will be seen that the Teleprinter relay coils and the condenser F form an effective filter for current into the coils of the " G " relay. The condenser usually placed in the base of the Teleprinter machine and connected in parallel with the relay coils is omitted. In some cases the resistance E could be omitted, but it is used to ensure a satisfactory minimum operating current for the Teleprinter relay and render its operation independent of any " G " auxiliary circuit adjustments.

At duplex it will be understood that the transmitter tongue may make contact either with the same pole, or with the opposite pole, as that with which the line receiving relay tongue is in contact. If the line receiving relay be held on one contact and the transmitter tongue moved from one pole to the other, a change in the value of the current in the local circuit is observed, viz., from 20 mA to 24 mA. Or, if under the same conditions a voltmeter be connected across either terminal of the D.C. output of the rectifier and its centre point, a change in voltage from 57 v. to 64 v. is observed. Even under working conditions understood to be

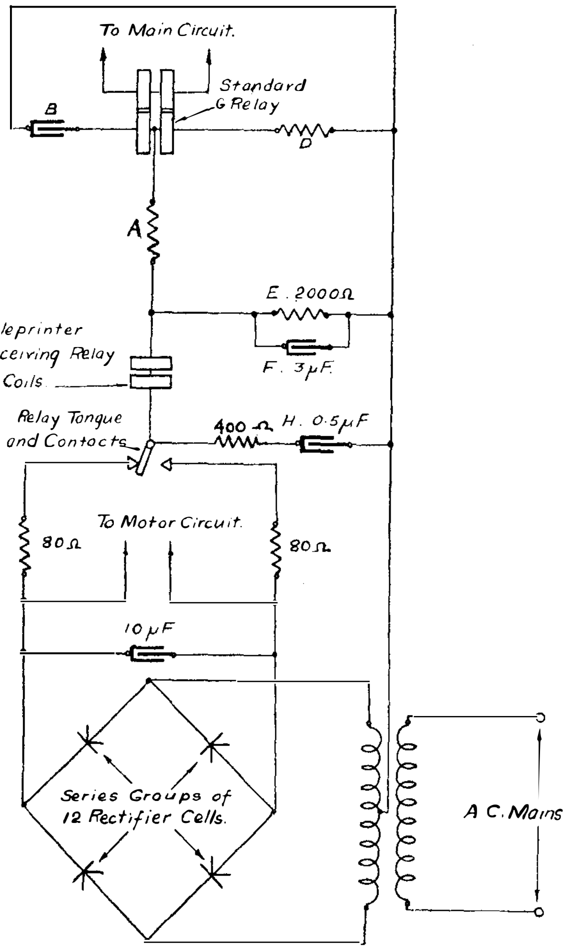


FIG. 7.—USING "G." RELAY.

exacting, this change did not affect operating. This effect can, however, be reduced to a "kick" only of 1.0 milliampere by connecting a condenser of suitable capacity across the output terminals of the rectifier. A condenser 4 μF is usually sufficient for this purpose, but in most cases this causes another variation. Without a condenser across the output terminals of the rectifier, and the motor running, the mean D.C. output volts may be between 120 v. and 130 v., according to the machine in use. When the receiver is printing, this voltage rises about 3% or 4%. If a condenser of 4 μF be connected across the output terminals, the total voltage is reduced by 15 or 20 volts, but in most cases rises by the same amount when the receiver prints. If, however, the capacity of the condenser be increased to 8 or 10 μF, this large increase on printing is reduced to about 3% in all cases and the D.C. output voltage of the rectifier corresponds very nearly to the normal output voltage with a pure resistance load taking a similar value of current to that taken by the motor. There is a certain optimum value for the condenser across the rectifier output terminals in order to reduce the interaction between line and local circuits to a minimum. This value depends on the characteristics of the line circuit in use, but has been between 8 μF and 10 μF in all cases observed and a value of 10 μF has been fixed.

When the motor is not running, the circuit conditions are altered, but not sufficiently to interfere with key duplex. Since, however, the normal condition of the circuit is with the motor running, no attempt is made to balance except when the motor is running. Balancing is effected with the relevant switches to "Morse" and to "Sounder" and either to "Resistance" at the distant end or to currents or to both in turn, exactly as with all ordinary duplex circuits. The battery "Resistance" value, obtained by adjusting it until the balance to currents was the same as the balance to "Resistance," was 60 ohms.

Previous reference has been made to variations in mains supply: it is only necessary to add that the change in the output voltage of the rectifier is proportional to the change in the mains voltage and that since the voltages in this case are obtained by connection to the centre of the total voltage output, bias cannot arise due to unequal voltages even if the mains voltage does vary.

The fuses provided are a 3 amps (R.C.) in each of the leads from the positive and negative output terminals, for the protection of the leads to the motor circuit, and a 1 amp (R.C.) fuse in the centre lead for the protection of the telegraph apparatus and leads. Another fuse, 1 amp (R.C.), is provided for the protection of the motor. By means of a "Twinob" switch, this latter fuse is short-circuited as long as the switch is held down and automatically inserted in the motor circuits when the switch is released. Thus if the motor starts up normally and the switch is held down as specified for three seconds before being released, the fuse will not be blown by the starting current. Should the motor not have started up when the Twinob switch is released, or should the motor stop after running for a time, the current through the armature will blow the fuse. The normal running current is not sufficient to blow the fuse. The circuit is shown in Fig. **1**.

Trials.—The circuit arrangements are shown, Fig. **8** and Fig. **9**, according as the line relay is a Standard " B " or a Standard " G " relay. In order to test the capabilities of the circuit a test was made between London and Leeds. The London (C.T.O.)-Leeds No. 1 circuit was taken over. This circuit is a 197 mile, U.G. 40-lb. metallic loop, having a D.C. resistance 8700 ohms. Normally, it works with " G " relay reception, line voltages of 120 volts at each end, local voltages of 80 volts supplied from secondary cells, and D.C. motor voltage of 110 volts. This

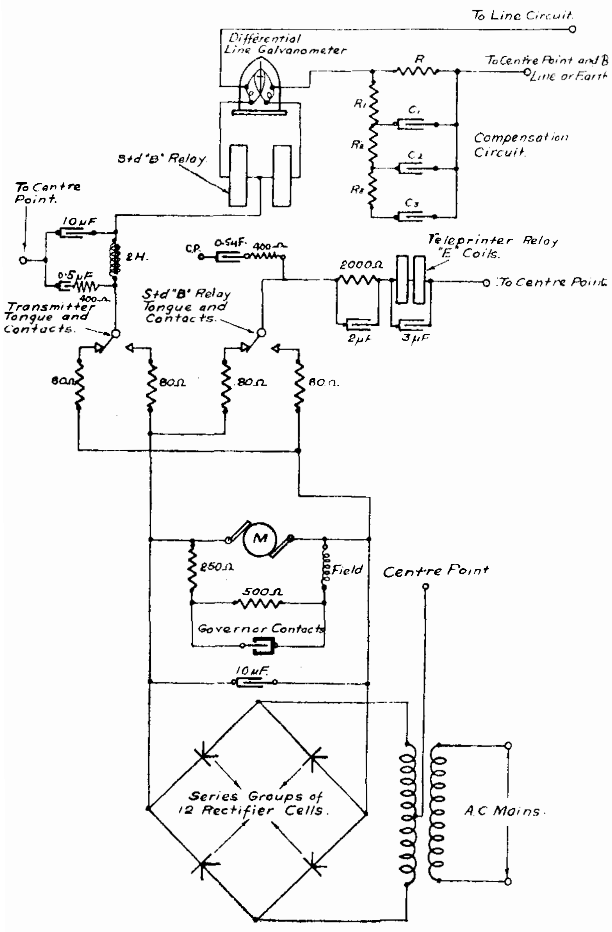


FIG. **8**.—COMPLETE CIRCUIT WITH " B " RELAY.

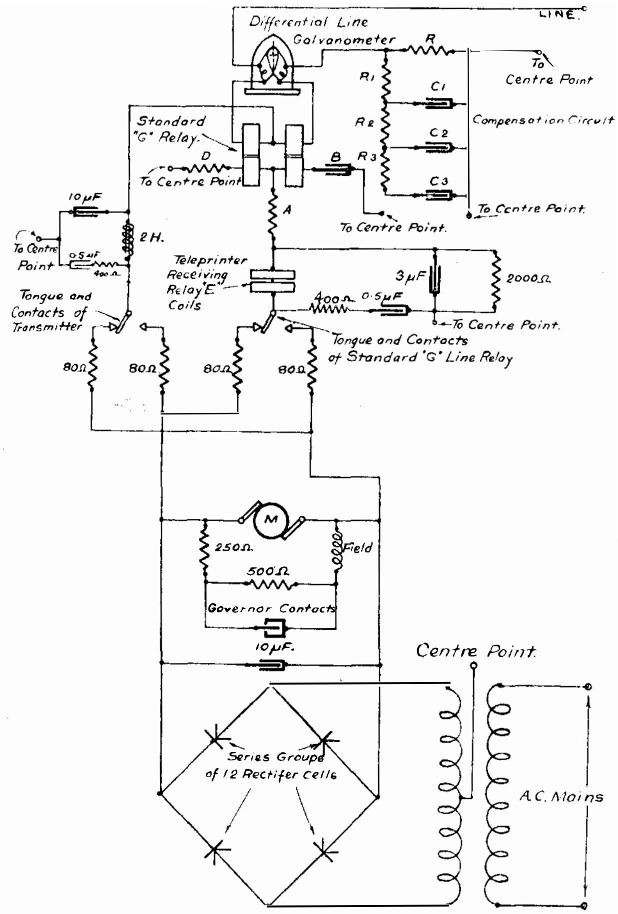


FIG. **9**.—COMPLETE CIRCUIT WITH " G." RELAY.

circuit was worked in full duplex traffic for a week with the rectifier supply sets at each end, the local and line voltages being 58 volts and the motor voltage double. The circuit functioned perfectly, the Leeds set being under " rack mounting " conditions with the Teleprinter remote from the remainder of the apparatus, and the line relay was not adjusted or cleaned during the whole week. This performance would appear to demonstrate the utility of such an arrangement. The power taken from the public mains supply, with all circuits connected, is approximately 110 watts only. Thus, not only is the first cost of such a unit small compared with normal battery installation, but the running costs are also negligible.

INTRODUCTION OF AUTOMATIC TELEPHONE SYSTEM AT BIRMINGHAM.

THE initial stage in the conversion of Birmingham's telephone system to automatic working was completed at 2 p.m. on the 7th March, 1931, when the first three exchanges were brought into use.

Particulars of the new exchanges are given below:—

Name of Exchange.		No. of Subscribers.	Multiple capacity. Initial.	Ultimate.
Northern	...	2,797	5,500	10,000
Victoria	...	1,775	3,100	7,200
Harborne	...	684	1,300	3,000

These exchanges are of the Director type, similar to those already in service in London and Manchester. The whole of the equipment, including that provided for the auto manual services located in the Midland Exchange building, was manufactured and installed by Messrs. The General Electric Co., Ltd.

The Birmingham telephone area, like that of Manchester, includes all exchanges within a radius of 7 miles from the centre, measured in this case from the Cathedral.

Fig. **1** shows the proposed locations of the 39 exchanges which are to serve this area.

Under the present programme the whole work of conversion has been projected over a period of about 10 years, but it is anticipated that at least 30 automatic exchanges will be brought into service during the next three years.

Call indicator positions have been installed by Messrs. The Automatic Telephone Manufacturing Co., Ltd., at certain manual exchanges in the area.

As the trunking arrangements for the Birmingham area and the general features of the equipment are almost identical in character with those described in an article by L. F. Morice, relating to the Manchester telephone system, published in the July, 1930, issue of this Journal, it is unnecessary to give further details on this occasion.

Fig. **2** is a photograph of the auto manual switchboard and Fig. **3** Tandem, First Selectors, Routiner and Relay Racks. These photographs were kindly supplied by Messrs. The General Electric Co., Ltd.

A.H.B.

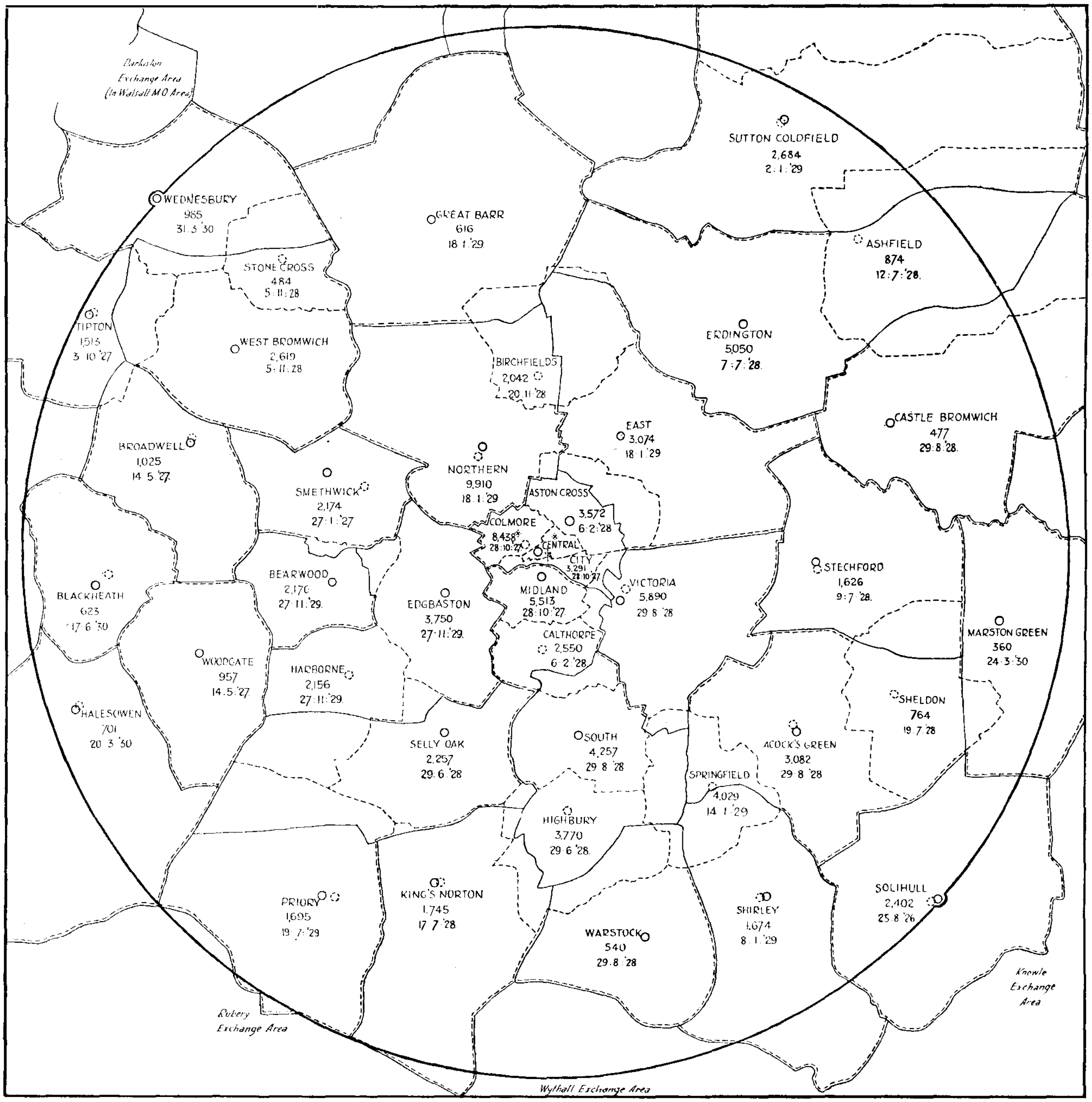


Fig. 1.—Birmingham Telephone Area.

Fig. 2.—Auto Manual Switchboard.

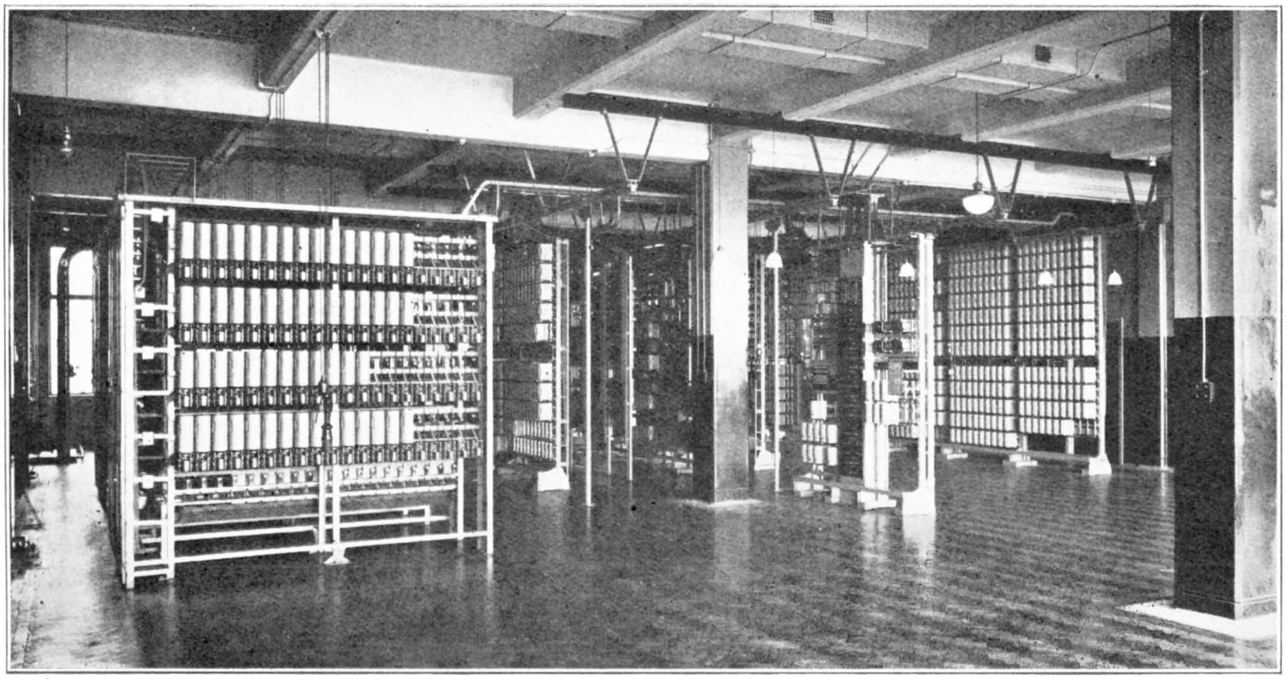


Fig. 3.—Tandem. First Selectors, Routiner and Relay Racks.

ACORN EXCHANGE.

PROGRESSIVE INSTALLATION OF THE NEW STANDARD OPEN TYPE RACKS AND SHELVES.

B. HOUGHTON BROWN,

Engineering Division, Standard Telephones and Cables, Limited.

THIS article forms the second of the series dealing with the progressive installation of Acorn Exchange, and is written to report progress since the April issue of this Journal.

It will be recollected that the Exchange under review is being installed on a progressive sequence or piece-meal basis, consisting of three distinct operations:

(1) The shipping and erecting of the racks and frameworks, and the running of the cables.

(2) The shipping and erecting of the shelves.

(3) The shipping of, and placing in position of the apparatus.

The previous article concluded with a series of photographs showing the rack frameworks erected and the cables run in position, and we will now deal with the next stage covering the shipping, erecting and wiring of the shelves and miscellaneous apparatus, and will show by a further series of photographs how this has been carried out.

Working on the assumption that it is preferable from all points of view to carry out as much work in the Factory as possible, it will be realised that, unless special arrangements are made to reduce the amount of wiring to be done on site, the piece-meal method of installation would suffer in this respect from a distinct disadvantage, and even by making special provision considerably more wiring is thrown on the Installer than is the case where the racks are shipped fully equipped. To mitigate this advantage, arrangements have been made to assemble shelves in their respective groups with their associated supervisory relays and fuse panels on specially constructed tie bars, thus all wiring common to a particular group can be carried out by the Shops. This method of assembly has been used wherever the amount of inter-shelf wiring has merited its use; for

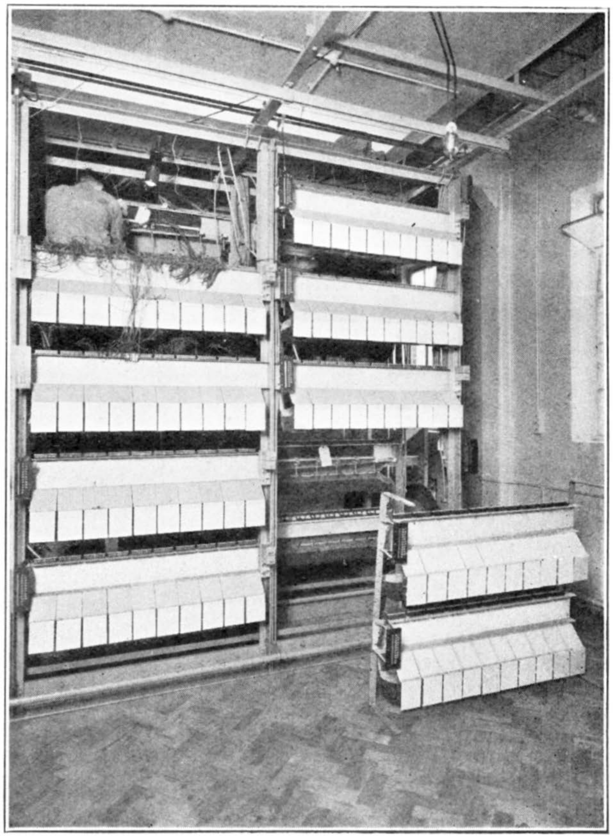


FIG. 11.

example, the C.C.I. relay sets and coder-finder shelves and director shelves.

The method of assembling the shelf groups on the racks will be seen in Fig. 11, and its advantages will be appreciated in that no heavy lifting gear is necessary, the unit of two shelves being easily lifted and fixed in position by two men, and the tie bars removed. Having assembled the shelves on the rack, the Installer is left to connect up the necessary supervisory equipment, and for this purpose he is provided with a hand-made cable made up in the Shops.

In the case of the subscribers' uni-selectors,

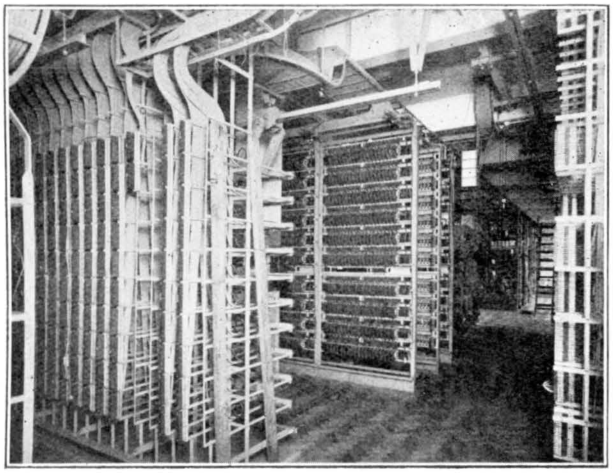


Fig. 12.—General View.

the shelves are shipped fully wired and equipped, and are placed in position by the Installer, who connects up the battery and earth feeds and multiples the shelves together. This multipling is carried out with switchboard cable between terminal strips located at the end of each shelf, and can be seen on the left-hand side of Fig. **13**.

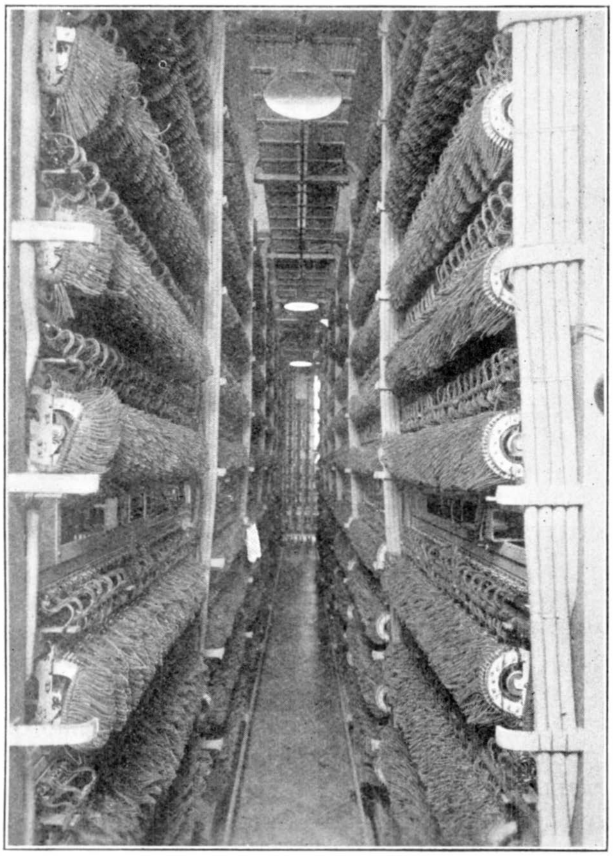


Fig. **13**.—Wiring Gangway, Uni-selector Racks.

Fig. **14**.—Apparatus Gangway, Uni-selector Racks.

The rear view of a fully equipped rack can be seen in the centre of Fig. **12**; this figure should be compared with Figs. **7** and **8** in the previous issue, and shows the general progress that has been made.

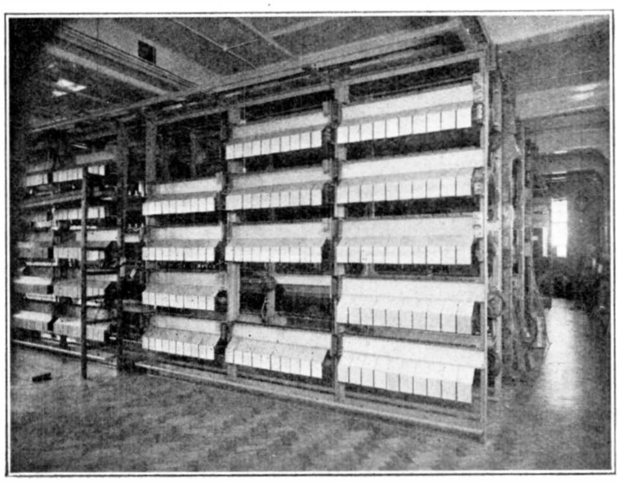


Fig. **15**.—Final Selector Racks.

Fig. **13** shows the wiring gangway between two suites of uni-selector racks, and should be compared with Fig. **9**, also in the previous issue, when the advantage of having the cables run in prior to the arrival of the shelves will be apparent.

In the previous article it was stated that a new system of flood lighting was being considered, and this is clearly shown up in both Figs. **13** and **14**. The flood lights are controlled from either end of the gangway, the switch being mounted on the right-hand upright. For maintenance and inspection purposes, each wiring gangway is provided with a socket for a hand lamp. Fig. **14** shows an apparatus gangway between two suites of uni-selectors; here it will be noted that a different method of flood lighting has been made use of, owing to the presence of a travelling ladder in the gangway.

Fig. **15** should be compared with Figs. **5** and **6**, in the previous issue, and shows the final selector racks fully wired and equipped with shelves and bank multiples. The general appearance of the miscellaneous apparatus mounted down the right-hand side of the racks will be noted.

In concluding this, the second article dealing with the progressive installation of Acorn Exchange, it should be stated that the installation has so far proceeded according to programme, the piece-meal shipping having presented no serious difficulties, and having considerably added to the ease of service during installation and factory production.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 31ST MARCH, 1931.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileage.				Engineering District.	Underground Wire Mileage.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
711,603	571	3,941	53,185	136	London	25,371	104,646	2,803,456	61,914
95,279	2,226	21,579	71,959	2,525	S. Eastern.	4,167	71,760	299,073	31,140
99,103	4,421	33,287	69,577	3,996	S. Western.	23,089	20,905	225,494	67,015
80,187	6,305	40,013	74,379	7,069	Eastern.	24,958	51,123	174,102	59,063
112,283	8,584	46,012	68,325	4,459	N. Mid.	35,225	74,722	296,280	92,812
99,346	4,779	32,163	84,106	4,063	S. Mid.	14,793	43,675	249,807	77,234
64,482	4,330	30,395	62,473	3,809	S. Wales.	7,973	34,852	147,336	64,231
123,570	8,016	27,469	59,056	4,504	N. Wales.	14,212	42,922	341,378	131,253
175,702	1,415	15,887	46,031	3,231	S. Lancs.	15,084	93,926	563,807	68,107
105,155	5,983	30,510	52,329	3,836	N. Eastern	16,028	54,362	288,605	66,945
71,091	3,795	24,002	42,316	3,121	N. Western.	8,371	38,155	191,789	41,858
54,687	2,412	16,154	28,848	3,187	Northern.	9,265	25,300	153,715	34,188
25,052	4,407	9,287	15,458	622	Ireland N.	138	3,162	59,436	2,406
75,744	4,658	28,157	44,497	1,472	Scotland E.	7,105	20,618	170,883	53,192
98,524	7,240	25,359	47,553	1,154	Scotland W.	11,989	31,508	250,404	32,775
1,991,808	69,142	384,215	820,092	47,184	Total	217,768	711,636	6,215,565	884,133
1,962,849	70,314	382,558	812,413	46,542	Figures as at 31 Dec., 1930	211,854	685,878	6,034,100	867,789

THE BYPATH AUTOMATIC TELEPHONE SYSTEM.

E. P. G. Wright and J. H. E. Baker, B.Sc., A.C.G.I.,
Standard Telephones and Cables, Ltd.

Introduction.

THE Bypath System is a universal automatic telephone system employing single motion switches (or uniselectors) of simple design as shown in Fig. 1. The development of this system has been carried out entirely in London and is the outcome of unremitting research work extending over a number of years, and resulting in the production of a system which, in the opinion of the authors, is superior to other Step-by-Step systems, and achieves in this class a standard of efficiency hitherto unattained.

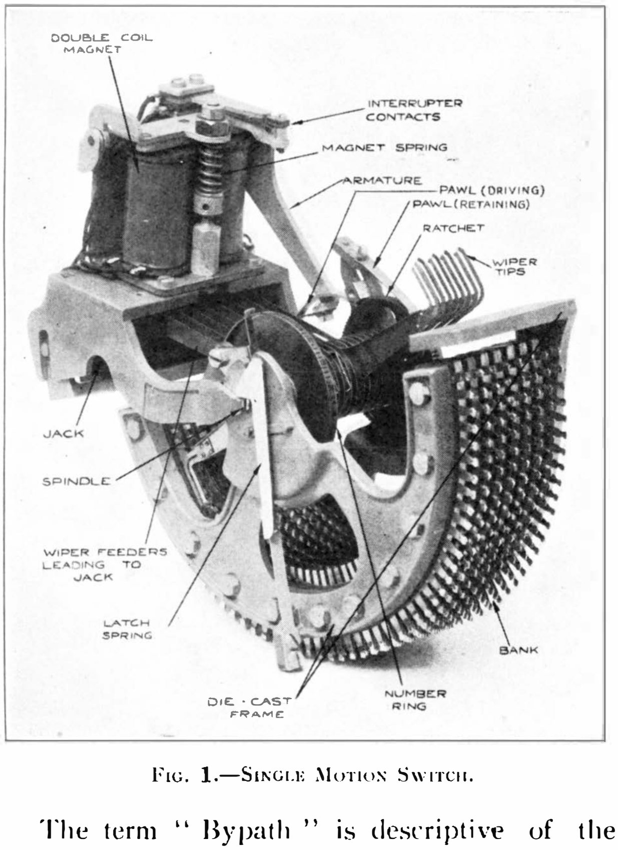


Fig. 1.—Single Motion Switch.

The term "Bypath" is descriptive of the operation of the system in that the circuits fall into two main categories conveniently known as paths and bypaths. The paths constitute the speaking connections which are engaged throughout a conversation, the bypaths being engaged only for a short period during the setting up of a call.

The bypaths control the positioning of the paths, and provide a temporary connection to the next switching stage until the connection *via* the path is completed. When the connection is established the bypaths are free for other calls, thus reducing the number of special relays associated with the apparatus individual to each call, and permitting the use of simple non-homing selectors in the paths.

The system caters for exchange capacities from a two digit unattended exchange to a 10,000 line exchange, which can exist as isolated exchanges or as units in a large metropolitan network, with or without exchange translation.

The system is designed to inter-work with the present Step-by-Step system or with any other system employing forward loop impulsing; a bypath exchange can therefore be introduced into areas at present employing such systems without modification to the existing exchanges.

Note:—The technical nomenclature used throughout this article is that defined in B.E.S.A. Publication No. 204—1930.

The main features of this system are:—

1. *Flexibility of grouping.*—Each switching stage has either 100 or 200 outlets, and the number of groups into which these outlets are divided, and the number of outlets in each group, are limited only by the total number of outlets.

2. *The use of a temporary bypath to the next switching stage.*—This arrangement greatly simplifies the conversational circuits and makes it possible for the path selectors to be non-homing without affecting the minimum allowable interdigital period.

3. *The use of common controlling circuits for positioning the conversational selectors.*—These circuits contain the impulsing relays and the slow and fast operating relays, thus reducing

the number of special relays required in an exchange. The ratio of bypaths to paths is about 1 to 10 for average traffic requirements, but, of course, is based upon trunking calculations.

4. *Circuit design.*—In designing the circuits, considerable attention has been given towards simplifying demands on relay design, and towards eliminating to a great extent the need for critical adjustments and timing requirements. A minimum contact pressure of 20 grammes has been adopted throughout.

5. *One type of selector.*—The use of only one type of selector is of special value for manufacture, maintenance and maintenance education. This selector has been especially designed for the system and has 6, 8 or 10 wipers arranged to give 51 or 102 outlets as required. An important feature of the new selector is the facility provided for jacking-in the brush carriage. This appreciably simplifies maintenance and allows for interchangeability.

6. *Translation.*—When translation is required, the registers and translators are used for setting up a call only when the call is to be routed by way of a tandem exchange or, in the case of the registers, when the call is to terminate at a call indicator exchange. This arrangement involves a considerably smaller number of registers than would be required if they were brought into use on every call.

7. *Alternative Trunking.*—This feature provides a means by which, in the event of all direct junctions between the two exchanges being busy, calls can be routed automatically through a tandem exchange. The advantage of this is that the number of inter-exchange junctions can be reduced by about 20% without materially affecting the number of junctions to tandem.

History.

The enormous amount of preliminary design work necessitated in the development of a new system is not generally realised, and it would be interesting briefly to run over some of the earlier arrangements which ultimately led to the bypath system and to show why each was abandoned.

The value of common controlling circuits and of the flexibility of the outlet groups on the bank of a single motion selector was apparent, and several schemes were worked out in detail showing how these principles could be applied to a typical exchange in the London area and to typical exchanges in the provinces, both with and without satellites. These schemes proved sufficiently economical and attractive to justify extensive further development.

The use of registers and revertive impulsing in conjunction with single motion selectors and common control circuits was investigated, but while results proved very satisfactory, the circuits did not readily interwork with existing Step-by-Step exchanges, and for this reason the method was abandoned.

It was felt that it might be advantageous to introduce common control working without materially departing from the principles at present employed in London and the Provinces and a scheme using two motion selectors with common control circuits at each switching stage was worked out in detail. This scheme was further developed to show how certain outlets on one or more levels could be used to increase the size of the trunk group of other levels, in order to give a higher trunking efficiency. This proved, however, to be cumbersome and the results were not encouraging.

The chief difficulty of a system using single motion switches without registers is in positioning the switches in the interdigital period. In the earlier schemes this was done by using comparatively complicated switches in the conversational circuits, which had to return home after every call and which had to be capable of testing two outlets at a time.

This latter requirement necessitated an additional switching relay in the conversational circuit and these schemes were not adopted since a system was subsequently evolved which enabled the common controlling circuit to establish a temporary connexion to the common controlling circuit of the next switching stage. Having thus established a bypath, the great majority (about 90%) of the complications referred to above are thus avoided and the selector in the conversational circuit moves in its own time to the position marked by the selector in the bypath.

Before the present system was decided upon several schemes employing this feature were developed, differing chiefly in the method of positioning the bypath switch in response to the dial, and in the method of associating the conversational circuit with the bypath during the setting up of the call.

The Main Features.

Application.—The system is designed for Step-by-Step areas and is suitable for equipments of all sizes from a two digit isolated equipment to a 10,000 line exchange in a large multi-exchange area such as London.

The system interworks without any change with Step-by-Step systems or with any other systems responding to loop impulses.

Interworking with manual systems is catered for either by means of the well-known keysending method or by direct voice frequency signalling from the manual exchange. Both call indicator and call announcer methods for handling auto-manual calls have also been worked out.

Service.—The service to a subscriber is equal to that now afforded by Post Office automatic exchanges, and in addition it has the following advantages:—

1. The system is substantially immune from double connections due to marginal battery testing when searching for idle outlets at all stages.
2. The relays which respond to the dial impulses and step the selectors do not have to supply the transmitter current.
3. Continuous ringing is given immediately a subscriber's line is seized. This is replaced a quarter of a second later by the normal interrupted ringing.

Flexibility of Grouping.—One of the most important features of the system is the use of single motion selectors. These selectors have 100 outlets which can be divided into groups as required. Most telephone systems employ selectors having a definite number of levels with a definite number of outlets per level. This means that unless special arrangements are made, no group can have more than this fixed number of outlets and that if a level is not used, its outlets are wasted. On the other hand, the number of groups is not necessarily limited to 10, for example, there may be 9 groups of direct junctions (4, 6, 6, 8, 6, 12, 4, 6, 6), one group to tandem (16) and one group to sub-tandem (26), making 100 outlets altogether, divided into 11 dissimilar groups.

The table below shows the number of circuits required to handle given traffics when preceded by standard two motion selectors or single motion selectors with their outlets grouped for optimum distribution of availability.

The traffic is assumed to consist of:—

34.3 TC on each of 4 levels.
17.15 TC ,, ,, ,, 2 ,,
Zero ,, ,, ,, 4 ,,

The table gives the figures both for non-graded and graded connections and for 100 and 200 outlet cases.

	100 Outlets.		200 Outlets.	
	Non-graded.	Graded.	Non. graded.	Graded.
Two-motion selector	500	402	360	300
Single-motion selector with flexible grouping ...	378	320	306	268
Percent Saving ...	24.4	20.4	15.0	10.7

The above economy is effected by allotting outlets to each level according to the traffic carried by it. The figures shown for the single-motion selector assume four outlets allotted to dead levels in each example.

Another advantage is that where 100 outlets are required initially, and possibly 200 outlets required ultimately, the extension can take the form of simply adding the second selector and distributing the outlets as required.

Translation.—A feature of the system is the manner in which translation is handled. The translators, which are common to the exchange, control the routing of all tandemed traffic. The remaining traffic, which forms the greater proportion, goes either to the local selectors or over inter-exchange junctions under the direct control of the dial. Each translator controls the routing of all calls going to nine exchanges. Thus the quantity of translators can be chosen to suit the number of exchanges in the area and can be varied as required.

The registers store the numerical digits and are taken into use only on tandem and call indicator traffic. They send out the code digits under the control of the appropriate translator. In the event of all direct junctions to an exchange being engaged, calls to that exchange are routed *via* a tandem exchange.

The advantages of these arrangements are as follows:—

(*a*) It is necessary to provide only a fraction of the number of storage registers which would be required with the present Step-by-Step System, as for example in London.

(*b*) The number of inter-exchange junctions is considerably reduced without appreciable increase to the tandem junctions. In most areas there will be a large group of junctions from each exchange to a tandem centre to cater for the traffic to the more outlying exchanges. With the alternative trunking feature, congestion on the inter-exchange junctions does not result in lost or delayed calls, unless in addition, all the tandem outlets are busy. Consequently, the direct junctions, which are usually in small groups, can be calculated on a much higher probability of congestion, resulting in an average reduction of about 20% in the number of junctions. The overflow traffic, which will be very small and probably not occur simultaneously in each group, will hardly affect the number of tandem junctions since they are already in a large group.

(*c*) Following on (*b*) the provision of alternative trunking allows the equipment to meet sudden emergency traffic conditions without degrading the service. The elasticity of this arrangement takes care of unavoidable deviations from the traffic predicted by the operating administration in forecasting the equipment and allows a greater traffic growth to occur before action need be taken.

(*d*) Each translation appears only once in the exchange, thus reducing the possible sources of error, facilitating alterations and considerably minimising routining and maintenance work.

(*e*) Since the local and direct junction calls are set up under the direct control of the dial as opposed to the intervention of a register or director, the average time the subscriber has to wait from the moment of dialling the last digit to the moment of hearing ringing tone, is reduced by 4 seconds, which is a considerable advantage from the subscriber's point of view.

Traffic to Manual Exchange.—The registers which store the numerical digits are designed to re-transmit them either as decimal impulses or as coded call indicator pulses. This means that only one type of register is required for tandem calls and direct manual calls.

Maintenance.—A very great effort has been made to reduce the maintenance costs, and the main factors leading to the advantages claimed are as follows:—

(*a*) The presence of common circuits in which are located the testing, guarding, impulsing and marginal relays, not only considerably reduces the number of relays of this class, but makes it economically possible to provide relief relays on a fairly lavish scale, which has the effect of easing the relay design limits and broadening the operating limits of the more difficult relays.

(*b*) A minimum contact pressure of 20 grammes on all relay springs materially reduces trouble due to dirty contacts.

(*c*) Selector maintenance has been reduced to a minimum by virtue of the following:—

1. The banks and mechanisms are interchangeable, and the wipers having been centred on one bank require no further centring on other banks.
2. The mechanism can be jacked in and out in a few seconds without the use of any tools, and the thumb screw which fixes the mechanism to the bank always remains attached to the mechanism.

3. These features enable the mechanism to be taken away for maintenance purposes to any convenient working position where all the necessary tools can be available, and the best conditions of working can be provided.
4. All the adjustable parts are readily accessible.
5. There are no auxiliary spring sets.

(*d*) The relay panels can also be jacked in in and out, and the winding tags of the more important relays are taken out to jack points to facilitate current adjustment on the bench.

(*e*) The bypaths which form the hub of the system are mounted at about four feet from the ground on all bays.

(*f*) The provision of automatic routiners which test the correct make and break of every contact at all selecting stages makes it possible to check all the apparatus in a very short time for correct operation, and in the case of failure gives, by means of lamps, a direct indication of the probable cause of failure.

(*g*) The use of bypaths makes it possible to have separate relays for receiving the dial impulses during the setting up of a call and for battery supply purposes when the call has been set up. Since the properties for good transmission and good impulsing are conflicting, this segregation of duties enables the most efficient relay to be used in each case.

(*h*) In the event of a subscriber failing to dial after a predetermined time interval, the common apparatus is forcibly released and the subscriber's line is tied to a first path and a P.G. (permanent loop) alarm is given. If this condition persists for more than a predetermined time an exchange alarm is given.

(*i*) The release of the connection is under the control of the calling subscriber who, on hanging up, breaks down the connection as far as the penultimate stage; the remainder of the connection is under the control of the called subscriber, but this control is not effective unless the calling subscriber has already hung up. This arrangement prevents the called subscriber getting dial tone if he is late in hanging up. If the last subscriber fails to hang up after a reasonable length of time, the connection is forcibly broken down and the line is treated as a P.G. It will be seen, therefore, that all the maintenance work connected with switchhook conditions is concentrated at the first stage. This eliminates the tracing back of C.S.H. (Called subscriber held) faults.

(*j*) In order to ensure that no bypath is held for an undue length of time, a fault detector is provided which continuously tests each bypath in turn. If the bypath is free, it passes to the next, but if a bypath is busy, it remains there until it becomes free, giving an alarm if this does not occur within a predetermined time. This fault detector is in addition to individual time alarm arrangements, which are provided on each circuit.

(*k*) The only alarms in the exchange are given when a fuse blows, when a routiner finds a fault, when the fault detector is held up, or when a P.G. persists for more than a predetermined time.

Preselection.—First and second line finders are used in such a manner as to give maximum availability between the first stage circuits and the subscriber's lines.

The bypaths search first for the 100 line group calling and then cause first line finders to search for the calling line within that group. The bypaths are arranged in pairs, and of each pair one is brought into operation at the initiation of every call, but only two first line finders search for the calling line within the 100 line group.

Junctions.—The Bypath System claims two advantages in relation to junctions. Firstly, by the use of alternative trunking the number of inter-exchange junctions is materially reduced, and, secondly, by the use of separate relays for impulsing and transmission it is possible to dial with more difficult line conditions and impulse repetition is made easier.

Incoming junctions are terminated on the banks of finders which are so arranged as to ensure even distribution of the finders around the arc. This gives an efficient method of introducing the bypath at the incoming stage without interfering with the interdigital time.

Traffic Recording.—The System lends itself very readily to the use of a traffic recorder. On account of the ease with which selector mechanisms can be jacked in and out, it is a simple matter to re-group the selectors to obtain the highest traffic carrying efficiency.

The outgoing tandemed traffic is measured at the translators, where means are provided for recording the total traffic to each exchange individually. This is effected by plugging a meter circuit into the start circuit jack for the particular exchange required, and gives a very ready method of checking the traffic without any wiring or strapping being necessary.

Metering.—The system caters for excess fee or zone metering. When the called subscriber answers, the calling subscriber's meter is operated a number of times according to the fee to be charged. The record of the fee to be charged is signalled to the outgoing relay set at the originating exchange from the register.

Equipment.—The equipment is mounted on vertical bays, 11 ft. 6 ins. high and about 2 ft. wide. Each bay carries either two or four bypaths (depending on the switching stage) and the paths normally associated with the bypaths. The relays, supervisory keys, and test jacks are mounted at approximately four feet from the ground on each bay, the selectors being mounted above and below them. The relays are mounted on jack-in panels and are provided with transparent covers so that the condition of the relays can be observed without removing the covers. Ordinary switchboard jacks are used for test jacks, and their robust construction avoids maintenance troubles.

Final Selectors.—The same group of final bypaths is used for regular and P.B.X. working and for the test and trunk trains, thus eliminating small groups for special services. Special finals are not required for P.B.X. working, since the paths are identical, and the small amount of equipment which is special to P.B.X. lines is provided in all the bypaths.

Facilities are provided for intermingling regular subscribers in P.B.X. groups and for extending P.B.X. groups over the home position. These facilities enable P.B.X. group extensions to be made and regular subscribers to be converted into P.B.X. subscribers without changing the subscriber's number.

Ringing.—Continuous ringing is applied to the terminals of the wanted line immediately after it is seized, and after about 200 milliseconds is replaced by the usual interrupted ringing. This feature is particularly useful in the case of P.B.X. lines since it prevents P.B.X. operator seizing a line to the exchange after it has been taken by a final selector due to the seizures coinciding in the silent period of the ringing. It also decreases the operating time, thereby improving the service from the subscriber's point of view.

Satellites.—The Bypath System is easily adaptable to satellite working and depending on the type of the area and the nature of the traffic, either a discriminating first stage is used with the discriminating apparatus located in the bypath, or for large satellites running into several thousand lines, a register with or without translators is used. Where registers are provided, only a few are required, since they are brought into operation only when they are required for the particular class of call. In this way the number of junctions between the satellites and the main exchange is materially reduced. The same path selector is used for both the local and junction traffic and facilities are provided for direct working to neighbouring satellites.

Bypath Change-over Keys.—The bypaths are arranged in pairs, each bypath normally serving a group of paths, but in the event of a bypath being cut out of service the paths normally associated with it can be made accessible from the partner bypath by means of a change-over key. With this key thrown, the remaining bypath will serve both groups of paths.

Automatic Routiners.—Automatic routiners are provided at every switching stage where the number of circuits is such as to justify their presence. These routiners test the correct making and breaking of every contact in the bypaths and paths and take, on the average, about 75 seconds to routine a bypath and its associated group of paths.

Facilities are also provided for continuously routining one particular circuit where an intermittent fault is suspected. In the event of a fault being found, its nature is indicated on a lamp field so that it can be readily tracked down.

The routiner is also used as the fault detector as has already been described.

Battery Supply.—The current consumption of a bypath exchange is approximately 10% to 20% less than that of an equivalent Step-by-Step exchange. A nominal voltage of 50 is used with a permissible variation from 46 to 52 volts. Separate battery feeds are provided for talking and operating purposes.

Location of the Feed.—In the Bypath System the transmission feed is located in the penultimate path and in the outgoing relay sets. This arrangement results in distinct economies compared with the usual practice of having the feed in the final selector, since the latter selectors which serve groups of 100 or 200 lines are more numerous than the penultimates which serve groups of 1,000 lines.

Discrimination is made in the relay sets and in the penultimate stages as to whether the call has come from an operator. In this case the operator's cord circuit already has a feed, and consequently a second feed is unnecessary and is accordingly replaced by a through metallic pair. One advantage of this arrangement is that busy flash need not be repeated through the relay set, the elimination of which facility considerably simplifies the circuit. A second advantage is that the transmission is improved.

Release.—When a call is broken down at the end of a conversation, the path selectors do not move, the wipers remaining disconnected on the contacts until the path is taken into use again for another call. This reduces the wear on the path selectors by approximately 50%, and maintenance is facilitated in that the selector remains on the outlet after the conversation has ceased.

Spark Quenches.—Only one path selector of a group of paths served by the same bypath can move at a time, since no movement can take place unless it is controlled by the bypath. Advantage has been taken of this fact and only one spark quench is provided for all the path selectors served by one bypath; this is located in the bypath and introduced when required. The method of introduction is such that with any combination of dirty contacts, it is not possible to drive the selector without the spark quench being connected correctly.

Testing for free Outlets.—A free outlet is indicated by having battery potential, and the testing circuits are so arranged that provided the apparatus is in adjustment it is impossible for two circuits to seize the same outlet. This makes double connections virtually impossible and has the additional advantage that a circuit cannot be seized if the fuse is blown.

The selectors drive at a speed of 60 steps per second (minimum) and the outlets are tested two at a time. This high speed of testing enables large groups to be hunted over without interfering with the interdigital period.

Traffic between the Auto-Manual Board and the Automatic Equipment.—A trunk indicator circuit is used for this purpose. The operator depresses the order wire button associated with the group of trunks required; the jack to be used is selected automatically, and is indicated by a lamp. This method does away with the click test for small groups, and the group click test or visual engaged signals for the large groups. The latter is not satisfactory on account of the glare and the battery drain, and the former is inconvenient for large groups.

General Description.

In principle the line finding arrangements are built up in 5,000 line units, comprising 50 groups of 100 lines. First and second line finders are used and in a 5,000 line unit every first stage path has access to every line.

Each selecting stage is divided up into paths and bypaths. The paths convey the conversational current and are held throughout the call. The bypaths are taken into use for positioning the path selectors and are released immediately the paths are ready to take over. The progress of a call is indicated in Fig. **2**, which shows how the bypath circuits are released stage by stage as the connection is established.

On the initiation of a call, half of the available first bypaths associated with the 5,000 line unit are seized momentarily. The bypath group finders hunt for the group of 100 lines in which the call originated. When two such bypaths have found the group, the remaining bypaths

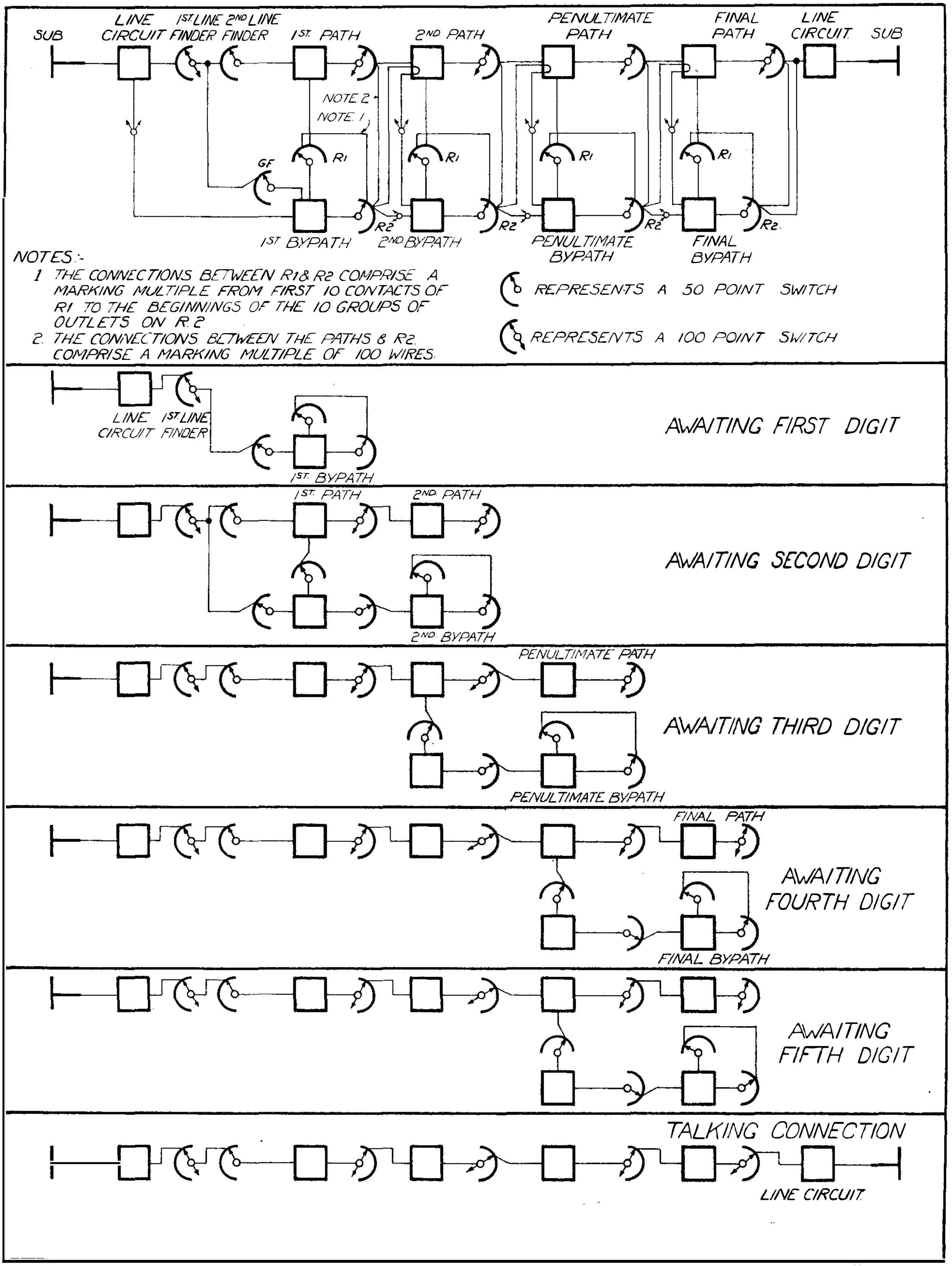


FIG. 2 SHOWS HOW BYPATHS ARE RELEASED STAGE BY STAGE.

come to rest. A test is made to ensure that access is available between the paths under the control of that bypath and the calling subscriber. Each of the two successful bypaths causes a first line finder in the correct 100 line group to hunt for the calling line. Two first line finders, therefore, hunt for each call.

When one first line finder has found the calling line, the other is brought to rest and its bypath released. The line is now extended over the first line finder and the group finder to an impulsing relay in the first bypath and dial tone is given to the calling subscriber.

Apart from the group finder, the bypath has two other selectors known as R1 and R2. R1 responds to the dial impulses and pilots R2 to the required group. R2 searches in that group for an idle second stage path whose bypath is also free and R1 hunts for an idle first stage path. When R2 has found a free second stage path, the positive and negative lines are switched through direct to the second stage bypath, while the test lead holds the path busy.

When R1 has seized its path, the second line finder is rotated to the position marked by the group finder in the bypath and the selector is rotated to the position marked by R2. During this period a temporary path has been established to convey the next series of dial impulses over the banks of the first finder, the group finder and R2, to the impulsing relay in the second stage bypath.

Like the first bypath, the second stage bypath has an R1 and an R2 selector. R1 responds to the second digit, piloting R2 to the correct group. R2 then searches for an idle outlet to the penultimate stage, while R1 hunts for the path as marked for the call by the first stage path, in order to provide paths of access between the bypath and the path to enable the positioning of the path to be controlled.

When communication has thus been established between the path and the bypath of the second stage, the first stage bypath is dropped and is available for another call.

The call proceeds in this manner from stage to stage, but the penultimate bypath remains in circuit until the wanted line is tested, in order to signal to the penultimate path whether the line is free or busy; immediately this signal is conveyed, the penultimate and final bypaths are released and the connection is left established over the paths.

The connection is held from the penultimate path, which provides the talking current to both subscribers.

At the moment the wanted line is seized, continuous ringing is transmitted for about 200 milliseconds, followed by the usual interrupted ringing, which is tripped when the called subscriber answers.

The release of the connection is normally under the control of the calling subscriber, but should the call be held for more than a predetermined period after the called subscriber has cleared, the whole connection is forcibly released, the calling line appearing as a permanent loop. Conversely, should the calling subscriber clear but the called subscriber fail to clear, the train will be released as far as the penultimate path, which path, together with the final path, is held under the control of the called subscriber, in order to prevent the line finders coming into operation unnecessarily. If the called subscriber continues to hold on for more than a predetermined period, the remainder of the train is forcibly released and the called subscriber is treated as a permanent loop.

In the event of the wanted line being busy, or the bypaths failing to find an idle outlet at any stage, busy tone is sent back to the calling subscriber.

If the system is applied to a multi-exchange area, outgoing relay sets and special incoming stage circuits are used.

The outgoing relay set is reached from the R2 switch of the 1st or 2nd bypath, repeats the impulses over the junction and holds the preceding stages operated. When the preceding path selector is positioned, a relay is operated in the relay set which causes the release of the bypath. The path circuits and the relay set remain in circuit during the conversation, the latter controlling supervision and metering.

The incoming stage circuit differs from an intermediate stage circuit in that the bypath cannot be tested directly over the junction. The junctions are terminated, therefore, on line and cut-off relays and the incoming paths and bypaths have finders which pick up the calling junction, special steps being taken to ensure rapid finding.

COMMON CONTROL SYSTEM.

R. Taylor and C. E. Beale,

Engineering Department, Automatic Telephone Manufacturing Company, Limited.

As a preliminary to a brief description of the Common Control System, it would appear desirable to draw attention to certain features of the British Post Office Step-by-Step System employing uni-selectors (rotary line switches), in order to emphasise the two basic principles that have been incorporated in the new system to secure important economic advantages.

In the Department's present standard system, each switching operation is effected under the control of a number of relays, which are definitely associated with individual switches. The number of relays provided depends upon the particular switching stage, and upon the functions to be performed. Thus, 10/10 group selectors have five relays, whilst regular final selectors have either eight or nine relays. It will be appreciated that, whilst each of the relays of group selectors rapidly functions in a definite sequence to establish connections, only one relay —*i.e.*, the wiper switching relay—remains held for the duration of the call. Thus for something like 99% of the holding time of the switch, four of the five relays perform no useful function. Similarly, on regular final selectors, only four of the eight or nine relays are held for the full duration of the call.

There are thus a number of relays that perform what may be termed transitory functions, and in the Common Control System these transitory functions are performed by detached groups of relays, each group being arranged to control a number of switches. To the switches themselves are fitted only the relays that are required for the full duration of the call, plus one relay that serves to link up with the common control group during the setting up of the call. The total number of relays is therefore considerably less than in the present standard system, and this, of course, effects important economies, both in first cost of the apparatus, and also in mounting space. For example, whilst a 10′ 6″ rack mounts 70—10/10 group selectors, having a total of 350 relays, the same rack mounts 80—10/10 common controlled selectors, together with the common control relay groups, making a total of only 220 relays. There is thus an average of only 2.75 relays per switch, as against 5 per switch, whilst 11.4% more can be mounted in the same space.

This principle of common control is by no means new, having been patented so long ago as 1913, but it is only recently that, due to the steady improvements in manufacturing methods and to the increasing use of auto-routiners, it was felt that advantage could be taken of the economies it makes possible.

Consideration will now be given to the line finder principle, which has already been extensively adopted in America and Canada by the Bell Telephone Companies and by the Canadian Bell Telephone Company respectively. 20,000 lines of line finder equipment have recently been installed in Victoria, B.C., for the British Columbia Telephone Co. and Director line finder equipment is being installed at the present time in the Johannesburg Area for the South African Post Office.

A total of approximately 700,000 lines of Strowger line finder equipment is giving service in large exchanges in various parts of the world.

Unlike the present system, in which each subscriber's line is provided with an individual uni-selector and pair of line and cut-off relays, the Common Control System employs small groups of two-motion switches operating in the reverse direction and functioning as line finders, each group serving 200 subscribers lines. Line finder switches are provided at the rate of from 12 to 30 per 200 subscribers, depending upon traffic values.

In regard therefore to the method of operation on originating calls, the two systems are fundamentally different. On the present system, the subscriber's uni-selector hunts to extend the caller to a trunking switch, whereas on the line finder system a preselected finder switch hunts to find the calling line for the purpose of extending it to a trunking switch. Hence, the line finder system is much more economical in regard to the apparatus employed to seize a switch for the first switching stage, due to the substitution of relatively few two-motion finder switches in place of individual uni-selectors.

Attention is drawn to the fact that, excepting the manner in which calling parties are extended to the first rank of switches, both the present and line finder equipments employ identically the same types of switches for subsequent switching operations.

Now the Common Control System combines the substantial economic advantage of the line finder system with that of the common control principle, the latter being incorporated in every switching stage, commencing with the seizure of a trunking switch in the first rank. The total resulting economy is thus substantial in comparison with the present standard system, amounting to the following approximate reductions in exchanges of average sizes.

	% Reductions.
First cost of automatic apparatus	20%
Mounting space	30%
Volume of apparatus	29%

It follows that these reductions will effect substantial economies in building costs also.

Furthermore, in view of the fact that the switching mechanisms employed in the Common Control System are practically all of the two-motion selector type, maintenance is still further simplified, since there is only one main type of switching component to maintain instead of two as on the present standard system.

Circuit arrangements of the Common Control System have been completed for both Non-Director and Director areas, including the well-known principle of satellite working, employing discriminating selector repeaters. All the circuits conform strictly to the Department's standard circuit principles, including "make drive," priority switching in 10/20 group selectors, fast wiper switching relay in final selectors, etc. Further, since the more important relays, (A, B and C) are in common groups, they are easier to maintain and, as they are required to function only in the setting up of calls, it is thus permissible to design them for maximum impulsing efficiency, instead of their being required to combine the dual functions of battery feed and impulsing, as in the individually controlled system.

Fig. **1** shows a 10/10 group selector of the existing type, having five relays arranged for individual control, whilst Fig. **2** shows the 10/10 group selector having only two relays and arranged for common control.

Fig. **3** shows the general arrangement of the Common Control System for Non-Director areas. In this particular arrangement each subscriber's line is provided with a single relay only, which combines the functions of separate line and cut-off relays. This relay functions satisfactorily on loops up to 1200 ohms. As previously mentioned, subscribers' lines are arranged in groups of 200 lines, which are served by groups of 200-point finder switches of the two-motion selector type.

When a calling party lifts the receiver to make a call, the operation of the line relay operates a start relay in the distributor. The operation of the line relay also " marks " the calling subscriber's line on the finder switches, whilst the operation of the start relay immediately causes a preselected finder switch to hunt both vertically and horizontally until the calling line is found. Thereupon, the calling line is switched through to a first selector and common control relay set. The calling subscriber's line relay is then caused to perform the cut-off function, to clear the line and release the distributor, which then preselects another finder switch in readiness to deal with the next call.

This sequence of operations is normally accomplished by the time the calling subscriber has placed his receiver to his ear to listen for dialling tone.

As each digit is dialled, the successive common control relay sets are released, leaving the connection held by a minimum number of relays, as shown in Fig. **3**.

Circuit Operation of 10/10 Group Controlled 2nd Group Selector. See Fig. **4**. As stated above, 200-point selectors would normally be employed, but to facilitate description the circuit of a 100-point, or 10/10 selector, is given.

When seized for the purpose of establishing a call, relay K in the switch and relay A in the common control relay set operate in series. Operated contacts A1 close the circuit of relay B, which operates to apply earth at operated

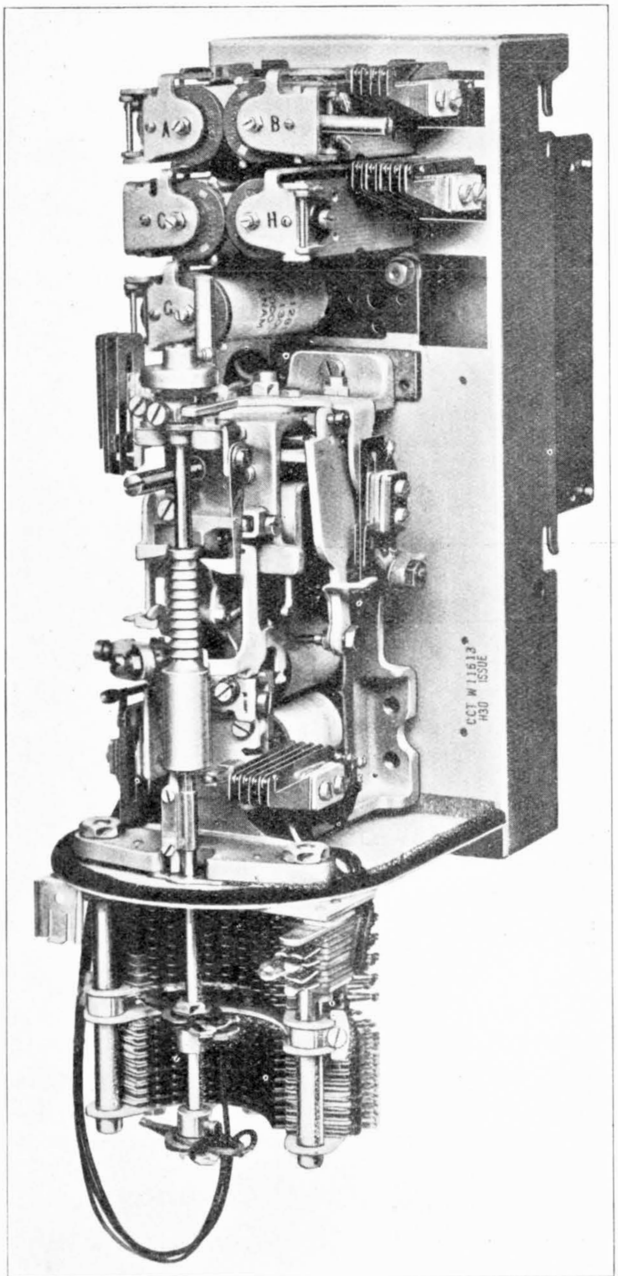


FIG. 1.—10/10 GROUP SELECTOR AS AT PRESENT USED.

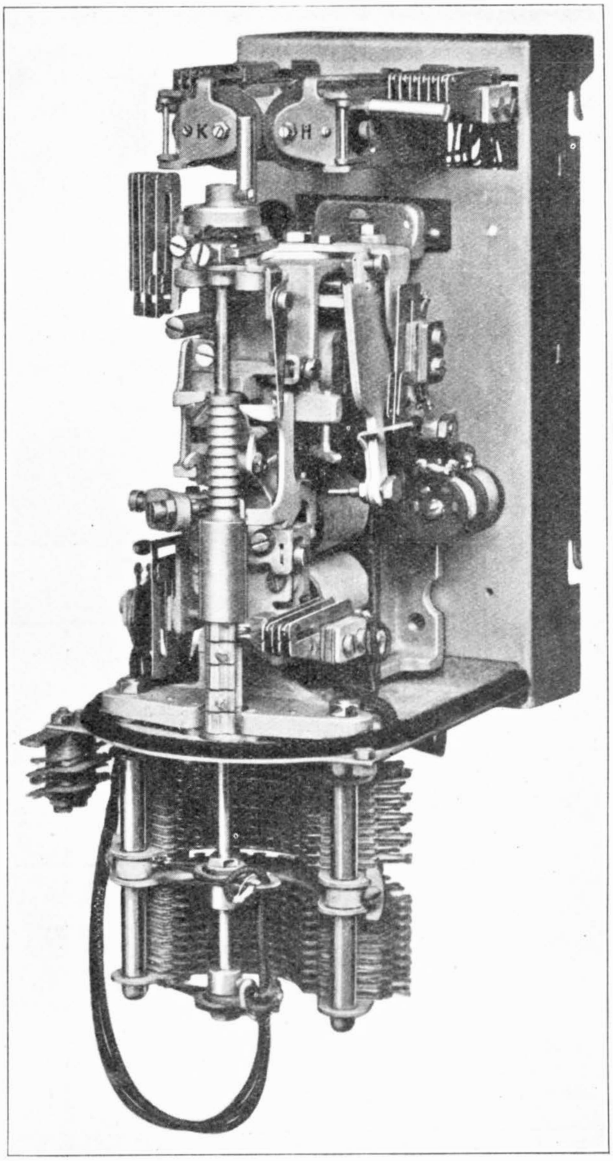


FIG. 2.—10/10 GROUP SELECTOR FOR COMMON CONTROL.

contacts B2 to the P wire to hold the preceding switches. Operated contacts B2 also complete a locking circuit for relay K, whilst operated contacts B3 prepare the vertical magnet circuit. Operated contacts B1 also earth the P wire, to provide an overlap earth on switching through. Relay A responds to the dialled impulses and causes the shaft to be stepped over the circuit-pulsing contacts A1, operated contacts B3, normal contacts BB2, 4 ohms winding of relay C, rotary normal springs NR and operated contacts K3. Relay C remains steadily operated during the vertical action and, due to being slugged, releases in about 100 milli-seconds after the shaft has been raised to the level dialled.

The rotary magnet circuit is then completed *via* operated off-normal springs, N, operated contacts K4, normal contacts G2 " *y*," restored contacts C3 and operated contacts B2. The wipers are therefore cut-in to the first set of contacts and, if these are engaged, relay G operates *via* the operated rotary interrupter contacts, R,

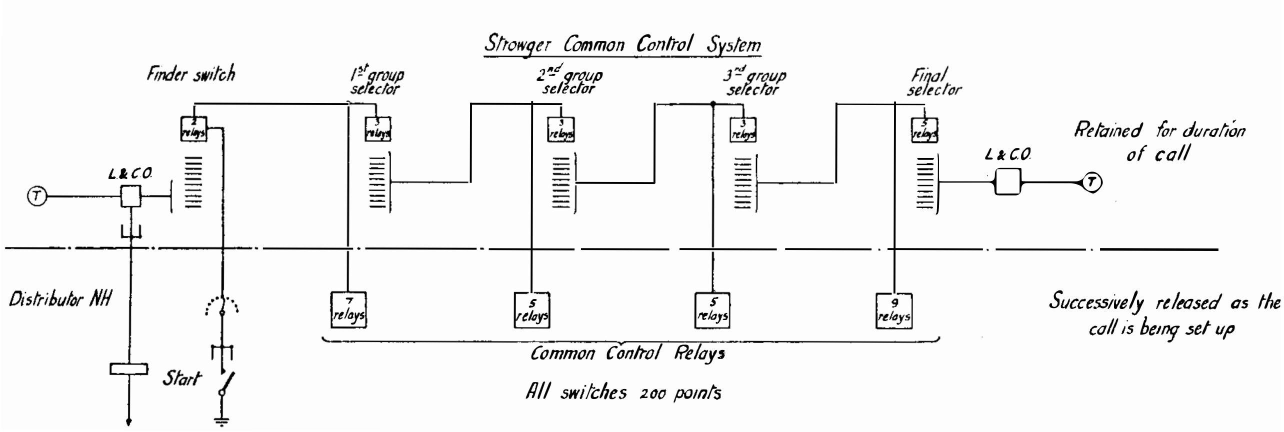


FIG. 3.—FOR NON-DIRECTOR AREAS.

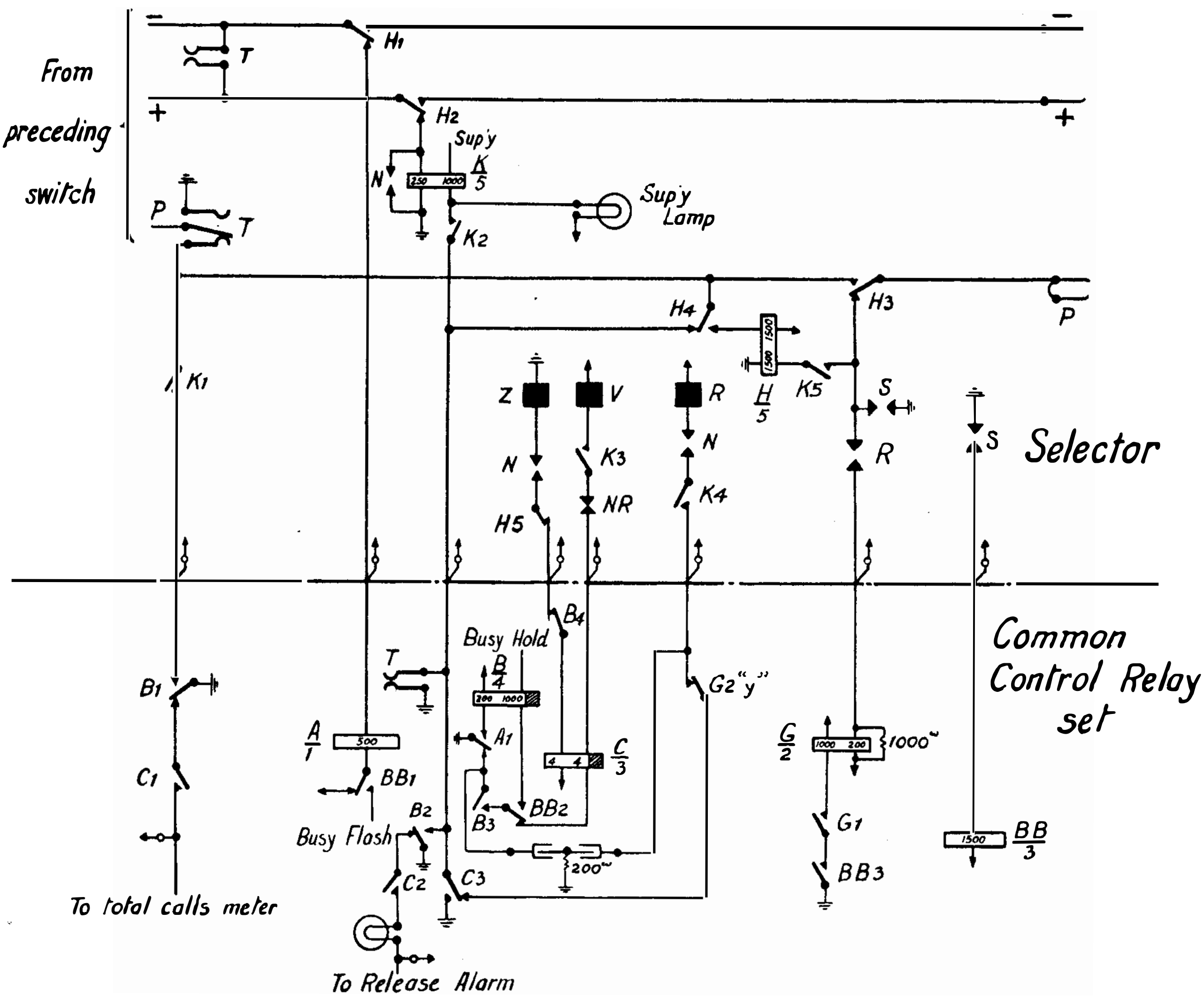


FIG. 4.

normal contacts H3, and positive on the P wiper. Relay G disconnects the rotary magnet circuit at operated contacts G2 "y." The rotary armature therefore releases and disconnects the rotary interrupter contacts, R, thus releasing relay G. This cycle of operations continues until the wipers reach a disengaged set of contacts, whereupon relay H operates in series with relay G, which, however, remains normal, due to the high resistance of relay H. The operation of relay H switches the line through to a selector in the next rank, *via* operated contacts H_1, H_2 and H_3. Relay A in the common control set is then disconnected and therefore releases, being closely followed by the release of relays B and K.

The switch is held by relay H to the P wire, whilst the common control relay set is now free for further use.

In the event of all outlets being engaged, the wipers would be rotated to the 11th step, whereupon the cam springs make contact to operate relay BB and connect earth to the private wiper for overflow metering. The operation of relay BB holds relay G to prevent further rotary motion, connects busy hold to relay B and connects busy tone and flash through relay A to the calling party.

One feature of the Common Control System that contributes to the high economy of the system as a whole is that of partial secondary trunking, which is employed in connection with the line finders, and may be explained as follows:—Assuming that the originating traffic per subscriber is 0.05 T.U., then the total traffic for a group of 200 subscribers would be 10 T.U., which, with a grade of service of 1 in 500, would require 20 line finders. If 10 T.U. are offered to 20 line finders in a definite order, it can be shown that the first 12 line finders will carry 8.8 T.U. or 88% of the total traffic, whilst the remaining 8 switches will only carry 1.2 T.U. or 12% of the traffic. Under these conditions the average occupancy of the first 12 line finders is 0.733 T.U., as against an average of only 0.150 T.U. for the last 8 switches. If now a group selector be definitely associated with all the 20 line finders, the average occupancy of the first 12 selectors would be satisfactory, whilst that of the last 8 selectors would be extremely low. Therefore, in order to increase the average occupancy of the selectors associated with the last 8 line finders in each 200-lines group, partial secondary finder equipment is employed, and consists of 8 groups of secondary finders of the uni-selector type. One line finder from each 200-line group is connected to each secondary finder group and full availability conditions thus obtain with regard to the selectors associated with the secondary finders.

It should be noted that the bulk of the busy hour traffic is carried by those line finders that are directly associated with selectors, and that the partial secondary equipment is only called upon during the peak periods of the busy hour. The circuit arrangements are such that, whilst the finder switches are not tested in a definite order, a call cannot engage a finder in the secondary group unless all the primary finders are engaged.

Under these conditions, the traffic overflowing from the direct group into the indirect group will be the same as if the line finders were tested in a definite order up to the dividing point between two groups.

In conclusion, it may be remarked that the

FIG. 5.—COMMON CONTROL SELECTORS AT BISHOPSGATE.

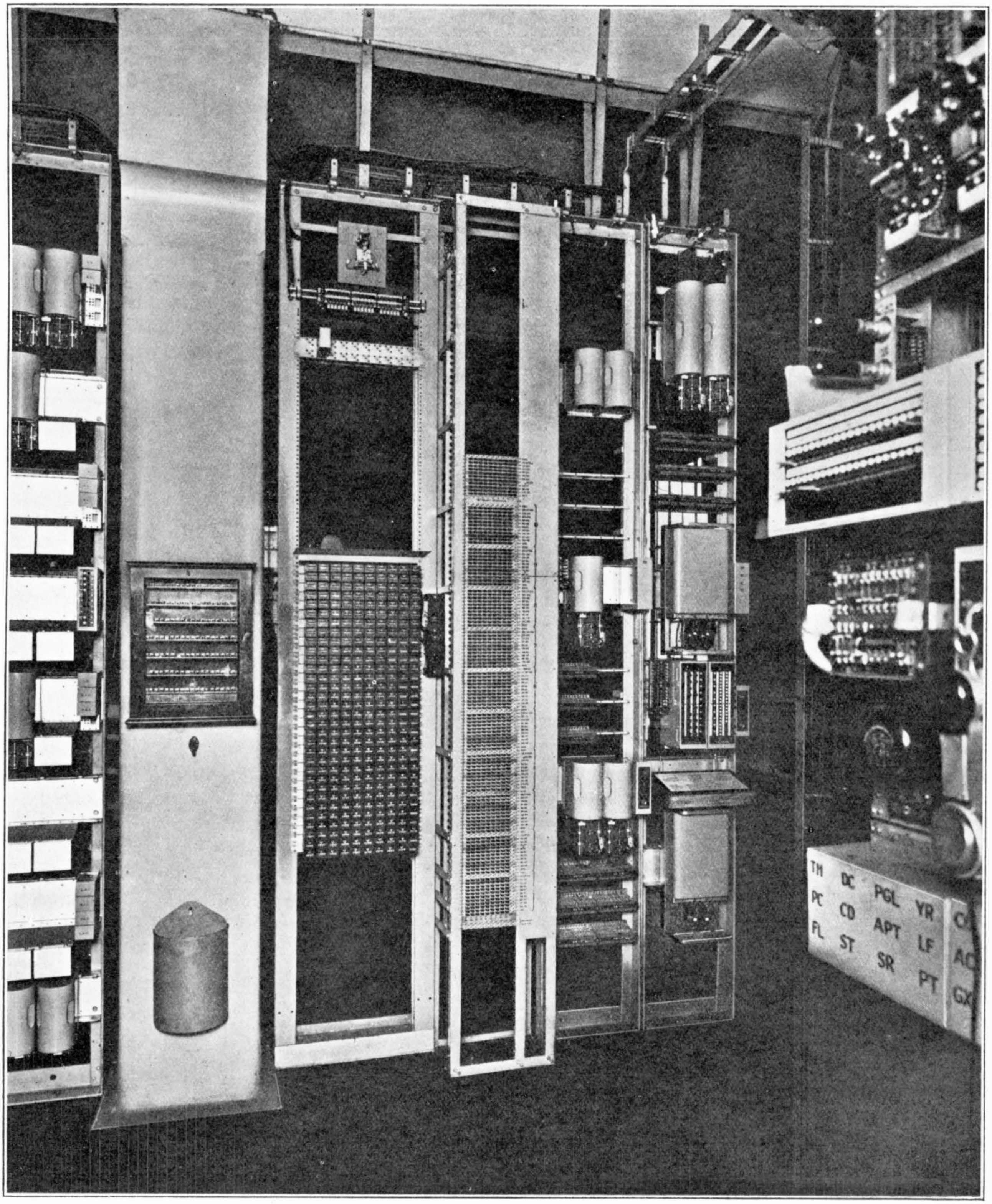


Fig. 6.—Routiner for Common Control Selectors and Auxiliary Equipment for Traffic Investigations.

physical disposition of the common control groups relative to the switches they control is such that the tracing of calls, usually a difficult and almost an impossible procedure on systems employing various forms of common control, is perfectly simple. For example, on a group selector rack containing say 8 shelves of 10 selectors each, there is also one shelf containing 10 common control relay sets. The wiring arrangements are such that the switches in position 1 on each shelf are each controlled by the common control relay set in position 1, and so on. This arrangement is, of course, of considerable importance for maintenance purposes. Furthermore, the order of testing by the preceding switch is arranged to be in the order A1, B2, C3, D4, E5, etc., thus ensuring that the common control relay sets are taken in order, and equalising the traffic over the shelves of switches.

An experimental trial equipment, consisting of three racks of common controlled 10/10 group selectors and a routiner, has recently been installed in Bishopsgate exchange. The purpose of this experimental trial equipment is primarily for traffic investigation. Auxiliary equipment in the form of traffic meters is therefore fitted for the purpose of obtaining traffic data, and means are provided whereby the holding times of both the common control relay sets and the switches can be ascertained at all stages of the calls. Ordinary exchange traffic is now passing through this equipment.

Fig. 5 shows a front view of the three selector racks, the shelf of uni-selectors being for the special purpose of applying varying holding times to simulate the traffic conditions on different ranks of switches.

Fig. 6 gives a view of the routiner and the auxiliary equipment employed for traffic investigations. The entire equipment has been handed over to the Department's engineers, to whom acknowledgements are due for the excellent facilities provided.

THE GRUB MENACE.

J. C. Dallow.

Telephone engineers, in the course of their foremost duty of the preservation of line wires, frequently find themselves at war with nature. In fact, the engineer has good reason to say that in Dame Nature he has a malicious enemy who adopts every means at her command to cause breakdown of his plant.

Passing over the more violent methods such as damage by storms, nature also uses more insidious ways to interfere with the lines of communication. Among these is destruction by microbes and insect life. Engineers are well aware of the expensive plant and process necessary to preserve poles against wet rot, and the manufacturers of submarine cables are forced to take special precautions against the teredo worm, with its remarkable boring capabilities.

Another member of the insect world has now made its first serious onslaught against telephone equipment in this country. This is a type of clothes moth, which has launched its attack in the heart of the London Telephone System, at Tandem Exchange.

Occasional moths are not uncommon amongst wiring which has lain undisturbed for some time. There is at least one case where insect powder was used effectively against them on main frame jumper wires in one of the older manual exchanges; but in no previous instance is there any record of destruction similar to that which has been experienced at Tandem.

About the middle of January last it was noticed that jumper wires recovered from the main frame had patches on them where the insulation had been removed almost to the conductor itself. At first this was assumed to be due to abrasion, but closer examination, coupled with the discovery of some maggot-like insects, showed that the latter were responsible for the damage. It was found that a large number of wires under the top layer in all parts of the frame were affected. A few moths were also seen, but these were far outnumbered by the grubs.

The matter was then taken up and in order to devise safe and certain methods of extermination it has been necessary to study the lives and habits of the insects.

Investigation has shown that the caterpillar is the larva of a moth belonging to the family of "Tineidæ," its name being "Tineola Bisselliella," the wool moth. Fig. 1 shows one of the insects considerably magnified, the actual size being ¼ to ⅜ inch long. The head of the larva is brown and has a hard cuticle. In the front the head is provided with mandibles or jaws, which operate with a sideways movement, meeting like a pair of pincers. By means of these the grub cuts into and eats the woollen insulation of the wire. The head is also equipped with six simple eyes. These are, however, very imperfect, and appear as small spots on the head.

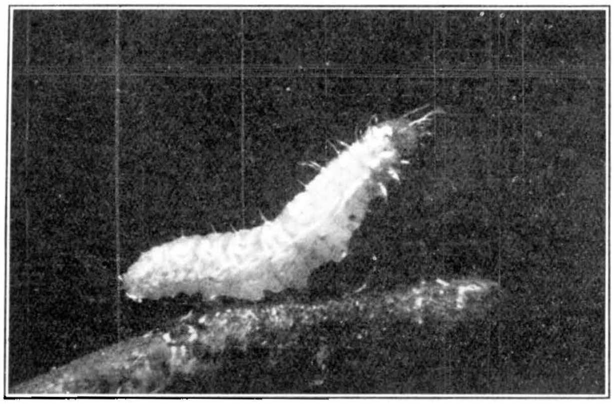


Fig. 1.
Photo by Dallow.

The body of the larva is white and is made up of a number of segments, each being equipped with hairs. Movement is accomplished with the aid of three pairs of legs near the head, each leg terminating in a small claw. Beneath the abdominal portion of the body are a number of circular protrusions, each equipped with minute hooks, which also assist the grub in its switchback method of progression.

The caterpillar has an insatiable appetite and feeds continually. Very fortunately, it dislikes rubber, so that the jumper wires which have been attacked still possess the thin layer of rubber adjacent to the conductor. After digestion of the food has taken place, during which process it travels the whole length of the body, the insect discharges tiny slate-coloured pellets. These are turned to good use by the larva. It spins silk, in which it entangles the pellets, along with particles of dust and other rubbish, to form a mass of web. In this the insect conceals itself. Fig. 2 shows a colony of larvæ together with a mass of the collected material, which clings to the wires. The silk is extremely fine, and is only visible in a powerful light as a glistening filament. The photograph also shows patches on the wires where the insulation has been eaten away to the rubber coating.

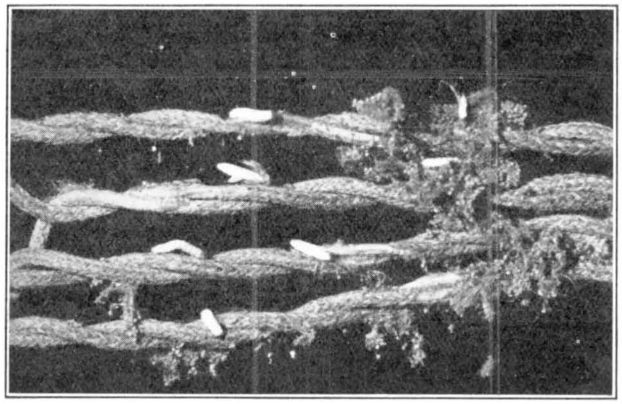


Fig. 2.
Photo by Dallow.

After a period of gorging, which is usually about ten weeks, but which varies according to the temperature and general surroundings, the larva spins silk around itself and forms a chrysalis. At this stage the metamorphosis occurs. The sluggish, repulsive larva which formed the chrysalis emerges after about two weeks as a flimsy moth, its wings gleaming with a golden metallic sheen. In Fig. 2 a moth is shown on each of the inner wires. The main function of the female moth is to lay eggs, which will hatch out into larvæ. It deposits a number of eggs at a time and one moth in the course of its short existence of a week or two may lay as many as 150 of the minute eggs. Contrary to the feeding-by-biting method of the caterpillar, the moth can absorb food only by suction through a tube or proboscis situated in its head. It also has two fairly long antennæ, and is provided with two large compound eyes. Each of these is actually a number of little eyes amalgamated together, and under the microscope the whole looks similar to the surface of a blackberry.

The moth during its short life feeds very little or not at all. The energy for the transformation from larva to moth and the strength necessary to manufacture the eggs are provided mainly by the fattened larva before it enters the pupal stage. Since the moth can absorb nutrition only by suction, its food must be in a liquid state. The fact that so few moths have been seen at Tandem may perhaps be due to their premature death owing to the extremely dry conditions prevailing.

Several methods of extermination of the pests have been suggested and the investigations in this direction may be divided into three stages:

1. To arrest the reproduction of the larvæ.
2. To destroy all eggs, larvæ, chrysalides and moths in order to effect a complete cure.
3. To impregnate or alter the composition of jumper wire insulation so that the insects cannot feed on it, thereby avoiding recurrence of the trouble.

It is, of course, necessary to examine very closely every means of combating the insects, since it is easily possible for the remedy to be more harmful than the affliction.

At the time of writing the pests are being effectively checked by brushing and agitating the wires; all the insects and material which are dislodged are caught on sheets and burned.

To effect a complete cure it has been suggested that the whole main frame should be heated to a temperature of 60°C., and that state maintained for 48 hours. This, however, has been abandoned since it would probably melt the wax of the terminating cable forms, and might have an injurious effect on the insulation of the frame.

Experiments are now being conducted with various chemical sprays with the object of destroying all forms of the insects in the present attack, and rendering the insulation of the wire permanently fatal to the larvæ. Future specifications for the wire will probably include particulars of treatment of the wool which will prevent a recurrence of the trouble.

A peculiar feature of the attack is that, so far as is known, it is confined to the one exchange. This is the more remarkable since there are, apparently, many other frames which would be more conducive to the development of this type of insect than that at Tandem. The frame at Tandem is in a warm, dry atmosphere, and one side of it receives no daylight. It is, however, of modern design and all the wires are comparatively free, there being no thick, tangled mats of wire such as are frequently found in older types of frame. Work is also being constantly carried out and the wires are thereby disturbed.

SELLING BY TELEPHONE.

IT is well known that the average day calling rate is considerably lower in this country than in the United States. The Ratio of day to busy-hour traffic is also lower. A higher day calling rate would mean greatly increased prosperity for British telephones, not only in regard to revenue but also in regard to the rate of growth in the number of stations. In a system such as ours, in which the proportion of telephones working on the automatic principle is rapidly increasing, the ratio of day to busy hour traffic is of special importance because every additional call completed outside the busy-hour yields a higher proportion of profit than calls completed within the busy hour. Increased profits enable tariffs to be reduced; rapid extension of the system follows as a logical consequence.

Our object in stating these principles is to emphasize the importance of tendencies or developments in business methods or social habits which may have the effect of raising the day calling rate or improving the ratio of day to busy-hour traffic. Such tendencies should be discovered and encouraged in their earliest stages and their development should be followed with the keenest interest by all who are anxious for increased prosperity in the telephone industry.

After reading a remarkable book entitled "Selling by Telephone," a second edition of which has recently been published in the United States, we are convinced that such a tendency is now well advanced and definitely operative in that country. We are also convinced that when the new methods so ably described in this book are understood and that when the success attending their application in America becomes more widely known, it is highly probable that they will be taken up, developed along lines to suit British conditions and applied with equal success in this country with consequent advantage to the British Telephone System.

"Selling by Telephone" is not written with the direct object of bringing more business to the telephone system. It is written for Manufacturers, Wholesalers, Department Stores, Retailers, Financial Houses, Newspapers, etc., with the object of bringing prominently to their notice:—

> "An exceedingly active series of changes, all of which tend strongly to place emphasis upon that medium of universal personal communication, combining speed with low cost—the telephone. They tend, in short, to adopt, to co-ordinate, and to develop effective methods for making the fullest practical use of this device, second only in importance, and complimentary to advertising in sales work."

The author, Mr. J. George Frederick, is widely known in the United States as an authority on business subjects and as a business research man actively engaged in advancing business practice and the technique of salesmanship. He has carried out an extensive and careful investigation into the principles and practices of successful telephone salesmanship and in this book the results of his labours with many examples of actual results in various branches of business which have been realised in practice are set forth in concise and convincing language. He shows clearly that business men are only just beginning to realise the enormous importance of the telephone as a sales instrument and that as its value is better understood its use will rapidly increase. To quote the author's own words:—

> "Here then is a communication machine of national scope whose usefulness in national selling is only beginning to be appreciated. . . . . The extent to which the telephone can be used for this purpose would seem to depend largely upon the vision, initiative, and ability of sales managers to organise for telephone selling activities and establish policies which shall guide them along lines that will co-ordinate rather than upset the equilibrium of forces of efficient distribution. Promising beginnings have been made, but much remains in observing and completing the essential facts about demand creation by telephone, in classifying them, co-ordinating them, and establishing their mutual relations. The relation, however, between the requirements of efficient distribution and the adaptability of a nation-wide system of telephone communication is obviously such as to provoke rapid progress in the art of telephone selling."

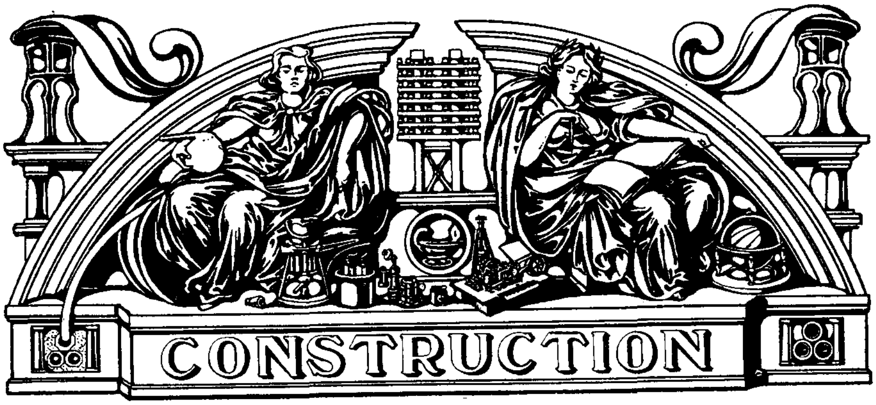
The telephone companies are, of course, co-operating in the new movement. In his description of what is known as the "Sequence Toll Call Plan" the author says:—

> "Very naturally one of the very first aids to telephone selling that suggests itself is an arrangement whereby the telephone company may facilitate in every possible way the handling of a large number of toll calls during a limited period. The telephone companies have now very thoroughly worked out plans for such assistance. They have taken upon themselves as much as possible of the labour and effort, in order to make telephone selling easier, faster, and better."

We wish that every Director and Sales Manager in this country would read and study this inspiring book. If, as a result, they decided to put the new methods to the test, they would find ready waiting for them an up-to-date nation-wide telephone system competent and eager to co-operate in the experiment.

"Selling by Telephone," by J. George Frederick. Published by Business Bourse, 80 West 40th Street, New York: 339 pp.: $4.00.

J.J.M.



REINFORCED CONCRETE POLES FOR TROPICAL USE.

E. Harper, M.I.E.E., Mem.I.R.E.,
Chief Engineer, Ceylon Post & Telegraph Department.

THE Telegraph Engineer is faced with many difficulties in the Tropics which his confrere in more temperate zones escapes, and the supply of suitable posts on which to erect his wires is one of the most troublesome of them.

A plentiful supply of specially grown larch, pitch pine, red fir and cedar impregnated with creosote has solved the problem of a cheap and suitable wood post, having a long life, in most countries within the temperate zones, but the tropical problem is rather more complicated.

Creosoting has a much shorter effective life under a tropical sun with the torrential rains to assist in washing it out of the surface wood and no soft woods can then withstand the attacks of the myriads of termites or white ants, so that even if freightage charges did not rule out the creosoted pole as an economic proposition the white ants would do so.

Most indigenous tropical trees are of hard wood species which will not absorb creosote to any extent. A few of them are white ant proof, but even in these cases the sap wood is quite useless. As the trees are jungle grown, straight growth of suitable length and girth can rarely be obtained and the poles must be square sawn to the necessary dimensions. When the cost of felling, sawing and carting is added to the heavy depreciation charge, the total cost per pole is very high.

During the past eight years the development of the telephone service in Ceylon has been very rapid and the demand for poles far exceeded the supply of suitable local timber. As much of the development was in rural districts, where costs had to be reduced to an absolute minimum owing to the length of the lines, the economic aspect required most careful consideration.

Galvanised tubular iron poles are in many respects ideal for tropical conditions, but the post-war prices of these have until quite recently been so high as to make their use prohibitive in developing a cheap rural service.

Attention was, therefore, turned about six years ago to the possibilities of locally manufactured reinforced concrete poles. The writer was aware that the suitability or otherwise of this type of pole was a subject of controversy and that they had been tried and abandoned in many countries. An analysis of all the adverse comments and reports on the subject showed that in practically all the countries which had abandoned their use the climate was subject to large variations of temperature, severe frosts, snow storms, and high winds. The concrete developed hair cracks which permitted water to enter and attack the reinforcement. If frost supervened in these circumstances the result would naturally be the rapid disintegration of the concrete.

Ceylon is fortunately not subject to these climatic extremes. Frosts never occur except very slightly in a few places up-country. The maximum daily range of shade temperature only amounts to about 14°, while the Observatory records for the past 10 years show only five occasions when the wind velocity exceeded 40 miles per hour and only two where it exceeded 60, in fact a velocity of 40 miles per hour may be considered very unusual.

Poles used for power transmission and distribution lines cannot as a rule be stayed owing to the dangers incidental thereto. They are, therefore, subject to very considerable horizontal stresses, varying rapidly due to the swinging of the wires, a condition of affairs admirably suited to the development of the hair cracks above referred to.

Poles used for telephone and telegraph lines are invariably stayed or strutted wherever anything more than a very slight angle occurs. All terminal poles are backstayed and on straight routes line stays are attached at frequent intervals to prevent any appreciable swing of the pole line as a whole. The bending stresses on such poles may therefore be regarded as quite small.

After taking into account all the known factors, it was decided in 1923 to experiment with reinforced concrete poles, in order to ascertain whether they could be manufactured locally at such prices as would compete satisfactorily with tubular iron poles and to obtain data for a suitable design.

Experimenting in reinforced concrete is decidedly slow work, owing to the length of time the finished article must be seasoned, and a period of two years was occupied in tests and experiments covering the following points:—

(1) Most suitable type of reinforcement.
(2) Design of reinforcement and composition of mixture to give maximum strength for minimum weight.
(3) Method of manufacture to give consistent results at lowest cost.

It was decided that the best results would be secured by concentrating the manufacture at one central depot in order that the work could be more thoroughly organised and checked. As all the material, excepting sand and granite chippings, were imported and landed at Colombo and distribution by road and rail was also most convenient at this point, this was obviously the most suitable site for the depot.

The experiments were satisfactorily concluded in 1925, and it was decided on the results obtained to go full speed ahead on the manufacture of concrete poles and abandon the use of wooden poles, excepting in certain special circumstances.

Portland cement was used for the mixture in all the poles turned out up to the end of 1929. Experiments were then made with some of the rapid setting aluminous cements. With these it was possible to obtain a pole of rather greater strength for the same weight and dimensions, while the period of seasoning could be considerably curtailed.

The aluminous cements are slightly more costly than Portland cement, but it was found that a mixture containing rather less of the former could be used, thus levelling up the cost of material. The speeding up of the seasoning process resulted in a small nett saving per pole, while the added convenience was considerable. Aluminous cement is, therefore, now used exclusively, and the following notes on manufacture are based on the use of this.

Moulds.—These are made of 1″ teak, the sides being keyed together as shown in the foreground of Fig. 1. With this method of building the

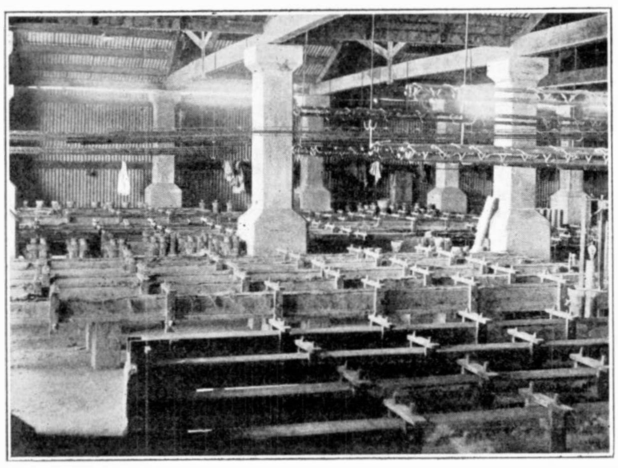


FIG. 1.—MOULDING SHOP.

moulds no difficulty has been experienced due to warping, and although the moulds have been in continuous use for five years the wood is only now beginning to lose its surface.

The moulds provide for the number of arm slots shown in Table A, each with a 9/16″ bolt hole. On one side is fitted a die for the purpose of embossing a crown, "G.P.O.," length of pole and year of manufacture, the bottom of the letters "G.P.O." being 10 feet from the butt end of the pole. This provides the usual means of checking the depth of setting.

Reinforcement.—The reinforcement consists of mild steel bars of the number and dimensions indicated in Table A, spaced by means of a spiral of No. 8 S.W.G. iron wire, uniformly tapered to correspond to the taper required on the pole.

The bars are tied symmetrically to the outside of the spiral at alternate turns by means of No. 10 S.W.G. iron wire, the flat side of the bars being against the spiral. As large quantities of these tie wires are required, a machine was designed to cut and bend them to the required lengths. Short bars are provided to strengthen the reinforcement at the lower part of the pole, and are tied flat to the inside of the spiral, excepting in the case of the 18 feet poles where they are placed on edge to permit of the mixture being better worked in. Joints in the bars are not permitted. Fig. **2** shows details. The ends of the long bars are turned inwards at the top to form a bearing for the saddle fitting referred to in the paragraph on casting.

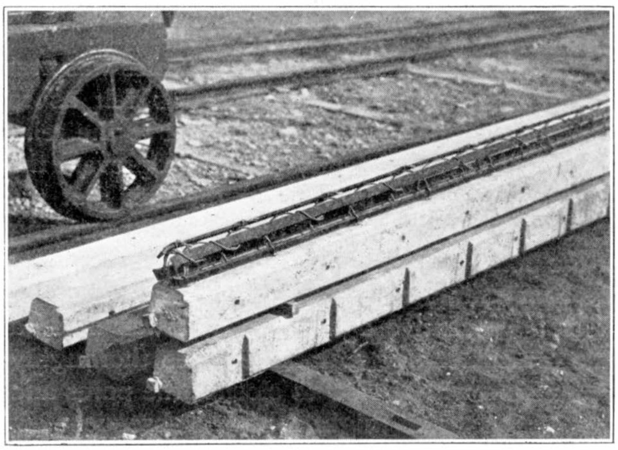


Fig. **2**.—Details of Reinforcement.

The Mixture consists of one part "Ferrocrete" rapid setting cement, two parts river sand and three parts of ½″ metal. Owing to the high humidity of the Tropics fresh cement must be used which must be imported in sealed iron drums. Clean sand and metal, which should preferably be granite chippings, must be used. In order to secure a homogeneous mixture, it is very desirable to use a power-driven cement mixer. The mixture should be sufficiently fluid to allow a good cast to be made, but excess of water is to be avoided. The exact amount of water to be added is largely a matter of experience.

Casting.—The reinforcement is placed centrally in the mould and the dimensions provide for a covering of not less than ¾″ at all points. In working the mixture into the mould, great care must be exercised to avoid air holes and to ensure a smooth surface on all sides of the finished pole.

At the top of the pole, a bolt and nut with thimble are inserted to take a saddle fitting when necessary, the square head of the bolt projecting above the pole. Normally, it remains in position and is unscrewed and replaced by the saddle bolt when the latter is used.

Treatment after Casting.—The poles remain in the moulds four days after casting and during this period are kept moist. On the fourth day they are transferred to a pickling tank of water where they remain for a further period of ten days. They are then stacked and air-dried and seasoned for a period of approximately 50 days before being issued for use. Vide Fig. **3**. These periods are increased by about 50% in the case of poles of 30 feet in length or over and represent

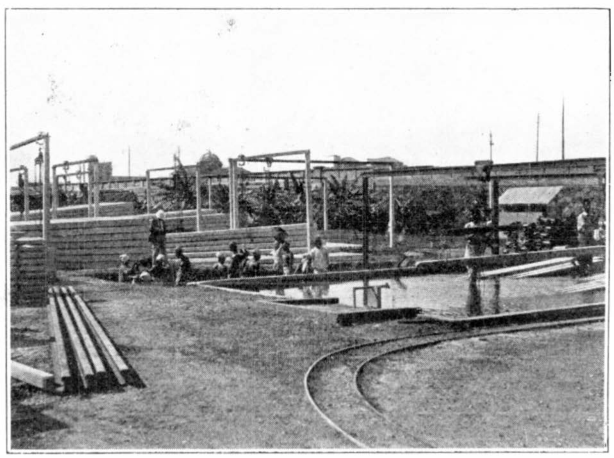


Fig. **3**.—Immersion Tank and Drying Ground.

a saving of 33 ⅓% on the time required for the same process using Portland cement.

Testing.—Frequent tests are made of the poles at 1 month, 3 months and 6 months in the following manner:—

They are rigidly clamped in a vertical position to a concrete base for a length corresponding to the depth of setting. On the other side of the concrete base is erected vertically a stout concrete pole, which is fitted with back stays to be perfectly rigid. A grooved pulley with ball bearings is fitted to the permanent pole and is adjustable in height to suit the pole under test. A wire rope is made off round the pole under test 1½ feet from the top and passed over the pulley. To the other end of the rope is fitted a straight vertical bar and holder for the testing weights. A divided scale, clamped at right angles to the permanent pole, provides means of measuring the deflection under various stresses and also enables the elasticity of the poles to be tested. The method is clearly shown in Fig. 4.

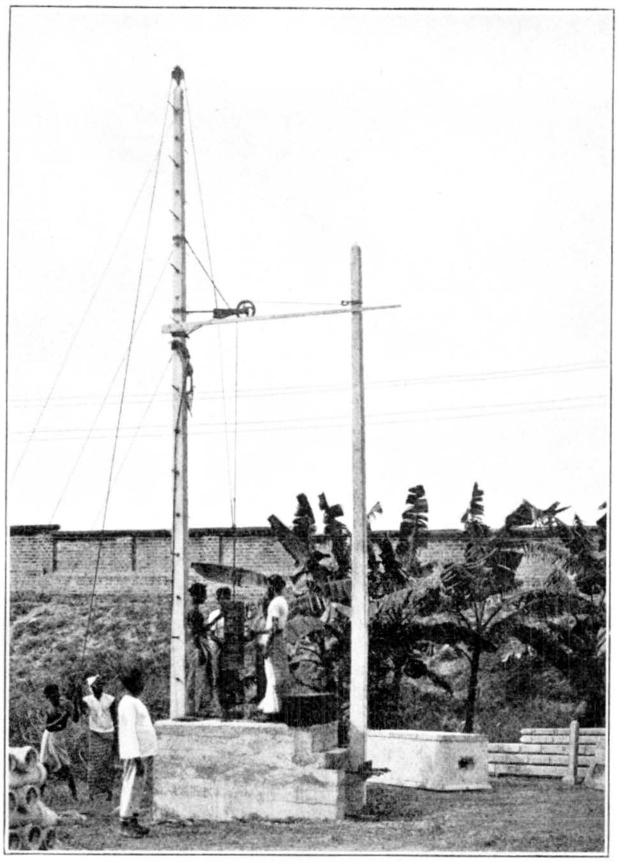


Fig. 4.—Pole under test.

Table A gives the breaking stresses of the various poles after seasoning, while Fig. 5 indicates the breaking stresses for a typical 18 ft. pole at intermediate periods.

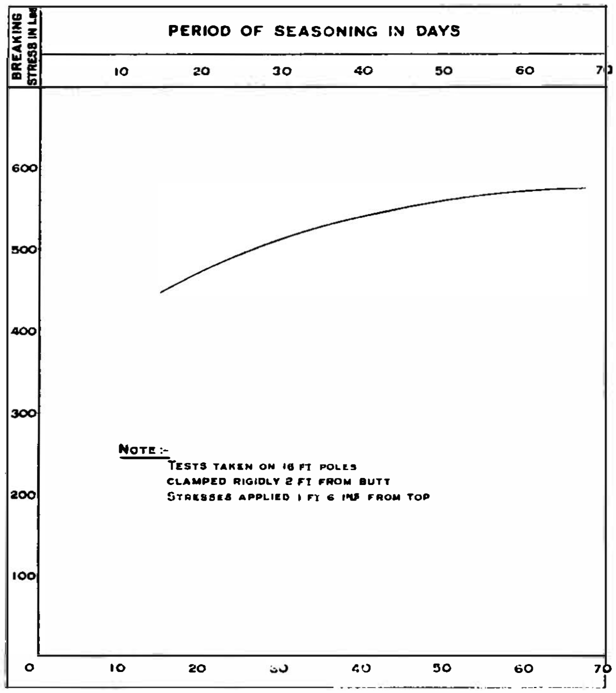


Fig. 5.

When the manufacture of these poles was first commenced, some little doubt was felt as to whether the adhesion of the cement to the reinforcement was sufficiently perfect to prevent the formation of rust, in view of the fact that the appearance of hair cracks due to slight swaying of the poles was inevitable, thus giving access to the heavy rains and humidity of the Tropics.

As a preventive against this, it was made a rule for some time to tar the poles thoroughly on erection with a view to closing the pores and any cracks which might form. Subsequent experience, however, proved that this was an unnecessary precaution.

A number of poles which had stood in unfavourable positions for five years and had received no treatment of any kind were recently taken down and tested. It was found that their breaking stresses were higher than when originally erected. The concrete was then carefully chipped off the reinforcement and the latter was found to be perfectly clean and in as good condition as when the pole was first made. Tarring was consequently stopped forthwith.

The manufacture of these poles in Ceylon gives employment to nearly 100 men, with an output of over 4,000 poles per annum, and nearly 30,000 poles are now in service.

Considerable interest has been shown by several other Colonial Administrations in the results obtained and in some cases it has been decided to follow the example of Ceylon.

It is, therefore, thought that the details now given may assist other Engineers who are faced with the same problems.

Table A.

DATA FOR REINFORCED CONCRETE POLES.

Length ft.	Dimensions of Sides. (Inches) Top	Dimensions of Sides. (Inches) Bottom	Cubic contents Cu. Ft.	Weight lbs.	Spiral Reinforcement Diameter In. Top	Spiral Reinforcement Diameter In. Bottom	Spiral Reinforcement No. of Turns	Bar reinforcement. No. of Bars	Bar reinforcement. Length Ft. In.	Bar reinforcement. Cross section In.	Breaking stress. Load applied $1\frac{1}{2}$ ft. from top of pole.	Bending moment in foot lbs. at ground line.	No. of Arm Slots.
18 (Light)	3 × 3	$4\frac{1}{2}\times4\frac{1}{2}$	2.0	315	$1\frac{1}{2}$	3	54	4	17-10	$\frac{3}{4}\times\frac{1}{4}$	364 lbs.	4925	2
								2	7-6	$\frac{3}{8}$ round			
								2	4-0	$\frac{3}{8}$ —			
18 (Heavy)	4 × 4	$5\frac{1}{2}\times5\frac{1}{2}$	2.8	450	$2\frac{1}{2}$	4	54	4	17-10	$\frac{3}{4}\times\frac{1}{4}$	577 lbs.	7500	3
								4	7-6	$\frac{3}{4}\times\frac{1}{4}$			
22	$4\frac{1}{2}\times4\frac{1}{2}$	7 × 7	5.0	820	$2\frac{5}{8}$	$5\frac{3}{4}$	64	4	21-10	$1\times\frac{1}{4}$	800 lbs.	13200	4
								4	9-00	$\frac{3}{4}\times\frac{1}{4}$			
24	$4\frac{1}{2}\times4\frac{1}{2}$	$7\frac{1}{4}\times7\frac{1}{4}$	5.5	900	$2\frac{5}{8}$	$5\frac{7}{8}$	69	4	23-10	$1\times\frac{1}{4}$	800 lbs.	14800	6
26	$4\frac{1}{2}\times4\frac{1}{2}$	$7\frac{1}{2}\times7\frac{1}{2}$	6.5	1008	$2\frac{5}{8}$	6	74	4	25-10	$1\times\frac{1}{4}$	800 lbs.	16000	6
								4	14-00	$\frac{3}{4}\times\frac{1}{4}$			
30	$4\frac{1}{2}\times4\frac{1}{2}$	8 × 8	8.0	1302	$2\frac{5}{8}$	$6\frac{5}{8}$	84	4	29-10	$1\times\frac{1}{4}$	800 lbs.	18800	6
								4	18-00	$\frac{3}{4}\times\frac{1}{4}$			

Table B.

REINFORCED CONCRETE POLES.

Average Cost of Manufacture in Ceylon.

	Lengths of Poles. 18 ft. L.	18 ft. H.	22 ft.	24 ft.	30 ft.
	s. d.	s. d.	s. d.	s. d.	s. d.
Materials	10 0	12 1	18 5	20 9	26 10
Labour *	4 2 (16)	4 2 (16)	6 0 (24)	6 5 (25)	7 10 (31)
	14 2	16 3	24 5	27 2	34 8
Overhead charges (including rent, depreciation, tools and supervision) 18%	2 $6\frac{1}{2}$	2 $11\frac{1}{2}$	4 $3\frac{1}{2}$	4 11	6 3
Total cost	16 $8\frac{1}{2}$	19 $2\frac{1}{2}$	28 $8\frac{1}{2}$	32 1	40 11

NOTE 1. The cost of materials includes all freight and cartage charges to the site of manufacture.

NOTE 2. * The figures in brackets represent manhours excluding supervision.

NOTE 3. For purposes of comparison it may be stated that the latest prices of tubular steel poles delivered in Colombo are—22 ft. = 38/3 and 30 ft. = 55/3.

THE TRANSANDEAN TELEPHONE CABLE.

THE WORLD'S HIGHEST TELEPHONE LINE.

THE telephone conversation between H.R.H. the Prince of Wales and H.M. the King on February 22nd from Santiago de Chile to Buckingham Palace, London, was an impressive event not only for the public who read of it in the newspapers next day, but also for the royal participants in this extraordinary event. One indication of this was a request received by the Argentine telephone officials from London over the telephone for some photographs that might be shown to His Majesty, illustrating how such a communication could be possible.

Acting upon this request, the Union Telefonica prepared an album of photographs of the laying of the British-made underground cable across the Cumbre of the Cordillera, bound in parchment, and dedicated to the Prince of Wales. This magnificent album, typically Argentine in style, and bearing on the cover the coats-of-arms of Great Britain, Chile and Argentina, was delivered, in a case of glass and parchment, to the British Ambassador in Buenos Aires, Sir Ronald McCleay, P.C.K., C.M.G., by the general manager of the Union Telefonica, Mr. R. E. Petley, with the request that it be presented to the Prince.

On the first inside page of the album is a dedicatory parchment, bearing the coat-of-arms of the British heir and two miniature paintings of typical scenes connected with the installation of the Transandean cable, and with the following text:—

> "To His Royal Highness, the Prince of Wales, this album of photographs, showing the difficult task of laying across the summit of the Andes Mountains the British-made underground cable which has brought Chile within speaking distance of nine-tenths of the world's telephones, and by means of which he was enabled to talk from Santiago de Chile on Sunday, February 22, 1931, with His Majesty King George V. in Buckingham Palace, is most respectfully offered by
>
> The United River Plate Telephone Company, Ltd."

The Ambassador expressed great pleasure at receiving the album, which was added to the Prince's collection of momentos of his second South American tour.

The cable was made at the North Woolwich Factory of Messrs. Standard Telephones and Cables, Ltd. The first of its kind to be laid in South America, it is some 8½ miles in length and it is laid in a shallow trench at an altitude of 12,000 feet amongst the snow peaks of the mighty Andes, amidst scenes of majestic grandeur. To lay a telephone cable over the top of the Andes was a formidable task, and the fact that the difficulties were successfully overcome is a tribute to the daring, the resourcefulness and the perseverance of all concerned.

The cable was sent to the Transandean railway stations closest to the new telephone line. From these stations the cable drums were transported on motor lorries to points as near as possible to the scene of operations, following the tortuous route across the Andes. The last stage of transportation had to be carried out by workmen, since the terrain crossed by the new cable is inaccessible to vehicles. This was a task full of difficulties, on account of the nature of the ground and of the great altitude, factors which diminish considerably human powers of endurance.

One of the special characteristics of this cable is the resistance it affords to earthquake shocks, which are sometimes registered in the zone through which it runs. For this purpose special protection is necessary, consisting of two metal wrappings, coiled spirally in opposite directions, and separated by one wrapping of hessian and one of specially prepared cloth. Thanks to this protection, the cable can resist very violent torsions, and security against interruption is thus afforded.

The work of opening a trench for the laying of the new cable was finished in the summer. This proved a tremendous task, for the shortest route was taken, though wherever possible slopes and other difficulties which would have made it impossible to carry through the installation were avoided. On account of the rocky nature of the soil, a great part of the trench had to be opened by means of explosives. In certain parts of the route the snow, which in winter reaches a depth of 15 to 18 feet, had not disappeared, even in the summer season. As soon as the trench was completed, the laying, testing and jointing of the numerous sections of the new cable was put in hand. The installation was carried through

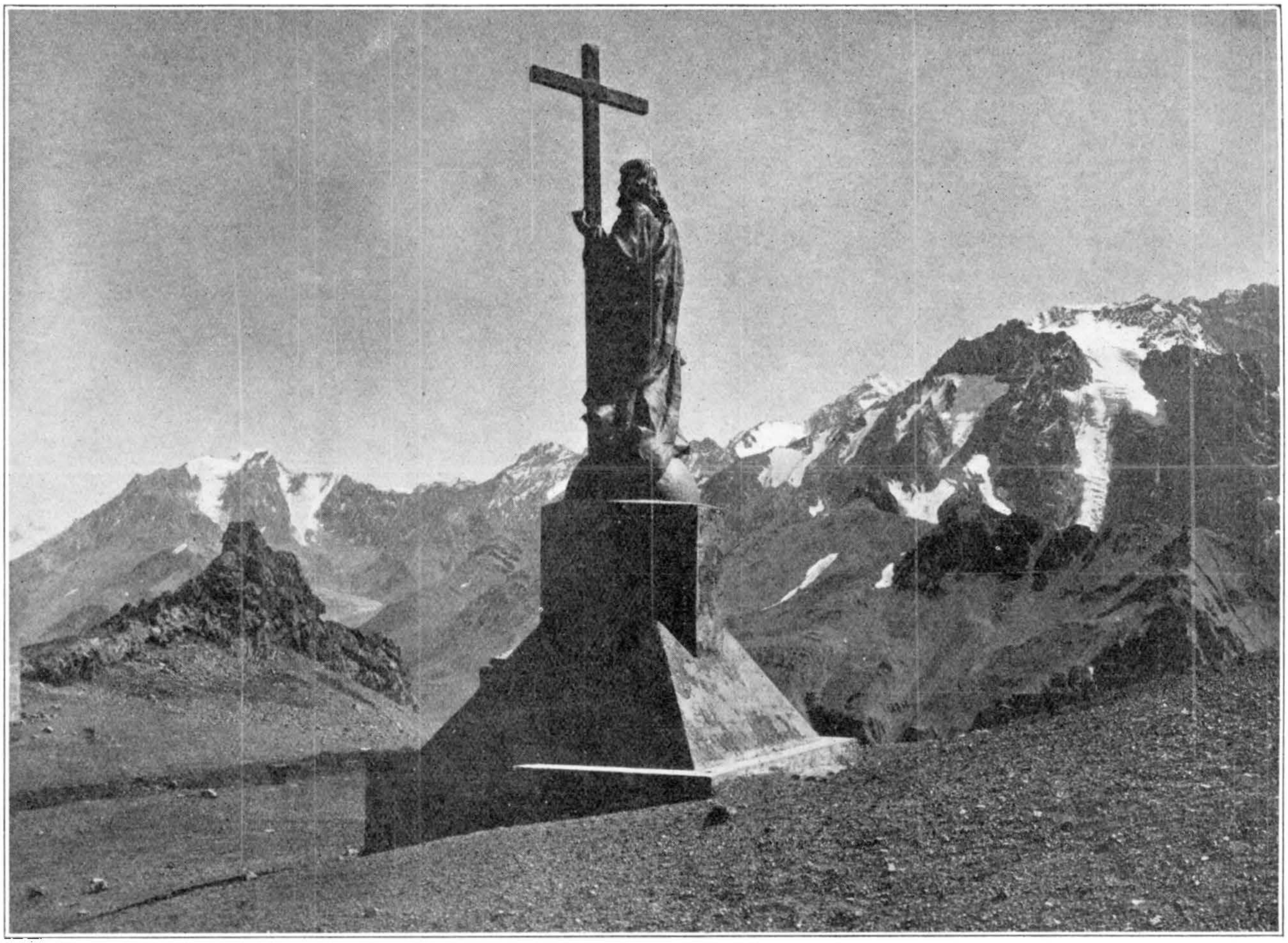


FIG. 1.—REAR VIEW OF THE CHRIST OF THE ANDES ON THE ARGENTINE-CHILEAN FRONTIER. In the background is the cable trench. The statue was erected to signify perpetual peace between the two countries.

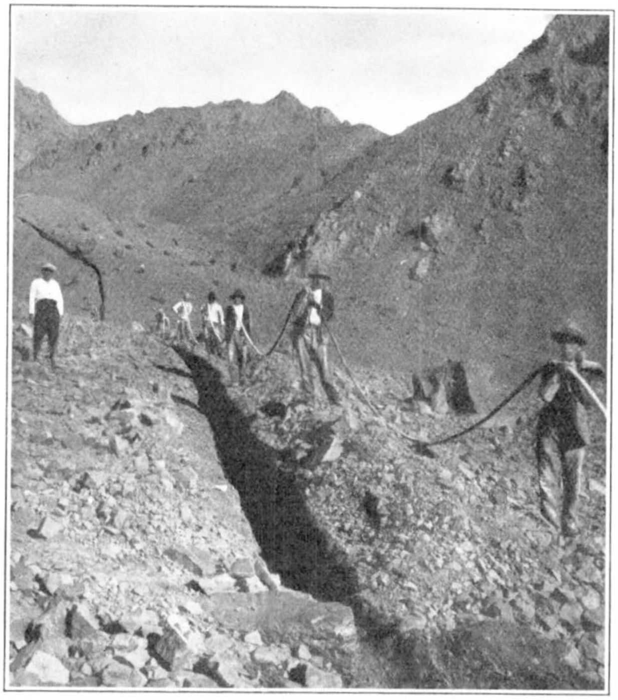


FIG. 2.—CARRYING CABLE FROM THE ROAD TO THE TRENCH.

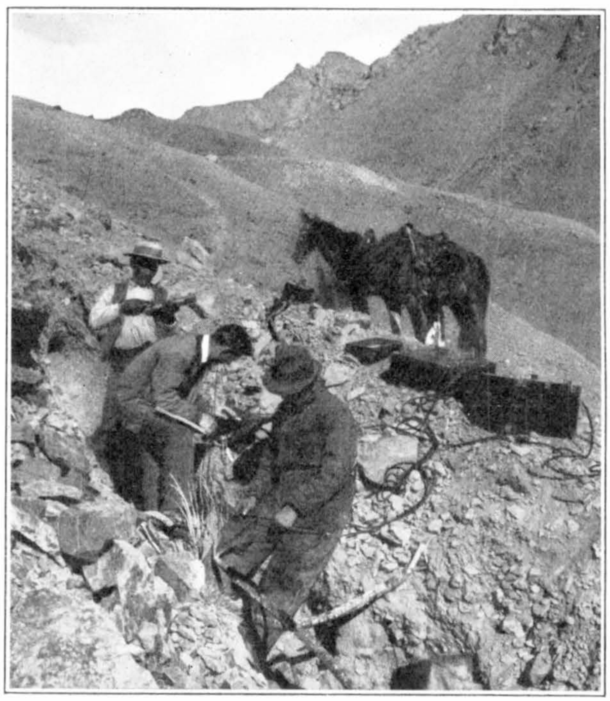


FIG. 3.—TESTING AND SPLICING AT A POINT IN THE HIGH ANDES.

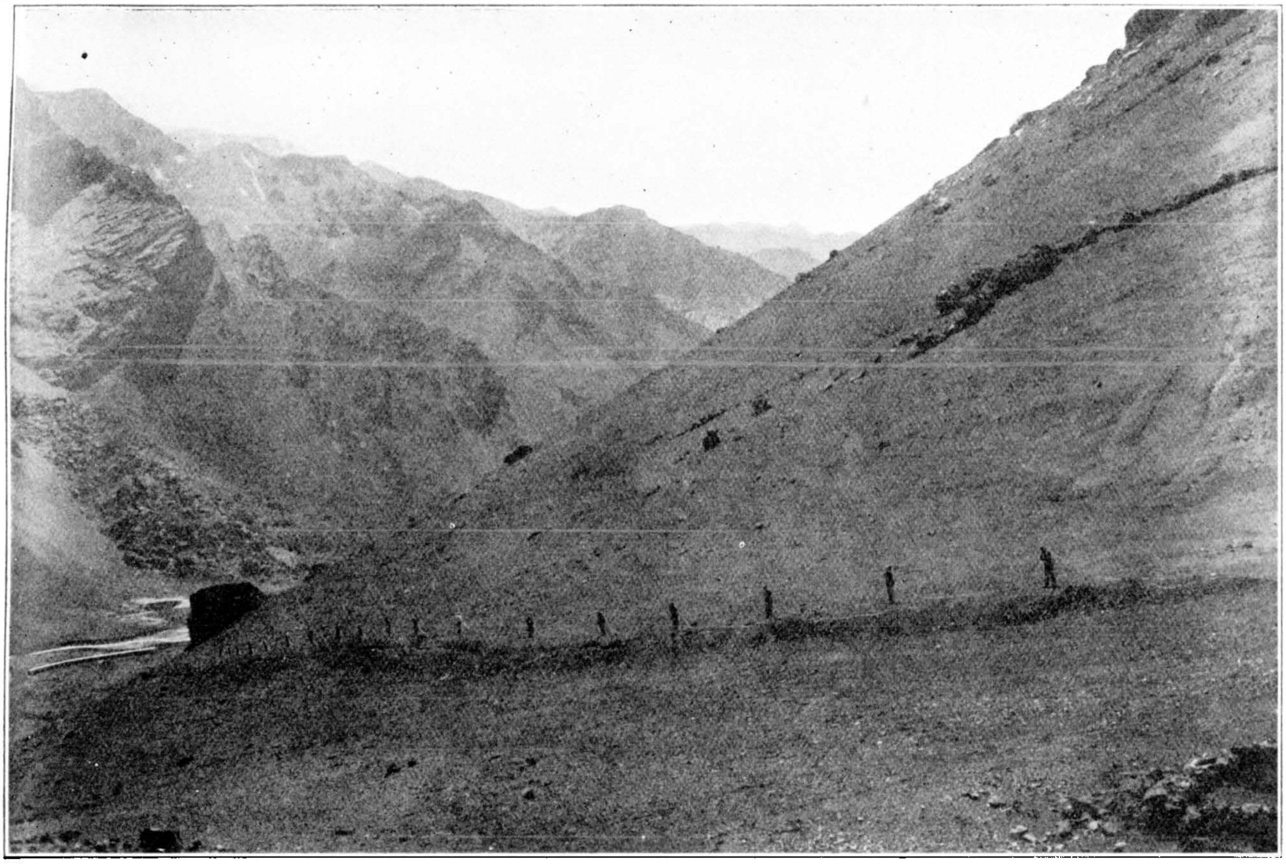


Fig. 4.—Workmen just finished cleaning the trench near the divide, Argentine side, before laying the cable.

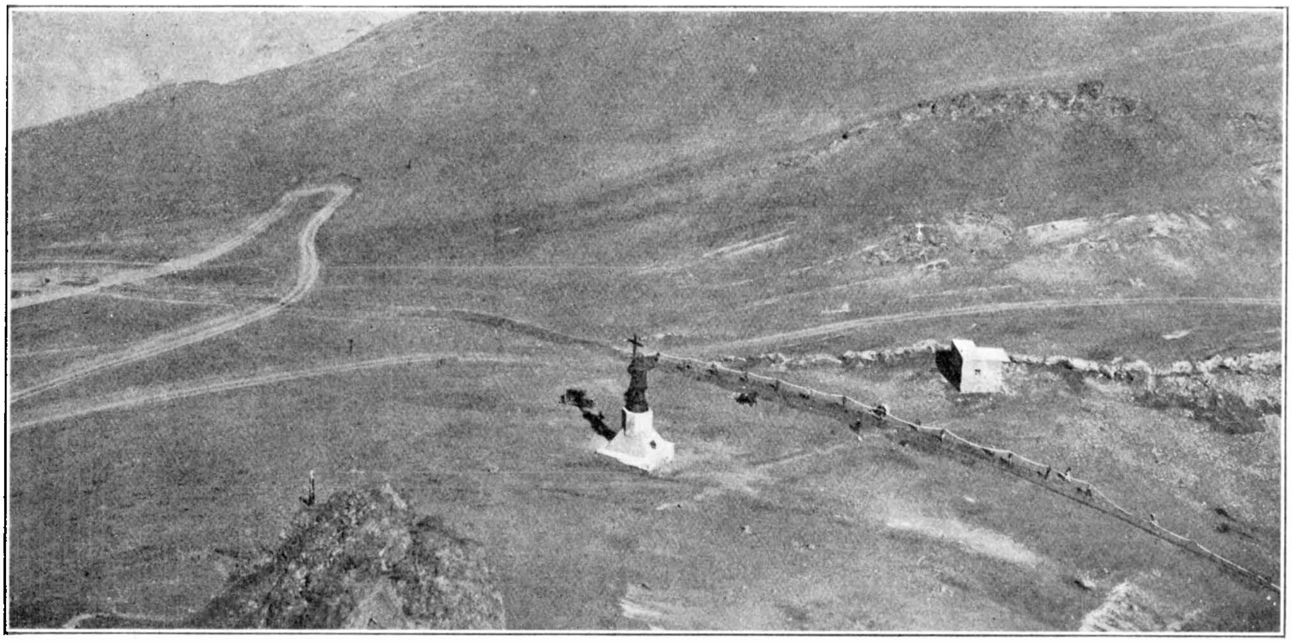


Fig. 5.—Placing the cable across the divide, near the statue of Christ.
To the left is the winding road down the Chilean side.

so rapidly, that in little more than one month after the completion of the trench it was finished and the new circuits were immediately put into action.

Some idea of the nature of the country and the magnitude of the task may be gathered from the illustrations accompanying this article.

OUTLINE NOTES ON TELEPHONE TRANSMISSION THEORY.

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

(SECTIONS 7—10).

SECTION 7—*continued.*

Coil-loaded Cables *(cont.)*

In underground and overhead cables the coils of all circuits are assembled in an iron case known as a "loading pot" (see Fig. **14**). The size of the coils is a large factor amongst those which influence the cost of coil loading. The importance of this factor has been reduced in recent years by the use of special dust-core coils and in some cases by the use of high permeability cores, such as permalloy, which give the required inductance and magnetic stability with a much smaller core than with the older wire and air-gap cores.

In submarine cables the practical question of coil-loading is a much more difficult problem and the cores of the inductance coils have to be assembled so as to occupy as little space as possible by being constructed with an overall shape nearly elliptical. (Fig **15**). A bulge is thus seen in the cable at loading-coil points, which must be of such diameter that when going over the sheave of the cable ship during laying or repair operations no damage is done to the coils or cable by undue strain.

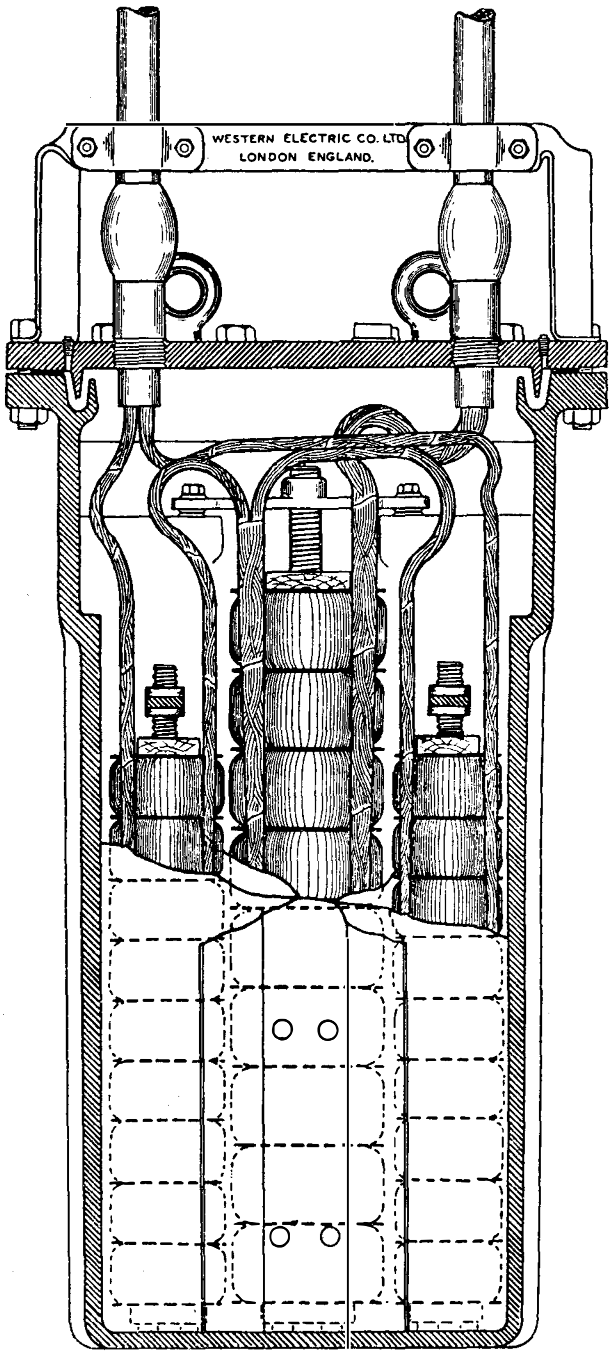


FIG. **14**.—SECTION OF LOADING COIL CASE, CONTAINING COILS FOR SIDE AND PHANTOM CIRCUITS.

II. Continuously-Loaded Cables.—First introduced by a Danish engineer named Krarup in 1902, this type of loaded cable is largely used for submarine cables. The loading consists of iron alloy wire of a few mils thickness, wound in a close spiral along the length of the copper conductor. A number of layers of loading wire may be used but, owing to increased electrostatic capacity of the loaded conductor and due regard being paid to the iron losses incurred, a limit is soon reached by increasing the inductance of the circuit in this manner.

Until the introduction of high permeability alloys with stable magnetic properties the maximum inductance per mile obtainable by the Krarup type of loading was of the order of 20 millihenries, but the recently laid telegraph cable

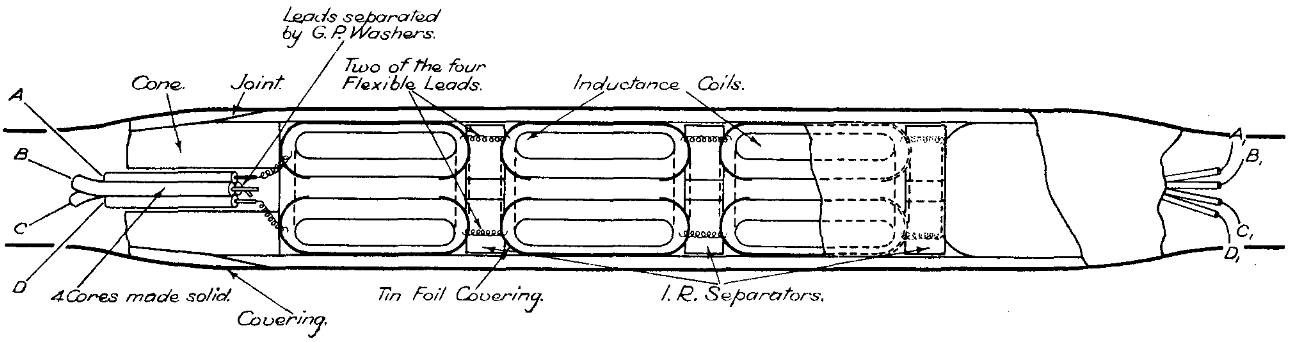


FIG. 15.— Loading Coil For Submarine Telephone Cable.

in the Pacific Ocean (between Fanning and Suva), continuously-loaded with permalloy, has an inductance of the order of 165 millihenries per nautical mile.

Principal Advantages of Continuous Loading:—

(1) When used for submarine cables the laying and repair operations are not more difficult than those for ordinary unloaded cables.

(2) The impedance-frequency characteristics can be made smoother than for coil-loaded cables.

(3) Useful for insertion in short U.G. cables between two aerial lines.

(4) Cheaper maintenance.

Principal Disadvantages of Continuous Loading:—

(1) For a given low attenuation a continuously-loaded cable is at present more expensive to construct than a coil-loaded cable.

(2) Cannot be applied to existing unloaded circuits.

(3) Liable to increased cross-talk produced by inductance unbalance due to age, excessive testing currents, etc.

Further References for Section 7:—

" Electrical Communication," Vol. 4, No. 1 (1925).—" The Loaded Submarine Cable," by D. E. Buckley.

Journal I.E.E., Vol. 67, April, 1929.—" The Continuously Loaded Telegraph Cable," by Foster, Ledger and Rosen.

SECTION 8.

Artificial Lines or Equivalent Networks— T and π Circuits.

It is frequently necessary for test purposes, for comparison or analysis, etc., to replace a complicated circuit by a simple one. A transmission line having uniformly distributed constants is a complex electrical circuit having resistance and inductance elements in series, and capacitance and leakance elements in shunt—See Fig. **4**, Section 2. Simple networks may be constructed to represent, in various degrees, such actual transmission lines and are known as *artificial* circuits. There are two principal classes:—

(*a*) " Nominal " circuits.

(*b*) " Equivalent " circuits.

It will be seen from what follows that, actually, (*a*) is a particular case of (*b*).

(*a*) Nominal Artificial Circuits.

One such circuit can be obtained by assuming the shunt elements (G and C) to be concentrated in the middle of the line and one-half the total line conductor resistance and inductance concentrated on either side of it.—Fig. **16** refers. This is usually simplified further by assuming the R and L normally in the two wires of the line to be lumped in a single wire and is then usually termed a " *nominal* **T**-*circuit* " from its shape. See Fig. **17**.

Another type of nominal circuit can be built by assuming the total G and C to be split into two equal parts and lumped, one at each end of the line, with the total R and L lumped between

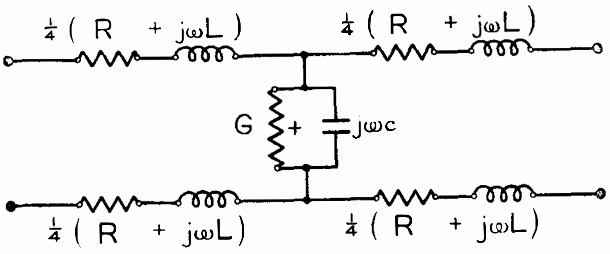


FIG. 16.

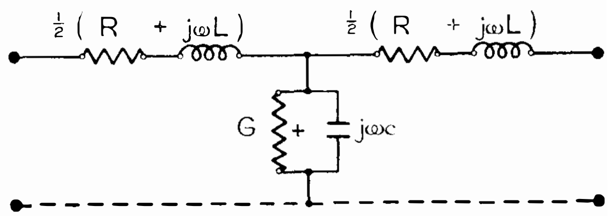


FIG. 17.— *Nominal T- Circuit.*

them. See Figs. **18** and **19**. The latter is termed a "*nominal* **π**-*circuit*" from its likeness to the letter π.

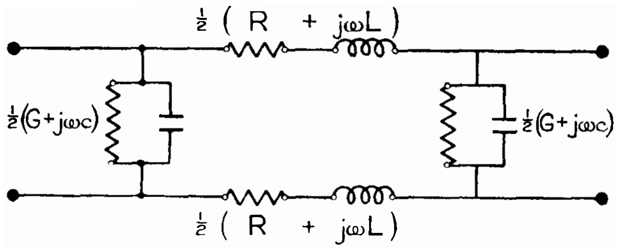


FIG. 18.

Such nominal circuits are *only approximations*, since with the same impressed voltage (at any particular frequency) on line and network the network does not give actual line receiving-end conditions, and hence the transmission effect is not exactly equivalent to that of the actual line. On the other hand, with equal impressed voltage at a definite frequency, a **T**-circuit and also a **π**-circuit can usually be constructed to give actual line-end conditions and such circuits are known as "*equivalent circuits*." The sum of the R, L, G and C of the equivalent circuit will not necessarily be equal to the total R, L, G and C respectively of the line it represents and the method of obtaining the necessary branch impedances required is as follows:—

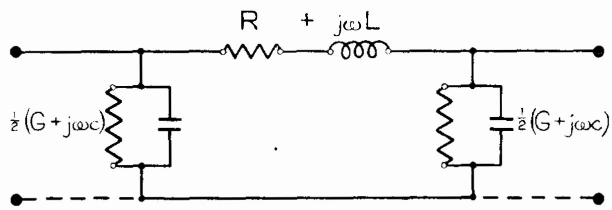


FIG. 19.— *Nominal Π-Circuit.*

(*b*) Equivalent Networks.

1. *Equivalent* **T**-*Circuit.*

Since most lines are terminated by a receiving impedance as nearly as possible equal to Z_0 (to avoid reflection effects, etc.) the following networks are made to represent any given *finite length of uniform line* on the assumption that the receiver impedance equals Z_0 in modulus and angle. Further, since the magnitudes of the branches Z_1 and Z_2 change with frequency, then these single section networks *only exactly represent the line at the one definite frequency* for which Z_1 and Z_2 are calculated. See Fig. **20**.

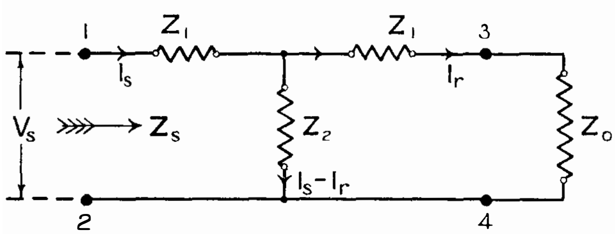


FIG. 20.

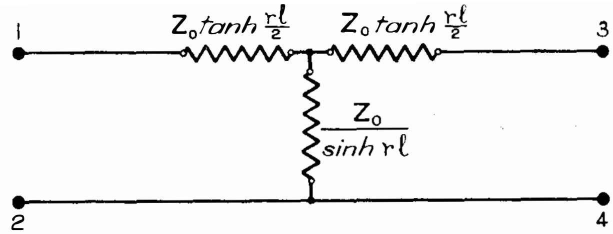


FIG. 21.— *Equivalent T- Circuit.*

Let Z_1 = impedance of series arms

Z_2 = ,, ,, shunt branch

Z_s = ,, measured at terminals 1—2, when the equivalent -T is closed by Z_0

I_s = sent current at terminals 1—2

I_r = received current at terminals 3—4 and flowing through Z_0.

Since Z_2 is in parallel with $Z_1 + Z_0$:—

$$Z_s = Z_1 + \frac{Z_2 (Z_1 + Z_0)}{Z_1 + Z_2 + Z_0} \quad \ldots\ldots(1)$$

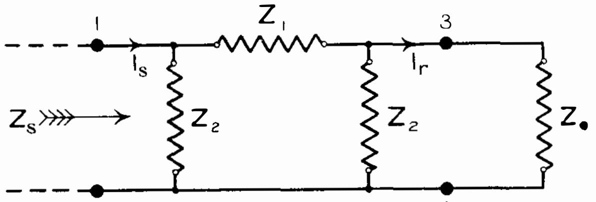


FIG. 22.

But if the network, 1—2 to 3—4, is to behave as an actual uniform line of length, l, and propagation constant, γ, terminated by Z_0, then :

$Z_s = Z_0$ (See pp. I. of Section 3 of Notes).

Hence equation (1) above becomes :—

$$Z_0 = Z_1 + \frac{Z_2 (Z_1 + Z_0)}{Z_1 + Z_2 + Z_0} \quad \ldots\ldots(2)$$

Again, if the network is to behave as a uniform line closed by Z_0, we have—from equation (4) of Section 3—

$$\frac{I_r}{I_s} = e^{-\gamma l}$$

But $I_r = \dfrac{Z_2}{Z_1 + Z_2 + Z_0} \times I_s$ and hence :—

$$\frac{Z_2}{Z_1 + Z_2 + Z_0} = e^{-\gamma l} \quad \ldots\ldots(3)$$

Combining equations (2) and (3)—

$$Z_0 = Z_1 + e^{-\gamma l} (Z_1 + Z_0) \quad \ldots\ldots(4)$$

$$\text{or } Z_1 = Z_0 \left(\frac{1 - e^{-\gamma l}}{1 + e^{-\gamma l}} \right) = Z_0 \left(\frac{e^{\frac{\gamma l}{2}} - e^{-\frac{\gamma l}{2}}}{e^{\frac{\gamma l}{2}} + e^{-\frac{\gamma l}{2}}} \right)$$

$$\therefore Z_1 = Z_0 \tanh \frac{\gamma l}{2} \quad \ldots\ldots(5)$$

From equations (3) and (4) :—

$$Z_0 \left(1 - \frac{1 - e^{-\gamma l}}{1 + e^{-\gamma l}} \right) = Z_2 (1 - e^{-\gamma l})$$

$$\therefore Z_2 = \frac{Z_0}{\sinh \gamma l} \quad \ldots\ldots(6)$$

Therefore, the equivalent **T**-network of a line length, l, closed by Z_0 and of propagation constant, γ, is as shown in Fig. **21**.

2. *Equivalent* **π**-*Circuit.* See Fig. **22**.

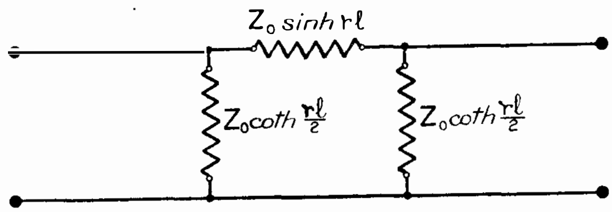


FIG. **23**.— Equivalent π-Circuit

Z_2 = shunt branch impedances,

Z_1 = series arm impedance,

I_s = current entering 1—2,

I_r = current leaving 3—4,

Z_0 = terminating impedance,

$$\text{Then } Z_s = Z_0 = \frac{Z_2 \left\{ Z_1 + \dfrac{Z_2 Z_0}{Z_2 + Z_0} \right\}}{Z_2 + Z_1 + \dfrac{Z_2 Z_0}{Z_2 + Z_0}} \quad \ldots\ldots(7)$$

Which can be written :—

$$Z_0^2 = \frac{Z_1 Z_2^2}{Z_1 + 2Z_2} \quad \ldots\ldots(8)$$

$$\text{Again } \frac{I_r}{I_s} = e^{-\gamma l} = \frac{Z_2}{Z_2 + Z_0} \times \frac{Z_2}{Z_1 + Z_2 + \dfrac{Z_2 Z_0}{Z_2 + Z_0}} \quad \ldots\ldots(9)$$

From equations (7) and (9) :—

$$Z_0 = \frac{Z_1 Z_2}{Z_2 (e^{\gamma l} - 1) - Z_1}$$

and writing $(e^{\gamma l} - 1) = d$ in this equation it becomes :—

$$Z_1 = \frac{Z_0 Z_2 \cdot d}{Z_2 + Z_0} \quad \ldots\ldots(10)$$

Substituting in equation (8), the value of Z_1 found in equation (10):—

$Z_2^2 \cdot d - 2Z_2Z_1 - Z_0^2(d+2) = 0$ which is a quadratic in Z_2. Solving for Z_2:—

$$Z_2 = \frac{2Z_1 \pm \sqrt{4Z_1^2 + 4Z_0^2 d(d+2)}}{2d}$$

Since d is always positive,

$$\therefore\ Z_2 = Z_0\left(\frac{2+d}{d}\right) = Z_0\left(\frac{e^{\frac{\gamma l}{2}} + e^{-\frac{\gamma l}{2}}}{e^{\frac{\gamma l}{2}} - e^{-\frac{\gamma l}{2}}}\right)$$

$$\therefore\ Z_2 = Z_0 \coth\frac{\gamma l}{2} \quad \text{.......................... (11)}$$

From equation (10), substituting $d = e^{\gamma l} - 1$ and $Z_2 = Z_0 \coth\frac{\gamma l}{2}$, then:—

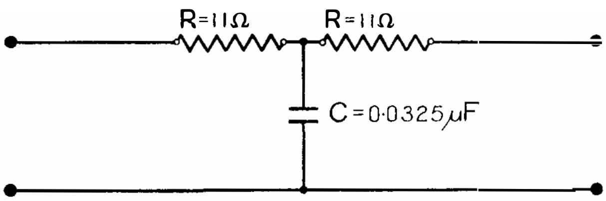


FIG. 24.— *Nominal T.*

$$Z_1 = \frac{Z_0(e^{2\gamma l} - 1)}{2e^{\gamma l}} = Z_0\left(\frac{e^{\gamma l} - e^{-\gamma l}}{2}\right)$$

$$\therefore\ Z_1 = Z_0 \sinh \gamma l \quad \text{.......................... (12)}$$

Therefore, the equivalent **π**-network of a line length, l, closed by Z_0 and of propagation constant, γ, is as shown in Fig. **23**.

Note.—If l is so small that

$\sinh \gamma l \rightarrow \gamma l$ and

$\tanh \gamma l \rightarrow \gamma l$

then, equations (5), (6), (11) and (12) reduce to the corresponding nominal circuit values. Hence, a criterion by which it can be determined whether a nominal circuit or equivalent circuit should be used is found in the degree of equivalence to γl of $\sinh \gamma l$ and $\tanh \gamma l$.

Example.—Find **T**-networks which shall represent at 5000 rads./sec., (*a*) ½ mile, (*b*) 40 miles, of a circuit with loop mile constants R = 44 ohms, C = 0.065 microfarad. Neglect natural inductance of the line and leakance.

Considering (*a*). The propagation constant $\gamma = 0.1195\ \underline{/45^\circ}$; $\gamma l = 0.05975\ \underline{/45^\circ}$; $\sinh \gamma l \doteqdot 0.05979$ and $\tanh \gamma l \doteqdot 0.05968$. It will be seen that $\gamma l \rightarrow \sinh \gamma l \rightarrow \tanh \gamma l$, and hence

$$Z_1 = Z_0 \cdot \frac{\gamma l}{2} = \frac{(R + j\omega L) \times \frac{1}{2}}{2} = \frac{R}{4}$$

since L = 0, *i.e.*, Z_1 = 11 ohms.

$$\text{Also } Z_2 = \frac{Z_0}{\gamma l} = \frac{1}{(G + j\omega C) \times \frac{1}{2}} = \frac{1}{j\omega\frac{C}{2}}$$

since G = 0, $Z_2 = -j\,6150$ ohms.

In such a case, therefore, the nominal circuit arrangement shown in Fig. **24** would be sufficiently accurate for practical purposes and would, of course, represent the line at all frequencies.

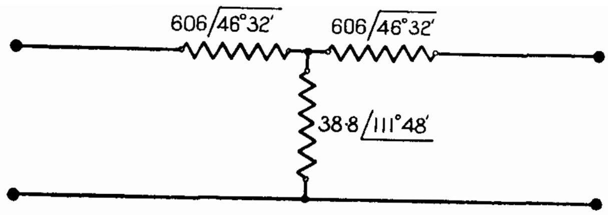


FIG. 25.—*Equivalent T.*

Considering (*b*). $\gamma = .1195\ \underline{/45^\circ}$

$\gamma l = 4.78\ \underline{/45^\circ}$

$\sinh \gamma l = 14.74\ \underline{/203^\circ 12'}$

$\tanh \frac{\gamma l}{2} = 1.064\ \overline{\backslash 1^\circ 32'}$

$Z_0 = 570\ \overline{\backslash 45^\circ}$

Hence $Z_1 = 606\ \underline{/46^\circ 32'}$

$Z_2 = 38.8\ \underline{/111^\circ 48'}$

It is interesting to note that this particular **T**-network (Fig. **25**) is a case of a "*mathematical equivalent*" only (useful in the solution of a more complicated problem) and cannot be physically constructed as the *resistance portion of Z_2 is negative.* In such a case a **π**-network is sometimes physically possible, though not always so, and should be calculated if an actual network is sought.

3. *Expressions for Characteristic Impedance and Propagation Constant of Equivalent Networks in Terms of the Branch Impedances Z_1 and Z_2. (These results are of great importance).*

Equivalent **T**-*Circuit.*

By considering Fig. **20** :—

$$Z_0 = Z_1 + \frac{Z_2 (Z_1 + Z_0)}{Z_1 + Z_2 + Z_0}$$

$$\therefore \quad Z_0^2 = Z_1^2 + 2Z_1Z_2$$

$$\therefore \quad Z_0 \quad \sqrt{2Z_1Z_2\left(1 + \frac{Z_1}{2Z_2}\right)} \quad \ldots\ldots\ldots\ldots (13)$$

Again, if P = propagation constant of one section of an infinite number of recurrent symmeterical networks ($P = \gamma l$ if each section represents l miles of cable closed by Z_0 and having a propagation constant γ per mile).

$$\text{Then } P = \log_e \frac{I_s}{I_r} = \log_e \frac{Z_1 + Z_2 + Z_0}{Z_2}$$

Substituting for Z_0 from equation (13) :—

$$\therefore \quad P = \log_e \left\{ \frac{Z_1+Z_2}{Z_2} + \frac{\sqrt{2Z_1Z_2\left(1 + \frac{Z_1}{2Z_2}\right)}}{Z_2} \right\} \ldots\ldots\ldots\ldots (14)$$

By putting $x = \frac{Z_1 + Z_2}{Z_2}$ equation (14) becomes :—

$$P = \log_e (x + \sqrt{x^2 - 1}) = \cosh^{-1} x$$

$$\therefore \quad P = \cosh^{-1}\left(1 + \frac{Z_1}{Z_2}\right) \ldots\ldots\ldots\ldots (15)$$

Equivalent **π**-*Circuit.*

By considering Fig. **22** :—

$$Z_0 = \frac{Z_2\left(Z_1 + \frac{Z_2Z_0}{Z_2 + Z_0}\right)}{Z_2 + Z_1 + \frac{Z_2Z_0}{Z_2 + Z_0}}$$

$$\therefore \quad Z_0 = \sqrt{\frac{Z_1Z_2}{2\left(1 + \frac{Z_1}{2Z_2}\right)}} \ldots\ldots\ldots\ldots (16)$$

Again, as in the case of recurrent **T** sections, let there be an infinite number of **π**-sections, each with propagation constant P. Then :—

$$P = \log_e \frac{I_s}{I_r} = \log_e \frac{(Z_1 + Z_0)\left(Z_1 + Z_2 + \frac{Z_2Z_0}{Z_2 + Z_0}\right)}{Z_2^2}$$

$$= \log_e \frac{Z_1Z_2 + Z_2^2 + Z_0 (Z_1 + 2Z_2)}{Z_2^2}$$

Substituting for Z_0 from equation (16) :—

$$\therefore \quad P = \log_e \left\{ \frac{Z_1 + Z_2}{Z_2} + \frac{\sqrt{2Z_1Z_2\left(1 + \frac{Z_1}{2Z_2}\right)}}{} \right\} \ldots\ldots\ldots\ldots (17)$$

which is the same as equation (14).

$$\therefore \quad P = \cosh^{-1}\left(1 + \frac{Z_1}{Z_2}\right) \ldots\ldots\ldots\ldots (18)$$

NOTE.—Expressions (15) and (18) are identical, and therefore the propagation constant per section is the same whether the structure is considered as an infinite number of T or π-networks.

SECTION 9.

Attenuation Constant of Lump-loaded Line.—Campbell's Formula.—" Cut-off " Frequency.

Let d miles be the coil spacing. Then each loading coil section can be represented by a **T**-network.

Let γ = propagation constant per mile of unloaded cable

γ' = propagation constant per mile of loaded cable

Z_c = loading coil impedance

Then, from equation (15) of Section 8 :—

$$\text{Cosh } \gamma d = 1 + \frac{Z_1}{Z_2} = \frac{Z_1 + Z_2}{Z_2} \ldots\ldots\ldots (1)$$

$$\therefore \text{ Also } \cosh \gamma^1 d = 1 + \frac{Z_1 + \frac{1}{2}Z_c}{Z_2}$$

$$= \frac{Z_1 + Z_2}{Z_2} + \frac{Z_c}{2Z_2} \ldots\ldots\ldots\ldots (2)$$

Hence from (1) and (2), and since $Z_2 = Z_0/\sinh \gamma d$,

$$\operatorname{Cosh} \gamma^1 d = \cosh \gamma d + \frac{Z_c}{2Z_0} \sinh \gamma d \quad \ldots\ldots(3)$$

which may be written

$$\gamma^1 \text{(Loaded Line)} = \frac{1}{d} \cosh^{-1} \left\{ \cosh \gamma d + \frac{Z_c}{2Z_0} \sinh \gamma d \right\} \quad \ldots\ldots\ldots\ldots(4)$$

and is Campbell's formula giving rigorously the propagation constant per mile of loaded cable in terms of the propagation constant of the unloaded conductor (γ), the impedance of the loading coils (Z_c) and unloaded conductor (Z_0) and the distance between coils (d).

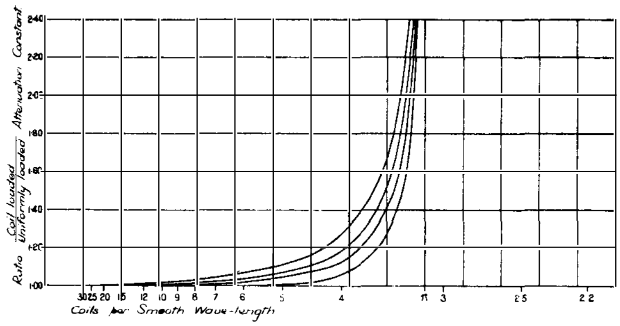


FIG. **26**. This family of curves has been drawn for different weights of conductor by using Campbell's formula for lump loaded line and equation (18) of Section 2 for a smooth line, to obtain the ratios given by the ordinates.

This formula usually involves much laborious evaluation, unless specially prepared charts of complex hyperbolic functions are used, and for practical determination of γ^1 various other approximate formulæ have been evolved. As an example of such approximate formulæ see H. F. Mayer in *Telegraphen and Fernsprechtechnik, Part 6, 1927*. See also References at end of Section 9.

Note 1.—Referring to Campbell's formula, equation (4), if values of γ^1 are plotted against frequency it will be found that in all cases γ^1 experiences an enormous and sudden increase when a value of frequency is approached such that:—

$$\omega = \frac{2}{d\sqrt{CL_1}} \quad \ldots\ldots\ldots\ldots(5)$$

where L_1 = total inductance per mile including coil, and C = total capacity per mile. See Fig. **26**. At this critical or "*cut-off*" *frequency* the wave-length of the circuit is related to d, the spacing as follows:—

Let ω_c be the cut-off pulsatance,

$$\alpha \fallingdotseq \omega_c \sqrt{CL_1} \quad \ldots\ldots\ldots\ldots(6)$$

and

$$\lambda = \frac{2\pi}{\alpha} \quad \ldots\ldots\ldots\ldots(7)$$

At the critical frequency,

$$\omega_c = \frac{2}{d\sqrt{CL_1}} \quad i.e., \sqrt{CL_1} = \frac{2}{\omega_c d}$$

$$\text{Hence } \lambda = \frac{2\pi}{\omega_c \sqrt{CL_1}} = \pi d \quad \ldots\ldots\ldots\ldots(8)$$

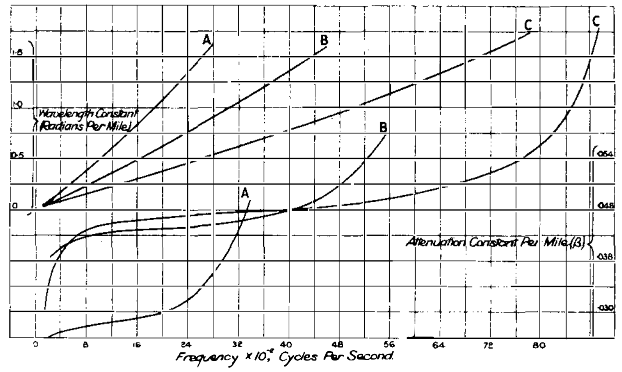


FIG. **27**.—TYPICAL ATTENUATION AND WAVE-LENGTH CHARACTERISTICS FOR MODERN COIL-LOADED REPEATER SECTIONS OF CABLE.

A—25 lb. conductor, 120 mH at 2000 yds.
B— ,, ,, 44 mH ,, ,,
C—40 lb. ,, 15.5 mH ,, ,,

From equation (8) and Fig. **26** it will be seen that there are π *coils per wave-length at the cut-off frequency*. (See Section 7, pp. I., on coil-loaded lines).

Note 2.—By considering the foregoing Sections 8 and 9, it will be seen that a coil-loaded line must *terminate in a half-value loading coil* (or *half* loading-coil *section length*) for smooth propagation, *i.e.*, for absence of reflections, etc.

Note 3.—The influence of the spacing of the coils in the cut-off frequency can be seen from equation 5 and the following example:—

Example 1. — Calculate the approximate theoretical cut-off frequencies for a circuit having C = 0.065 μF per mile and loaded with:—

(1) 15.5 millihenries at 2000 yds. spacing.

(2) 44 mH. at 2000 yds. spacing.

(3) 120 mH. at 2000 yds. spacing.

The cut-off frequency $f_c \fallingdotseq \dfrac{1}{\pi d \sqrt{CL_1}}$ equation (5).

$\therefore$ For the 15.5 mH. case $f_c = \dfrac{1}{\pi \sqrt{15.5 \times .074}}$

$\fallingdotseq$ 9,700 p.p.s.

Similarly for the 44 mH.,

$f_c \fallingdotseq$ 5,700 p.p.s.

For the 120 mH.,

$f_c \fallingdotseq$ 3,000 p.p.s.

In connection with this example, See Fig. **27**, which shows some actual measured attenuation-frequency curves for circuits loaded as in the above example. Note the close agreement of actual with calculated cut-off frequencies. The larger conductor (40 lb.) in the case of curve C accounts for its attenuation over the frequency range 400-4000 p.p.s. being *nearly the same as that for the curve B,—a heavier loaded circuit* which has 20 lb. conductor—the lower resistance in the case of C keeping the attenuation of C down to that of B.

Example 2.—A cable has the following constants:—

R = 88, C = 0.054, L = 0.001, G = 5×10^{-6}.

What inductance per mile must be added to make the circuit distortionless? If coils of 175 millihenries be used, what spacing will be necessary? Calculate transmission equivalents per mile of the cable before and after loading. Neglect resistance of loading coils. [*C. and G., 1931*].

Assuming R is in ohms, C in μF, L in Henrys and G in mhos per mile loop, then, from the formula in Section 3, LG = CR, the required

inductance $\fallingdotseq \dfrac{0.054 \times 88}{10^6 \times 5 \times 10^{-6}}$ H per mile loop.

From this *consideration only* the spacing is $\fallingdotseq$ 324 yds.

The transmission equivalents will be given in Section 10 of these notes.

Useful References for Sections 7 to 9:—

" Transmission Circuits for Telephonic Communication," by K. S. Johnson. Published by the Library Press, Ltd., London.

" Telephonic Transmission," by J. G. Hill, (Chapter IX.). Published by Longmans, Green & Co., Ltd.

" Telephone Transmission," by J. E. Statters. I.P.O.E.E. Paper 101.

" Attenuation of Coil Loaded Lines," by H. F. Mayer. T.F.T., Part 6, 1927.

SECTION 10.

Elementary Considerations of the Transmission Efficiency of Telephone Circuits. — Transmission Units Used.

It is of little use to have a telephone system over which a large volume of sound is transmitted unless the quality of the received sound is of such a standard as to render the reproduction easily intelligible; and equally undesirable to have a system which has a very high standard of reproduction but so little received volume as to render it almost unintelligible. It therefore becomes necessary to provide means for measuring and comparing *both volume and quality* of received sounds when dealing with parts (terminal apparatus, intermediate apparatus, connecting lines, etc.), or the whole of a complete transmission system. To this end certain standard reference systems have been devised and the European Master Reference System, situated in Paris, (which is a replica of the Master Reference Standard used in America) represents the present stage in the development of an absolute international standard—(See Section 11 of Notes).

There are thus two main factors which determine the **intelligibility** of a telephone system (*i.e.*, its overall efficiency for transmission of the meaning of ordinary speech sounds used for conversation), viz.:—

(1) *Volume efficiency* which determines the ratio of acoustic power, or volume, of the sounds received over the system to the sent power.

(2) *Articulation efficiency* which determines the quality or faithfulness of reproduction of the transmitted sounds.

In addition to the influence of the above two factors, upon the intelligibility of the system there will be

(3) *Cross-Talk* and over-hearing—*i.e.*, interference from neighbouring telephone circuits.

(4) *Cross-fire, i.e.,* interference from telegraph circuits.

(5) *Noise* extraneous to the terminal apparatus, *i.e.*, room noises, etc.

(6) *Noise* in the circuit itself, *i.e.*, bad joints, microphonic " frying " noises, etc.

(7) *Power-Circuit* interference, *i.e.*, principally the influence of the higher harmonics of an A.C. power-supply frequency and of the ripple in the case of D.C. supplies.

A brief consideration of these factors and the units concerned follows :—

(Section 10 to be continued.)

A SUGGESTION TO EXTEND FACILITIES IN RESIDENTIAL AREAS.

12, Lothian Road,
Stockwell,
S.W.9.
April 21, 1931.

The Managing Editor,
P.O.E.E. Journal,
Alder House, E.C.1.

Dear Sir,

Enclosed please find a scheme by which the telephone system of this country could be extended. If you deem it worthy of publication in the *P.O.E.E. Journal,* to which I subscribe, I should be greatly obliged.

Yours faithfully,
A. L. Marriott,
Youth in Training,
Brixton External.

SCHEME FOR THE PROVISION AND EXTENSION OF TELEPHONES IN RESIDENTIAL AREAS.

Houses or flats in the course of construction under Local or National building schemes that could be classified as Telephone property.

(*a*) The builders or governmental authorities responsible for the building be approached and arrangements made for the payments of the hire charges as outlined below, and also for the installation of plant.

(*b*) That where the houses are intended for sale by monthly or quarterly payments off a mortgage, the deposit and quarterly hire charges be included in the repayments of mortgage made by the tenant-subscriber to the firm or local authority holding the mortgage.

(*c*) The cost of the calls made by the subscriber to be invoiced to him in the usual manner.

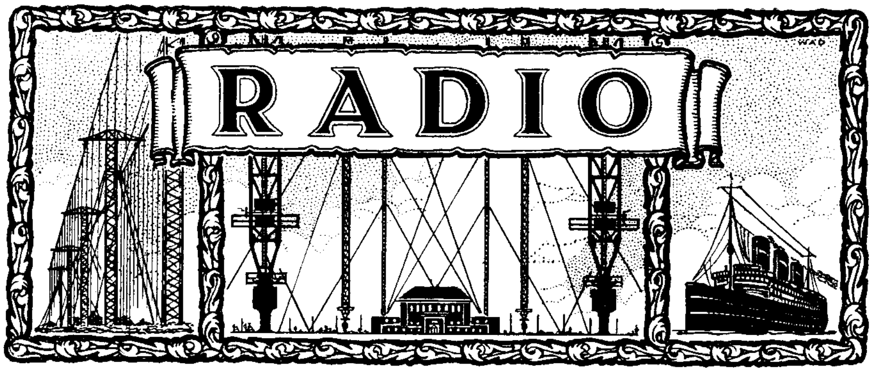
(*d*) In the case of houses or flats intended for weekly rental the deposit and quarterly charges be added to the rent in the form of weekly payments. The cost of the calls per quarter to be credited to the subscriber in the usual way. The quarterly hire charges to be collected from the owners of the property.

(*e*) In the advent of a house or houses qualifying for a government subsidy, a liaison could be established with the Ministry of Health for the purpose of ensuring that the applicants for the subsidy would be willing to allow the G.P.O. to instal plant in the property.

Summary and Advantages.

It would enormously increase the demand for telephones in residential areas.

The chief bar to the extension of the system in residential areas is due to the deposit and quarterly hire charges. With the removal of this bar, the extension of the system would be greatly facilitated.



DEVELOPMENTS IN THE USE OF VERY SHORT RADIO WAVES.

ABOUT the year 1924 it began to transpire that short radio waves, that is to say, waves below 50 metres in length, had unsuspected propagation properties and that by their use it was possible to obtain communication over long distances with powers which would be hopelessly inadequate with longer waves. As a result of this discovery, great activity was manifested all over the world in opening short-wave services for long distance communication. It soon became evident that for long distance work the lower useful limit of wave-length was about 12 metres and that for waves shorter than this the range was extremely restricted. In the light of our present knowledge, we know that this is due to the fact that waves of between 12 and 50 metres length are reflected efficiently by the medium in the upper regions of the atmosphere, and by repeated reflections are projected for great distances. Waves below about 10 metres in length are not reflected and in consequence their range is limited to that of the direct ray. The range is short because obstructions in the path of the ray, including the earth itself, readily absorb the energy in the wave.

As a result, it is generally desirable, if not essential, that there should be a clear and unobstructed path between the transmitter and the receiver for these very short waves. That is to say, they require a clear optical path and in many ways the characteristics of these waves resemble light waves. Directive transmission is readily achieved, either by means of metallic reflectors or by small antenna array systems, both of which can be made extremely effective on these wave-lengths. The fact that the radius of action of these waves is definitely limited suggests a number of useful applications for them. For example, one of the disadvantages of broadcast waves between 200 and 500 metres is that they cause disturbance over distances much greater than their useful range. For broadcast relay stations the very short waves of the order of, say, 5 to 10 metres seem particularly suitable. They are also suitable for low power short range services, such as between islands and the mainland, or across narrow estuaries or channels.

The simplest way of producing these short waves is by means of a spark discharge, as was used by Hertz in his classical experiments, which were conducted with waves of this order. Owing to its disturbing effects the use of spark apparatus is forbidden by international convention. It is possible to generate waves between 12 metres and 1 metre in length by ordinary three-electrode valves having coupled grid and anode circuits, as are used to generate longer waves. For the generation of waves shorter than about 1 metre in length, other arrangements are necessary, as the dimensions of the internal structure of the valve play an important part in determining the wave-length generated. There are two well-known types of valve oscillations capable of generating these waves, known as the Barkhausen-Kurz oscillations and the Gill-

Morrell oscillations. In each system, the grid of the valve has a positive potential in respect to the filament, while the anode is at zero or at a negative potential in respect to the filament. Oscillations are set up by electrons in the inter-electrode space, either between the plate and the cathode, or between the grid and the plate. The frequency of the Barkhausen-Kurz oscillations is determined solely by the electrode dimensions and the applied potentials, while the frequency of the Gill-Morrell oscillations are determined exclusively by the circuits connected to the valve and not by the electrode potentials.

General Ferrié has now appeared in the " Annales des Postes " of April, 1931.

Using waves of 17 cms. in conjunction with circular mirrors of 120 cms. aperture, telegraph communication has been obtained up to 37 km., and using small cylindric parabolic mirrors of 60 cms. aperture, telephone communication has been obtained up to 7½ km.

The Laboratoires Standard, Paris, have recently used waves of 16 cms. in an experimental radio telephone circuit between Dover and Calais, and a demonstration of the working of this system was given on 31st March, 1931,

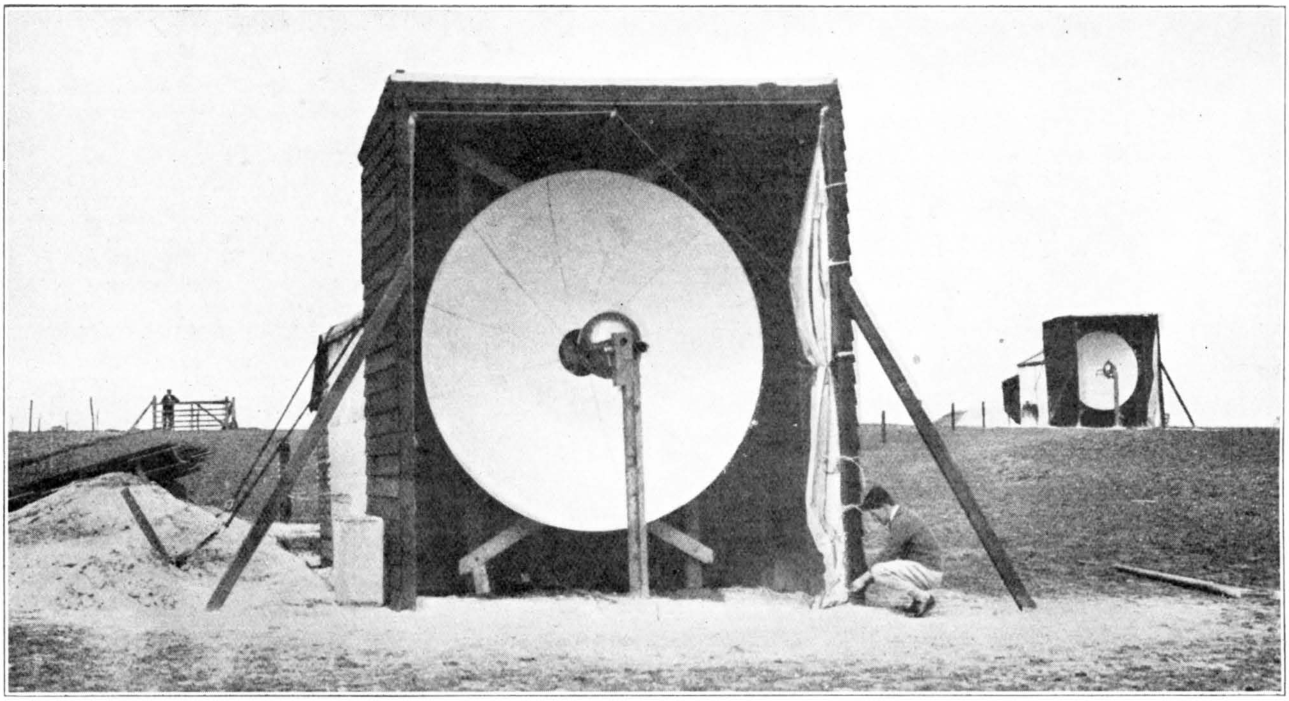


FIG. 1.—TRANSMITTER AND RECEIVER AT DOVER.

The lower limit of wave-lengths of these oscillations appears to be of the order of 12 cms. Research work on the practical utilisation of these short waves for transmission has been carried out by a number of experimenters, notably Uda in Japan, and Pierret, Beauvais and Gutton in France. Uda used waves of about 50 cm. and obtained telegraphic communication up to 39 km. Particulars of the French experiments have been published from time to time and an interesting summary of this work by

to a large and influential audience, including prominent representatives from Government services and the press. The installation consists of a transmitter and receiver at each place so that two-way conversation is possible.

Fig. **1** shows the transmitting and receiving installations, while Fig. **2** shows a more detailed view of the transmitter. The transmitting and receiving valves are each situated near the focus of a paraboloid mirror of about 200 cms. aperture, a small antenna external to the valve being

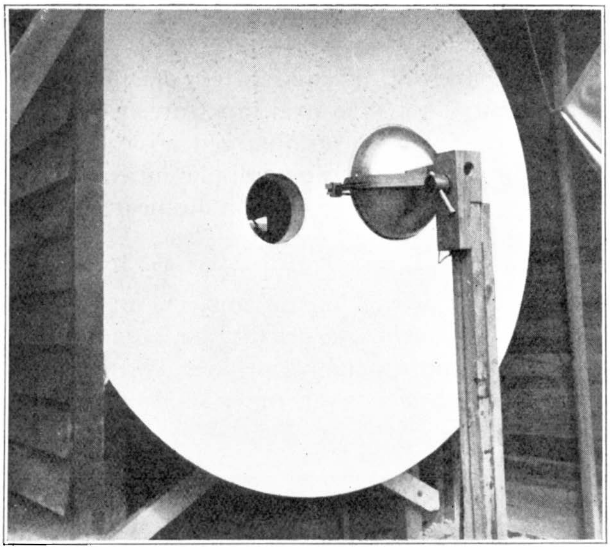


FIG. 2.—CLOSE-UP VIEW OF THE DOVER TRANSMITTER.
The micro-radion is housed in the small casing seen in foreground. Immediately in front of it is the one inch aerial.

FIG. 3.—INTERESTED SPECTATORS.
Col. Sir T. F. Purves, Capt. Davies (Mayor of Deal), Mr. L. Simon (Director of Telegraphs and Telephones). Left background, Mr. G. F. Greenham.

arranged at the focal point. In order to prevent unreflected divergent radiation from the antenna, a small semi-hemispherical mirror is placed outside the antenna so that all forward radiation from the antenna is reflected back to the paraboloid reflector. Due to the use of mirrors at each end a gain of 52 decibels is obtained; this represents a gain of 26 decibels at each mirror, which is as high as that obtained with a high efficiency antenna array on waves of about 16 metres.

The actual details of the valve used for this circuit have not yet been published. The quality of transmission obtained over this circuit is excellent and suggests that a wide field of usefulness is open to development, particularly for cross-channel services of this kind.

Very little information is yet available as to the frequency spacing necessary between services located near each other but, presuming that this is not abnormal, the number of channels available on these wave-lengths is stupendous. Assuming a frequency spacing of 100 kilocycles between services, on wave-lengths between 16 cms. and 1 metre it would be possible to operate contiguously 15,000 channels. If a frequency spacing of 1000 kilocycles is found to be necessary, we should still have 1500 channels available. Even at the present rate of growth this would provide all the cross-channel circuits for many years to come.

BIBLIOGRAPHY.

Hollman. *" Electron Oscillations in a Triode." Proc. I.R.E., February, 1929.*

Uda. *" Radiotelegraphy and Radiotelephony on half metre waves." Proc. I.R.E., June, 1930.*

Ferrié. *" Radiotelegraph and Radiotelephone Transmission with very Short Waves." " Annales des Postes," April, 1931.*

The first and third of the above mentioned papers contain comprehensive bibliographies.

FREQUENCY MEASUREMENT IN THE BRITISH POST OFFICE.

F. E. Nancarrow, A.R.C.Sc., A.M.I.E.E.

P. O. *FREQUENCY STANDARDS*.—In the Radio Department of the British Post Office, all frequencies are measured by reference to the harmonic frequencies of a tuning-fork maintained in the Radio Laboratories at Dollis Hill, London. This fork can be regarded as the Post Office standard of frequency and it is arranged that the frequency of vibration of the fork can be checked at any time by comparison with unit time as obtained directly from the Greenwich Observatory.

Fork and Temperature Control.—The fork is of elinvar of the type now generally known and is used for driving a multivibrator equipment. In the Post Office equipment, the fork and its associated driving valve are contained in a small unit which is separated from the main multivibrator apparatus. This unit is contained within the inner space of a double oven, each space of which is thermostatically controlled. The outside dimensions of this oven are 3 feet × 3 feet × 3 feet, and the inner oven is mounted symmetrically within the space of the outer, with an air space of 6 inches between the inner walls of the outer and the outer walls of the inner oven. The actual fork equipment is mounted symmetically within the inner space of the inner oven. The construction of the ovens follows recognised lines, the ovens being made up of layers of heat-insulating and heat-distributing materials. A photographic view of the interior of the ovens is given in Fig. 1.

The temperature of the outer oven is maintained at about 25°C. by means of a bi-metallic strip thermostat. The heaters for this oven are distributed over four of the faces of the inner heat-distributing layer and the thermostat is mounted on one of these faces. The heaters of the inner oven are distributed over four of the outer faces of the inner heat-distributing layer and the thermostat is also mounted on one of these faces. This thermostat is that associated with a Cambridge Instrument Co.'s Recording Thermostat (See Fig. 2) and the control is such that the heat cycle is of the order of eight seconds and the temperature variation of the heat-distributing layer is not greater than ± .05°C. Under these conditions it can be presumed that the actual temperature variation of the fork is not greater than ± .01°C. and, since the temperature coefficient of the fork is + 5 parts in 10^6 per 1°C. rise in temperature, it can be safely assumed that the change in frequency of the fork on account of temperature is never greater than 5 parts in 10^8.

The temperature of the inner oven in which the fork is contained is maintained at about 30°C., this temperature being chosen to ensure that the fork is always above the summer temperature of the room in which the oven is kept. At this temperature the fork vibrates at 1000.000 cycles per second and the temperature of the inner oven was critically adjusted to procure this result.

Pressure Effect.—The extent to which changes in pressure contribute to the variation in frequency of the fork are under investigation and at the present time the fork is not sealed against the effect of pressure changes. In any case, the fork is maintained under conditions whereby frequent comparisons with unit time are made and hence any change due to pressure accounted for.

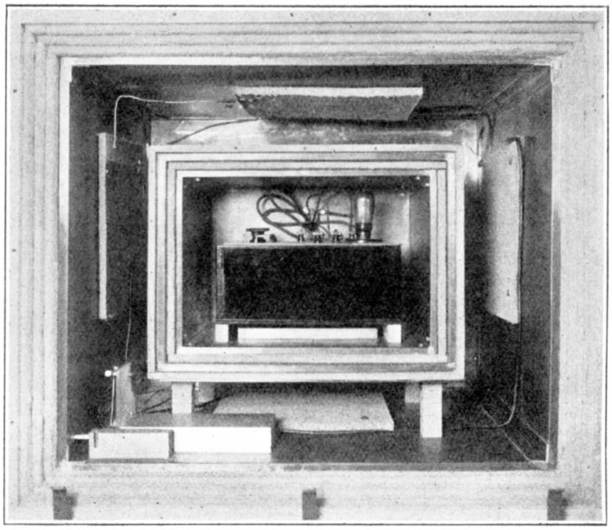


Fig. 1.—Double Oven.

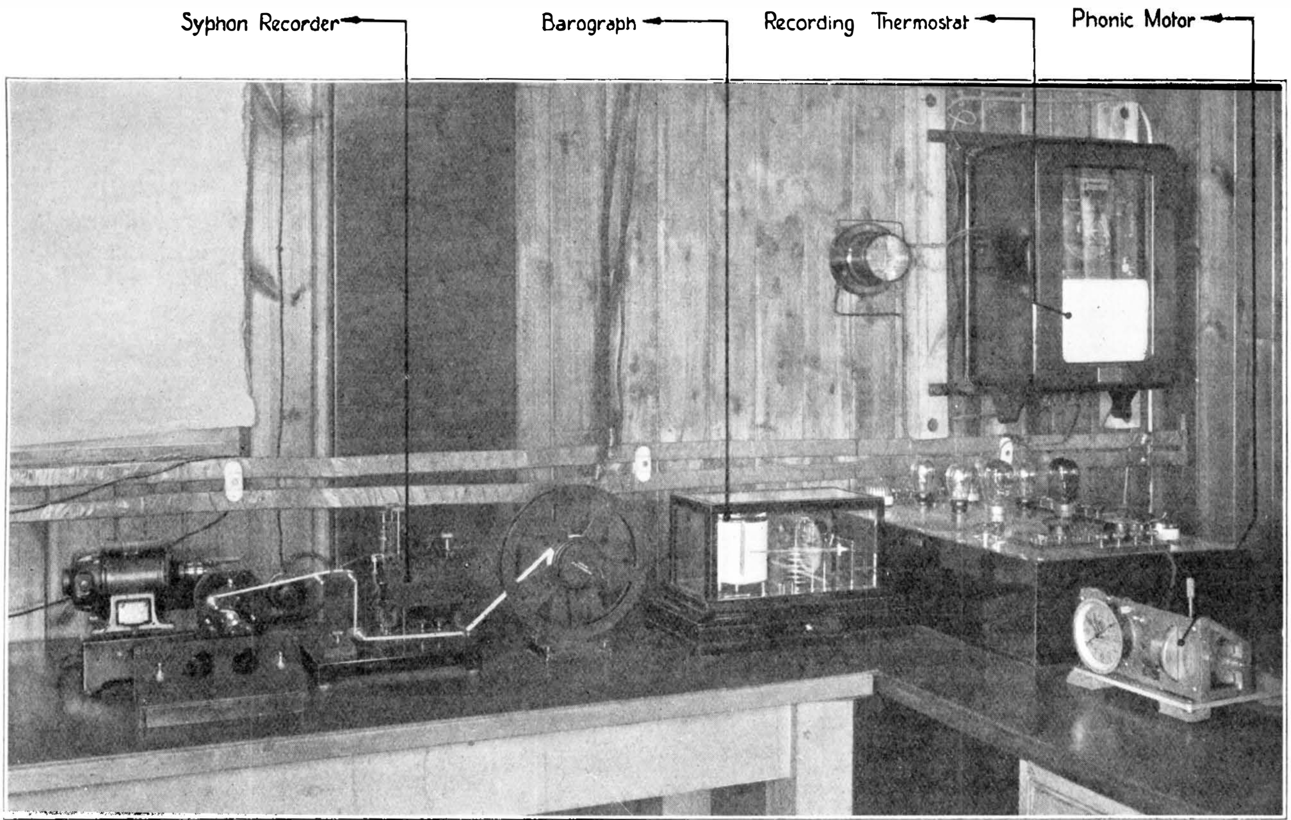


Fig. 2.—Timing Gear, etc.

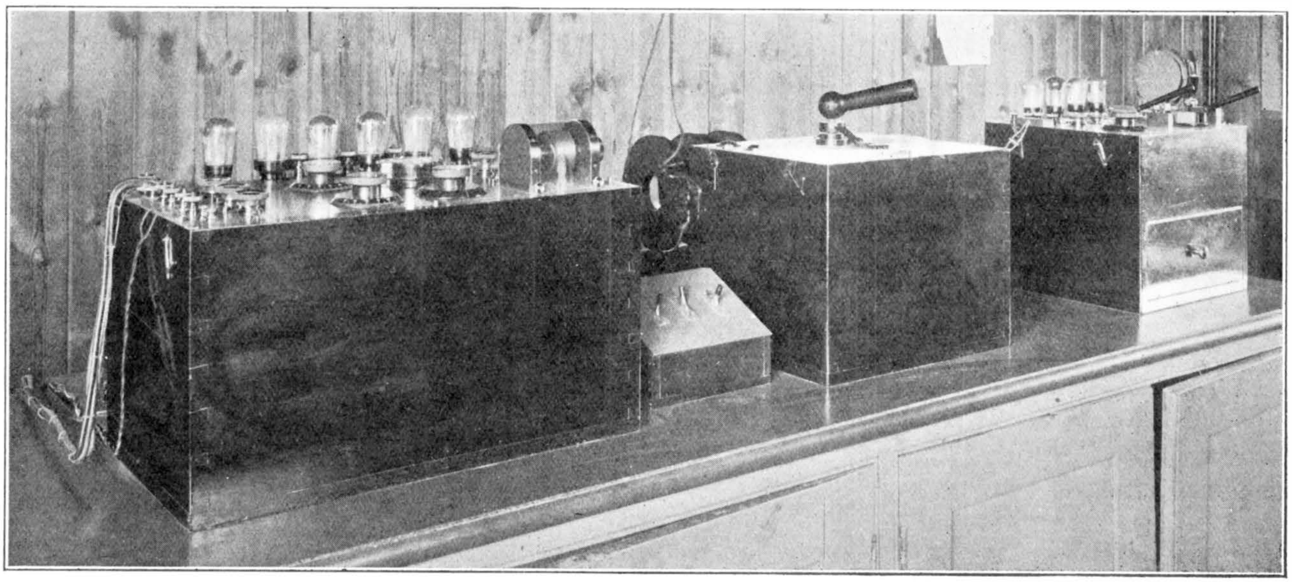


Fig. 3.—Multivibrator.

Effect of load on Frequency.—An intermediate circuit is interposed between the fork circuit and the multivibrator to minimise any possible effect upon the frequency of the driving circuit due to the reaction of the load. The multivibrator equipment is shown in Fig. **3**.

Determination of Absolute Frequency of Fork.—The method adopted in obtaining a comparison with unit time depends firstly upon utilising an output from the intermediate circuit following the tuning fork and, after amplification, causing this to drive a phonic motor. The particular phonic motor used is constructed by General Radio Co. and is designed to reduce hunting to a minimum. It is equipped with a cam which makes contact every second, provided that the frequency of the controlling source is precisely 1000 cycles per second. The motor is also geared to a clock which, at this frequency of control, is arranged to record accurate time.

The contacts which are operated by the cam are in circuit with one of the coils of a double coiled syphon recorder, so that a record is made on the tape each time the cam closes the contacts. The other coil of the syphon recorder is energised either from the current impulses received hourly from the Greenwich Observatory, or by the time signals emitted from the Rugby Radio Station. These latter signals, which are sent out at 1000 GMT and 1800 GMT respectively and maintain a time interval seldom in error by more than .01 second, allow of a long period check of the frequency of the fork, whilst the hourly signals allow of a shorter period and, incidentally, because of the slightly less reliable time interval, slightly less reliable comparison with the unit time.

Fig. **2** shows the lay-out of the phonic motor and amplifier, the Cambridge Instrument Co.'s Recording Thermostat, Barograph and Syphon Recorder.

The velocity of the tape of the syphon recorder is such that the second marks from the phonic motor are separated about three inches, and the error in measuring the displacement of the two records, *i.e.*, the record from the phonic motor and that derived from the time signals, does not exceed .02 inches. The error in frequency estimation due to this cause should therefore not exceed .0066 parts in 28,800 when operating on the long period comparison, *i.e.*, 0.23 parts in 10^6. The error due to the possible deviation of the signalled period from exactly 28,800 seconds, *i.e.*, .01 second, gives rise to a frequency error of 0.35 parts in 10^6 and hence the total maximum error in this method of comparison is of the order of 0.58 parts in 10^6. With a shorter interval for comparison, the error due to these causes is of course correspondingly increased.

These estimations take no account of possible frequency changes due to pressure, but as stated previously, the effect of pressure in this connection is under investigation.

Application to Measurements.—The standard fork maintained as previously described is caused to control the multivibrator equipment of fundamental frequency 1000 cycles per second and 20,000 cycles per second in the manner described by Dr. D. W. Dye in the Philosophical Transactions of the Royal Society Series A, Vol. 224.

Equipment is maintained in the Radio Laboratory in intimate association with this apparatus for receiving signals of frequencies over the commercially worked range, and for relating these frequencies to the harmonic frequencies of the tuning fork.

Measurement of Low and Medium Radio Frequencies.—The method relies upon the utilisation of two beating or heterodyne oscillators used in connection with a receiver. One of these oscillators, called the beating oscillator, is of the type which would be normally used with such a receiver, whilst the other, termed the comparison oscillator, is of special construction in that it is designed to maintain constant frequency with variation in load, H.T. or L.T. supplies, and its oscillating circuit is arranged to have maximum capacity. This capacity is made up of two parts, one much smaller in value than the other; the smaller capacity has the form of a specially designed variable condenser having a very large and finely divided scale, whose capacity change is proportional to change in scale reading.

The operation of measurement of frequency of an incoming signal is as follows. The signal is received in the normal manner, using the beating oscillator, and the comparison oscillator adjusted to exact synchronism with the incoming signal by the well-known method of double beating. The reading of the scale of the variable condenser on the comparison oscillator is noted, and from the multivibrator apparatus consecutive harmonics are selected, such that their frequencies synchronise with frequencies of the comparison oscillator corresponding to settings of the variable condenser lying respectively above and below the reading obtained for synchronism with the incoming signal. The frequency of the incoming signal can then be obtained by interpolation between the three readings of the condenser, since the frequencies corresponding to the selected harmonics are known.

Normally, true harmonics of the tuning fork are utilised for the interpolation, *i.e.*, the interpolation is carried out within a frequency space of 1000 cycles per second, but if greater accuracy is required this interval can be reduced to any convenient integral fraction of this frequency interval.

Measurement of Medium High and High Radio Frequencies.—The method employed for the measurement of Medium High and High Frequencies is similar in principle to that already described, inasmuch as it relies upon the adjustment of an interpolating condenser to synchronise an oscillator with the incoming signal and with harmonics of a source whose fundamental frequency is a known multiple of the tuning-fork frequency.

In this system the output from either the Low or High Frequency Multivibrator is passed through an amplifier, the output of which is caused to control the frequency of an oscillator which will be termed the reference oscillator. By this means the reference oscillator can be caused to oscillate at any harmonic frequency up to the three hundredth of the Low Frequency Multivibrator and it is calibrated at various of these harmonic frequencies. The harmonics of this reference oscillator are used as reference points when measuring the frequency of an incoming signal, as described below. The reference oscillator, as used for the measurement of high frequencies, is thus analogous to the Low Frequency Multivibrator as used for the measurement of low frequencies.

Another oscillator, termed the comparison oscillator, with whose tuning circuit is associated the special interpolating condenser, is used to obtain the actual signal frequency measurement. The oscillator is synchronised alternately with the signal and with two harmonic frequencies of the reference oscillator situated on either side of the signal frequency and the required frequency obtained by interpolation.

Thus it is possible to synchronise the reference oscillator to such an order of harmonic, say the nth, of the Low Frequency Multivibrator that the mth harmonic for the oscillator is less than m kc/sec: (assuming the tuning fork frequency is 1 kc/sec) removed from the frequency to be measured. If now the reference oscillator be synchronised with the $(n \pm 1)$th harmonic (the sign being dependent upon whether the frequency to be measured was above or below the harmonic frequency already dealt with) then the mth harmonic of the reference oscillator at

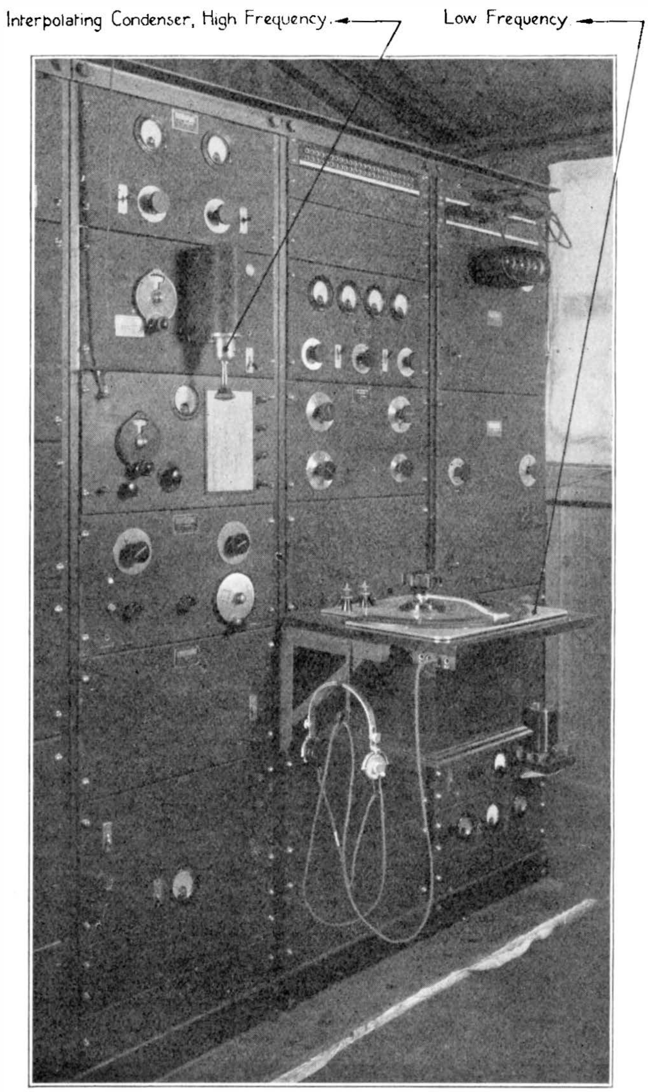


Fig. 4.—Receiving and Measuring Apparatus.

this fundamental frequency will give the second interpolation point, from which the incoming signal frequency can be obtained.

If in the above description, n is assumed to be 300 and a frequency of the order of 15,000 kc/sec is to be measured, the harmonic number m would be of the order of 50 and hence the interpolation interval 50 kc/sec.

The comparison oscillator in association with the short-wave receiver used for obtaining the signal can be set to absolute synchronism with the signal and also to synchronism with the two frequencies of the reference oscillator, which are spaced 50 kc/sec apart, and which are arranged to lie on either side of the signal frequency. The signal frequency is then obtained by interpolation from the three readings of the interpolating condenser of the comparison oscillator. This condenser is of special design and consists essentially of a cylindrical plunger moving inside a hollow cylinder, the motion being controlled by a micrometer screw. The total variation in capacity is of the order of 12 μF and there is linear relation between scale reading and capacity change.

For more precise measurements than can be obtained as described above, it is arranged that the reference oscillator is set such that the harmonic combination nm kc/sec is less than, say, 10 kc/sec from the frequency to be measured. The comparison oscillator setting is synchronised with this harmonic frequency of the reference oscillator and then successively with frequencies differing in steps of 1 kc/sec from this frequency until the setting corresponding to synchronism with the signal frequency is overlapped. In this manner the comparison oscillator can be set to two frequencies differing by 1 kc/sec, which are on either side of the signal frequency, and hence the interpolation interval reduced to 1 kc/sec.

The above procedure is that usually followed when it is required to follow small changes in frequency of a transmitter or when a very high degree of accuracy is required. With an unknown station it requires a preliminary measurement of the frequency by the method first described, but once measurement has been made checks can be made very rapidly and with an extremely high order of accuracy.

Allowing for the possible errors in the standard as previously described, and using the 1 kc/sec interval method of measurement, it is considered that the maximum error in making frequency measurements on the medium high, and high frequency ranges should not exceed $\pm$ 3 parts in 10^6.

The whole of the receiving equipment and the various oscillators as described are mounted in rack form and are shown in Fig. **4**.

FREQUENCY CONTROL EQUIPMENT OF POST OFFICE SHORT-WAVE TRANSMITTERS.

E. J. C. Dixon, A.C.G.I., B.Sc., D.I.C.

I.

INTRODUCTION. — The first short-wave transmitters constructed by the Post Office consisted of self-oscillating single valve circuits, employing glass envelope valves of about 1500 watts dissipation, and the frequencies on which the transmitters operated were checked by means of simple wavemeters of the absorption type. The frequency constancy was often little better than plus or minus 2000 parts in a million, due to variations in the supplies to the oscillator, variations in the internal characteristics of the valves, changes in the values of the circuit components due to heating and changes in the antenna load with varying conditions of wind and weather. As the advantages of the short-wave channels became more apparent and more stations sought to transmit on frequencies in the commercial range, *i.e.*, 3,000 to 30,000 kilocycles per second, it soon became necessary to restrict the variation of frequency of transmitters using this band. A demand for some method of frequency control of telephony transmitters also arose, owing to the peculiar phenomena associated with the transmission of modulated carriers at the high frequencies employed.

The method in use for the frequency control of long-wave transmitters was the selection of harmonics from a valve-maintained tuning-fork oscillating at a frequency of the order of 1500 cycles per second, and in order to extend this equipment to the very high frequencies it would have been necessary to instal a large number of harmonic selecting, filter and amplifying stages. A method of frequency control was therefore developed in which the constant frequency source was a piezo-electric crystal plate oscillating at a frequency of the order of 1500 kilocycles per second. The frequency was raised to that of the required carrier, usually from 5,000 kc/sec to 20,000 kc/sec, by means of two or three frequency-doubler stages and the power level was then raised to ten kilowatts by means of amplifying stages at the carrier frequency. The present article describes typical equipment designed for frequency control of a high order of accuracy and is illustrated by photographs of the apparatus recently installed for the telegraph transmitter GBM at Oxford Radio Station.

The Quartz Oscillator.—The brothers Curie, investigating piezo-electric substances in 1880, showed that all non-conducting hemihedral crystals became electrically polarised when caused to contract and became polarised in the opposite sense when caused to expand. Owing to its mechanical strength and chemical stability, quartz is the most useful of the natural piezo-electric substances and, since 1922, when Cady developed quartz resonators and oscillators for frequency standardisation, the use of quartz plates and bars for frequency standards has greatly increased. The Post Office made use of quartz resonators in 1925 in connection with frequency standardisation and in an article by F. E. Nancarrow* it was stated that an oscillator could be set to the resonant frequency of a quartz rod with an accuracy of the order of 1 part in 50,000, which was much greater than the accuracy with which the frequency of the oscillator itself could be measured. It is interesting to note that the accuracy of frequency measurement using the Multivibrator apparatus was 100 parts in a million at that date, whereas at the present time the accuracy of measurement using similar apparatus with refinements and the provision of a method of referring the frequency standard to G.M.T. is of the order of 5 parts in a million, while the accuracy of transmitters themselves can be made considerably better than 100 parts in a million. The quartz oscillator is a thermionic valve circuit in which a quartz resonator is used as an oscillatory circuit of low decrement, in such a way that the frequency of oscillation of the circuit is mainly dependent on the dimensions of the quartz plate. There are several circuits which may be used and the one used by the Post Office has a tuned-anode circuit and a quartz crystal connected between grid and filament. Fig. **1***a* shows the original circuit, in which a 50 watt valve having an anode voltage of the order of 800 was used, and Fig. **1***b* shows

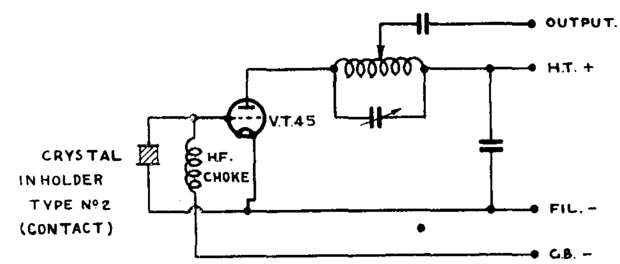


FIG. **1***a*.

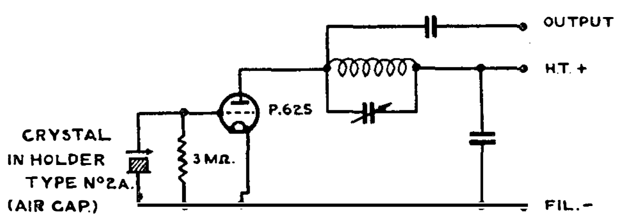


FIG. **1***b*.—CRYSTAL OSCILLATOR CIRCUIT.

the circuit in use at present with a P625 valve and an anode voltage not exceeding 120. In reducing the power of the oscillator, two advantages were gained, viz., (*a*) the heating of the crystal due to the high frequency current through it was reduced and therefore the variation due to the crystal temperature coefficient was reduced and (*b*) it became possible to use an air-gap type holder which reduced variations due to the upper

* *Journal P.O.E.E., Vol. 18, Part 2, July, 1925.*

contact electrode and provided a vernier adjustment of frequency which is extremely useful.

The method of cutting the quartz crystal plate may be understood by reference to Fig. 2, which

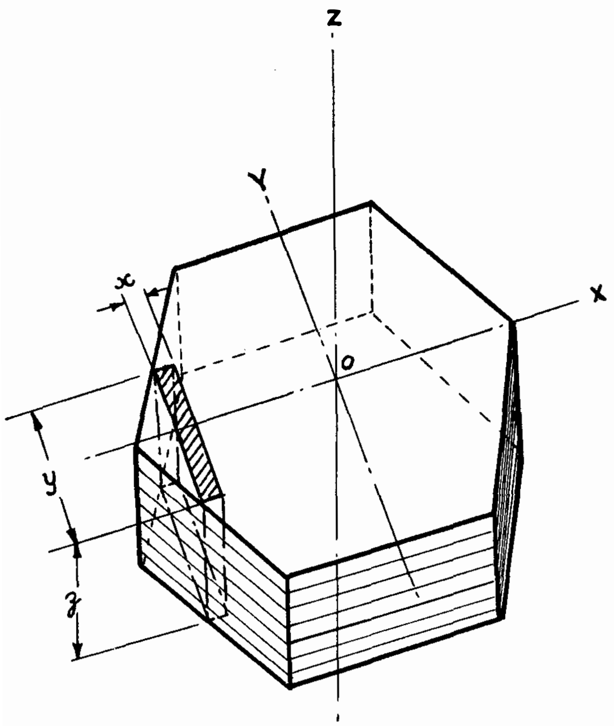


FIG. 2.—SECTION OF QUARTZ CRYSTAL.

represents a section about an inch in thickness cut parallel to the lines of crystal growth, which may be seen on the faces of the crystal. The area of cross-section is seldom a perfect hexagon, but the angles between the faces are always 120 degrees. OZ represents the trigonal axis, usually referred to as the optical axis, and OX represents one of the three diagonal axes, usually called the electric axes, which are parallel to the faces of the crystal. OY is one of the third or "mechanical" axes and is at right angles to OZ and OX.* The quartz plates are cut perpendicular to an electric axis as shown in Fig. 2, in which case they are known as "X cut plates" or perpendicular to a mechanical axis, in which case they are called "Y cut plates." Owing to the fact that the Modulus of Elasticity is not the same in all directions through the crystal, the properties of X and Y cut plates are different. There are two quantities which are of importance —(*a*) the relation between the thickness (x in the case of the X cut crystal shown in Fig. 2) and the frequency of response of the plate, and (*b*) the temperature coefficient of frequency. The former quantity, which may be called the "thickness coefficient," is usually expressed in kilocycles per second per millimetre and the temperature coefficient of frequency is expressed in parts per million per degree Centigrade. The differences between X and Y cut plates may be summarised as under:—

	X cut.	*Y cut.*
Thickness Coefficient ...	2.7	2.0 kc/sec/mm.
Temperature Coefficient ...	−25	+70 parts/10^6/°C.

These are average values, since the modulus of elasticity appears to vary from specimen to specimen of quartz crystal, and the value of temperature coefficient is complicated by the fact that it is almost impossible to cause a quartz plate to oscillate in a single mode, *i.e.*, components of other modes of oscillation than the thickness vibration are always present. The trigonal symmetry of quartz and the fact that the modulus of elasticity varies with direction thus give rise to considerable difficulties in the practical working of a quartz plate, and in practice it is found that the X cut usually presents less difficulties due to unwanted modes of oscillation. This property, coupled with the fact that the temperature coefficient is invariably smaller than with the Y cut, has led to the adoption of X cut crystals in Post Office practice.

The procedure in producing a quartz plate is as follows:—A section as shown in Fig. 2 is cut parallel to the lines of crystal growth and the section is examined optically, using light passed through crossed Nicol prisms, to detect flaws or twinning. If satisfactory, the section is marked with an electric axis by scribing a line parallel to a face. Lines perpendicular to the electric axis, separated by a thickness somewhat greater than that required for the finished plate, are then set out and the section is sliced along them by means of a lapidary's saw or wheel. Several plates of the same length (y) are usually cut of

* *Note.—The "third" axes are not axes of symmetry in α or low quartz, but become axes of symmetry when the quartz is heated above 570°C and is no longer piezo-electric.*

the same thickness and worked in a gang grinding machine so that the faces are accurately parallel. They are then tested for piezo electric response in a test circuit and adjusted by hand grinding until the correct frequency is given. Sometimes it is necessary to reduce the length y or the length z so that harmonics of oscillations corresponding to these lengths do not interfere with the required thickness vibration and, owing to the complicated nature of the responses, there are often discontinuities in the oscillations obtained as the thickness of the plate is progressively reduced. It is thus often necessary to prepare several plates in order to get one completely satisfactory specimen, especially when a high order of accuracy is required.

It has been shown by Dye* that the equivalent electrical circuit of a quartz crystal is as shown in Fig. **3**, in which K2 represents the

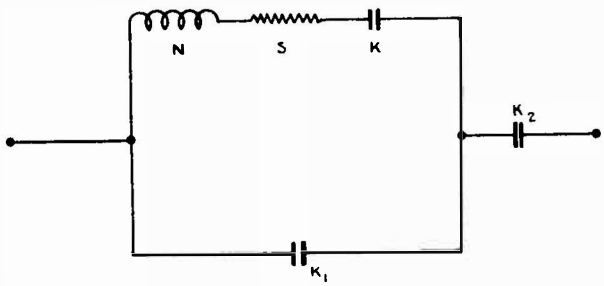


FIG. **3**.—EQUIVALENT CIRCUIT OF QUARTZ CRYSTAL IN HOLDER.

capacity of the air gap and the rest of the circuit represents the quartz crystal. The capacity K1 will, however, include the stray capacity of the holder, and the natural frequency of the whole circuit will depend on the values of K1 and K2, *i.e.*, the frequency of a given crystal will be different in holders of different capacities or of different air gaps. The equivalent circuit of the quartz oscillator is as shown in Fig. **4**, in which the dotted lines represent the inter-electrode capacities and conductances. The frequency of oscillation of this circuit will not be the same as the frequency of response of the crystal as a resonator, and will depend to a small extent on the valve capacities and conductances and the tuning of the anode circuit LC. This circuit has been fully analysed by P. Vigoureux† and compared with a similar circuit in which the crystal is connected between the grid and anode of the valve.

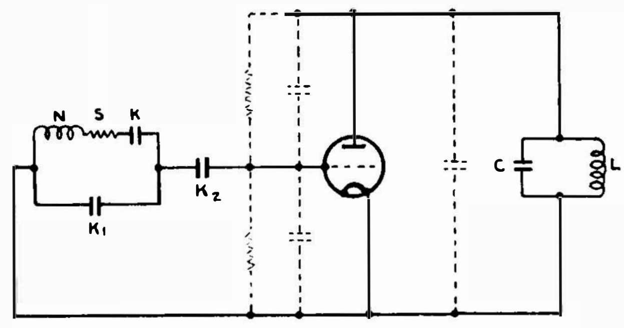


FIG. **4**.—EQUIVALENT CIRCUIT OF QUARTZ OSCILLATOR.

The magnitude of the variations that are likely to occur in a quartz oscillator has been found for typical crystal plates, and are as under:—

Temperature—25 parts per million per degree Centigrade.

Air trap—50 parts per million per mil air gap.

Anode Tune—30 parts per million over full range of oscillation.

Anode Voltage less than 1 part per million per 1% change.

Filament Voltage less than 1 part per million per 1% change.

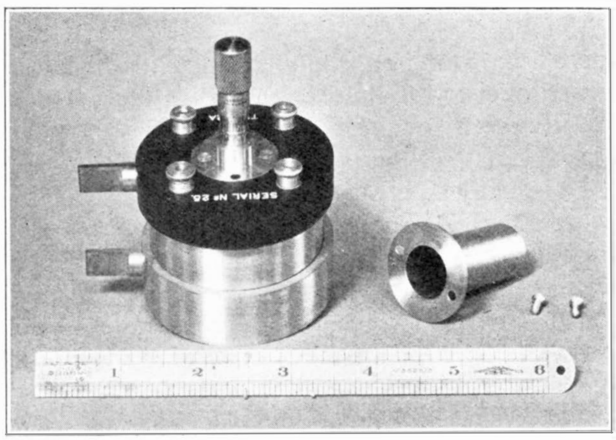


FIG. **5**. QUARTZ CRYSTAL HOLDER.

To achieve the accuracy required, the crystals and the oscillator are enclosed in a thermostat-controlled oven, thus reducing variation in temperature to a small amount and precluding the possibility of alteration of the air gap or of the anode tune, while the supply voltages are derived from the most constant source available.

* *Proc. Phys. Soc. Lond.* 1926, 38.

† *J. Inst. Elect. Engrs.* 1930. 18.

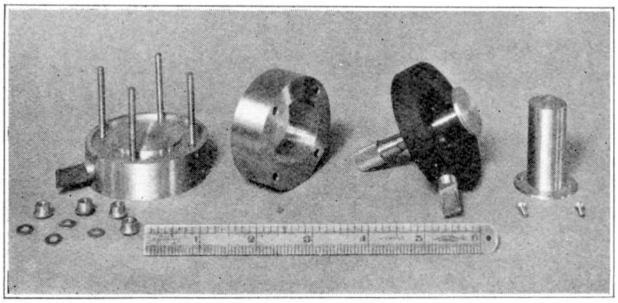


Fig. 6.—Parts of Quartz Crystal Holder.

The temperature of the oven is usually adjusted to 50°C. and the bimetallic thermostats are capable of maintaining this value to ± 0.25°C. In testing quartz plates supplied by manufacturers a standard crystal holder is provided and the oscillators are tested with the standard circuit at 50°C. Tests of the quartz plate as a resonator are also made to check that there are no spurious " crevasses " near the required frequency.

Description of Quartz Oscillator and Oven Equipment.—The standard holder at present in use is shown assembled in Fig. 5, while the parts are shown in Fig. 6 and consist of a lower electrode with contact blade, a metal spacer, an upper electrode support with micrometer variable electrode and contact blade, and a micrometer cover. The crystal plate, which is roughly one inch square, rests freely on the lower electrode and its movement is limited by the spacer which is just greater in diameter than the longest dimension of the crystal plate. The holder is clamped up by four nuts and the air gap may be read to 1/10,000 inch by means of the micrometer head. The cover is screwed in position when the final adjustment has been made to prevent subsequent alteration of the air gap.

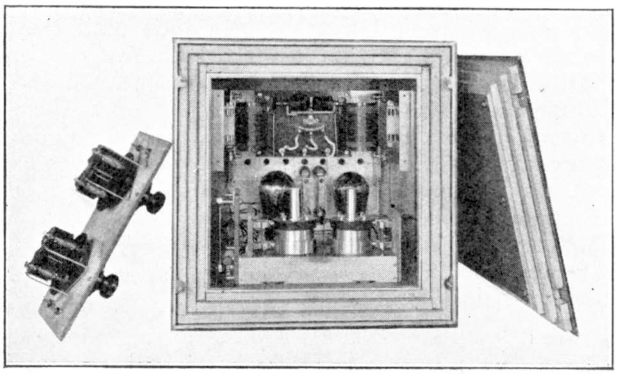


Fig. 7.—Quartz Oscillators, Thermostat and Oven.

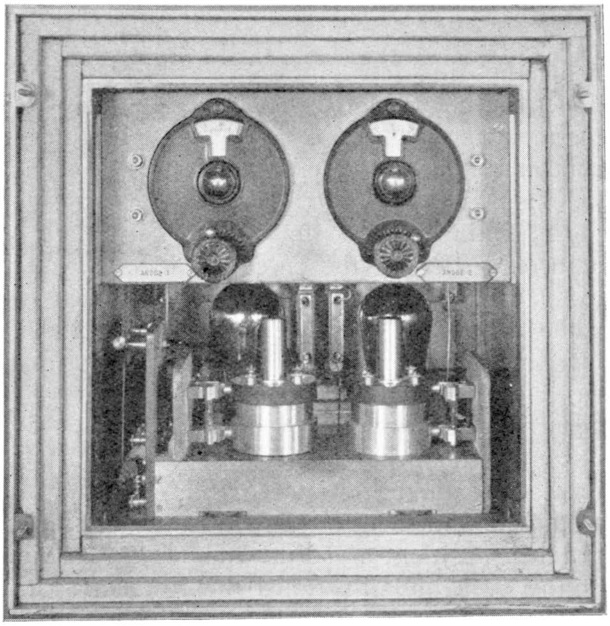


Fig. 8.—Quartz Oscillator Oven. Condenser Panel in position.

Fig. 7 shows an oven with two similar quartz oscillators. The oven consists of two shells of aluminium separated by three layers of

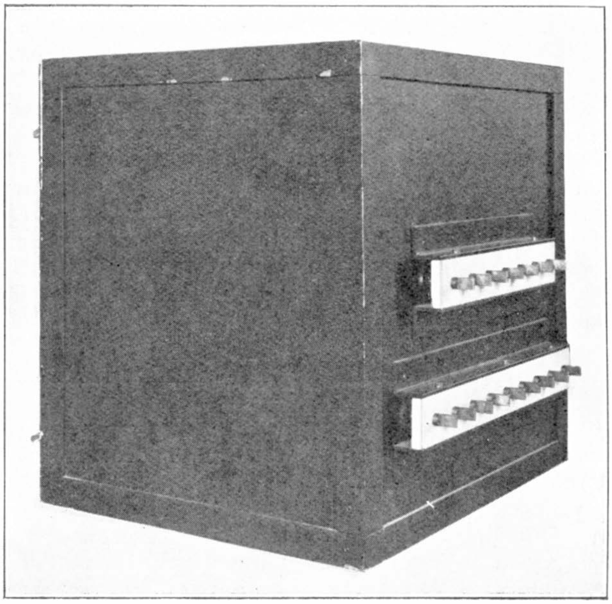


Fig. 9.—Rear view of Oven.

"Celotex"—a building material manufactured from cane fibre. The crystal holders rest on a metal housing containing the oven heaters, bimetallic helix thermostat and nickel resistance thermometer. The arm carrying the thermostat contact is seen to the left of the heater housing, together with the worm gear by means of which the operating temperature of the helix may be adjusted. Behind the crystal holders are seen the valves and the output blocking condensers, while above are seen the anode coils and the mercury switch which selects the output from either of the oscillators. The anode tuning condensers are mounted on a mycalex panel which is connected to the circuit by switch contacts so that access to the interior of the oven may be readily obtained. Fig. **8** shows the condenser panel in position, and Fig. **9** shows a rear view of the oven and illustrates the rows of switch blades mounted on mycalex bars by which the various supplies are connected to the oven. The corresponding connections are carried on a panel (Fig. **10**) which serves for switching and metering the supplies to the oscillators. The switches and meters are described by the labels on the panel and there are, in addition, two fuse alarm lamps, an oven pilot lamp which indicates the operation of the thermostat contact and two filament rheostats of the "preset" type. The lay-out of the front of this panel is typical of present practice in transmitter equipment.

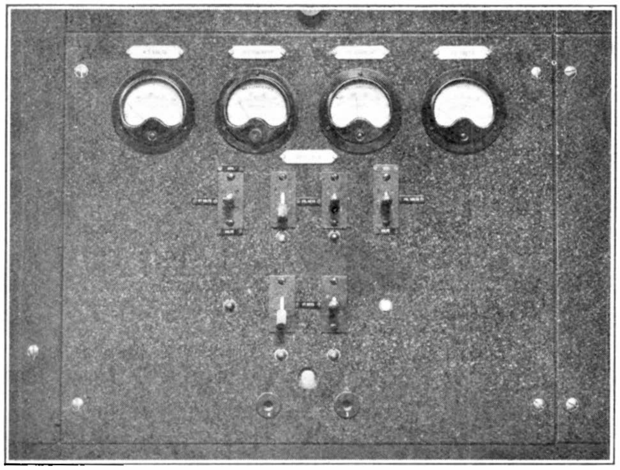


FIG. **10**.—OSCILLATOR METERING PANEL.

[*This article will be concluded in the next issue of this Journal.*]

(*Continued from page 166*)—

to eight or even to seven after being considered by the Secretary! However, on one occasion some "absent-minded beggar" drew out the wires and left an empty pipe! It was years before sweeps' rods for pipework were thought of. What was to be done? Somebody suggested a rat and length of twine. So far so good; but the rat thought it wise to settle down half-way and it was not until a ferret was sent in to discuss matters with him that he decided to finish the journey. I don't know whether it was the rat or the ferret who was rewarded! Mr. C. T. Fleetwood was the London Underground expert in those days—I do not know whether the rat idea originated with him or with one of his subordinates.

It would probably surprise many present-day Engineers to know that even when multiple ducts were first installed we used to run sash lines in those that were to be filled at once and iron wire in spare ducts. I find the need for a rat in these days a little perplexing.

I wonder if your readers would feel any interest in a "fishing" story? Soon after I succeeded Mr. Fleetwood at Met.N. one of my Engineers told me that they had been trying in vain for two or three days to get rods through a pipe in Hackney. "Fishing" from both ends by means of rods specially fitted with wire hooks had entirely failed, and he thought there was nothing for it but to open up midway. I discussed the problem and made a rough sketch of a spring coupling as a substitute for the "fishing" hooks. It was made by the mechanic, the two halves of the coupling were fixed on the sets of rods served from each end and they engaged as soon as they met! A few days later the Engineer explained that often it was difficult to rod a long section as the rearward rods spiralled in the duct owing to the weight of or the friction on the rods in front. I said that although the spring coupling would meet the case it would be interesting to try another device. So I had a "thick to thin" adaptor made and we passed forward thin rods until they bound and would go no further; then five or six lengths were withdrawn, the adaptor connected and the thin rods pushed forward by thick rods. This also was entirely successful. I duly submitted the Spring Coupling and a complete set of Adaptors to H.Q. and it was adopted.

Probably standardisation of cable lengths has abolished any need for such devices to-day—except at Turin!

Yours faithfully,

A. J. STUBBS,
Carlisle Lodge,
58, Howard Road,
S.E.25.

NOTES & COMMENTS

MICHAEL FARADAY was one of the greatest Englishmen that ever lived. He was a great man, not only by what he did but also because of his simple kindliness, which did not allow him to lose his head when honours were thrust upon him. His memory is revered at the Royal Institution, and it is fitting that that august body should combine with the Institution of Electrical Engineers to celebrate the centenary of the discovery of electromagnetic induction by Faraday in the year 1831. An exhibition will be held at the Albert Hall, London, for ten days, beginning on the 22nd September, which will illustrate the development of industrial science due to the intuition and work of this remarkable genius. The exhibition will coincide with the meetings of the British Association, and the I.E.E. will hold its annual conversationé at the hall on the 22nd September. The P.O. is to participate in the Communications Engineering section and arrangements are in train for a very representative exhibit of what is called sometimes,, although quite erroneously, light electrical engineering. In all the sections, the items will be arranged in historical order, from a statue of Faraday in the centre to the screen that will cut off the arena from the boxes.

In this issue we start a new venture in the shape of a Supplement to the Journal, one of which is enclosed in each copy. The main object of the Supplement is to cater for the needs of the younger members of the staff and the Department's workmen who have responded to our appeal in a most gratifying manner. In this number, the current year's C. and G's Magnetism and Electricity and Telephony Preliminary grade examination papers are answered by a capable officer of the Department. The other grade papers will follow in October. The addition of a Supplement throws a very heavy burden on the Board, but we think it will be appreciated and will, we hope, result in a still further increase in our circulation, which is now between seven and eight thousand copies per quarter.

Mr. Sydney Evershed, M.I.E.E., has sent us a copy of his Discourse given at the I.E.E. on the "Commemoration of the Centenary of the birth of David Hughes." We regret we have no room in this issue for the paper, which relates the life history and doings of a man whose inventions have been closely associated with telegraphs and telephones. He was a Welshman, born in London, but his father took him when a boy of seven to Virginia. He returned to London in 1857 with his telegraph printer, but, in the words of Mr. Evershed, John Bull said "No" to Hughes. In a few years the Hughes was at work all over Europe. In 1877 he invented his "microphone," and in 1879 the Induction Balance. In 1880 Hughes was elected a Fellow of the Royal Society and in 1885 he was awarded the Society's gold medal. He was president of the I.E.E. in 1886. He died on 22nd January, 1900, and in his will he left a large sum to scientific societies, the Hughes Scholarship to the I.E.E. and the greater part of his fortune to four London hospitals.

RATS AS DUCT THREADERS.

The story from Turin which we published in last issue has brought forth quite a large correspondence on the subject. First we have a protest from our venerable friend, Mr. C. B. Clay, who writes from Bromley, Kent, as follows :—

May 8th, 1931.

Dear Sir,

In your notes in the April number under the heading "Rats," you mention as original a story from Turin.

A very similar one was told to me in 1885 or 1886. In this case instead of the blow lamp a ferret was used with satisfactory result. I do not remember hearing the fate of the rat.

Surely you won't let Turin claim originality for a device used in Newcastle-on-Tyne more than 44 years ago.

Yours faithfully,

C. B. Clay.

Then comes a letter from Mr. Procter, of the T.I. Group, who confirms the ferret edition, and gives a sketch illustrating the pursuit. We do not agree with Mr. Procter that the method has any advantage since the ferret might overtake the rat in the duct, and the evil would then be worse confounded!

11th May, 1931.

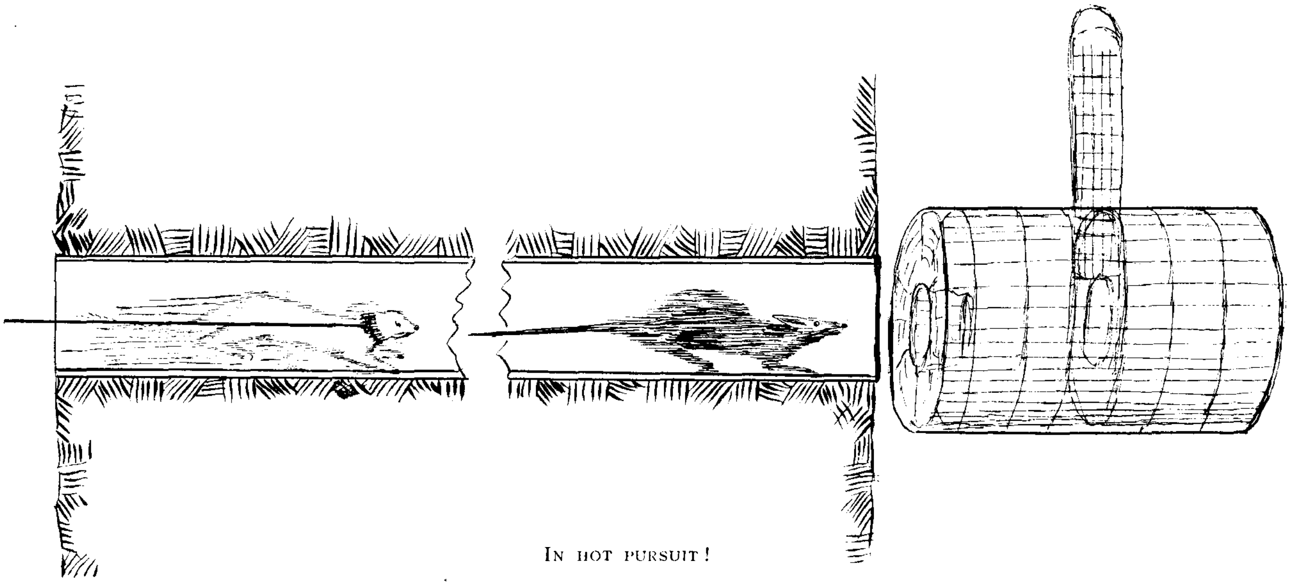
Dear Sir,

The account, in the last issue of the Journal, of the episode of the Turin rat was very interesting, but the method employed was surely crude and was certainly not original. Some years ago, I was searching through a pile of old electrical trade papers dating about the latter part of the 19th century and I recollect having seen a description in one of them of a method of getting a length of string through a duct; in the method described, a ferret was employed in addition to the rat. The article was illustrated and I enclose a sketch of the arrangement so far as I remember it.

The rat was put into the duct and then the ferret, muzzled and with one end of a length of strong twine fastened to the muzzle, was sent down the duct after the rat. In theory, of course, both went with all speed to the far end where a double-compartment wire cage, such as is to be found on most farmsteads, was waiting to receive them. The rat having run to the end of the cage, the dividing partition was dropped in readiness for the reception of the ferret.

This method has the advantage of possessing a much greater degree of certainty in attaining the desired object, though I do not remember reading that it had ever been tried out in practice. Possibly, however, some of the older readers of the Journal may be able to relate actual experiences with the method.

Yours truly,
W. S. Procter.



In hot pursuit!

Then our esteemed friend M. L. Kristiansen writes from Oslo and puts the seal, as it were, on the story by quoting from the classics :—

Dear Sir,

"And the rat came back."

The Italian process of using a rat for pulling or drawing wire into a telephone duct—told in your last issue—is anticipated by the time-honoured authority : Preece and Sivewright : "Telegraphy," tenth edition (1892), page 313—but of course the blow lamp has improved it (*i.e.*, the process—not the rat!)

Yours sincerely,
M. L. Kristiansen
(Foreign Member).

And, lastly, Mr. A. J. Stubbs, whose veracity, we all agree, is beyond dispute, writes :—

To The Editor, *P.O. Engineers' Journal.*

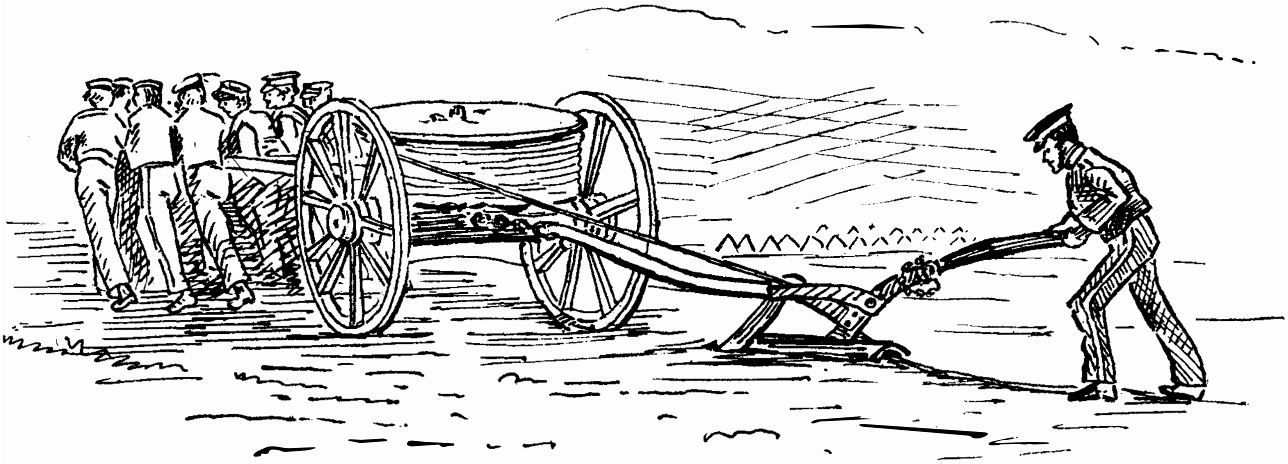
8th June, 1931.

Dear Sir,

Rats! There's nothing new under the Sun!

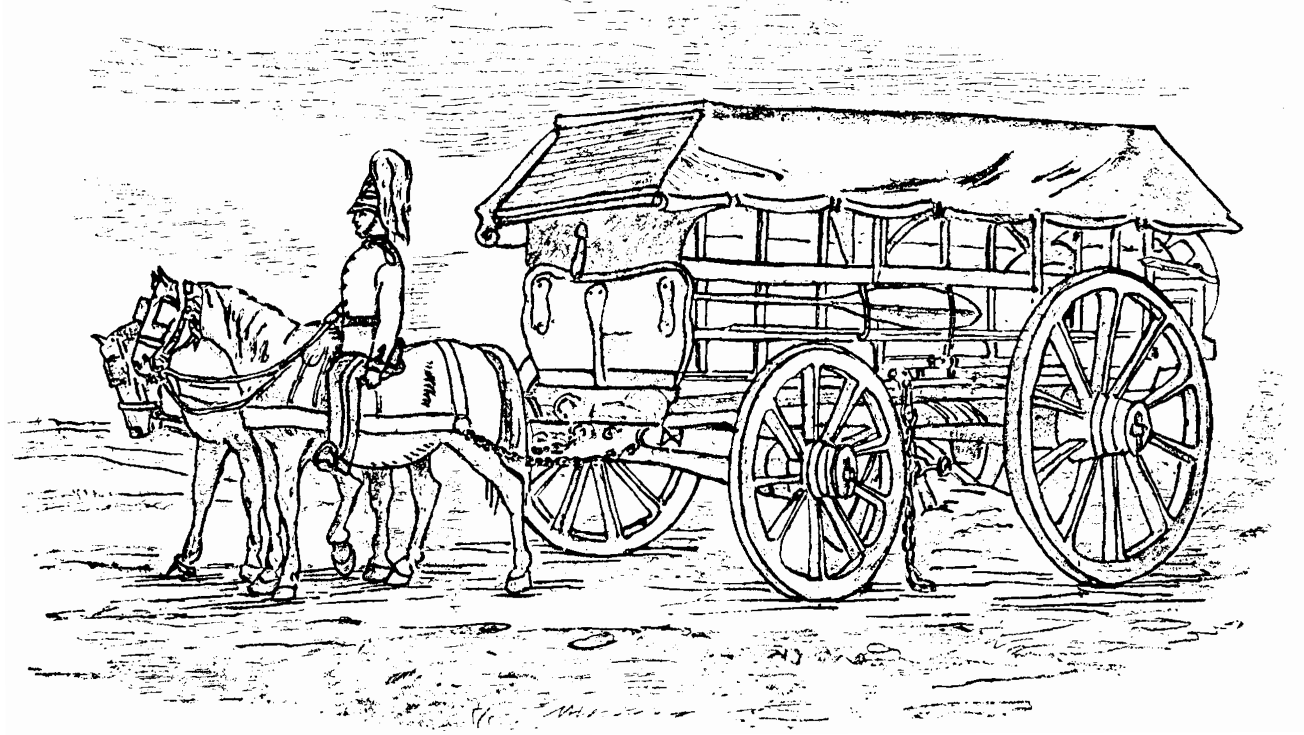
The most interesting point to me about Mr. Briggs' Rat Story on p. 66 is the implication that only the "absolute veracity" of the correspondent secured acceptance of the story. I trust that my veracity may be esteemed equally unimpeachable, because I want to assure you that this novel way of getting wires into a pipe was practised fifty years ago. In those days when a pipe was laid it was going to be used at once so it was sufficient to thread a sash line through as it was laid (This of course is not novel even to-day!) The gutta-percha covered wires were drawn in by its means (or by means of a larger rope). In those days an increase in the number of wires in a pipe was a very serious matter—an S.E's suggestion to increase by (say) ten wires might be reduced

(Continued on page 164.)



"Cannons to left of them volleyed and thundered."

PLOUGH FOR LAYING COVERED WIRE SUPPLIED BY THE ELECTRIC TELEGRAPH COY. CRIMEA, 1854.



TELEGRAPH WAGON SENT OUT TO THE CRIMEA, 1854.

HOW "SIGNALS" FUNCTIONED IN THE CRIMEAN WAR, 1854.

G.P.O.,
Gloucester.
11-5-31.

The Managing Editor,
P.O.E.E. Journal.

Sir,

Having read with interest about the experiment carried out in connection with the laying of cable in the grass margin, N.E. District (Vol. 24, Part 1, Page 73, April, 1931), I thought this picture might be of interest to you.

You are quite at liberty to keep this, also the one of the Utility Wagon.

E. F. G. HOBRO, SW.II.,
Gloucester.

LOCATION OF SPLIT PAIRS IN CABLE.

Research Station,
Dollis Hill.
19-5-31.

The Editor, *P.O.E.E. Journal.*

Locating the Crosses in Split Pair Cables.

Dear Sir,

In the April, 1931, issue of the Journal (page 71) there appears under the above title an account of a somewhat novel method of locating split pair joints in cable sections of not more than about two miles in length. The use of the formula given for obtaining from the bridge reading the distance to the faulty joint would appear, however, to give rise to serious error, except in certain circumstances. This is because the formula neglects to take account of a number of capacity couplings between the wires, which would generally be large enough to affect the conditions for the balance of the bridge.

Fig. 1 corresponds to the figure given by Mr. Brown, but includes all the capacity couplings involved. The diagram has been simplified by combining, in the usual manner, the wire-to-earth capacities with the wire-to-wire capacities to give "resultant" wire-to-wire capacities. The significance of the letters used is as follows:—

W, X, Y, Z are resultant capacities between wires in different pairs.

M, N are resultant capacities between wires in the same pair.

Also,

$$W = w + \frac{ac}{a+b+c+d}, \quad X = x + \frac{bc}{a+b+c+d},$$

$$Y = y + \frac{bd}{a+b+c+d}, \quad Z = z + \frac{ad}{a+b+c+d},$$

$$M = m + \frac{ab}{a+b+c+d}, \quad N = n + \frac{cd}{a+b+c+d}$$

where w, x, y, z, m, n are direct wire-to-wire capacities, and a, b, c, d are direct wire-to-earth capacities.

Mr. Brown's method of joining the wires to the bridge enables capacities W_1, Z_1, N_1 and M_2, Z_2, Y_2 to be neglected, so long as the cable section is not more than a few miles in length.

The condition for silence in the telephone is then, essentially

$$\frac{Q}{P} = \frac{M_1 + W_2}{X_1 + Y_1 + X_2 + N_2} \quad \text{.......} (1)$$

Assuming that the two pairs are very similar and are well balanced, and that the capacity distribution is uniform, then

$$\frac{Q}{P} = \frac{\overline{M}_1 + \overline{W}_2}{2\overline{W}_1 + \overline{W}_2 + \overline{M}_2} \text{ (very nearly)} \quad \text{......} (2)$$

where $\overline{M} = \frac{M + N}{2}$

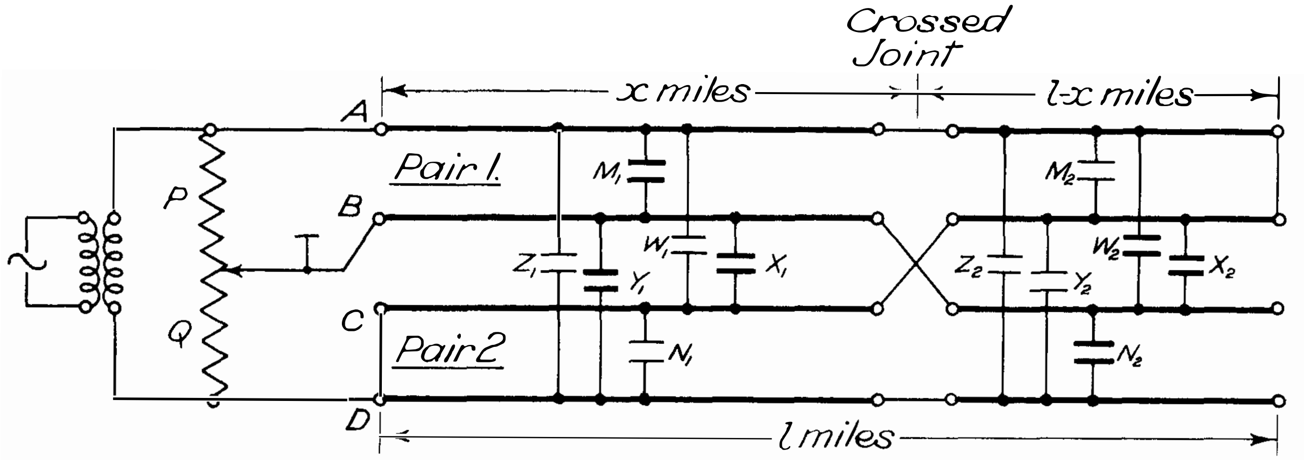


FIG. 1.

and $\overline{W} = \frac{W + X + Y + Z}{4}$

Also, it can be easily shown that in this case

$$\overline{C} = \overline{M} + \overline{W} \text{ (very nearly)}$$

where $\overline{C}$ is the average mutual capacity of the two pairs.

Substituting in (2) gives

$$\frac{Q}{P} = \frac{\overline{C}_1 - \overline{W}_1 + \overline{W}_2}{\overline{C}_2 + 2\overline{W}_1}$$

and therefore

$$\frac{Q}{P + Q} = \frac{\overline{C}_1 - (\overline{W}_1 - \overline{W}_2)}{\overline{C}_1 + \overline{C}_2 + \overline{W}_1 + \overline{W}_2} \quad \text{............} (3)$$

By putting $\overline{W}_1 = \overline{W}_2 = 0$ in this equation we arrive at the equation (numbered (1)) given by Mr. Brown; but in general $\overline{W}_1$ and $\overline{W}_2$ could not be neglected.

Let $\frac{\overline{W}_1}{C_1} = \frac{\overline{W}_2}{C_2} = k$, which is justifiable on the assumption of uniform capacity distribution. Then

$$\frac{Q}{P + Q} = \frac{C_1 - k (C_1 - C_2)}{(C_1 + C_2)(1 + k)}$$

On the same assumption

$$\frac{x}{l - x} = \frac{C_1}{C_2} \text{ and therefore}$$

$$\frac{Q}{P + Q} = \frac{x - k(2x - l)}{l(1 + k)} \text{ and}$$

$$\frac{x}{l} = \frac{\frac{Q}{P + Q}(1 + k) - k}{1 - 2k} \quad \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

This shows that in order to secure an accurate location it is necessary to know the value of the k for the cable pairs in question.

For $x = 0$

$$\frac{Q}{P + Q} = \frac{k}{1 + k} \text{ or } k = \frac{Q}{P} \quad \ldots\ldots\ldots\ldots\ldots\ldots(5)$$

For $x = l$

$$\frac{Q}{P + Q} = \frac{1 - k}{1 + k} \text{ or } k = \frac{P}{P + 2Q} \quad \ldots\ldots\ldots(6)$$

Putting $k = 0$ in equation (4) gives Mr. Brown's formula for the distance to the crossed joint. The effect of thus neglecting k can best be illustrated by specific examples.

Taking the case of Multiple-Twin cable, $k \fallingdotseq 0.4$, for pairs in the same quad, so that for $x = 0$, $\frac{Q}{P + Q} = 0.29$, and for $x = l$, $\frac{Q}{P + Q} = 0.43$. Thus, no matter what the distance to the fault, $\frac{Q}{P + Q}$ will never be less than 0.29 nor greater than 0.43; and the large error which may arise by using the relation $\frac{Q}{P + Q}$ to give $\frac{x}{l}$ is apparent. This error would not be cancelled by taking tests from each end of the line. It so happens that with the above value of k there would be no error if $\frac{x}{l}$ were equal to 0.35, but for values of $\frac{x}{l}$ greater or less than this, the error progressively increases. For $\frac{x}{l} = 0.2$, $\frac{Q}{P + Q} = 0.3$ giving an error of $+ 50\%$; and for $\frac{x}{l} = 0.8$, $\frac{Q}{P + Q} = 0.4$ giving an error of -50%. These values, and also equations (4), (5) and (6) have been verified by experimental tests on a length of M.T. cable, pairs being looped up with crosses introduced at various distances from the testing end.

In Star-Quad cable, $k \fallingdotseq 0.65$, for pairs in the same quad, and therefore still larger errors would occur in this case. When the faulty pairs are not in the same quad, and also in the case of Twin cable, k would not be so large and the errors involved would probably be rather less. It is interesting to note that if k were exactly equal to 0.5, $\frac{Q}{P + Q}$ would always be 0.33 no matter what was the distance to the crossed joint.

Equation (4) shows that the method is only reliable when the factor k for the pairs concerned is known to a fair degree of accuracy. A value for k could be obtained by making use of equations (5) and (6); that is, by testing on " good " pairs in the cable and at the same time introducing a " split " at the testing end or distant end as the case may be. When the faulty pairs are in the same quad, a fairly accurate value could be secured in this way, but when the faulty pairs are in different quads, or if Twin cable is concerned, k will to some extent be dependent on the degree of adjacency of the faulty pairs in the successive cable lengths, and tests such as the above to find k would not necessarily give accurate results.

Alternative Method.—It may perhaps not be out of place to give a brief description of another method of locating split pairs which has been used. This method does not involve difficulties or sources of inaccuracies such as those discussed above and is not theoretically restricted by the cable section being either too short or too long. In this method the following capacities are measured on the faulty pairs (the wires being insulated at the distant end) :—

(1) Measure the capacities A to B and C to D.
(2) ,, ,, ,, A to C and B to D.
(3) ,, ,, ,, A to D and B to C.

The mean of the two readings is taken in each case and calling these mean values K_1, K_2 and K_3 respectively, then if B and C or A and D are the crossed wires

$$\frac{x}{l} = \frac{K_1 - K_3}{(K_1 - K_3) + (K_2 - K_3)} \quad \ldots\ldots\ldots\ldots\ldots\ldots(7)$$

If A and C or B and D are the crossed wires

$$\frac{x}{l} = \frac{K_1 - K_2}{(K_1 - K_2) + (K_3 - K_2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots(8)$$

The equation to be used in any given case can always be determined by inspection of the measured values of K_2 and K_3. The rule is that if K_2 is greater than K_3 use equation (7); and if K_3 is greater than K_2 use equation (8). There is one exception to this rule, viz., when the faulty pairs are two pairs in the *same* quad in a Star-Quad Cable. In this case the rule is reversed because the capacity of a split pair is greater than that of a normal pair, whereas in all other cases the split pair capacity is less than the normal pair capacity.

When the fault consists of " rectified " split pairs, that is, when a second crossed joint has been made in an attempt to correct the first cross, x is the distance between the two crosses, and this information may sometimes be of help in deciding where first to open the cable. If the cable is opened between the two crosses, each can then of course be located in the usual manner.

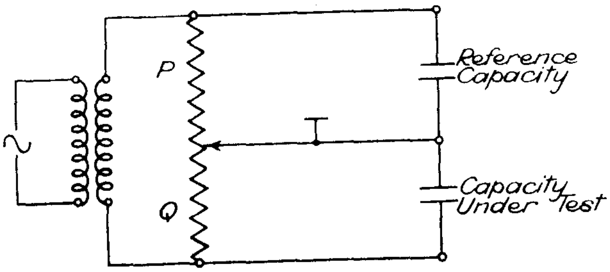


FIG. 2.

On short lengths of cable the measurements are generally made with a Wien bridge as used for ordinary mutual capacity tests on loading sections. On long lengths of cable, a ballistic method of measurement can be employed.

On short lengths, simple apparatus such as that suggested by Mr. Brown could be used with fairly accurate results, although in this case it would be preferable to secure the use of a properly graduated non-reactive slide wire having a resistance of 1000 ohms, or, alternatively, to use two resistances, of the order of 1000 ohms, in series, one of which is adjustable in steps of 1 ohm. The value of the fixed resistance need not be accurately known. A diagram showing the method of joining up the components is given in Fig. **2**, a small condenser (about 0.1 μF) or another cable pair being used as a reference capacity. Using this bridge the capacities K_1, K_2 and K_3 would be successively compared with the reference capacity.

If P_1/Q_1, P_2/Q_2, P_3/Q_3 are the ratios of K_1, K_2 and K_3 to the reference pair, equations (7) and (8) can now be written

$$\frac{x}{l} = \frac{P_1/Q_1 - P_3/Q_3}{(P_1/Q_1 - P_3/Q_3) + (P_2/Q_2 - P_3/Q_3)} \quad \ldots\ldots\ldots\ldots(9)$$

and

$$\frac{x}{l} = \frac{P_1/Q_1 - P_2/Q_2}{(P_1/Q_2 - P_2/Q_2) + (P_3/Q_3 - P_2/Q_2)} \quad \ldots\ldots\ldots\ldots(10)$$

respectively.

In conclusion, it should be mentioned that a high degree of accuracy is not, as a rule, essential in locating faults of this character, which must always occur at one of the joints. This probably accounts for the success claimed when the method in question has been used. Nevertheless, its limitations are such that in the general case it would be much safer to employ the alternative method described in this letter.

Yours faithfully,
E. H. JOLLEY.

MR. THOMAS PLUMMER, M.I.E.E.

The many friends and colleagues of Mr. Thomas Plummer who are still in harness, and those in retirement, will regret to hear of his death, which took place after a short illness at his residence " Dunbrody," Port Hill, Shrewsbury, on the 12th March, 1931. Some four years ago, just prior to retirement, he suffered a somewhat severe illness from which he did not recover completely. It had been hoped that freedom from the increasing stress of official life, and the pursuit of interests at leisure would have given him many enjoyable years, but this was not to be, and he was laid to rest in the beautiful cemetery at Shrewsbury on the 16th March. He leaves a son and daughter, and two sisters, one of whom, Miss K. Plummer, has devoted many years of her life to her brother and his children.

A notice of his retirement appeared in the October, 1927, issue of this Journal. B.J.G.

HEADQUARTER'S NOTES.

REMOVAL OF TRAINING SCHOOL TO DOLLIS HILL.

The Training School which has so long been a feature of King Edward Building has removed to Dollis Hill and now forms part of the Research Section instead of the Telephone Section. As our readers are aware, Automatic Telephony in this country began on a small scale and elaborate training of staff could not be evolved for a considerable period. Soon after the close of the War, however, training became an important issue and it is largely owing to the perseverance of Mr. Anson that the present School was started at the end of 1924 and was installed in such a favourable position in the heart of London.

Since its inception the School has obtained a very high reputation, not only among the staff of the Post Office, for whom it was primarily intended, but also among our Manufacturing Firms and the staff of overseas Administrations. Such a reputation has been built up very largely by the helpful and stimulating atmosphere created by Mr. C. W. Brown, who is in charge of the School, and his staff of able assistants.

The removal of the School to Dollis Hill, therefore, does mark something of the close of an epoch in the history of training in this country, more particularly as since its inception its scope has been extended to cover training in transmission and other branches of work as well as in automatic telephony.

A few facts with regard to the removal may be of interest. The bulk of the Courses closed down on the 28th March, 1931, and the work of dismantling, for which preparation had already been made, began immediately. The whole of the apparatus, including racks and cabling, had been recovered in a period of two weeks and practically the whole staff transferred to the new headquarters on the 20th April. But it is of interest to note, too, that Courses on Rural Automatic Exchanges will continue throughout the period of the removal. In addition a course for Probationary Inspectors was commenced at the new headquarters on May 1st, so that it can be said that the work of the School was never entirely interrupted, even by the dislocation caused by the removal.

It is possible to look forward to a time when the School, its scope considerably extended, will be firmly established in its new headquarters and achieve an even bigger reputation there than in K.E.B.

TRAINED.

The Reactions to Training of a Probationary Assistant Engineer.

A complementary article to "Training," J.I.P.O.E.E., October, '30.

When training for the Olympic games, it is said that Grecian athletes practised for long periods with lead weights tied to their ankles. After such preparation it was thought that they would not easily tire in the actual race, for which, of course, the weights were removed. The Engineering Department of the Post Office undoubtedly has a similar end in view when training its employees, particularly the younger ones, but it seeks to accomplish its object by means less brutal and probably more effective.

In the anti-penultimate issue of this Journal an outline was given of the syllabus that had been followed during the early months of 1930 in the training of those Probationary Assistant Engineers and Inspectors who had entered these grades by examination. Accurate as may have been the information contained in that article, justice could hardly be done to the subject by the author concerned for reasons of personal modesty. In this article is given a chronological summary of a few of the reactions, which in retrospect stand out most prominently, of one who underwent the course of training.

It will make large demands on the imagination of those who have been engaged in situations for a number of years to conjure up recollections of the excitement which is engendered by the anticipation of taking up a new post. The excitement for most of us was enormous, being bolstered up by the great pride that we felt in ourselves in having attained an object on which we had been persistently intent from the moment that we completed the first official form in our existence, our entry form. Apart from having read sundry technical publications of the Department and possibly Sir Evelyn Murray's handbook treating of the general ramifications of the Post Office, most of us had probably gained our detailed knowledge of this much abused organization from the daily press.

The attitude of employers towards new members of their staff varies; naturally, they are to a large extent influenced by the impression that they wish to create. In our case, assessed by the extent of the desirable atmosphere it created, the welcome extended to us was conspicuous by the completeness of its success. On arrival, an official welcome was extended by some of the dignatories of the Department, not to the new entrants collectively, but to each one individually. Immediately we were handed over to the Training School, at that time (February, 1930) housed in King Edward Building; a period then followed in which every effort was made by the School staff to assist the new students to accommodate themselves to their fresh surroundings. Meanwhile to each one was issued suitable armour to carry him through the impending battle. Not the least amusing incident, at least to one who had entered from a very up-to-the-minute concern, where two weeks extra remuneration took the place of annual leave, was the appearance of the ubiquitous leave form, for, having entered the Service on the 10th February there would be leave accruing to us before the end of the "leave year," February 28th. Now as the course proceeded, an amazing thing transpired which was this, everybody in the Post Office was actually working hard; and, moreover, nothing was left undone that might be done to promote efficiency in that Department. This, of course, was absolutely contrary to the information that had been gained from wiseacres in the outside world; not that the writer is complaining of having been attracted into the Service under false pretences!

During the first three months of the course that was to follow in the Training School, it was to be our lot to assimilate the accumulated knowledge of the Accountant General and the Engineer-in-Chief; later we were to wander out into Engineering Districts to study how the knowledge of these two giants was being exploited. It is not possible for any syllabus adequately to describe the subject matter that was dealt with in the lectures; all the lecturers gave freely of their knowledge, not only of that part of it which is of necessity stereotyped and which could have been obtained from the regulations, but of that part of it which is sometimes absent from the Regulations and Technical Instructions, the detailed fruits of their experience. The subject matter was presented in the following sequence. The earlier lectures were confined to expositions on the administrative and organizing activities of the staff of the Department. Then, gradually, stage by stage, the lectures merged into those more directly associated with the activities of the average assistant engineer and inspector. The vast amount of detail which constituted a large part of these lectures might have proved monotonous but for the welcome relief of practical work. Demonstrations and informal lectures on External work were given by a lineman from the London Engineering District. The practical side of Overhead work was dealt with in a manner that no one less familiar with the details than an actual lineman could have equalled. On many occasions since these lectures has the writer been able to acquit himself with honour when it has been necessary to tie knots under conditions of great strain, *e.g.*, for towing a motor car, fixing a jam cover, etc. !

Among the Internal practical work was included the forming and lacing of cable, soldering, the dissection of apparatus that some of us had not had the opportunity of handling before on such familiar terms, the erection of, and identifying of faults on, subscriber's apparatus. Possibly amongst the Internal practical work might be included several conducted visits to manual and automatic exchanges. To anyone who has been bred in an atmosphere of manual working it may be difficult to conjecture how intricate does manual operation appear at first sight. On all these visits we were accompanied by two members of the School staff, who were our tutors and advisers while the lectures were in progress. Two visits were made to Contractor's works during the School part of the course, both of which left pleasant recollections (and valuable information) in the minds of the visitors. Spectacular and impressive as were the technical demonstrations that had been staged for us, undoubtedly these left a much smaller impression than did the hospitality extended.

As the time allotted for lectures grew less, the more did we appreciate how well we were being treated. No great exercise of the imagination is called for to realize how entertaining the course proved; every fresh member of the staff that we encountered endeavoured to convince us that we were having the time of our Departmental lives. Even as all good things come to an end so did the School portion of our training terminate at Whitsun, and, on Whit Tuesday we reported to the various Engineering Districts in which we were to proceed with the rest of the syllabus. The sensation was one of beginning a long journey, of several months duration in fact; now did each student go his own way, the Probationary Assistant Engineers for eighteen and the Probationary Inspectors for thirty-six weeks training in the Districts. So must the writer's tale be now considered individual, although on the various occasions on which he has had an opportunity of comparing reminiscences with his late colleagues a marked similarity of experience has always been observed. The description that follows centres round those things that are to be seen while training in a " country " section of the London Engineering District. Undoubtedly the staff of this section must have thought unkindly of the writer on not a few occasions, but with one exception, they were sufficiently sympathetic or discreet to conceal it.

The first six weeks of the District experience were spent in an external section. Having interviewed the probationer, the Sectional Engineer introduced him to the chief of his clerical staff. The latter, after furnishing the writer with a list of all the clerical duties in the office, introduced him to his assistants. It was then the writer's embarrassing privilege to take a chair and sit by each clerical officer, watching his every action and making copious notes, lest at any time in his career he should be called upon to organize a Sectional Engineer's office from " scratch." Concurrently the work of the Development office was studied. The study of Development technique was to prove exceedingly fascinating, for, not only was the actual planning of the schemes witnessed, visits being made to the sites during the survey, but later the checking of the plans in the Superintending Engineer's office and the execution of the work were seen. And now for the one exception to the generous welcome, it was that extended by a Plumber-Jointer whose work the writer was due to investigate in much the same way as he did that of the clerical officers. It was later discovered that this same man had on a previous occasion chased his Inspector with a spanner. *Verb. sap.*—especially to anyone who may seek information from a similar source.

In country sections in summer time, training in an Internal Section is no less interesting than in an External Section, and it was about this time that the writer began to find the way to make the most of the training resources at his disposal. For instance, not least of his discoveries was that U.S.W. was the abbreviation, not for Un-Skilled Workman but for Unestablished Skilled Workman. Another discovery of great utility was that of the standard method to be employed in gaining a man's confidence, namely, to assist him in arriving at satisfactory explanations, harmless to his dignity, for his having been " passed over," masterly phrase ! When the writer reported to Section Headquarters in the middle of June, the Internal course of training was begun in the reverse direction to that followed in the External training. The writer saw first a selection of the practical sides of Internal work, witnessing in turn, Section activities from a maintenance Inspector's office and in the various exchanges in his charge, Construction and Fitting. The study of the administrative aspects of the work were left until the last. Owing to the similarity between Internal and External administrative work this represented no great disadvantage. It is difficult to decide whether there is any choice between the two methods, taking the Administrative or the "Practical" aspect first. Probably the reversal of the procedure, as explained above, is the more interesting. The first Inspector under whose care the writer was placed had in his charge a large variety of maintenance work, including one Director Exchange, one manual exchange in the Automatic area, and five recently constructed C.B. exchanges. Construction work was seen in progress in great variety, embracing such things as a Director exchange, a Rural Automatic exchange, complete manual exchanges and extensions thereto. To an onlooker, Fitting probably provides the maximum of entertainment, although apparently for those actively engaged on it the entertainment is tempered with a considerable amount of nervous strain. At this point of contact with the public everyone endeavours to show an exemplary front, although, not infrequently the odds against the department's staff are excessive, the odds amounting to anything from satisfying the many prospective (and other) subscribers who demand absolute precedence for their installations to the peculiar local conditions of their premises. Included in the good fortune of the Probationer was the realization of an old ambition, no less than that of pulling a real Fire alarm, and, for the purposes of unravelling the mysteries of the alarm system, of being given the free run of a large Fire station. The name of the Section may be had on application, although it is possible that the writer may have spoiled the pitch for other players.

And so the passage of time brought the training to its closing phase, the six weeks in the Superintending Engineer's Office. This, however, was brought to an early conclusion, for, after ten days, the author was despatched to his appointed rut or mountain slope. The first week, spent in ignorance of the impending change of headquarters, was organized according to the prescribed programme. The remaining three days were utilized in what a globe-trotter would refer to as an effort to "do" the Technical Section in that time. Thanks to the untiring consideration of the staff, these efforts to gain a superficial knowledge of this section's work were neither unpleasant nor unsuccessful.

During the entire course, and actually after it had finished, the members of the training School Staff who were responsible for its administration and those members of the staff of the Engineer-in-Chief's Office who were connected with it in any capacity, maintained an attitude of intense and kindly interest in the welfare of the students. The latter were persistently solicited to express their views on any alterations or additions to the syllabus that they thought could possibly add to the usefulness of the training. One is naturally led to speculate on the means by which the Department hopes to gain by its generosity, in proportion to the obviously large expenditure incurred by such a training course. Some of the means available are these; newcomers are deprived of any idea that they may have wrongly acquired that their new employer is going to force them to make bricks without straw; the Department endeavours to ensure that when the straw is distributed it will be put to the best advantage from the beginning, a minimum being required for practice. The new staff are inspired with confidence in the firm they are to represent and the goods they will have to handle. What proves of great use to the Probationer, and indirectly a benefit to the Department, is that as a result of the introductions gained to members of the staff in all quarters, including his late colleagues in training, the Probationer invariably knows good authorities to consult when occasion arises after the conclusion of the course. Encounters with the colleagues referred to above are always the scene of exchanges of new experience and advertisement of recent "discoveries." Let those who are not yet convinced of the mutual benefits emanating from such a course consider a "psycho-mercenary" aspect of the case. If the Department is willing to start its new entrants with such a large credit account, it can safely rely on even the meanest feeling some compunction in the necessity for paying it back and on the more magnanimous a compunction for repayment with interest!

G.B.W.H.

April 30th, 1931.

EXCHANGE EQUIPMENT.

The following works have been completed :—

Exchange.	Type.	No. of Lines
Preston	New Auto.	3790
Fulwood	,,	560
Newcastle Area (12)	,,	19500
Harborne	,,	1290
Leytonstone	,,	2470
Birmingham Northern	,,	5280
Birmingham Victoria	,,	2815
Evington	,,	800
Ayr	,,	1780
Prestwick	,,	510
Rainham	Auto Extn.	200
Tandem	,,	Positions
Stoke	,,	P.A.B.X. Selectors.
Macclesfield	,,	Re-arrangements
Perth	Manual Extensions.	360
Bexhill	,,	Observation Equipt.
Truro	,,	240
Eccles	,,	560
Hastings	,,	Observation Equipt.
Maggs & Co. (Bristol)	P.A.B.X.	30
Lesme, Ltd. (Willesden)	,,	30
Cumberland C.C.	,,	20
King & Hutchings (Uxbridge)	,,	30

Orders have been placed for the following works :—

Exchange.	Type.	No. of Lines
Castle Bromwich	New Auto	300
Wordsworth	,,	2440
Bowes Park	,,	3580
Valentine	,,	4100
Park (Dundee)	,,	1020
Springfield	,,	2000
Wolverhampton Area (6) ...	,,	7500
Hunslet	,,	730
Adel	,,	300
Horsforth	,,	700
Corstorphine	,,	680
Middleton	,,	900
Tipton Area (5)	,,	2880
Gibbet Hill	,,	400
Churston	,,	200
Pinhoe	,,	200
Failsworth	,,	1300
Walkden	,,	500
Urmston	,,	1200
Ardwick	Auto Extn.	Routiner Equipment.
Coventry	,,	Re-arrangements
York	,,	,,
Ipswich	,,	1140
Hove	,,	Re-arrangements

Exchange.	Type.	No. of Lines
Portslade	Auto Extn.	710
Leeds	,,	800
Hillside	,,	Routiner Equipment.
Collyhurst	,,	,,
Colchester	,,	Observation Equipment.
Newbury	New Manual	1080
Northwood	,,	1600
Uxbridge	,,	1900
Pinner	,,	3500
London Trunk Record and Demand Suite	,,	Positions.
St. Albans	Manual Extensions.	Observation Equipment.
Kilmarnock	,,	240
Morris Cars (Smethwick) ...	P.A.B.X.	50
L.C.C.	,,	300
Cumberland C.C.	,,	20
Chapman, Ltd. (Taunton) ...	,,	20
Courage & Co. (London, S.E.)	,,	30
Thorpe Meadows and Co. (Hastings)	,,	20
Norton Grinding Wheel (Welwyn)	,,	30
Burnley Corporation	,,	30
McIlroy, Ltd. (Reading) ...	,,	30

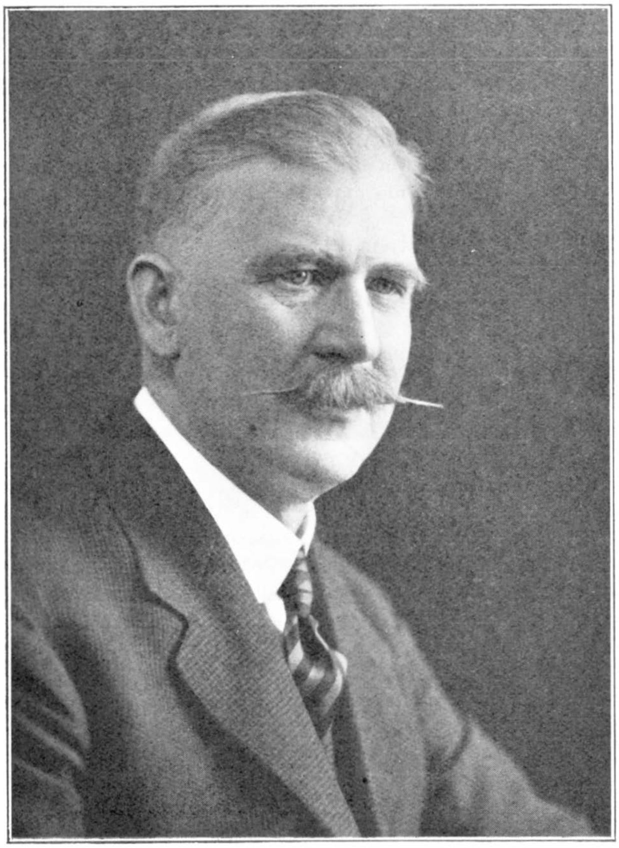
MR. E. H. SHAUGHNESSY, O.B.E., M.I.E.E., M.I.R.E.

By the retirement of Mr. E. H. Shaughnessy, Assistant Engineer-in-Chief, on 30th June, 1931, the Post Office Engineering Department loses an outstanding and popular member of its staff.

Mr. Shaughnessy entered the service of the Post Office as a telegraphist at the Central Telegraph Office in April, 1887. He was transferred to the Engineering Department as a sub-engineer in 1896, and he passed through the ranks of 2nd Class Engineer (1898), 1st Class Engineer (1901), and 2nd Class Technical Officer (1903). The operation of the scheme introduced by Major O'Meara by which Headquarters officers were required to serve in provincial districts resulted in Mr. Shaughnessy taking up duty as Assistant Superintending Engineer in the Eastern District in 1908. In 1913 he returned to Headquarters as the Staff Engineer in charge of the Radio Section. He became Assistant Engineer-in-Chief in 1925, the appointment being a new one, created " for wireless services," in connection with the second Imperial Wireless Scheme, adopted on the recommendation of the Imperial Wireless Telegraph Committee presided over by Sir Robert Donald.

The scope of Mr. Shaughnessy's early activities was extraordinarily wide. In addition to service in the Test and Telegraph Sections he took part in the experimental work in transmission which followed the development of the air-space paper core cable : he served as a cable engineer on the s.s. " Faraday " during the laying of cables in the Gulf of Mexico, and he took charge of the Experimenting Room in G.P.O. (West) when one room sufficed, or, rather, was the only space allotted, for development and research work in the Engineering Department.

It is as a radio engineer that Mr. Shaughnessy will be best remembered, and it is largely due to his energy, foresight and forceful handling of problems arising, as well as to his highly successful methods of selecting, training and using staff, that the Post Office is now in possession of radio-telegraph and radio-telephone services and equipment which are second to those of no other Administration. He took charge of the Radio Section when radio had barely passed the stage of infancy, although it was a healthy child, giving every promise of attaining vigorous maturity. The Coast Stations round the British Isles had been purchased from the Marconi Company four years earlier, and their equipment was in course of replacement and improvement. The proposed Imperial Wireless Chain of Stations was the subject of much discussion and comment, and, in 1913, a contract was entered into with Marconi's Wireless Telegraph Company for their erection. War broke out, and the contract was cancelled in 1915. The Company sued for breach of contract and were awarded damages approaching £600,000. Mr. Shaughnessy acted as an expert technical witness for the Crown in this case. It was a severe set-back, brought about by extraordinary conditions



MR. E. H. SHAUGHNESSY.

beyond the control of either Post Office or Company, but the lesson was not lost, and henceforth the Radio Section, with Mr. Shaughnessy as its leader, aimed at an organisation which, in the technical sense, would make it master of its own fate.

During the early period of the war, Mr. Shaughnessy was responsible for the measures taken for the detection of illicit wireless transmission, a phase of war activity which had its foundation more on rumour than on actual fact. A number of investigations were made of alleged or suspected infraction of the regulations without any serious case coming to light. Later on, he undertook the organisation and control of the Direction Finding Stations, the function of which was to identify and locate the movements of enemy aircraft during their voyages to this country on bombing expeditions. The scheme proved highly successful and gave material assistance to the Home Defence Forces in their efforts to discourage the intensification of this form of enemy warfare. Mr. Shaughnessy was made an Officer of the Order of the British Empire for his services in this connection.

With the restoration of peace, the work of recruitment and training of staff for further radio development was undertaken. A small group of able young men was added to Mr. Shaughnessy's pre-war staff. The first task to be undertaken was the completion of the Leafield and Cairo stations, the sites for which had been acquired for the Imperial Scheme, and on which the erection of buildings and masts had been commenced. The choice of the system of transmission for these stations of a power of 250 kilowatts was a matter of some concern. Valve transmission had not reached the stage at which the handling of anything approaching this power was possible. After careful consideration the Elwell-Poulsen Arc System was recommended by Mr. Shaughnessy as being the only system, available at that time, capable of producing the required amount of continuous wave high frequency energy for the services in contemplation. Leafield and Cairo were completed, and put into operation in 1922, and the success of Leafield in particular, from the references made to it, seems to have been largely responsible for inducing the Donald Committee to report upon the larger issue of the new Imperial Scheme in terms of Post Office ownership and control.

In the meantime Mr. Shaughnessy had set his staff to work on the problems of valve transmission. Experiments at Caister and Stonehaven were followed by the building of valve transmitters at these stations with powers of approximately 1½ and 25 kilowatts respectively, using in the latter case the output of six air-cooled valves. The Stonehaven transmitter replaced an arc transmitter, and a similar process of replacement was followed at Northolt where a 30 kW. set was constructed, the output being from three 10 kW. water-cooled valves. The Northolt transmitter utilised on a small scale the methods which it had been decided to adopt for the Rugby transmitter, preliminary steps for the construction of which had already been taken.

On the 5th March, 1923, the Prime Minister (Mr. Bonar Law) made the following announcement in the House of Commons, ". . . . the Government has decided that it is necessary in the interests of national security that there should be a wireless station in this country capable of communicating with the Dominions and owned and operated by the State." The design of the new station was entrusted to the Wireless Telegraphy Commission, which was originally appointed under the chairmanship of the late Lord Milner, with Dr. W. H. Eccles, Mr. L. B. Turner and Mr. Shaughnessy as members. The site chosen was at Hillmorton, near Rugby, and the task of design in detail, in accordance with the principles laid down by the Commission, and the erection of the station, were undertaken by the Post Office Engineering Department. Mr. Shaughnessy thus served in a double capacity, and the Rugby station may be regarded as his radio *chef d'œuvre*. The design provided for an aerial power of 500 Kilowatts from 54 10 kW. water-cooled valves. Nothing had previously been done in valve transmission which approached this figure in power handled, although, as already stated, some of the methods used, including water-cooled valves and tuning fork frequency control, had been employed in the Northolt transmitter completed a short time before. The transmitter, with its 820 ft. masts, dominating the surrounding countryside, was completed, tested and put into operation without serious hitch or accident. Rugby was, to a large extent, a plunge into the unknown, and although it is not in the official records, Mr. Shaughnessy probably breathed a sigh of relief when aerial current reached the 500 ampere mark and reports of reception arrived from the uttermost parts of the earth. Actually it was found that the aerial current aimed at was capable of being exceeded by over 50%.

Rugby, GBR, has been described in detail in numerous articles in this Journal, as well as by Mr. Shaughnessy himself in the paper which he read before the Institution of Electrical Engineers on 14th April, 1926; in a paper by Messrs. Hansford and Faulkner before the same Institution, and by Col. Angwin and Mr. T. Walmsley at the Institution of Civil Engineers.

Rugby was a worthy effort of the man who was mainly responsible for seeing it through, Mr. Shaughnessy. Throughout the task he never faltered in his belief in himself, or in his confidence in the subordinates, to whom he was proud to ascribe most of the credit.

The Imperial Wireless Telegraph Committee, 1924, recommended the construction of high power stations in this country capable of communicating with similar stations in India, South Africa and Australia. Canada was added to this list. The British stations were erected for the Post Office under contract by Marconi's Wireless Telegraph Company, the system adopted being that known as the " Beam "; short wave with directive antennæ. A great deal has been said and written about the attitude of Post Office engineers towards the " Beam " in its early days, with the usual exaggeration and lack of accuracy, but the outstanding fact is that, when information was forthcoming of its ability to perform the task required from the new Imperial Scheme, it was adopted wholeheartedly by the Post Office staff and worked to its utmost capacity. Mr. Shaughnessy was largely concerned in this decision, and the task of supervising, testing, accepting and working the stations erected under the contract fell upon him. The complaint against Post Office ownership of the " Beam " stations turned, not on inefficient handling of them, but on their ability to attract traffic from the older cable services. A very large amount of new traffic was also created by the lower rates in operation. The " Empiradio " system was, indeed, a highly successful business venture which probably more than fulfilled the hopes of the Committee responsible for its creation, while the Marconi " Beam " was tried out under Post Office management with a thoroughness which it would probably have obtained in no other circumstances. The Imperial Wireless and Cable Conference which was assembled in 1928, " to examine the situation which has arisen as a result of the competition of the Beam Wireless with the Cable Services . . . . " reported in favour of the amalgamation of the two interests by a merger of the Eastern and Associated Telegraph Companies and Marconi's Wireless Telegraph Company, and the transfer of the Empiradio and Government cable systems to the Merger. The report was adopted and the scheme put into effect by the Government of the day, and thus ended the episode of the Beam, so far as Post Office operation of the system was concerned. Whether this was a case in which it was wise to subordinate the new art to the requirements of the old only the passage of time can fully reveal.

The original long wave channel of the American radio-telephony service was developed and brought into operation during Mr. Shaughnessy's *regime*, and his experience and knowledge contributed greatly to its success. Mr. Shaughnessy should also be given credit for the later short wave developments which were made possible largely owing to the efficient organisation which he had set up, and to his selection and training of expert staff.

Mr. Shaughnessy has taken more than his full share of extraneous work, incidental to his profession, but much of it outside the scope of his official duties. Apart from his membership of the Wireless Telegraph Commission he served for a time on the Radio Research Board, on several committees of the British Engineering Standards Association and on the Royal Society's National Committee of the International Research Council. In 1921 he attended as a delegate at the Inter-Allied Technical Conference on Wireless Telegraphy which was held in Paris, and in 1922 he went to Brussels as one of the representatives of the Royal Society at the Assembly of the International Research Council of the Union Internationale de Radiotelegraphie Scientifique. He has been a Member of Council of the Institution of Electrical Engineers for a number of years and he is a Past Chairman of the Wireless Section. He is also a Vice-President of the Radio Society of Great Britain. He has served as Treasurer and as Chairman of Council of the Institution of Post Office Electrical Engineers, and he was for many years Chairman of the Board of Editors of this Journal. He has also undertaken the duties of examiner in Telegraphy for the City and Guilds of London Institute.

Mr. Shaughnessy attended the International Radiotelegraphic Conference at Washington in 1927, as one of the British delegates, and he served as President of the 2nd Technical Sub-Commission during its proceedings.

Mr. Shaughnessy was for a number of years lecturer in telegraphy and cognate subjects at the Northampton Institute and other technical colleges. His old students will remember the thoroughness with which he hammered in fundamentals, and the delight with which his not infrequent sallies of humour, largely at his own expense, were received. Mr. Shaughnessy's facility for the descriptive presentation of technical subjects has caused him to be much sought after as a lecturer on Post Office achievements in radio, and his orations have been delivered apparently with equal enjoyment to his audience and himself. He is, indeed, a man who in addition to knowing his subject thoroughly has the gift of imparting information to others in an interesting and entertaining manner.

During the last few years of his service Mr. Shaughnessy was concerned mainly with staff matters. His strict sense of justice and his ability to inspire confidence in his judgment made it a foregone conclusion that he would be successful in this sphere. He discussed claims and grievances with representatives of staff associations on a footing of equality of interest, and the many agreements which have been obtained and put into operation are the best possible evidence of his conciliatory methods and of his skill in negotiation. At the same time the staff associations of the Engineering Department, in addition to obtaining substantial advantages, have gained, what is perhaps of equal importance, a reputation for moderation and reasonableness which should stand them in good stead in further negotiations for a long time to come.

Time appears to have dealt lightly with Mr. Shaughnessy and he has reached the age of retirement while still enjoying the vigour and the outlook of youth. It will be the earnest wish of all with whom he has been associated, and especially of his friends and colleagues—in his case the terms are synonymous—in the Radio Section, that this happy state of affairs may long continue. Mr. Shaughnessy has always played the straight game and he has reaped his reward in the universal esteem in which he is held. Our best wishes go with Mr. Shaughnessy and his family in his retirement.

C.J.M.

MR. A. B. HART, M.I.E.E.

ASSISTANT ENGINEER-IN-CHIEF.

MR. A. B. HART.

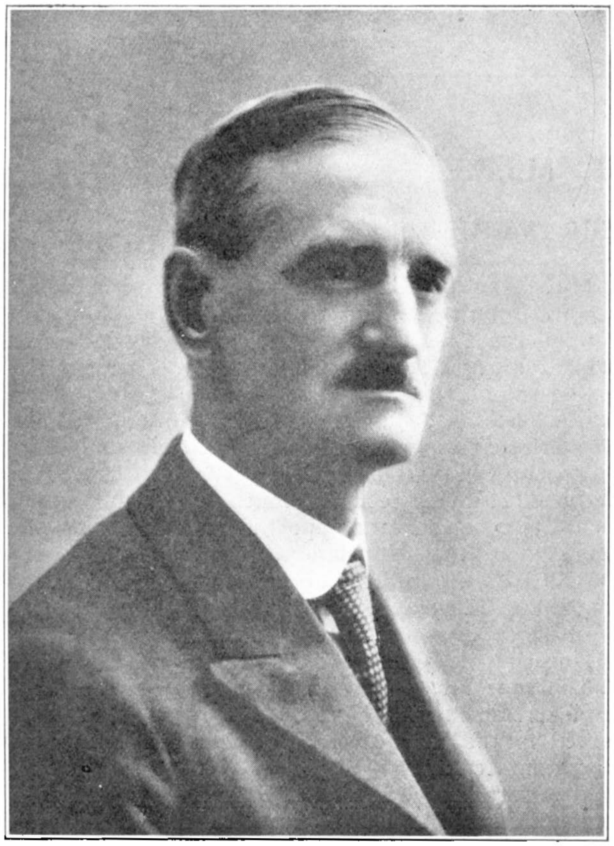
MR. HART is a Cambridge man and was educated at St. John's College School in that city. He entered the Post Office service as a telegraphist in the Cambridge office in 1893, but was transferred to the engineering side in 1896 when he entered the S.E's office as a Junior Clerk. In March, '98, he was selected for service at headquarters and came up to the Chief's Office as a 3rd Class Clerk. He had been studying technical matters and while in the head office he took the opportunity of attending the courses at the Northampton Institute and the People's Palace, and secured the C. and G's Silver Medal for Telegraphy.

In those days clerks with technical bent in the engineering department were eligible for engineers, and in 1901 Mr. Hart was promoted to a 2nd Class engineership in South Wales. In 1907 he was promoted to the First Class and placed in charge of Brighton section.

Mr. Hart was successful in passing a Civil Service examination for 2nd Class Staff Engineer (the grade is now known as Assistant Staff Engineer) and returned to headquarters in 1909, where he joined the transmission group under the control of the late Mr. A. W. Martin and took over the group when Mr. Martin died. At that time the underground trunk network was in progress of development, and during the seventeen years Mr. Hart was an Assistant Staff Engineer he was engaged entirely on this work and greatly fostered the growth of the system, introducing loading and superintending the installation of the chain of repeater stations which make long distance telephony possible on small gauge underground conductors. On the 1st November, 1928, he took over the charge of the Lines Section, and now he has been promoted to be an Assistant Engineer-in-Chief. He was one of the original members of the C.C.I. and attended the first meeting in Paris, in 1923, with Col. Purves and Mr. J. G. Hill.

So much for his official career. Mr. Hart has a fine pair of hands and drives a straight ball at golf, when he can find time. He is also a first rate mechanic and keenly interested in motoring, his first licence dating from 1903. Born and bred in the country, he lives there now. His wife, a farmer's daughter, aids and abets him in his unofficial capacity as a yeoman of England.

CAPTAIN J. G. HINES, M.I.E.E.



CAPT. J. G. HINES.

CAPTAIN HINES entered the Post Office Engineering Department in March, 1900, and was employed as a draughtsman in the preparation of the scheme for telephoning London, which the Post Office was about to undertake. Subsequently he assisted in supervising the provision of the initial underground plant. Most of the methods were new and much ingenuity had to be exercised to overcome the difficulties inherent to new systems.

When the installation of the Common Battery Exchanges commenced, Capt. Hines was employed as Assistant Engineer in supervising some of this work.

In 1905 he was transferred to the Engineer-in-Chief's Office, where he wrote the first edition of Technical Instructions XIV, which described the new methods of underground plant provision and also various special appliances, some of which he had designed. Included in these were motor-driven desiccators and winches, and it is interesting to recall that the P.O. Engineering Department was one of the pioneers in the introduction of portable machine-driven plant to replace heavy manual labour. In 1909, Capt. Hines went to the Test Section and was engaged in testing cables and other engineering plant at manufacturers' works. In 1911 he returned to the London Engineering District as Executive Engineer of the City Internal Section. While in this Section he established a school for telephone fitters and faultsmen, with the necessary equipment for giving adequate training. It is believed that this was the first of its kind.

During the war Capt. Hines served for a period in Mesopotamia and subsequently came back to England and organised training courses for Signal Service officers and men. On his return to civil life, he was placed in charge of the Technical Section of the London District and prepared a lay-out scheme for the introduction of automatic working.

In 1925 he was appointed Assistant Superintending Engineer in the London District and was principally engaged in the execution of the scheme above referred to and the provision of plant to provide for growth.

In 1924 he received the Senior Silver Medal of the I.P.O.E.E. for a paper on the lay-out of multi-exchange areas, and in 1930 he was awarded the "Webber Award" of the Institution of Electrical Engineers for a paper on "The Economics of Plant Provision."

MR. W. J. BAILEY, M.I.E.E.

MR. W. J. BAILEY.

MR. WM. J. BAILEY was educated at Peckham Birkbeck School and passed an Open Competitive Civil Service Examination for male telegraph learners and was appointed skilled telegraphist at the Central Telegraph Office, London, on the 29th August, 1885. He studied technology at the Telegraphists' School of Science under the then Mr. William Slingo.

In January, 1896, he was transferred as Acting Sub-Engineer to the Electrician's Room, Holloway Factory, and was engaged chiefly in testing Trunk Switch Sections, etc. In November, 1896, he took up duty as Sub-Engineer at Sunderland, in which district the Post Office was in serious competition with the National Telephone Coy. He received commendation for various improvements which he effected in the Secret Switching System in use in that District at that time. In November, 1899, he was promoted to the grade of 2nd Class Engineer at Sunderland. From 1898 to 1906 he held lectureships in Technical Telegraph and Telephony at South Shields Higher Grade Schools, the Sunderland Technical College and Armstrong College, Newcastle-on-Tyne. In November, 1906, he was appointed 1st Class Engineer at Bradford. In December, 1908, Mr. Bailey passed the Civil Service examination for 2nd Class Staff Engineer and was appointed to the Designs Section, E.-in-C.O., in April, 1909, where he took a very active part in the introduction of the first Automatic Exchanges and wrote comprehensive technical descriptions of the Strowger & Lorimer Systems, which were published in this Journal, Vols. 5 & 6.

On 23rd March, 1927, he was appointed Staff Engineer, in charge of the Equipment Section, succeeding the late Mr. M. Ramsay as Chairman of the London Automatic Committee.

Mr. Bailey initiated the Section swimming club and presented a Challenge Cup for competition He took a very active part in the Engineer-in-Chief's Social & Sports Club, being chairman of the Central Committee.

MR. BERNARD OGLIE ANSON, M.I.E.E.

MR. B. O. ANSON was promoted to be Staff Engineer in charge of the Equipment Section on 1st June last. He entered the telegraph service of the Post Office in 1896 and began his career in the Engineering Department in 1903.

Characterised by a progressive outlook, it is natural that Mr. Anson should have been identified from the outset with the introduction of Automatic Telephony into this country and that he should have been prominently associated with every stage of development of automatic telephones in their application to the British Post Office telephone system. He was a member of the Commission that visited the United States of America with Sir William Noble to study automatic telephone systems in 1919, and he has also made official and semi-official visits to France, Holland, Sweden, Japan, China, India and Egypt.

In 1929 his services were placed at the disposal of the Shanghai Municipal Council to investigate and report upon the telephone system of that city. The report which he presented to the Council at the end of a few weeks visit to Shanghai was far-reaching and convincing. Such was the confidence of the Municipal Council in Mr. Anson's ability and judgment, that his report was adopted in its entirety and

Mr. B. O. Anson.

his recommendations are now in course of being implemented, notwithstanding the fact that their adoption involves the rebuilding of the Shanghai telephone system within a period of two years at a capital cost exceeding one million pounds.

Mr. Anson instituted, organised and planned the Engineer-in-Chief's Automatic and Repeater Training School, which is known throughout the service as a model of efficiency and which has contributed so largely to the successful introduction and maintenance of automatic telephones in the London and other important areas.

The success which has attended the widespread introduction of Rural Automatic Exchanges throughout the country during the past few years is also largely due to Mr. Anson's foresight and energy and his ability to achieve important results quickly.

Always keenly interested in the training of personnel he was a member of the Committee on the Training of Probationary Engineers and Inspectors and of the Committee on the Training of Youths. He has also been a member of the following and other Departmental Committees :—Work and Staff of the Engineer-in-Chief's Office, Co-ordination of Development and Research, Design of Automatic Systems for London and Large Cities, Traffic Control for Automatic Exchanges.

He is Examiner in Telephony for the City and Guilds of London Institute and in the same subject for the Graduates examination of the Institution of Electrical Engineers.

His wide experience of negotiation in matters connected with staff conditions caused him to be chosen as first Joint Secretary of the Official Side of the Departmental Whitley Council when Whitleyism was first introduced into the Engineering Department.

Readers of this Journal will be familiar with the name of Mr. B. O. Anson. He has been an energetic member of the Board of Editors for many years and has been Chairman of the Board since 1926. His Chairmanship is distinguished by the same spirit of progress and enterprise as he displays in all his official and other activities. He is also a Member of Council of the Institution of Post Office Electrical Engineers and is Treasurer to the Institution for the present year.

MR. J. J. MARKWICK.

Mr. Markwick retired from the service at the end of March last, having reached the allotted span. His name had been associated for many years with Fire Alarms, but it is a mistake to think his activities were confined entirely to that branch of the Department's manifold services. As Assistant Staff Engineer in the Designs Section he was responsible for Telegraph apparatus and he was also entrusted with the task of standardising telephone subscribers' apparatus.

He, like Mr. Shaughnessy and many other well-known men, graduated in the hard but bracing school of TS and was promoted Sub-Engineer with headquarters in the Electricians' Room, Holloway Factory. While there he won the medal for Telephony, Final grade. Sir T. F. Purves, then plain Mr. T. F. P., selected Mr. Markwick to take charge of and test out the installation of the Metropolitan Inter-Com Switch by the B.I. and H. Coy. When the board was taken over by the Department Mr. Markwick went to assist Mr. Sinnott in the Designs Section on Fire Alarms and soon made himself master of the various systems then in use and developed and improved the L.C.C. and other corporation services. He passed through the grades of Second Class, Assistant and Executive Engineers and then succeeded the late Mr. McInnes as Assistant Staff Engineer, all in the Designs Section. During the war he carried out many experiments on the use of the buzzer with search coils for various purposes and also on the Fullerphone. He retires with the best wishes of his many friends in the Department and outside. In his youth he was an enthusiastic cyclist and spent many holidays on tour in Europe. He has now turned his attention to motoring and has already covered most of the roads in the fine country that lies north, west and south of Harrow.

DISTRICT NOTES.

LONDON DISTRICT.

Growth of Telephone System.—During the quarter ended 31st March, 1931, the nett additions in exchange lines and stations amounted to 6,343 and 10,033 respectively. The total is now 413,882 exchange lines and 696,108 telephone stations.

The total loop mileage of telephone wire is 1,514,622. This includes the junction and trunk mileage. The number of telephone kiosks in the London area now exceeds 2,300 and additions are being made daily.

New Automatic Exchange.—The Leytonstone exchange was opened on Thursday, 7th May, at 1.30 p.m., with the transfer of 1,786 subscribers' lines, of which 780 were transferred from the hypothetical exchange at Walthamstow, 516 from Wanstead and 490 from Maryland. The exchange was installed by the General Electric Company, Limited, and has an initial capacity of 2,470 lines with an ultimate capacity of 10,000. At the time of opening 186 outgoing and 146 incoming junctions were also brought into use.

The successful nature of the transfer may be gauged from the fact that in the post-transfer tests, which were completed in an hour and a half, only two subscribers lines were faulty and not a single junction was out of order.

New Trunk Record Positions G.P.O. South.—The new suite of Trunk Record positions on the 5th floor, G.P.O. South, installed by Standard Telephones and Cables Limited, in conjunction with the local staff, was brought into use on the afternoon of Saturday, May 9th. The positions, which number 60, are arranged in three suites, and will in due course be utilised for combined Record and No Delay working, but at present they will only be used as Record positions, in replacement of the existing suite on the 1st floor. Ultimately, the outgoing junction multiple on these new positions will accommodate circuits to the main Trunk centres and thus enable direct connections to be made. For the present, the record tickets will be made out in the usual way and passed, *via* ticket tubes accessible to every operator, to a central point from which they can be retransmitted by tube to the appropriate Trunk position.

Prior to the transfer, a complete test was made of every calling circuit and cord circuit, both from the Trunk Main Frame and the distant exchange manual board. The transfer of the record lines was effected in three groups, viz. :—

Group I.—3.0 p.m.—3.30 p.m. All single record circuits from London Exchanges.

Group II.—3.30 p.m.—4.0 p.m. The second half of each group of more than one.

Group III.—4.0 p.m.—4.30 p.m. The first half of each group of more than one.

The arrangements thus made enabled continuous service to be given from all exchanges in the London area during the change over period. Subsequent to the transfer a test was made of all circuits from all manual and automatic local exchanges and indicated that the whole transfer was satisfactory.

Gamewell Fire Alarm System.—Reference was made in the last issue to the installation of a new Fire Alarm System for the London County Council in the Southwark area. The new system, on which the apparatus was installed by Standard Telephones and Cables, Ltd., was brought into use on Tuesday, May 5th, and was regarded of such importance that many of the officials of the L.C.C. and Fire Brigade were present to see the system in operation. The following additional details may be of interest :—

Two loops are provided in the Southwark area with 28 call points in all. These loops are continued on junctions from the Southwark Fire Station to Whitefriars Superintendent Station, where four batteries, of which two are standbys, and each composed of 90 10-A.H. cells of the Chloride MMG1 type, provide the necessary current for the loops. In the event of faults on the junction lines, power may be supplied to the loops from the Power Supply at Southwark Fire Station by means of a rectifier.

Fire calls made from the boxes give audible and visual indication at both stations at the same time. The system provides for uninterrupted service in the event of an earth fault or break in the street loops. It also incorporates telephone facilities for the use of the Fire Brigade for communicating between alarm boxes and the Fire Stations.

The equipment at the Superintendent Station at Whitefriars comprises a switchboard, register table, bell and batteries. The switchboard accommodates two fire alarm circuits and is mounted with apparatus and instruments for use in the recording circuit, telephone circuit and battery charge and discharge circuits. The register table carries a multi-circuit register, time and date stamp with clock, and paper take-up reel.

The Out-Station equipment at Southwark comprises a switchboard, a register table, three gongs and a bell. The switchboard accommodates two fire alarm circuits and carries the apparatus and instruments for use in the recording and telephone circuits as well as the rectifier for emergency purposes. The register table carries three single circuit registers with associated take-up reel, one for normal use, and one spare. The gongs are mounted in the Fire Engine Room and give audible indication of the fire calls. The registers in use are arranged to close circuits for the ringing of call bells in the Firemen's Quarters upon the receipt of fire calls.

Teleprinters.—The use of this type of apparatus is steadily increasing and there are now 250 sets in the Central Telegraph Office.

Stamp Vending Machines.—A number of machines have been installed in the London area at which it is possible to obtain a two shilling book of stamps by the insertion of a florin or two separate shillings.

Traffic Signals.—A new and improved system of traffic signals is being installed in Oxford Street. The telephone apparatus and the lines for both telephones and signals are being supplied by the Post Office. This system will enable a traffic control officer stationed at Oxford Circus not only to supervise traffic at that point from North to South and East to West, but he will also be able to control traffic which enters Oxford Street from side streets between Marble Arch and Tottenham Court Road.

Unique Telephone System.—Dorchester House, a palatial hotel which has been erected near Hyde Park, contains many uncommon features, not least of which is the telephone system. Each room has an extension from the main switchboard for obtaining access to the public telephone system in the usual way, but the telephones are of special design. Each consists of a hand micro-telephone with accommodation for two press buttons. One of these buttons is used to effect direct connection with the service room where the circuit terminates on a special switchboard equipped with lamp signals and an automatic searching device to pick up the calling line. Requests can thus be made without the aid of a P.B.X. operator. When the second press button is depressed a sectional signal and alarm is operated in the service room and at the same time a lamp signal is operated outside the room door in the corridor. This lamp can only be extinguished from inside the room and is effected by a servant inserting an insulated peg which disengages a mechanical lock on a relay.

SCOTLAND WEST DISTRICT.

The conversion of the Ayr and Prestwick Exchanges to automatic working was successfully carried out on the 2nd instant. The installation at both of these exchanges has been installed by Messrs. Ericsson Telephones Ltd.

At Ayr, calling equipment is provided for 1,835 lines with an ultimate of 3,960 lines. At Prestwick the corresponding figures are 560 and 1,260 respectively.

NORTHERN DISTRICT.

The Sixth Annual Dinner of the Middlesbrough Engineering Section was held at the Wellington Hotel, Middlesbrough, on the 14th March. It was a large and representative gathering, the interest and enthusiasm with regard to this function being well maintained. The guests of the evening were Mr. F. G. C. Baldwin, the Superintending Engineer; Mr. B. A. Burton, the Head Postmaster of Middlesbrough and Stockton-on-Tees, and Capt. H. A. Berry, the District Manager, North Eastern Telephone District.

The Chairman—Mr. J. I. Smith, Sectional Engineer—in his opening remarks spoke of the good relations which existed between the various Departments. We were honoured in having as our guests, the Superintending Engineer, the Head Postmaster, and the District Manager. Mr. Baldwin we all know very well, but both Mr. Burton and Capt. Berry were newcomers to the district, and we give them a hearty welcome. He hoped it would not be the last time they would be with us at our annual function.

The Head Postmaster in proposing the toast of "The Post Office Engineering Department," said he had the greatest admiration for the Engineering Department on account of the intricacy and magnitude of its work. He had many friends in this Department, and he was grateful for the opportunity of expressing his appreciation of Mr. Smith and his staff at Middlesbrough who took care that the relationship between the Commercial side and the Technical side was of the happiest, and whether it be telephones, telegraphs, electric lighting, clocks or lifts, if they were in any difficulty one or other of the Engineer's staff was quickly along with the remedy.

Mr. Baldwin, in replying to the toast, spoke of the many changes that had taken place in the Northern District both in the work and in the Staff. He referred to the Engineering achievements, the largest of which was the simultaneous transfer from thirteen Manual Exchanges to twelve Automatic Exchanges in the Newcastle area—this being the largest transfer of its kind ever undertaken in this country. He took this opportunity of expressing personally his thanks to all those in the Middlesbrough Section who had helped to make the transfer a success.

Mr. W. D. Williamson—Chairman of the Middlesbrough Branch of the P.O. Engineering Union—in proposing the toast of "Our Guests" spoke in a few well chosen words of the aim and object for which not only the Engineering Department, but the other Departments represented by our Guests, were working in unison—the success of that vast undertaking the British Post Office.

Capt. Berry responded to this toast in a very breezy and witty speech. He spoke of the hearty welcome he had received from the people in the North and he felt sure he was going to be happy in his new sphere.

During the evening the Sectional Engineer, on behalf of the Staff, presented a bureau to Mr. W. Tait, who had recently been promoted to a Chief Inspectorship at Coventry—and also a gold watch to Mr. H. Bowron, late Foreman, recently retired.

An excellent musical programme was provided by members of the local staffs.

NORTH EASTERN DISTRICT.

Mr. R. Alexander.

The passing of Richard Alexander on 27th December, 1930, was one of those tragic happenings which reminded us, with unusual force, of the uncertainty of life. He left Leeds early on December 24th and, with his wife and daughter, travelled in his motor-car to Dunbar, where a very happy Christmas was spent in the house to which he intended to remove on his retirement from the service—timed for the latter part of the present summer. During the morning of December 27th he was taken ill but apparently recovered, only to suffer, in the evening, a relapse which culminated fatally in a few minutes.

Mr. Alexander commenced his service in Edinburgh as a S.C. and T., at the age of 15, on 29th October, 1885; later, he took up the study of technical and scientific subjects and the knowledge thus acquired led to his transfer on 1st March, 1898, to a Clerkship in the office of the Superintending Engineer, Mr. James Gibson.

Early in 1903 he was promoted to an Engineership (2nd Class) and proceeded to London where he took up duty in the Estimates Section of the E.-in-C.O. : in those pre-devolution days, the Estimates Section was responsible for a very wide range of estimate scrutiny work, as well as for questions of external plant design and of stores requirements; and those who worked with Mr. Alexander can bear testimony to the big output of work which resulted from the steady and continuous application of his methodical mind to the many problems which arose during the infancy of the " P.O. London Telephone System."

The next promotion came after eight years' service at headquarters, during which period many lasting friendships were formed; and, in February, 1911, Mr. Alexander returned to Edinburgh as Sectional Engineer. He acted in that capacity for 17 years and his ability as an engineer and administrator enabled him to cope successfully with the numerous issues involved, first, in connection with the transfer of the N.T. Co's plant and staff at the end of 1911; secondly, in securing a steady increase in efficiency and a reduction in costs; and, thirdly, in the big task of converting the Edinburgh exchange system from manual to automatic working.

He remained at Edinburgh long enough to see the result of his planning of the auto. transfer work, in the shape of a greatly improved public service; and in August, 1928, he came to Leeds as Assistant Superintending Engineer.

In the last stage of his career, Mr. Alexander displayed the same high qualities as in earlier positions; and he rapidly gained both the respect and the friendship of those new colleagues with whom he came into contact. We parted with him two days before Christmas, knowing that he was contemplating a pleasant interlude in the little town from which, later on, we expected to receive from time to time many friendly messages couched in the humorous strain characteristic of the man : it was not to be, and we mourn the loss of one who, in the short space of two years, had become a real force in the North Eastern Engineering District.

J.W.A.

SOUTH WALES DISTRICT.

Exhibition of Official Films.—The films showing the improved methods of pole hole excavation and cable jointing have been shown at Swansea, Cardiff, Newport, Worcester and Hereford. Keen interest was displayed at all of these places by the workmen, about 400 of whom attended altogether, and Mr. Albry, of the Engineer-in-Chief's Office, was kept busily occupied in answering the inquiries and comments made.

Types of R.A.X. Buildings.—In negotiating for a plot of land on which to erect an R.A.X. it is frequently necessary to meet the wishes of the land owner in regard to the type of building to be erected. For example, in villages in the Cotswold Hills the Department is generally asked to use Cotswold stone for the walls and roof instead of brick and slate. In a case some months ago at the village of Moccas in Herefordshire, in order to harmonise with the local amenities it was decided to erect a " mock " half-timbered building. It is thought that the imitation is an exceedingly good one. The imitation of timbering is effected by a cement band course floated smooth and coated on the top of the rough cast walls and gables.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS ANNUAL MEETING, 12th MAY, 1931.

The President of the Institution, Col. Sir T. F. Purves, Engineer-in-Chief, occupied the chair and in opening the proceedings said :—

We have now reached the close of another Session —passed another milestone in the progress of the Institution. For several years I have been making a kind of hobby of calling attention here to the advancement in age of the Institution, and this year I have to announce that it has now completed the full quadrant of its first century since the year of the first session 25 years ago.

Those of you who have been wedded to it since the beginning and done so much by your work and help to further its interests and causes, can look on this meeting as a kind of celebration of your Golden Wedding.

The Annual Report and the Accounts will be placed before you, and I think that, taken in conjunction with several other items of the agenda, it shows that the Institution is not showing any signs of staleness or symptoms of moribundity. It continues to be active and progressive and I am sure it is doing a great educational work—one that is being in a widespread way recognised and appreciated in this country and abroad.

As you all know, the human race still has many years of existence to spend on this earth and it is impossible to know what may be attained. I think, however, that if we could come back in a million years we should find the Institution carrying on and still playing a great and essential part in dealing with problems and subject matter far beyond the reach of our present thoughts or imagination.

However, to-night we are more concerned with the immediate past than with the more or less remote and speculative future.

The first item is the presentation of the Annual Report of the Council.

The Annual Report of the Council was read by the Secretary, Mr. P. G. Hay, and the Financial Statement for year 1930-31 was presented by the Hon. Treasurer, Mr. C. J. Mercer. A resolution that the Annual Report and Financial Statement be accepted was proposed by Mr. T. E. Herbert and seconded by Mr. P J. Ridd. After a statement by Mr. Cruickshank on the satisfactory position of the Journal and a complaint by Capt. Timmis on the time occupied in printing papers, the report and financial statement were adopted. A vote of thanks to retiring Members of Council was proposed by Mr. B. O. Anson, seconded by Mr. C. W. Brown, and replied to by Capt. N. F. Cave-Browne-Cave.

PRESENTATION BY THE PRESIDENT OF MEDALS FOR SESSION 1929-30.

The President then presented the following medals :—

Senior Silver Medal to Mr. A. Morris, A.R.C.Sc., M.I.E.E., for his paper, "Telephone Cable Circuit Interference."

Senior Bronze Medal to Capt. A. C. Timmis, B.Sc., A.M.I.E.E., for his paper, "Carrier Current Telephony."

Junior Silver Medals to Messrs. J. M. Owen, A.M.I.E.E., and J. A. S. Martin, for their joint paper, "Composited Telegraph & Telephone Working."

Junior Bronze Medal to Mr. J. N. Hill, for his paper, "Critical Methods of Investigation as Applied to the Study of Telephone Areas and Plant Lay-out."

An award of £5 to Mr. G. T. Evans in respect of developments in telegraph technique as applied to Radio Circuits (Valve relay), and a joint award of £5 to Messrs. F. I. Ray, B.Sc. (Eng.), A.M.I.E.E., and A. W. Biddlecombe in respect of a new type of relay for use in Automatic Telephone Exchanges, were then given under the terms of the Booth-Baudot Award.

The President announced that Mr. G. F. Greenham and Mr. E. J. Wilby would be respectively Chairman and Vice-Chairman of the London Centre for the session 1931-32.

COUNCIL FOR THE YEAR 1931-32.

The constitution of the Council for the year 1931-32 will be as follows :—

Chairman—Col. A. G. Lee.

Honorary Treasurer—Mr. B. O. Anson.

Representing Staff of the Engineer-in-Chief's Office—
Mr. C. W. Brown and Mr. E. S. Ritter.

,, Executive Engineers—
London : Mr. W. C. Burbridge.
Provinces : Capt. H. Hill.

,, Asst. & Second Class Engineers—
London : Mr. J. Prescott.
Provinces : Mr. G. Bailey.

,, Chief Inspectors—
London : *Mr. A. Miller.
Provinces : Mr. W. Weightman.

,, Clerical Staff—
London : Mr. J. T. Kelly.
Provinces : Mr. J. Mawson and Mr. A. C. Smith.

,, Inspectors—
London : Mr. A. E. Donovan.
Provinces : Mr. R. P. Collins.

,, Draughtsmen—
London and Provinces : Mr. F. Downward.

* This representative has since been promoted, and a further election is now proceeding in connection with the resultant vacancy.

ESSAY COMPETITION.

The Judges reported to the Council that the Prize Winners in the recent Essay Competition for the Session, arranged in order of merit, are as follows :

L. F. J. Brunel, S.W. Class II., Guildford. " Modern Aspects of Electricity and Magnetism."

J. C. Alexander, U.S.W., London. " An Introduction to the Electronic Theory and the Conduction of Electricity in Matter."

G. E. Clarke, S.W. Class I., Radio Section, E.-in-C.O. " The Piezo-electric Crystal."

W. E. T. Andrews, S.W. Class II., Cambridge. " Sound and Hearing."

H. Miles, S.W. Class I., Manchester. " The Faultsman and the Subscriber."

The Council decided to award Certificates of Merit to the following four competitors who were next in order of merit :—

A. A. Hard, S.W. Class II., Ipswich. " Insulation in Automatic Areas."

R. N. Renton, S.W. Class I., Circuit Lab., E.-in-C.O. " The Development of A.C. Apparatus in Telegraphy and Telephony."

C. G. Wardrop, U.S.W., London. " Radio Frequency Waves in Space."

W. H. Maddison, U.S.W., Research Section, E.-in-C.O. " The Electron."

The number of essays received this year was 54, an increase of 12 over last year's competition. The Judges reported the quality of the winning essays to be well up to the standard of previous years and the average marking also satisfactory.

PRINTED PAPERS.

The following is a list of the printed papers issued to the Membership during the Session :—

No. 125. " The Development of Automatic Routiners in the British Post Office," A. Speight, A.M.I.E.E.

No. 126. " Telephone Cable Circuit Interference," A. Morris, A.R.C.Sc., M.I.E.E.

No. 127. " Secondary Cells," H. M. Turner.

No. 128. " Critical Methods of Investigation as applied to the study of telephone areas and Plant lay-out," J. N. Hill.

No. 129. " Picture Telegraphy," E. S. Ritter, D.F.H., A.M.I.E.E.

No. 130. " Composited Telegraph and Telephone Working," J. McOwen, A.M.I.E.E., and J. A. S. Martin.

No. 131. " Carrier Current Telephony," A. C. Timmis, B.Sc., A.M.I.E.E.

No. 132. " Heating and Ventilation of Post Offices and Telephone Exchanges," W. T. Gemmell, B.Sc., A.M.I.E.E.

No. 133. " Rural Automatic Exchanges," J. C. Dallow.

The meeting concluded after the reading and discussion on a paper on " Making the Most of Automatic Telephone Apparatus. The Development of Traffic Recording," by W. G. N. Chew.

LOCAL CENTRE NOTES.

NORTH WALES CENTRE.

The sixth and final meeting of the 1930-31 Session was held at Shrewsbury on the 18th March with an attendance of over 70 members. In opening the meeting the Chairman recalled in feeling terms the recent death of the late Superintending Engineer of the North Wales District (Mr. T. Plummer), the members paying the usual token of respect. A fuller note on the loss that the District and the Centre has sustained is written elsewhere.

Mr. R. Sheppard read a lengthy and comprehensive paper on the Birmingham Automatic Scheme. As the transfer of the four initial Exchanges to be dealt with under the proposals had been successfully carried out only a fortnight previously, the subject was eminently topical and the lecturer was able to clothe the bare bones of statistics with the flesh of personal experience as a result of long and intimate association with the scheme. A keen discussion was prolonged to a late hour and Mr. Sheppard was cordially thanked for his masterly handling of the past, present and future of a subject which will eventually be the largest of its kind in the Provinces.

J.T.W.

SCOTLAND EAST CENTRE.

The Session was opened on the 18th November, 1930, when a paper entitled "Free Wayleaves" was read by Mr. James Patrick. The paper dealt with (1) the conditions under which wayleaves on private property are sought; (2) the measure of success which has attended the efforts made to obtain wayleaves free of payment; (3) the methods in force for recording free wayleaves and (4) the need for safeguarding wayleaves after they have been obtained. An interesting discussion followed.

A paper, entitled "A.C. Rectification for Power Purposes," was read by Mr. R. McWhirter, B.Sc., of the Scotland West District, at the December meeting. The method of converting A.C. to D.C. was explained; various types of rectifiers were discussed, the Tungar rectifier being specially dealt with. The theory and characteristics of dry plate and electrolytic rectifiers; voltage and current relationships between the A.C. and D.C. sides of a rectifier were also dealt with, and reference was made to the Department's requirements. The subsequent discussion brought out some interesting points.

At the January meeting a paper on "Allocations" was read by Mr. J. Airey. The objects of allocation were first pointed out and the importance of the correct allocation of capital and revenue expenditure in business concerns was stressed. The following items as they affected Post Office Engineering expenditure were dealt with :—Budgetary system of control; Capital and Revenue Account; Composite Works; The importance of data on primary vouchers; Adjustment of expenditure. The District expenditure in terms of percentages under the various sub-heads was stated. The paper aroused an interesting and lively discussion, particularly regarding Capital and Revenue expenditure and the accounting methods for surplus and recovered stores.

An informal meeting was held in February where two short papers on the following subjects were read :—"Advice Notes, Motor Transport and Light Construction," by Mr. W. Petrie, and "Drawing Office Records," by Mr. R. A. H. Paterson.

Mr. Petrie dealt with the methods employed in providing subscribers' circuits and carrying out light construction works consequent on the rapid growth of underground plant, the multiplicity of distributing points and the increased motor transport facilities. Other points discussed were the duties of survey men, the size of gangs, suitability of tools, organisation of work, use of motor transport and suitability of vehicles.

Mr. Paterson detailed the various records and the method of preparing them and emphasised the necessity for furnishing correct details with the minimum of delay, and the value of correct and up-to-date records. The need for consulting the standard records before commencing work affecting existing plant was demonstrated.

At the meeting in March the subject of "Development and Underground Relief Schemes," with a discussion on the new T.O.38, was introduced by Mr. H. Burgher. He considered the telephone service to be the cheapest thing sold to-day in the British Isles and that it should be extensively advertised. Too much emphasis was put on the "house" and too little on the possible "subscriber." Important points in the different Sections of T.I.38 were dealt with and suggestions were made with a view to improvements. A number of important points were raised in an interesting and profitable discussion.

The last meeting of the Session was held on the 21st April, when a display of Educational Films illustrated—

(1) The jointing and plumbing of lead-covered cables.

(2) Pole hole excavation by the "bar and spoon" method and "Iwan" earth auger.

(3) Shifting poles by means of pole lifting jacks

Explanatory remarks were offered by Mr. W. H. Albry, who made running comments on the pictures as they were shown.

The new methods brought forth a considerable number of questions and many suggestions were put to the lecturer.

The ordinary attendance was increased by a number of the Department's workmen as well as officials of the Corporation, Railway Companies, Power and Lighting Companies and the Scottish Command.

Local Organisation—1931-2.

Chairman—Mr. J. D. Taylor, M.I.E.E.
Vice-Chairman—Mr. J. T. Tattersall, A.M.I.E.E.
Committee—Messrs. J. A. Gunston, J. W. Jarvis, T. Lawrie, J. McIntosh, R. Ramsay, and W. V. Ryder, M.I.E.E.
Librarian—Mr. T. Lawrie.
Secretary—Mr. J. Airey, Superintending Engineer's Office, G.P.O., Edinburgh.

SOUTH WALES CENTRE.

A visit to Messrs. Lysaghts' Works, Newport, Mon., in October, 1930, inaugurated the meetings of the South Wales District. A large attendance of members under the guidance of one of the Company's Engineers was greatly interested in the various processes of steel plate manufacture.

In November, the second lecture was given by Mr. W. Day, on " Some notes on the conversion of the London Telephonic network from Manual to Director Working." The lecture was illustrated by lantern slides. Opportunity was taken at this meeting to congratulate Mr. H. J. Hunter, late Sectional Engineer, Newport, on his promotion to the position of Assistant Superintending Engineer at Cardiff.

The third lecture in December was given by Mr. E. A. Pearson, on " Waste, with general reference to Engineering work and Design." Mr. Pearson's paper dealt with the question of economy in the cost of production and showed that the elimination of waste, whether of money, material or labour, was the greatest need of all staple industries to-day.

The fourth paper given by Mr. S. G. Joscelyn, Swansea, on " The Drawing Office and its Functions," dealt with the place and functions of the Drawing Office in Engineering work generally, and reviewed in detail the application of these to the particular case of the Post Office Engineering Department.

The fifth paper was jointly given by Messrs. R. D Fuse and A. E. Tiley on the subject of " R.A.X's." Mr. Fuse dealt with the constructional side of the subject and from his expert and practical knowledge uch valuable information was obtained. Mr. Tiley then dealt with the equipment details. Many lantern slides were shown of R.A.X. buildings installed in various parts of the District.

The last lecture of the series was given by Mr. H. C. A. Linck and was entitled " The Construction and Operation of Teleprinter 3A." Apparatus was installed in the Lecture Theatre and a practical demonstration was given of the working of Teleprinters.

THE INSTITUTION OF P.O. ELECTRICAL ENGINEERS.

Officers of Colonial and Foreign Telegraph Administrations who are engaged in Electrical Engineering Works may be admitted as Colonial and Foreign Corresponding Members respectively, after application.

Subscription payable annually in advance on 1st April in each year :

Colonial Members	... ...	£1 0 0
Foreign ,,	... ...	£1 10 0

These sums include Annual Subscription to the Journal of P.O. Electrical Engineers and the supply of all Professional Papers issued during the period covered by subscription.

Forms of application for Colonial and Foreign Membership can be obtained on application to

The Secretary,
Institution of P.O.E. Engineers,
G.P.O. (Alder House), E.C.1,

or the undermentioned gentlemen who have kindly agreed to act as representatives of the Institution in their respective countries :—

R. Badenach, Esq., B.Sc. (Melb.),
Chief Engineer's Office,
Postmaster-General's Department,
Treasury Gardens,
Melbourne, C.2,
Australia.

H. C. Brent, Esq.,
District Telegraph Engineer's Office,
Wellington, N.Z.

N. N. Banerjee, Esq., A.M.I.E.E. (Ind.),
Divisional Engineer, Telegraphs,
Calcutta West Division,
8, Wellesley Place,
Calcutta,
India.

A. T. Kingston, Esq., M.B.E., A.M.I.E.E.,
Office of the Chief Engineer,
Telegraphs & Telephones,
C.T.O.,
Colombo,
Ceylon.

A. J. Kellaway, Esq.,
Department of Posts and Telegraphs,
P.O. Box 366,
Pietermaritzburg,
South Africa.

E. L. Jephcott, Esq., A.M.I.R.E.,
Chief Engineer's Department,
G.P.O. Box 391,
Salisbury,
South Rhodesia.

BOOK REVIEWS.

" High Frequency Alternating Currents." By Knox McIlwain and J. C. Brainerd. (London: Messrs. Chapman & Hall). 510 pages. Price 30/- net.

The subject matter of this book outlines a course designed for senior or first year graduate students in electrical communications and, as such, has been given for the past several years to students at the Moore School of Electrical Engineering, University of Pennsylvania.

A knowledge of the calculus, some familiarity with differential equations and acquaintance with the elementary theory of alternating currents, including the use of complex numbers, is assumed.

The term " high frequency " is used in this book to designate any frequency used in telephony and sound reproduction, in carrier telegraphy and telephony, and in radio telegraphy and telephony.

The following is a brief summary of the contents. In an introduction the nature of sound and the requirements to be considered in its transmission are discussed. Carbon granule and condenser transmitters, telephone receivers, loud speakers and the transmission unit are dealt with in the first chapter. Separate chapters are then devoted to resonance phenomena, coupled circuits, thermionic vacuum tubes, amplification, modulation, detection, production of high frequency currents, filters, transmission lines, electromagnetic waves, reflection and refraction, electro-mechanical systems.

Although the authors lay no claim to an exhaustive treatment of the subject, a large amount of information is nevertheless given on each particular section.

The material included and the method of presentation has been chosen with a view to its suitability for students in electrical engineering and in this the authors have been very successful.

The book is well illustrated with curves and diagrams and at the end of each chapter a bibliography, bearing upon the subject dealt with in that chapter, is given.

Included in each chapter are a number of problems which are intended to be solved by the student.

The book can be recommended to students in electrical communications and it should also prove very useful to engineers.

G.W.H.

" Elementary Technical Electricity." By L. T. Agger, B.E. 268 pps. (Published by Longmans, Green & Co.). Price 3/6.

This little book is intended to meet the needs of first year electrical students in evening Technical Schools and, although it does not cover the whole of the City and Guilds syllabus in Magnetism and Electricity, it should prove useful to students preparing for this examination. After a preliminary survey of elementary Mechanics, the author deals with Magnetism, the effects of an electric current, primary and secondary cells, ending with a short account of electro-magnetic induction. The exercises given at the end of each chapter have been carefully chosen and form a useful feature.

W.S.P.

" Corso di Telefonia: Part 1; Telephone Apparatus." By Ing. Dott. Scipione Treves. (Sten: Turin). 35 Lire.

The rapid development in Italy, during recent years, of modern telephone communication has stimulated the interest of Italian engineers, technicians and teachers of physical science in the art of modern telephony and the author of the present volume is to be congratulated on having produced the first part of what is almost certain to become the standard Italian text-book on the subject. The whole subject is to be covered in three volumes. The present volume deals mainly with subscriber's station equipment, including protective devices, prepayment, and intercommunicating systems. Sufficient theory is included and practical consideration in regard to installation, maintenance and testing receive ample treatment. The diagrams and illustrations, of which there are many, are uniformly clear and distinct. Naturally, the type of apparatus and the practices described are those in current use in Italy. Part 2 will deal with Telephone Lines and Networks and Part 3 with Telephone Exchanges.

J.J.M.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	From	To	Date.
Hart, A. B.	Staff Engineer, E.-in-C.O.	Assistant Engineer-in-Chief.	1-7-31
Hines, Capt. J. G.	Assistant Suptg. Engineer, London District.	Staff Engineer, E.-in-C.O.	1-7-31
Blick, F.	Executive Engineer, E.-in-C.O.	Assistant Suptg. Engineer, London District.	1-7-31
Cottle, Maj. P. J., O.B.E., M.C.	Assistant Engineer, S. West District.	Executive Engineer, S. West District.	1-4-31
Bell, R. L.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	1-4-31
Chamney, R. M.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	To be fixed later.
Noyes, H. S.	Assistant Engineer, E. District.	Executive Engineer, E. District.	16-3-31
Albry, W. H.	Assistant Engineer, E.-in-C.O.	Executive Engineer, Testing Branch Birmingham.	1-4-31
White, A. E.	Assistant Engineer, S. Lancs. District.	Executive Engineer, S. Lancs. District.	16-3-31
Jeary, L. G.	Assistant Engineer, Scot. West. District.	Executive Engineer, S. Lancs. District.	7-4-31
Dipple, H. W.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.in-C.O.	1-6-31
Stevenson, B. J., O.B.E.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.in-C.O.	1-4-31
Paish, P. B.	Chief Inspector, S. East District.	Assistant Engineer, S. East District.	To be fixed later.
Veale, A. H.	Chief Inspector, London District.	Assistant Engineer, E.-in-C.O.	To be fixed later.
Miller, A.	Chief Inspector, London District.	Assistant Engineer, London District.	To be fixed later.
Little, W. R.	Chief Inspector, London District.	Assistant Engineer, London District.	To be fixed later.
King, A. G.	Chief Inspector, S. Mid. District.	Assistant Engineer, S. Wales District.	To be fixed later.
Dunk, W. G.	Chief Inspector, E.-in-C.O.	Assistant Engineer, E.-in-C.O.	1-4-31
Cresswell, W. H.	Chief Inspector, E.-in-C.O.	Assistant Engineer, E.-in-C.O.	To be fixed later.
Meldrum, F. A.	Chief Inspector, E.-in-C.O.	Assistant Engineer, S. Lancs. District.	To be fixed later.
Wilson, C. F.	Repeater Officer, Cl. II., E. District.	Chief Inspector, E.-in-C.O.	22-3-31
Pirie, H. A.	Repeater Officer, Cl. II., E. District.	Chief Inspector, E.-in-C.O.	22-3-31
Wood, Capt. J. A., M.C.	Repeater Officer, Cl. II., S. Wales District.	Chief Inspector, E.-in-C.O.	1-9-30
Robinson, R. P.	Chief Inspector, E.-in-C.O.	Assistant Engineer, E. District.	To be fixed later.
Davies, L.	Inspector, N. Wales District.	Chief Inspector, N. Wales District.	To be fixed later.
Collins, T. J.	Inspector, S. Mid. District.	Chief Inspector, S. Mid. District.	To be fixed later.
Bryant, G. H.	Inspector, S. East District.	Chief Inspector, S. East District.	To be fixed later.
Davidson, T.	Inspector, N. District.	Chief Inspector, Scot. W. District.	To be fixed later.
Heaton, A.	Inspector, S. Lancs. District.	Chief Inspector, S. Lancs. District.	To be fixed later.
Howcroft, A.	Inspector, N. East District.	Chief Inspector, N. West District.	To be fixed later.
Bolton, G. F.	Inspector, S. Mid. District.	Chief Inspector, S. Mid. District.	To be fixed later.
Layton, N.	Inspector, London District.	Chief Inspector, London District.	15-2-31
French, W. S.	Inspector, N. Ire. District.	Chief Inspector, N. Ire. District.	16-8-30
Sims, A. E.	Inspector, E.-in-C.O.	Chief Inspector, E.-in-C.O.	To be fixed later.
Carr, G. E.	Inspector, E.-in-C.O.	Chief Inspector, E.-in-C.O.	To be fixed later.
Downes, A. D. W.	Inspector, Testing Branch.	Chief Inspector, Testing Branch.	To be fixed later.
Bevis, W. F.	Repeater Officer, Cl. II., E. District.	Chief Inspector, E.-in-C.O.	To be fixed later.
Leece, W.	Skilled Workmen, Cl. I., N. District.	Inspectors, N. District.	17-2-31
Grant, C.	Skilled Workmen, Cl. I., N. District.	Inspectors, N. District.	15-3-31
Mickler, L.	Skilled Workmen, Cl. I., N. District.	Inspectors, N. District.	28-12-30
Mellish, A.	Skilled Workmen, Cl. I., Scot. W. District.	Inspectors, Scot. W. District.	27-11-30
Hutton, R.	Skilled Workmen, Cl. I., Scot. W. District.	Inspectors, Scot. W. District.	23-11-30
McCullough, J.	Skilled Workmen, Cl. I., Scot. W. District.	Inspectors, Scot. W. District.	25-3-31

PROMOTIONS—*continued.*

Name.	From	To	Date.
Bogg, A.	Skilled Workman, Cl. I., E.-in-C.O.	Inspectors, E.-in-C.O.	16-11-30
Voss, L. C.	Skilled Workman, Cl. II., E.-in-C.O.	Inspectors, E.-in-C.O.	1-1-31
Hay, J.	Skilled Workman, Cl. II., E.-in-C.O.	Inspectors, E.-in-C.O.	1-1-31
O'Roark, A. F.	Skilled Workman, Cl. II., N. Wales District.	Inspector, N. Wales District.	13-7-30
Strathern, J.	Skilled Workman, Cl. I., Scot. W. District.	Inspector, Scot. W. District.	19-4-31
Stokes, B. C.	Skilled Workman, Cl. I., S.W. District.	Inspector, S.W. District.	11-2-29
McClarnon, J. R.	Skilled Workman, Cl. I., N. Ire. District.	Inspector, N. Ire. District.	27-5-30
Smith, W. C.	Skilled Workman, Cl. I., Scot. W. District.	Inspector, Scot. W. District.	19-2-31
Hogarth, R. N.	Skilled Workman, Cl. I., Scot. W. District.	Inspector, Scot. W. District.	13-4-31
Speight, E. A., Ph.D.	Unest- Skilled Workman, E.-in-C.O.	Inspector, E.-in-C.O.	To be fixed later.
Brogden, A. E.	Skilled Workman, Cl. I., N.E. District.	Inspector, E.-in-C.O.	To be fixed later.

APPOINTMENTS.

Name.	From	To	Date.
Knight, N. V.	Limited Competition.	Probationary Inspectors.	1-5-31
Turner, A. F.	Limited Competition.	Probationary Inspectors.	1-5-31
Prescott, J.	Limited Competition.	Probationary Inspectors.	1-5-31
Goodchild, R. F.	Limited Competition.	Probationary Inspectors.	1-5-31
Atkinson, J.	Limited Competition.	Probationary Inspectors.	1-5-31
Harnden, A. B.	Limited Competition.	Probationary Inspectors.	1-5-31
Nickolls, C. A. L.	Limited Competition.	Probationary Inspectors.	1-5-31
Owens, W. H.	Limited Competition.	Probationary Inspectors.	1-5-31
Renton, R. N.	Limited Competition.	Probationary Inspectors.	1-5-31
Dunn, W. K.	Limited Competition.	Probationary Inspectors.	1-5-31
Prickett, W.	Limited Competition.	Probationary Inspectors.	1-5-31
Carrette, A. D.	Limited Competition.	Probationary Inspectors.	1-5-31
Hamilton, D. F.	Limited Competition.	Probationary Inspectors.	1-5-31
Stonebanks, A. M.	Limited Competition.	Probationary Inspectors.	1-5-31
Judson, J. E.	Limited Competition.	Probationary Inspectors.	1-5-31
Porter, W. F.	Limited Competition.	Probationary Inspectors.	1-5-31
Watling, C. E. G.	Limited Competition.	Probationary Inspectors.	1-5-31
Fairs, A. E.	Limited Competition.	Probationary Inspectors.	1-5-31
Ellendon, A. H.	Limited Competition.	Probationary Inspectors.	1-5-31
Pilcher, C. J. F.	Limited Competition.	Probationary Inspectors.	1-5-31
James, L. R.	Open Competition.	Probationary Inspectors	1-5-31
Combridge, J. H.	Open Competition.	Probationary Inspectors	1-5-31
Mayne, E. A.	Open Competition.	Probationary Inspectors	1-5-31
Fogg, G .H.	Open Competition.	Probationary Inspectors	1-5-31
Trott, L. J.	Open Competition.	Probationary Inspectors	1-5-31
Button, G. E.	Open Competition.	Probationary Inspectors	1-5-31
Reed, R. E.	Open Competition.	Probationary Inspectors	1-5-31
Leach, F.	Open Competition.	Probationary Inspectors	1-5-31
Edwards, S. J.	Open Competition.	Probationary Inspectors	1-5-31
Pugh, S. E.	Open Competition.	Probationary Inspectors	1-5-31
Dolan, W. H.	Open Competition.	Probationary Inspectors	1-5-31
Maddison, W. H.	Open Competition.	Probationary Inspectors	1-5-31
Watson, L. R.	Open Competition.	Probationary Inspectors	1-5-31

Retirements.

Name.	Rank.	District.	Date.
Shaughnessy, E. H., O.B.E. ...	Assistant Engineer-in-Chief.		30-6-31
Bailey, W. J.	Staff Engineer.	E.-in-C.O.	31-5-31
Markwick, J. J.	Assistant Staff Engineer.	E.-in-C.O.	30-4-31
Cheshire, F. W.	Assistant Suptg. Engineer.	Eastern.	31-3-31
Brown, J.	Assistant Suptg. Engineer.	London.	30-6-31
Bannister, G. W.	Executive Engineer.	S. West.	31-3-31
Chambers, H. M.	Assistant Engineer.	London.	31-3-31
Vaughan, G. H.	Assistant Engineer.	S Lancs.	28-2-31
MacLean, M. J.	Chief Inspector.	Scot. West.	19-3-31
MacKenzie, K.	Inspector.	Scot. West.	12-4-31
Wilshen, H. G.	Inspector.	London.	31-3-31
Edwards, F.	Inspector.	N. West.	14-6-31

Deaths.

Name.	Rank.	District.	Date.
Coward, C.	Chief Inspector.	N. West.	8-5-31
Gough, H. H.	Inspector.	S. Lancs.	7-2-31
McEwan, J.	Inspector.	Scot. West.	2-5-31
Husband, W. J.	Inspector.	London.	6-3-31

COLONIAL APPOINTMENTS.

Name.	Rank and District.	To	Date.
Graham, C.	Assistant Engineer, S. Lancs.	Palestine.	1-4-31
Millar, H. T. W.	Assistant Engineer, E.-in-C.O.	Egypt.	19-6-31

CLERICAL ESTABLISHMENT.

Retirements.

Name.	Rank.	District.	Date.
Crossley, W. C.	H.C.O.	S. Lancs.	12-4-31
Payne, W. J. A.	H.C.O.	L. E. D.	30-4-31
Gell, E. R.	Executive Officer.	L. E. D.	12-6-31
Brockett, A. W.	H.C.O.	L. E. D.	30-6-31
Harmsworth, W. H.	H.C.O.	S. Eastern.	26-6-31

Promotions.

Name.	From	To	Date.
Tyson, J.	H.C.O. (Scot. East).	Staff Officer (Scot. W.)	1-4-31
Donaldson, J. G. K.	Clerical Officer (N. Wa.)	H.C.O. (N. Wales).	11-4-31
Willcock, H.	Clerical Officer (S.Lcs.)	H.C.O. (S. Lancs.)	13-4-31
Swan, R. K.	Clerical Officer (Scot. E.)	(H.C.O. (Scot. E.)	1-4-31
Sells, W. E.	Clerical Officer (L.E.D.)	H.C.O. (L.E.D.)	1-5-31

Death.

Name.	Rank.	From	Date.
Golding, F.	H.C.O.	North Wales.	10-4-31

Transfers.

Name.	Rank.	From	To	Date.
Williams, J. T.	H.C.O.	Oxford.	Croydon.	27-6-31

COMMUNICATIONS.

All Remittances and Communications should be addressed to the Managing Editor, P.O.E.E. Journal, Engineer-in-Chief's Office, Alder House, London, E.C.1.

Binding covers and copies of the Contents for Vol. 3 to 23 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. 23 bound, with index included, at a cost of 3*s*., by sending the Journals to the local agents. Orders for bindings, Vols. 1—19, should indicate whether the original binding with black lettering, or the latter pattern in gold, is required. Covers with gold lettering will be the only type stocked from Vol. 20 onwards.

The price of the Journal is 1*s*. (1*s*. 3*d*. post free) per copy, or 5*s*. per annum, post free. All back numbers 2*s*. each.