THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

VOL. 19 PART 4

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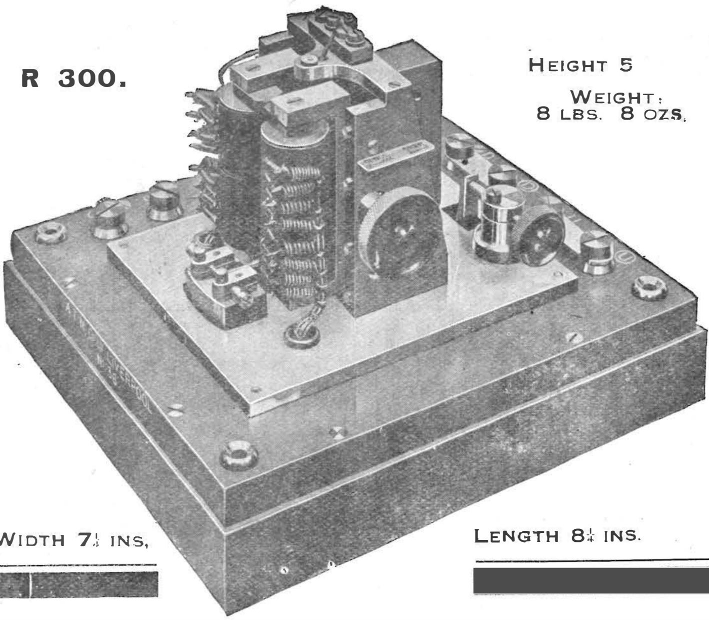

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AN OSCILLATOR GIVING A SINUSOIDAL AND CONSTANT OUTPUT OVER THE COMPLETE AUDIO FREQUENCY RANGE.

By B. S. Cohen, M.I.E.E.

Introductory.—The variation of sensitivity with frequency over the Audio Range for telephonic apparatus such as transmitters, receivers, and repeating coils, etc., may be referred to as the Frequency Characteristic of the apparatus in question. In a frequency characteristic is included nearly all the necessary information regarding the behaviour of the apparatus from a transmission standpoint, both as regards volume efficiency and articulation.

Apparatus has been designed in the Research Section to enable frequency characteristics to be quickly obtained. One of the main essentials is a source of alternating current readily variable over the important audio frequency range which is from 0 to at least 5,000 p.p.s. and capable of reaching to 10,000 p.p.s. if necessary, and which shall be practically pure in wave form (*i.e.*, harmonics present should be less than 5%) and should remain constant in voltage over the greater part of the range. Such a source of alternating current is essential not only for the plotting of frequency characteristics but it is also highly desirable in connection with a number of transmission measurements, such as transmission testing in repeater stations, transmission maintenance, etc., and also for general acoustic research.

If the frequency of the output is capable of being varied over the whole of its range by a single and simple operation such as the rotating of a variable condenser or inductance through a few degrees, the use and value of the apparatus is much increased. With such apparatus it becomes possible to arrange for the complete frequency range, or any portion of it, to recur at a rapid rate, so that ordinary types of measuring instruments can be used to give an integrated reading for the rhythmically recurring frequency band. This opens up still another important field of use in connection with the rapid efficiency testing of telephone apparatus. (See "Telephonometry," B. S. Cohen, I.P.O.E.E. Paper No. 70; 1916).

The ordinary direct audio frequency valve oscillator is incapable of fulfilling these varied conditions, and even under the limited condition of ability to supply audio frequency current of comparatively pure wave form, although not constant volume, over the important audio range, the direct audio frequency oscillator becomes very costly and cumbersome.

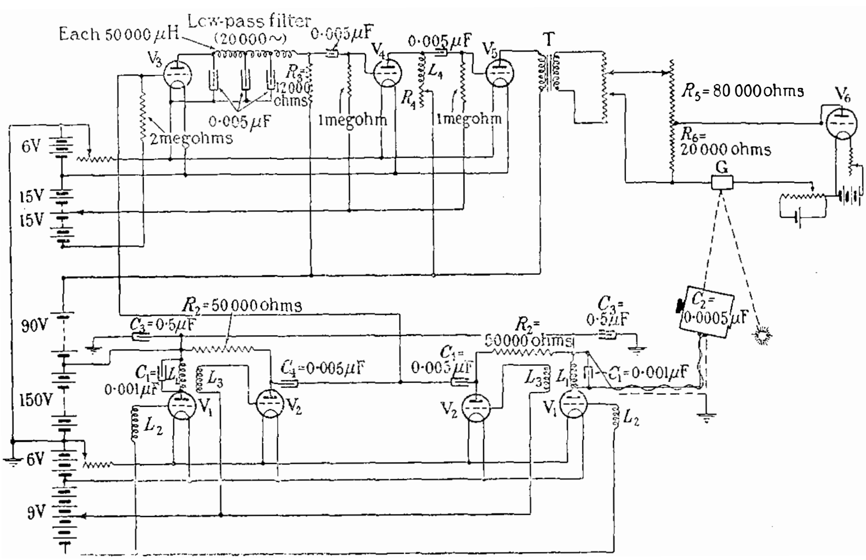


Fig. 1.—Circuit of Complete Table Pattern Heterodyne Oscillator.

The Heterodyne Oscillator.—In order to meet the full requirements, a heterodyne oscillator has been developed in the Research Section. The principle of operation is briefly as follows:—

Two valve oscillators, oscillating at ultra-audio frequencies are set up and the resulting oscillations are combined. One of these oscillators is maintained at a constant frequency and the other is capable of being varied from the same frequency by an amount which depends on the range of audio frequency required. If, for example, the fixed ultra-audio frequency is 30,000 p.p.s. and the second ultra-audio component can be varied from 30,000 to 25,000 p.p.s., a heterodyne or beat frequency, varying from 0-5000 p.p.s. will be obtained and similarly a variation of from 30,000 p.p.s. to 20,000 p.p.s. will give an audio range 0-10,000 p.p.s.

It should be noted that even in this extreme case, a variation of only $33\frac{1}{3}\%$ is required to obtain the 0-10,000 p.p.s. range and this percentage can be reduced still further by putting up the ultra-audio frequencies. It is this factor which renders it comparatively easy to obtain a constant output over the required range.

The heterodyne or beat audio frequencies can be separated from the ultra-audio component by small and simple filters and by rectification, and the separated wave can then be amplified to any

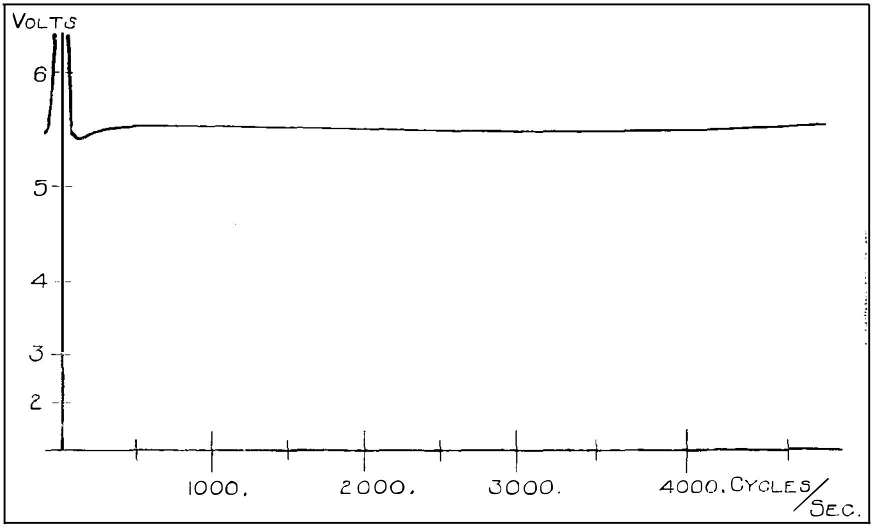


FIG. 2.—HETERODYNE OSCILLATOR. VOLTAGE-FREQUENCY CHARACTERISTIC.

extent desired. Apparatus of this type has been constructed in two forms, both of which are proving of great value.

Fig 1 is the circuit for a complete oscillator outfit.

V_1 V_1 are the two oscillator valves.

L_1 L_1 and L_2 L_2 are the plate and grid inductances and the former are tuned. In the case of the fixed ultra-audio frequency the tuning is only by a condenser C_1. In the case of the variable ultra-audio frequency the condenser C_1 is supplemented by a variable condenser C_2, which is combined with a camera in which characteristics can be photographically recorded. This will be described more fully later on.

The frequency of the fixed oscillator is set at about 30,000 p.p.s. and the other is so arranged that with the variable condenser at a few divisions above 0°, the same frequency is obtained, *i.e.*, zero audio frequency and at 180° the frequency is 25,000 p.p.s., so that the audio frequency will be 5,000 p.p.s. The oscillations are picked up by coils L_3 L_3.

With each oscillator is associated a single stage amplifier V_2 V_2. This is mainly for the purpose of eliminating interaction between oscillators, but it has been found possible in the portable set described further on to dispense with these valves.

It should be noted here that the oscillator valves, coils and condensers are set up in two separated iron boxes which are earthed, and that the variable condenser is placed in an earthed screen and is connected up by a screened conductor.

The ultra-audio oscillators are operated on the resistance capacity principle (see R_2 R_2 and C_1 C_1) and the beat oscillations are connected to detector valve V_3, which is operated by anode bend rectification. Finally, to eliminate all traces of ultra-audio

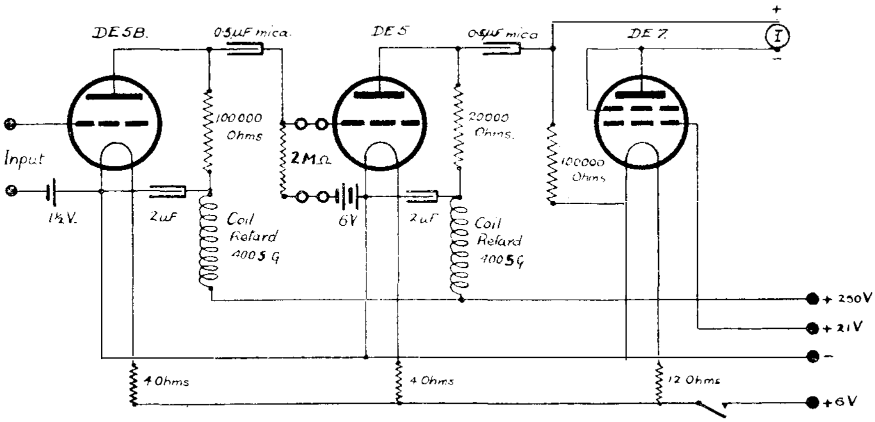


FIG. 3.—CIRCUIT OF STRAIGHT LINE DETECTOR AND AMPLIFIER.

frequency, a low pass filter is inserted in the plate circuit of the detector valve. This is a 3 section filter designed to block out all frequencies above 20,000 p.p.s.

The audio frequencies are then amplified by 2 stages of resistance-capacity coupled amplifiers and connected through a transformer T and potentiometer R_5 R_6 to an A.C. voltmeter of the Moullin type or to a special valve voltmeter as shown, consisting of a high period reflecting galvanometer connected through a diode rectifier. The galvanometer has a sensitivity of the order of 0.1 m.a. for full scale deflection on the condenser camera, and a natural period of the order of 1/25th of a second.

If this galvanometer be connected and arranged as shown in Fig. 1, it will record on condenser camera C_2 the frequency characteristic of the complete oscillator outfit itself. Such a characteristic is shown in Fig. 2 and it will be observed that from a few cycles up to 4,500 p.p.s. the output remains constant at a voltage of 5.5 volts. This is due partly to the special output transformer T. with large cross-section core and interleaved slab coil primary and secondary windings.

With the secondary coupled to a non-reactive load, this transformer gives plenty of output at the lower frequencies; there is, however, a slight tendency of the output to fall off at the higher frequencies. In order to compensate for this, it will be observed that the plate of the first audio frequency amplifier is coupled to the grid of the second stage by an inductance L_1, which is about 0.2 henry, and a variable resistance R_4, which can be adjusted

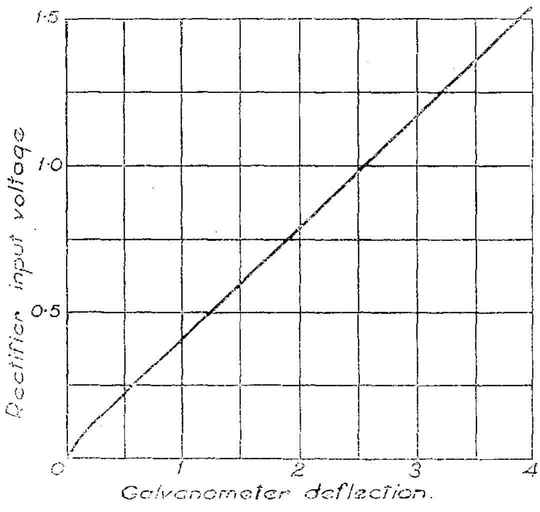


FIG. 4.—CHARACTERISTIC OF STRAIGHT LINE DETECTOR.

until the characteristic becomes flat. The high tension battery supplies are fed to the valves through chokes and condensers. These are omitted from the diagram Fig. 1.

The galvanometer rectifier just described does not give a straight line characteristic, but recently a modified galvanometer amplifier and rectifier has been designed and constructed which gives practically straight line rectification. Fig. 3 is the circuit and it will be observed that this consists of two stages resistance-capacity coupled amplifiers and a four-electrode valve D.E.7 with one grid and the plate in parallel and the second grid positively primed with 21 volts. Under these conditions the plate circuit becomes of very low impedance. This combination is a very satisfactory one and the characteristic, which is reproduced in Fig. 4, is practically a straight line.

Further details of the items comprising this testing set are given below:—

Valves V_1 V_1 V_3 V_4 and V_5 are all P.O. pattern V.T.24;

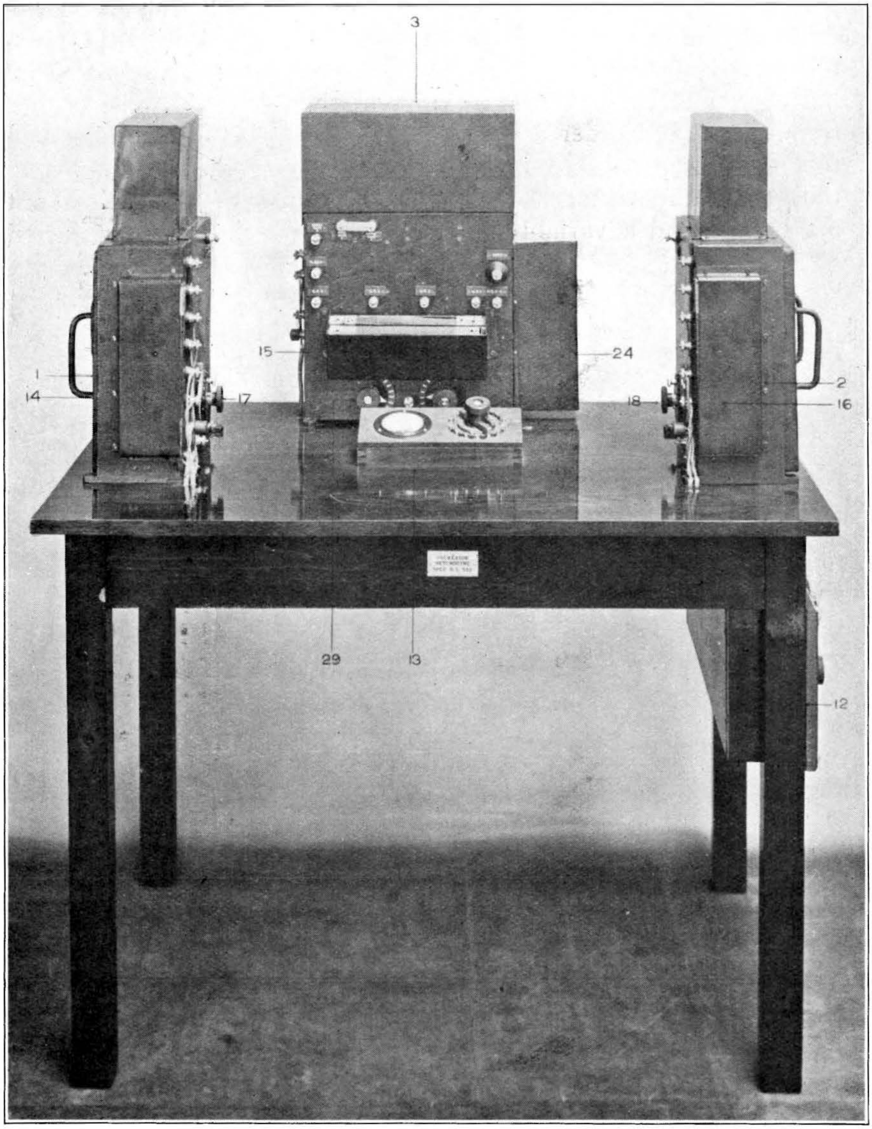


FIG. 5.—OSCILLATOR ASSEMBLY.

which corresponds to the Marconi-Osram L.S.5, and V_2 V_2 are V.T.4, corresponding to most R type valves.

Constancy of filament battery supply is an essential condition for reliability of operation and a 100 amp. hour filament battery is employed.

L_1 L_1 are 20,000 μH coils; L_2 L_2 are 50,000 μH coils;

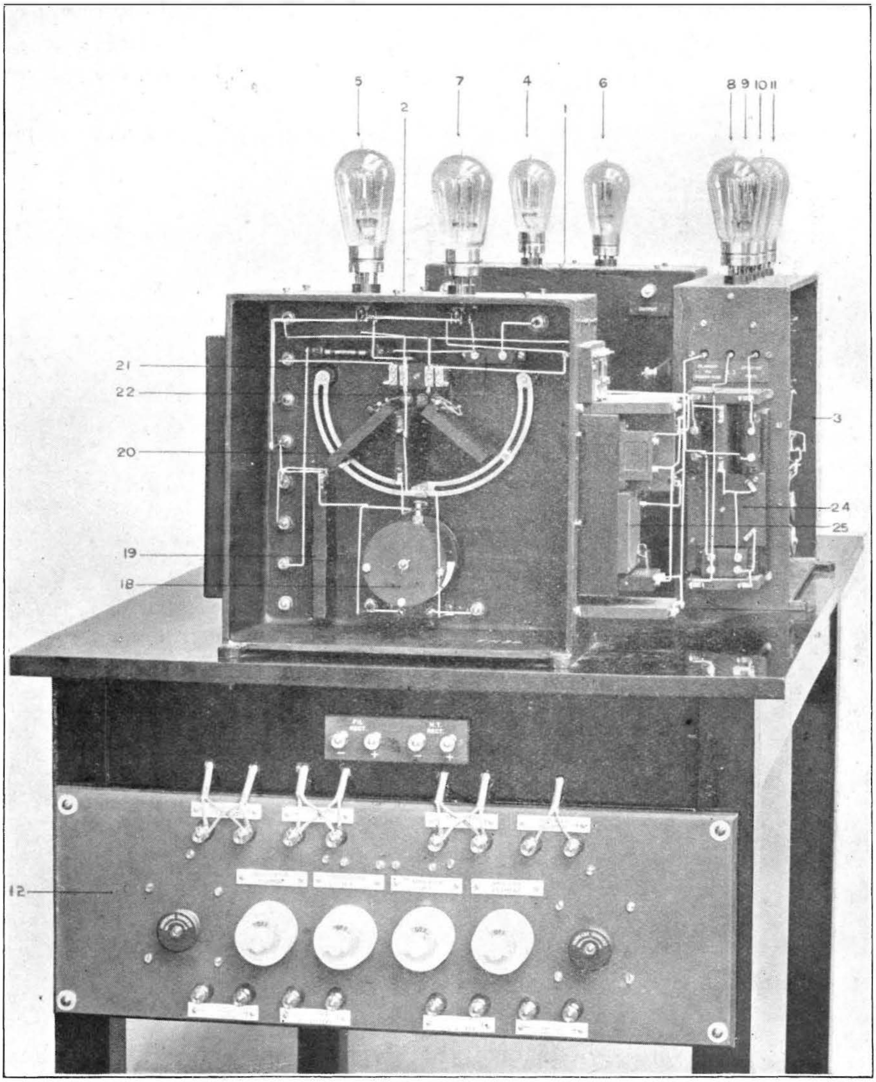


Fig. 6.—Oscillator: End View.

L_3 L_3 are 10,000 μH coils; C_1 C_1 are .001 μF; C_2 is .0005 μF. Other electrical values will be found marked on Fig. 1.

Although not shown in the diagram, a variable condenser (max. 0.001 μF) is shunted across the input of detector valve V_3. As the value of this condenser is increased, the output falls off but the wave form is improved. This condenser acts as a selective shunt with a tendency to reduce the amplitude of the harmonics more than that of the fundamental. Fig. 5 shows the complete oscillator asembly mounted on a table.

The two high frequency oscillators are on the left and right respectively, and the detector and audio frequency amplifier and filter are in the centre. On the right lower part of table is a battery panel.

Fig. 6 is an end view with the covers removed and shows the valve oscillator and coupler coils, which are mounted in rectangular ebonite slabs, the back of one of the oscillator condensers and also the battery panel with high and low tension connections are shown.

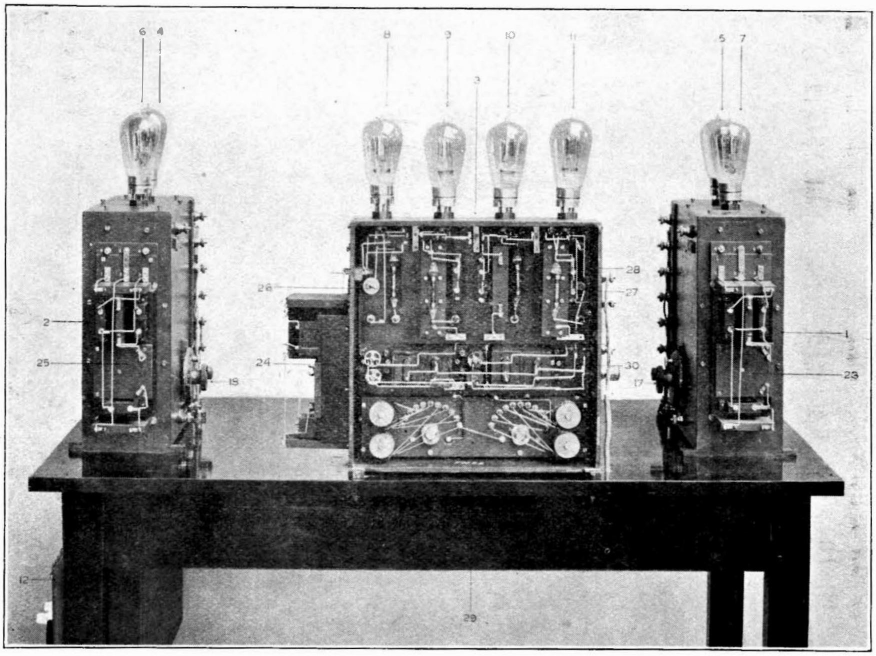


FIG. 7.—OSCILLATOR, DETECTOR AND AUDIO-FREQUENCY AMPLIFIER.

Fig. 7 shows the detector and audio frequency amplifier on the left. The low pass filter will be observed and similar filters will be noted on each of the high frequency oscillators. These have, however, not been found essential and are not used.

The H.T. feeding chokes and condensers are also to be seen in this illustration.

Fig. 8 shows the condenser camera with the cylindrical camera cover open, showing the drum surrounding the condenser to which the sensitized paper is attached and a developed characteristic is shown *in situ*. The light of a Pointolite lantern reflected from the galvo mirror falls through the camera shutter when the latter is open and passes through a cylindrical lens, forming a spot of light on the paper. The large wheel to rotate the condenser is graduated in degrees and must be rotated very slowly. Two condensers, each of 0.0005 $\mu F.$, are incorporated in the camera One of these has a straight line relationship between frequency and angle, whilst the other is a square law condenser. Either of them can be used individually. Fig. **9** is a general view of the recording apparatus comprising the lantern, galvanometer, and condenser camera. A separate wheel will also be noticed in the foreground.

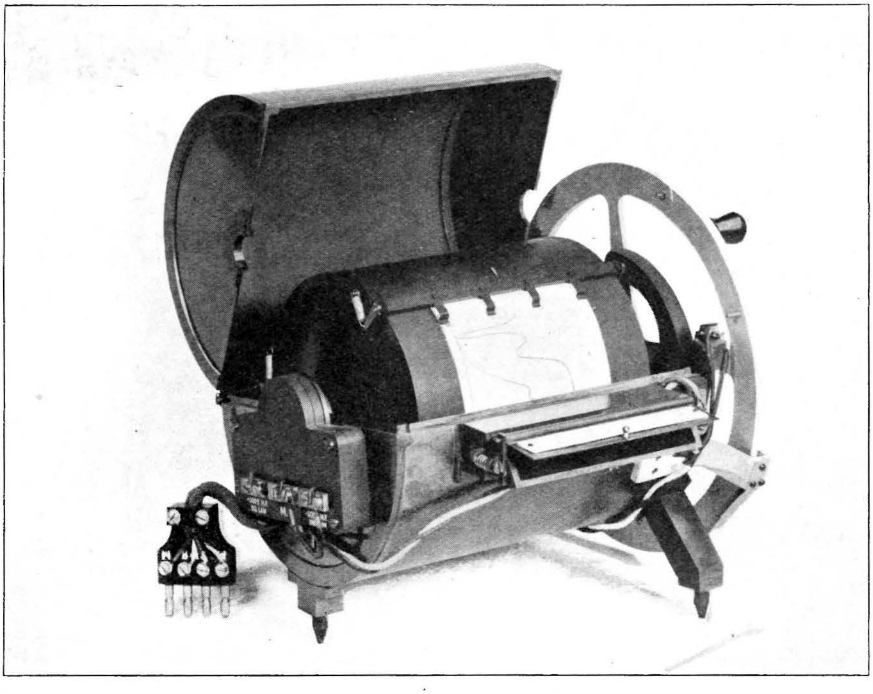


FIG. 8.—CONDENSER CAMERA.

This can be coupled to the camera wheel to give the latter an extremely slow motion when desired.

Some indication of the purity of the wave form is given by the oscillograms reproduced in Fig. **10** for audio frequencies ranging from 38 p.p.s. to 1000 p.p.s. Quantitative measurements of the actual impurity of the wave form have been made by measuring the capacity of a condenser and the method would have indicated the existence of any harmonic not less than 5% of the fundamental amplitude. As no trace of discrepancy was found it may be concluded that impurities are less than 5% of the fundamental.

Portable Pattern Heterodyne Oscillator.—The circuit arrangements adopted for the portable pattern oscillator are shown in Fig. **11**. It will be observed that the circuit has been simplified and by the omission of the high frequency amplifying valves only 5 valves are required, and these are all dull emitter valves, thus considerably reducing the total filament current required. In other respects this oscillator is generally similar to the instrument previously described. Output characteristics of this instrument are given in Fig. **12**, and as the load resistance is given the power outputs can be obtained. With a 1000 ohm load, the average voltage is of the order of 12.5 volts over the range, and with a 600

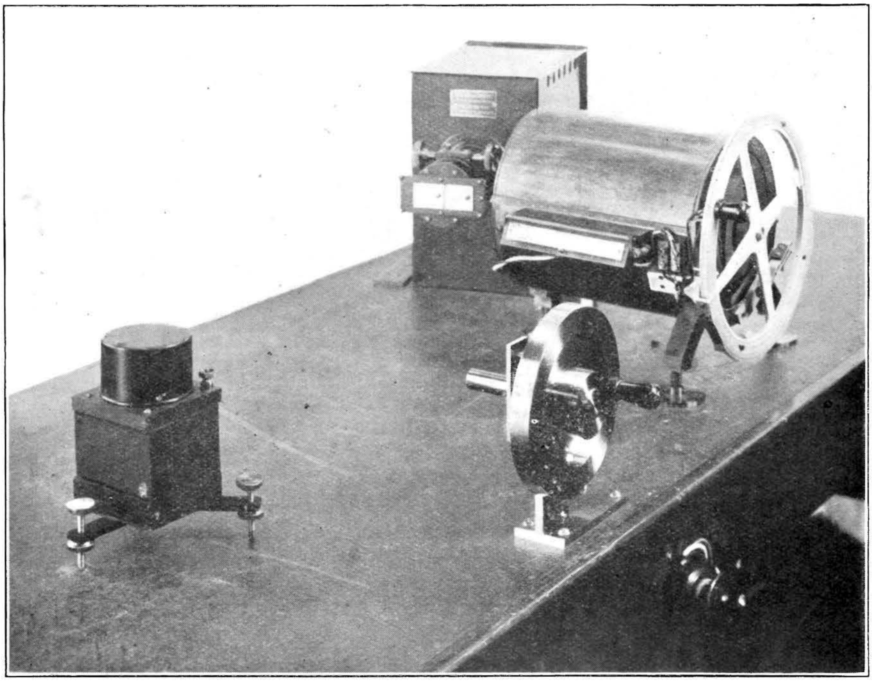


Fig. **9**.—Recording Apparatus : General View.

ohm load the average voltage is about 8.5 volts. The power available is of the order of 120—150 milliwatts, which is ample for most purposes. The general arrangement of this portable set is shown in Fig. **12***a*.

Notes on the uses of Heterodyne Oscillators.—The simplest use for the heterodyne oscillator is as a source of sinusoidal electric power of constant volume and of variable frequency over the audio range. For this purpose the frequency control can be a single air condenser with a straight line frequency characteristic and provided with a vernier to enable zero frequency to be obtained at any convenient point of the condenser scale (say 10 degrees). A calibration of any other point on the condenser scale for frequency is then all that is required, and this can be effected by operating a telephone receiver from the oscillator and adjusting to the required frequency by means of a tuning fork or frequency bridge. The condenser can then, if desired, be provided with an adjustable scale calibrated direct in frequency. It is sometimes found convenient to use two condensers of different ranges in parallel, one of which is provided with a vernier for zero adjustments. For example, if

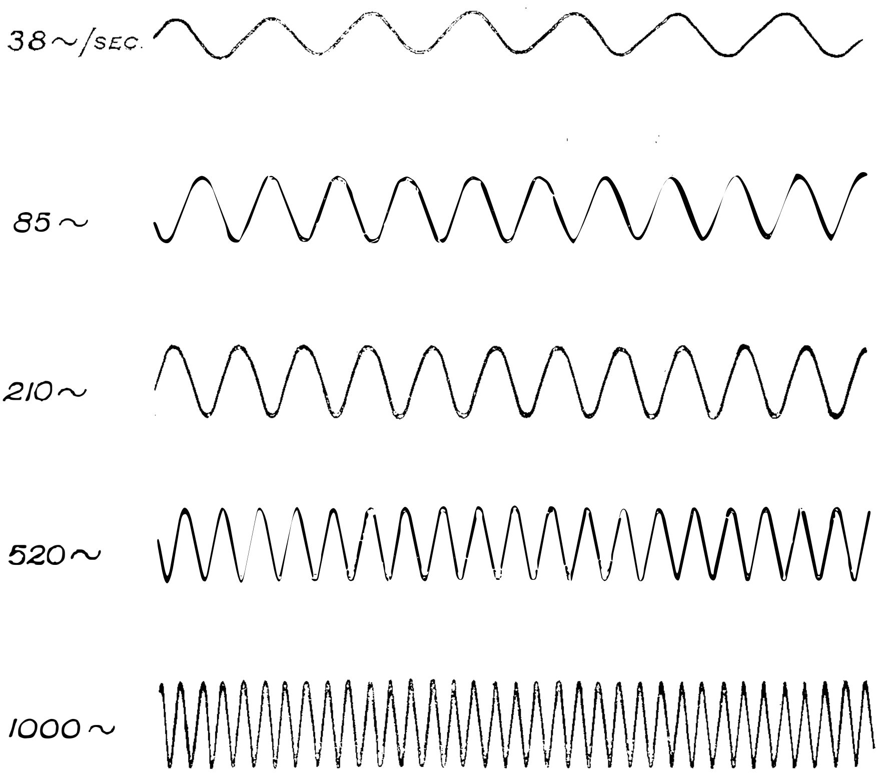


FIG. 10.—WAVE-FORM OSCILLOGRAM.

one condenser be 0.005 μF and the other 0.0025 μF, and the larger condenser give a frequency of 5000 p.p.s. at 180 degrees the smaller one will give a range up to 2,500 p.p.s., with a correspondingly more open scale.

The next use of the oscillator is to feed an electro acoustic transformer in order to obtain pure sounds over the audio range. Moving coil electro magnetic receivers can be used for this purpose, as also can specially damped Bell receivers, also condenser receivers. In an article in the last issue of this Journal on "A

High Quality Telephone Transmission System," will be found a description of a moving coil receiver which is suitable for this purpose. (See Figs. **7**, **8**A, B and C, and electro-acoustic characteristic Fig. **10**.) For determining transmitter characteristics the output of this receiver when actuated by the oscillator can be used to operate the transmitter and the output of the latter recorded either point by point or photographically on the condenser camera.

Correction can of course be made for the non-uniformity of the receiver characteristic by means of the calibrating curve just referred to (Fig. **10**, Page 248, *P.O.E.E.J.*).

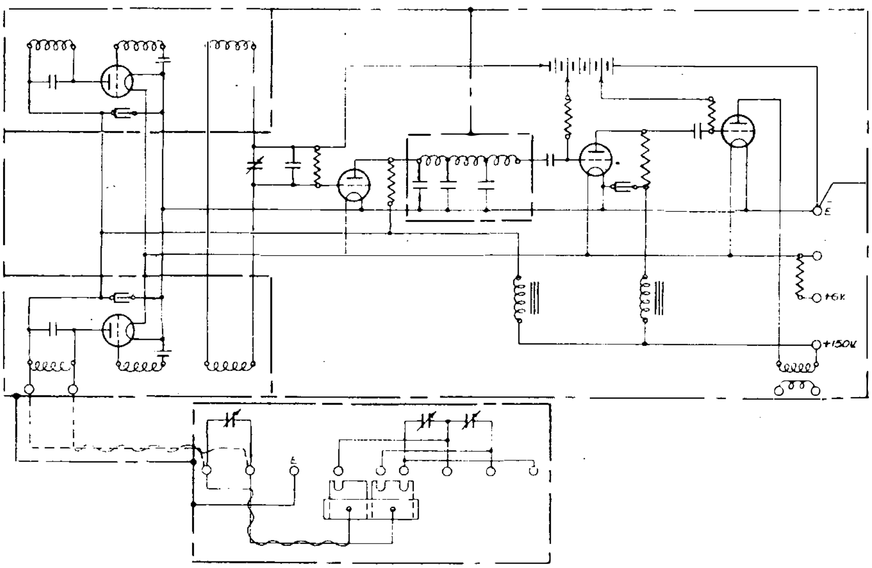


FIG. **11**.—CIRCUIT OF PORTABLE PATTERN OSCILLATOR.

When investigating the characteristics of telephone receivers and loud speakers, these instruments can be actuated by the oscillator and the acoustic output recorded on the condenser camera by means of a suitable " pick up " transmitter which may be condenser, thermophone or electro magnetic type, *e.g.*, the eddy current transmitter illustrated in the last issue of the Journal (Fig. **1**, Page 238, and calibration curve Fig. **6**, Page 244). Various precautions are necessary in taking such acousto-electric and electro-acoustic characteristics in order to get results which truly represent the behaviour of the instrument under investigation. For example, if a loud speaker be tested by means of an eddy current transmitter placed at a few feet from the loud speaker in an ordinary room, the characteristic obtained will include standing waves produced by reflection from the walls of the room, and also from the front of the eddy current transmitter. These will of course vary with every change in the position of the instruments with regard to each other and to the room walls.

These standing waves are of importance to study, as they will always occur to a more or less considerable extent under the normal conditions of use of a loud speaker; it is necessary, however, to eliminate them when investigating the absolute or comparative efficiencies of the loud speaker, and to do this it is necessary to carry out tests under non-reflecting conditions, *i.e.*,

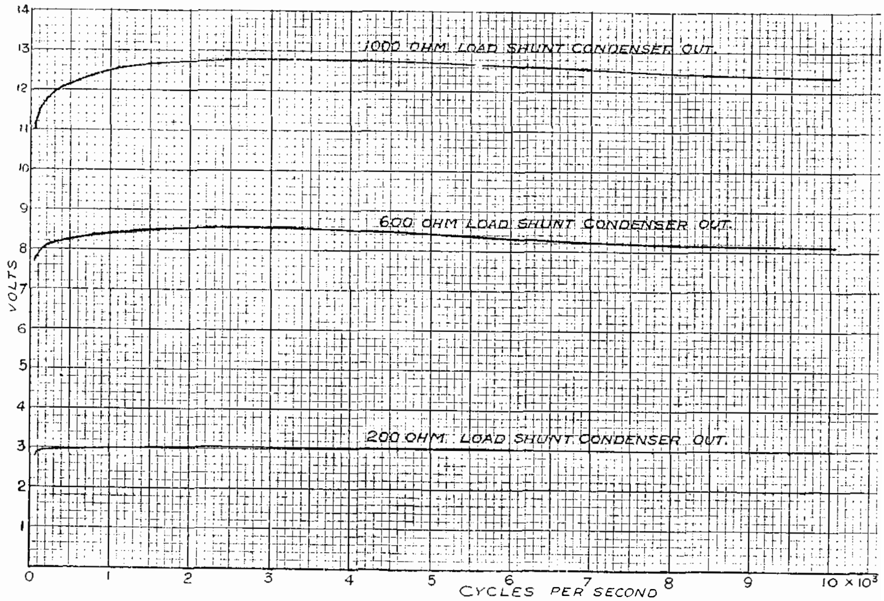


FIG. 12.—OUTPUT CHARACTERISTIC OF PORTABLE OSCILLATOR.

in the open air and with the acoustic pick up at as great a distance as possible from the loud speaker and with its reflecting surfaces as far as possible covered with cotton waste or some other sound absorbing materials.

The alternative method is to carry out the measurements in a suitable chamber or room provided with sound absorbing draperies or materials. Elaborate experiments have been carried out at Dollis Hill in connection with the construction of a special room arranged for this purpose, but details will be outside the scope of this article.

Rhythmic Oscillations.—Reference has already been made at the beginning of this article to the use of a rhythmically recurring frequency band and an integrating measuring instrument for the purpose of rapidly testing the transmission efficiency of telephonic apparatus, etc. For this purpose it is necessary to drive the frequency control condenser from some convenient source. Clock work and electric motors have both been used and by suitably arranging fixed capacity condensers any part or the whole of the audio frequency band can be utilised. Condenser circuit arrangements for obtaining these results will be found in Fig. 11.

If the recurrence be of the order of five times per second, an ordinary commercial needle or reflecting pattern microammeter will give a steady deflection.

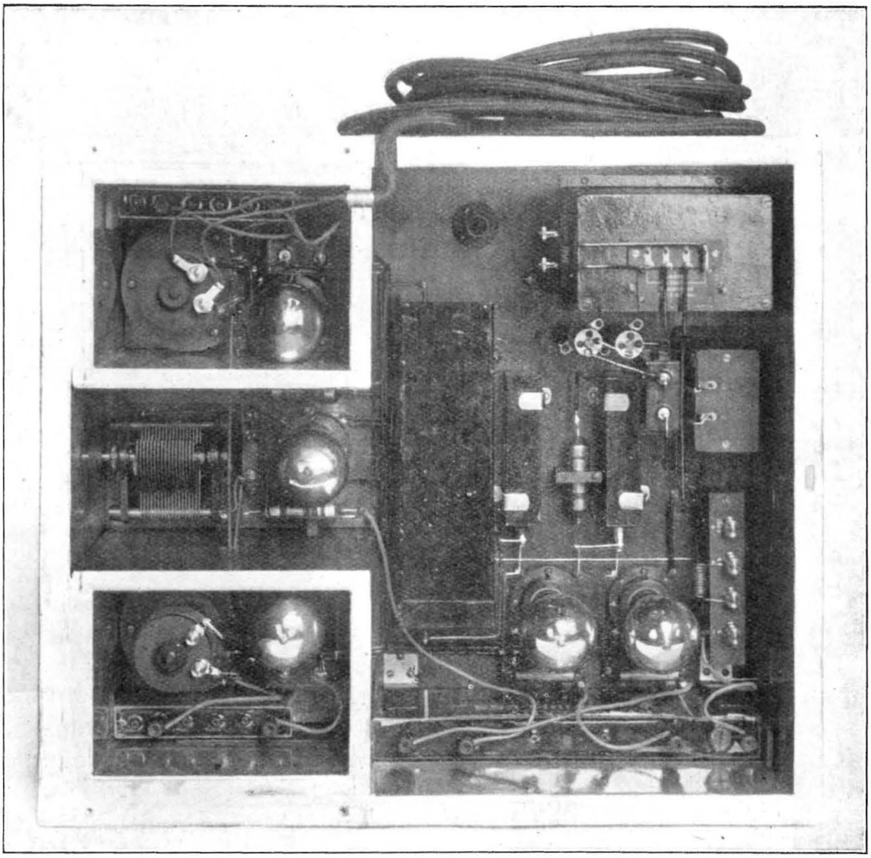


FIG. 12*a*.—PORTABLE OSCILLATOR.

The rhythmic oscilator outfit will, it is expected, be of great value in replacing the voice and ear for the rapid bulk testing of new deliveries of transmitters and receivers and also for the transmission maintenance of these instruments *in situ*, and apparatus for this purpose is now under trial with promising results. Similar apparatus is also being tried out for line and circuit testing and for cross-talk measurements.

Some characteristics obtained with the Heterodyne Oscillator Outfit.—In conclusion a brief reference will be made to some of the typical results obtained. These, as well as some of the other illustrations included in this article, are reproduced by kind per-

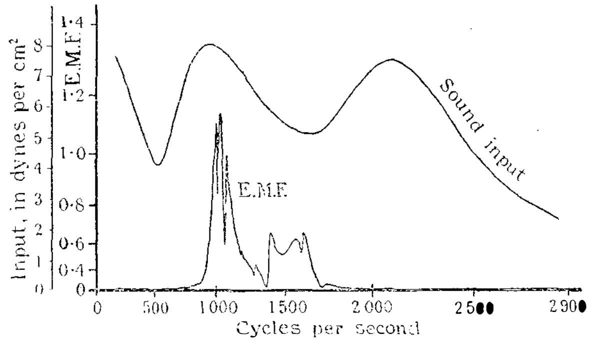


FIG. 13.—CHARACTERISTIC OF TRANSMITTER NO. 1 C.B.

mission of the Institution of Electrical Engineers from a paper entitled "The Frequency Characteristics of Telephone Systems and Audio Frequency Apparatus," B. S. Cohen, A. J. Aldridge and W. West. Vol. 64, part 358, October, 1926.

Fig. **13** shows the characteristic of a No. 1 C.B. transmitter. The sound input in dynes per square centimetre from a moving coil receiver is recorded, and also the corresponding voltage output of the transmitter when connected in a normal manner.

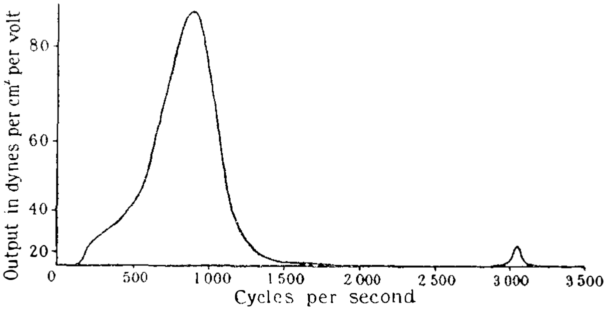


FIG. **14**.—CHARACTERISTIC OF BELL RECEIVER HELD TO EAR.

It will be observed that there is comparatively little if any response until a frequency of the order of 700 p.p.s. is reached and that resonance occurs at about 1000 p.p.s. There is a flat resonance peak due to mouthpiece at 1500—1700 p.p.s. and practically no response beyond 1900 p.p.s.

Fig. **14** is the characteristic of a Bell receiver. The receiver was placed against an artificial ear, so that the output was damped in the same way as it would be in practical use. The receiver commences to respond at about 150 p.p.s. and output rises rapidly to a maximum at about 900 p.p.s. Between 1,500 and 2,900 p.p.s. there is very little response and there is a small resonance point just above 3,000 p.p.s. This is due to another mode of vibration of the receiver diaphragm. This charcteristic is very different from that of the receiver not held against the ear, but for further details reference must be made to the I.E.E. paper.

Fig. **15** is the overall acoustic-electric-acoustic characteristic of a trunk connection. The circuit is shown in the figure and consists of 32 standard miles of non-reactive artificial cable, equivalent to a perfect continuously-loaded telephone line without cut-off.

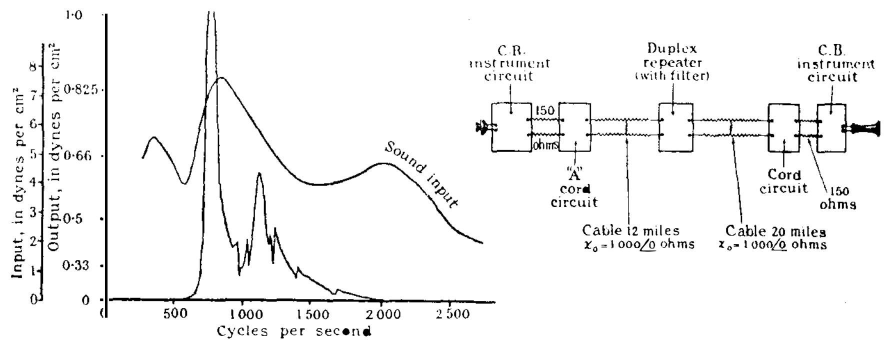


FIG. **15**.—CHARACTERISTIC OF COMPLETE CIRCUIT (TRUNK).

A duplex repeater is inserted as shown and this has the usual filter cutting off about 2,200 p.p.s. Standard C.B. cord circuits are used and 150 ohms subscribers' loops. Also Standard C.B. instruments and a No. 1 C.B. transmitter and 60 ohm Bell receiver (not held to the ear). The overall characteristic, it will be observed, is mainly a combination of the transmitter and receiver characteristics and the effective audio frequency band is limited to about 600—2000 p.p.s.

Space will not permit the inclusion of further characteristics of other apparatus, lines and circuits, but it is thought that sufficient has been given to demonstrate the possibilities of the method, and it may fairly be said in conclusion that a new and powerful method of investigating the efficiency of telephonic systems and apparatus is now available which forms a ready means of enabling the effect of change in construction and design to be conveniently observed, measured and recorded.

HOUSING THE BELL SYSTEM.

[*We are indebted to the American Telegraph and Telephone Coy, for permission to reproduce this article from the July issue of the "Bell Telephone Quarterly" and also for the loan of the blocks.*—Eds., *P.O.E.E.J.*]

We are celebrating this year the telephone's fiftieth birthday. As we look back over this relatively brief span of time we cannot but be impressed by the signs on every hand of the phenomenal growth and progress in the industry. The great advancements in the art of communication itself, through the comprehensive development and research activities carried on by the System, and the marked progress made in the construction and operating activities all form interesting stories in themselves. Similarly, there has been great progress in the other essential and related phases of the business, the scope of which at first is perhaps scarcely realized.

Among the more important of these related activities is that of housing all the component parts of this vast enterprise. There are close to 6,000 buildings in the System ranging in size from small and isolated repeater stations on the western prairies housing the appartus which makes communication possible from coast to coast, to huge combination office and equipment buildings in the midst of metropolitan traffic, through a list comprising garages, warehouses, factories, shops, office buildings and even hospitals. It doubtless will be of interest, therefore, to review the character and scope of the housing phase of the System's activities starting with the famous garret in Court Street, Boston.

In the earliest days of the telephone service, the housing problem was a simple one. A very small switchboard, simple in character and easily moved if necessary, was placed in some convenient location, usually in rented quarters, and from that switchboard wires were run one by one as needed either on poles or over housetops to the premises of those desiring service.

It will be seen, therefore, that in these early days, the housing activities were substantially no different in a particular city than those of the local merchant. Almost any space fairly centrally located with respect to the customers to be served was entirely suitable, particularly as no undue expense or inconvenience was involved in relocating the equipment and wires and personnel. It may be of interest to mention here that the first commercial telephone central office was established at New Haven in 1878, and occupied, as did a great many subsequent offices in different parts of the country, a few hundred feet of space in rented quarters.

In a relatively few years, however, as the telephone became more and more a part of the community life the picture changed. The rapid increase in the number of subscribers brought about the necessity for more elaborate and expensive switchboards, which in turn introduced more exacting requirements as to the location and character of the building space. This problem multiplied as the art developed, each subsequent advancement introducing new problems in the building phase of the work. In fact, only within the last few years, important changes in the art such as improved transmission developments and the dial telephone brought about fundamental problems not heretofore encountered.

How different, then, is the problem of to-day, particularly in the large cities. Each of the buildings must be placed in some definite location, and it is necessary to plan this well in advance and to direct the growth of the plant toward that location even though the building may not be erected for some years. Otherwise, very serious and costly rearrangements of plant would be necessary at the time the office is opened. Furthermore, each building must be planned to fit the particular circumstances surrounding the central office in question. Not only must very careful consideration be given to the erection of the immediate building, but the plans must provide for ready expansion to care for the telephone growth without excessive cost or reaction on the service. Moreover, suitable real estate at the theoretical wire center may be unobtainable in some cases, in which event studies must be made weighing the costs of various available sites near the wire center against the varying lengths of conduit and cable runs involved in each case.

The extent of our building activities is perhaps most strikingly illustrated by the structures shown in Fig. 1, which portrays an imaginary city composed of Bell Telephone buildings.

Of course, the bulk of our buildings are used for housing central office switchboards and associated personnel and the records indicate that the Schenley central office building at Pittsburgh erected in 1886 was one of the first, if not the very first, building planned and erected for this purpose.

With the Schenley building as a background let us survey the situation as of to-day. There are some 2,000 or so of these company-owned properties, representing a capital investment of close to $50,000,000 in land and something over $200,000,000 in buildings. Their aggregate area is well over 30,000,000 square feet, of which about 75% is in non-combustible buildings, and in addition to providing for central office switchboards, they provide working space for about 250,000 employees.

The scope of the construction activities involved in the erection of these numerous buildings is apparent. However, perhaps a

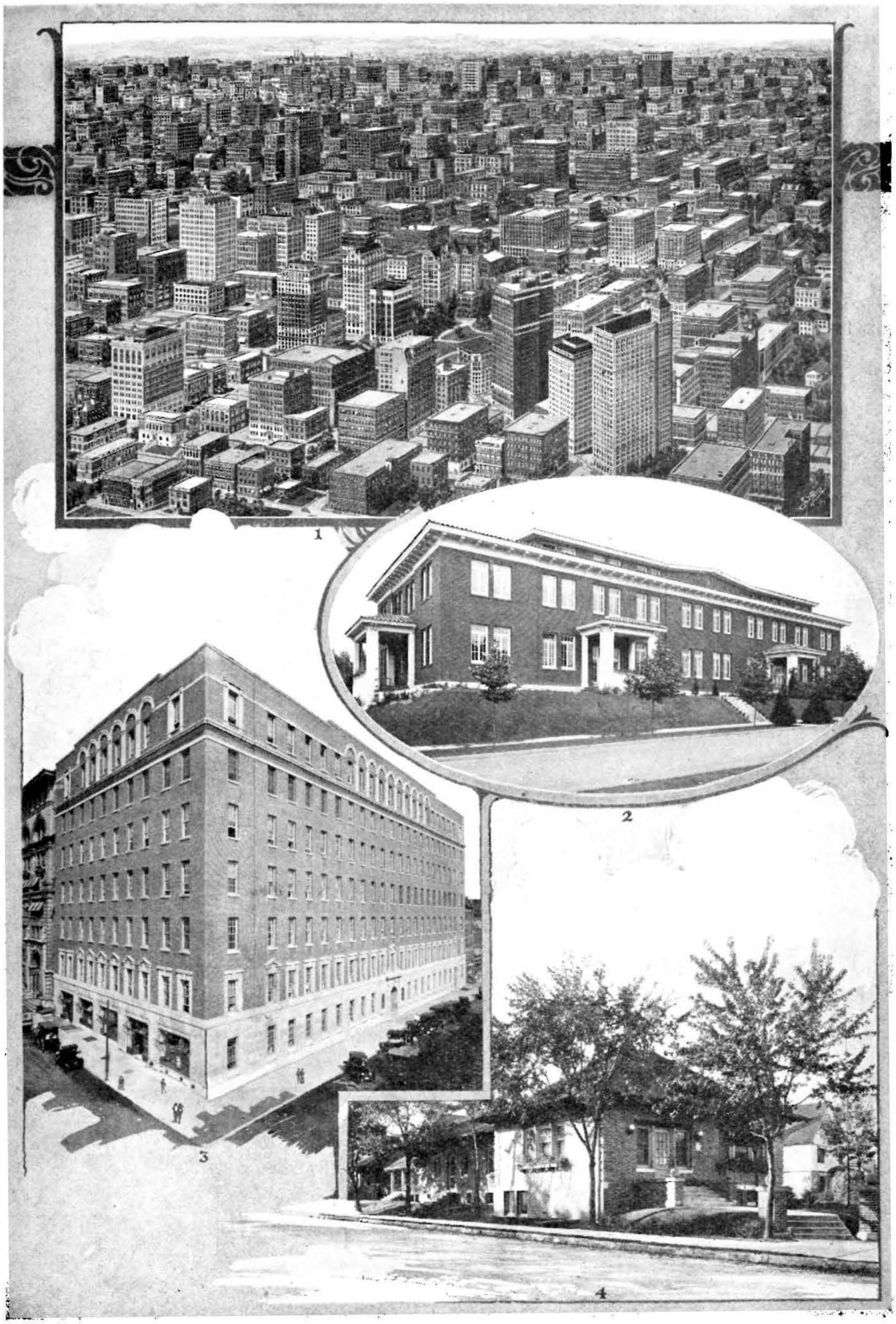


FIG. 1.—A TELEPHONE CITY—ONE-FIFTH OF THE BUILDINGS OWNED BY THE BELL SYSTEM.
FIG. 2.—A MULTI-UNIT OFFICE IN A RESIDENTIAL DISTRICT.
FIG. 3.—A MULTI-UNIT OFFICE IN A METROPOLITAN BUSINESS DISTRICT.
FIG. 4.—A SMALL SUBURBAN OFFICE.

few facts as to the magnitude of the housekeeping involved in their upkeep will be of particular interest.

The Bell System keeps house just as truly as a housewife does, but on a gigantic scale. It requires the entire working time of over 6,000 people to insure that all company-owned buildings are adequately heated, lighted, cleaned and serviced. It requires the services of close to 2,500 people to cook for and wait upon Bell System employees who secure lunch or other meals in telephone buildings—in fact, this is another closely related activity which would make an interesting story in itself. Hundreds of electricians, machinists, carpenters, painters, and other mechanics are regularly employed for the making of minor alterations, repairs and replacements.

Aside from those engaged in the architectural and construction phases of the work, there are several hundred telephone engineers in the System whose principal activities are concerned with the problems involved in planning central office buildings. A new building of this character involves consideration of the relative advantages of the different pieces of property available. It includes the preparation and careful examination of preliminary plans covering the more promising building and equipment arrangements which might be employed for the property finally acquired.

The facility with which these layouts could be expanded from time to time as required to care for growth, the advantages from an operating and maintenance point of view, and the relative costs are carefully weighed. The most desirable scheme is then fully developed. This requires careful study in collaboration with the architect and the other departments of the company of a great variety of interesting problems ranging from each detail involved in the arrangement of the central office equipment to the broader considerations affecting the occupancy of the different floors throughout the entire life of the building. These engineering plans when completed form the basis for the architectural plans and for the specifications covering the requirements for engineering, manufacturing and installing the central office equipment.

Protection against fire is, of course, one of the most important considerations involved in planning our buildings. Next to the safety of the personnel, continuity of service is the main objective. The most approved fire resisting devices such as metal and wire glass windows, hollow steel doors, extra strong partitions enclosing shafts and exits, and rolling steel shutters for openings facing hazardous exposures are employed. In addition, very complete fire fighting appliances are provided in all buildings.

Finally, in connection with the architectural phases, whether the building be in a small community or in a metropolitan centre,

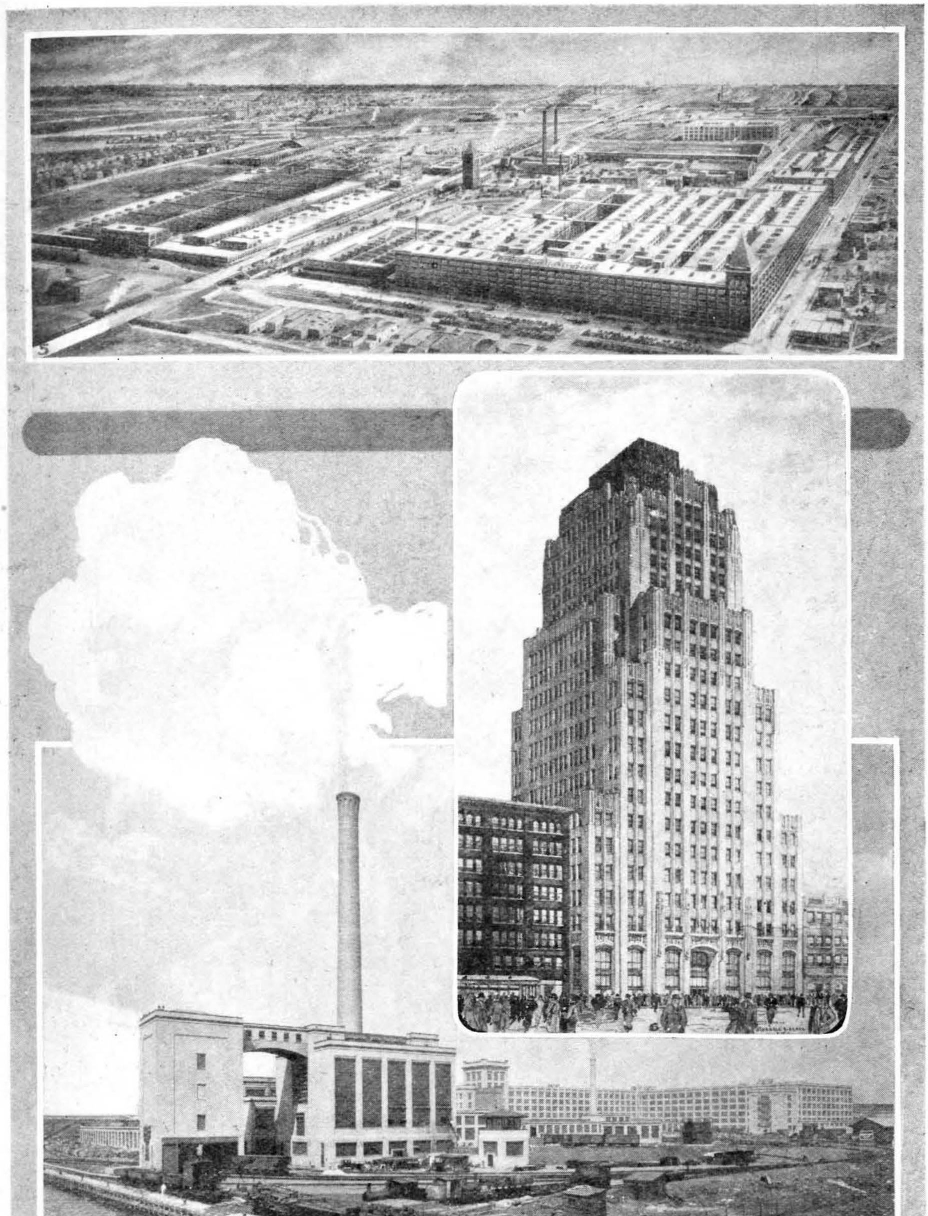


FIG. 5.—THE HAWTHORNE (ILL.) PLANT OF THE WESTERN ELECTRIC COMPANY.
FIG. 6.—THE NEW ADMINISTRATION BUILDING IN CLEVELAND OF THE OHIO BELL TELEPHONE COMPANY.
FIG. 7.—THE KEARNEY (N. J.) PLANT OF THE WESTERN ELECTRIC COMPANY.

constantly increasing consideration is given to the desirability of having it display individuality and character consistent with its surroundings. Also, where landscaping is appropriate, careful attention is given to beautifying the grounds. Our buildings from the very nature of the telephone problems must be more or less centrally located with respect to the subscribers served, and many of them therefore, must be placed in residential areas. In these cases in particular, stress is laid on insuring that the building and grounds be appropriate to their surroundings.

Figs. **2**, **3** and **4** illustrate typical central office buildings such as are provided in large and small communities throughout the System.

Up to this point the discussion has centered around the buildings housing the operating activities. The manufacturing branch of the System—the Western Electric Company—presents another interesting phase of this housing problem. The requirements to be met here are, of course, of a substantially different character from those of the operating companies.

Moving about 1878 from La Salle Street, to larger quarters in Kinzie Street, Chicago, the personnel employed by the firm which later became the Western Electric Company consisted of perhaps 100 people occupying about 12,000 square feet of floor space. In a span of little less than 50 years, this has expanded to the enormous manufacturing plants at Hawthorne and Kearny and to the 34 distributing warehouses located strategetically throughout the country and engaged solely in the manufacture and supply of telephone facilities.

Fig. **5** shows a general view of the Hawthorne works which contain close to 4,000,000 square feet of floor space and provide working space for some 41,000 employees.

The existing construction at Kearny already develops close to 800,000 square feet of space and the coming Fall will see completed and occupied something over 1,000,000 square feet in the aggregate. Approximately 2600 employees are now engaged at Kearny. Fig. **7** shows the development of the Kearny works.

Also besides these tremendous areas at Hawthorne and Kearny, the manufacturing department occupies at other localities a little more than 600,000 square feet, substantially all of which is leased space. This space was taken over as the direct result of the Western Electric Company's extensive participation in the activities brought about by the European War and according to the present plans will all be replaced by new space at Kearny.

It is of interest to note that the 34 distributing warehouses contain in themselves 1,800,000 square feet of floor space. Each distributing house must, of course, be located suitably with respect to the center of distribution for telephone supplies and also

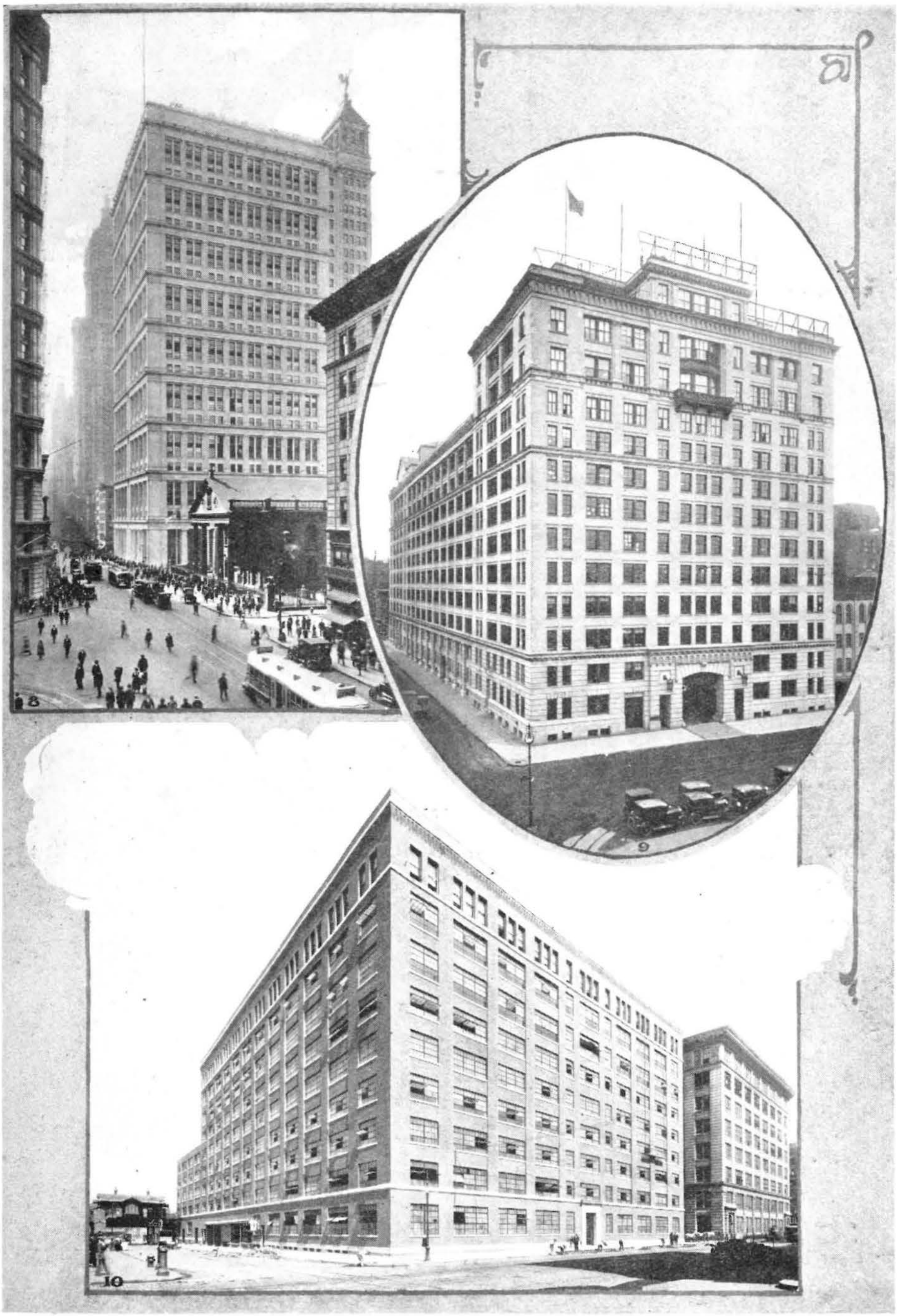


FIG. 8.—THE HEADQUARTERS OF THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY AT 195 BROADWAY, NEW YORK.
FIG. 9.—THE BELL TELEPHONE LABORATORIES, NEW YORK.
FIG. 10.—A LARGE EASTERN DISTRIBUTING WAREHOUSE FOR TELEPHONE SUPPLIES.

from the standpoint of satisfactory transportation facilities. Fig. **10** shows one of the large eastern distributing houses.

In a word, the Western Electric Company to-day occupies in round numbers over 7,400,000 square feet of floor space, 75 per cent. of which is in company-owned buildings. Area figures in the Western Electric case must be almost meaningless if expressed only in square feet. A better appreciation can be obtained of what it means to house so vast an enterprise as the manufacturing and distributing branches of the Bell System when it is pointed out that the area comprised by this 7,400,000 square feet is equivalent to 170 acres.

When it is considered that the housing problems of the Western Electric Company range from foundries and iron working shops on the one hand to shops for the turning out of the most intricate precision instruments on the other, and comprise wood, fabric and wire working mills, it will be seen how wide and comprehensive must be the scope of these housing activities.

Factory planning as practised to-day by the Western Electric building engineers was unknown when their problems first became apparent, and their solution, allied with the advance in the art of telephony are a most valuable contribution to the science of factorv engineering in general.

Still another phase of the housing problem of the System is that of providing space for administrative, research and laboratory purposes.

The Bell Telephone Laboratories building at West and Bethune Streets, New York, is shown in Fig. **9**. Within the past year the original structure has been increased in size to take care of the increasing volume of research work. The building as it stands contains about 600,000 square feet of floor space devoted wholly to laboratory purposes and to housing the more than 3,500 scientists, engineers and assistants who are engaged in every phase of the development and research work. Also the building houses a most complete and valuable display of historical telephone apparatus, and has in the top story an auditorium with a seating capacity of about 1000. It is interesting to compare all this with the few hundred square feet of floor space which sufficed for Dr. Bell and his one assistant in Court Street, Boston.

The headquarters building of the American Telephone and Telegraph Company at 195 and 205 Broadway, New York, is shown in Fig. **8**. This building is 26 stories high and contains roughly 600,000 square feet of floor space, about 500,000 of which are used by the 5,000 or so telephone employees engaged in the general departments of the American Company and the Western Electric Company.

Many other large buildings are required for the administrative

Fig. 11.—The New Administration Building in New York of the New York Telephone Company.
Fig. 12.—The New Administration Building in St. Louis for the Southwestern Bell Telephone System.
Fig. 13.—The New Administration Building in San Francisco of the Pacific Telephone and Telegraph Company.

staffs of the operating companies. The last year has seen the completion or start of four outstanding Bell System structures located in New York, Cleveland, St. Louis and San Francisco. These buildings which are shown in Figs. **11**, **6**, **12** and **13**, represent an investment aggregating close to $35,000,000. The combined productive floor area is roundly 1,600,000 square feet—which is about 37 acres. Their aggregate volume is close to 40,000,000 cubic feet—or about the volume which would be developed by a pyramid 450 feet square at the base and extending upward somewhat beyond the height of the Washington monument. The size of these structures does not, of course, reflect a desire for large buildings, but rather indicates the vastness of the enterprise. An appreciation of this is obtained when it is realised that the aggregate plant investment of the four companies whose administrative staffs are housed in these buildings is over a billion dollars and that space is also available to house central office switchboards for some 300,000 stations. This is equivalent to the number of telephones in a city having a population of 1,500,000.

These four buildings represent different treatments of the new architectural design, developed in America to give beauty and distinction to the so-called skyscraper.

Where a many-storied building is necessary in order to utilize to the best advantage valuable land, it has been found in this country that such a building can be made so architecturally fine that it becomes an object of pride to the community as a whole. Such buildings not only are attractive in themselves, but they also exemplify the high ideals of the Bell System.

Telephone building history from the first New Haven office with its few hundred feet of leased space to these tremendous office and equipment buildings of to-day, contains an absorbing record of the development of the housing phase of the System's activities. The great structures shown are striking examples of the way in which the Bell System has grown in this relatively brief span of fifty years.

H. P. CHARLESWORTH.

EDINBURGH'S AUTOMATIC TELEPHONE EXCHANGES.

By H. W. Dipple, A.M.I.E.E.

The conversion of the central portion of the Edinburgh Exchange area and the transfer of 11,583 subscribers and 1,153 junctions and trunks to automatic working on 3rd October, 1926, represents the largest task of this kind that the Engineering Department of the British Post Office has yet undertaken.

Fig. 1.—Newington Auto. Exchange, Edinburgh.

The Edinburgh area was served originally by a 10,000 line No. 1 C.B. Exchange at Central, with sub-exchanges at Colinton, Corstorphine, Davidsons Mains, Granton, Portobello and Leith. About 3 years ago a 2,000 line relief exchange named Museum was opened in the Central building to carry development until the automatic equipment was ready for use.

Before automatic working was decided upon a complete study of the area was made, and it was found economical to relieve the Central building by opening satellite exchanges at Newington, Morningside and Murrayfield. After the transfer was effected, the subscribers' lines were re-distributed as follows :—

Central	6,778
Newington	1,724
Morningside	1,832
Murrayfield	1,249
Total	11,583 lines

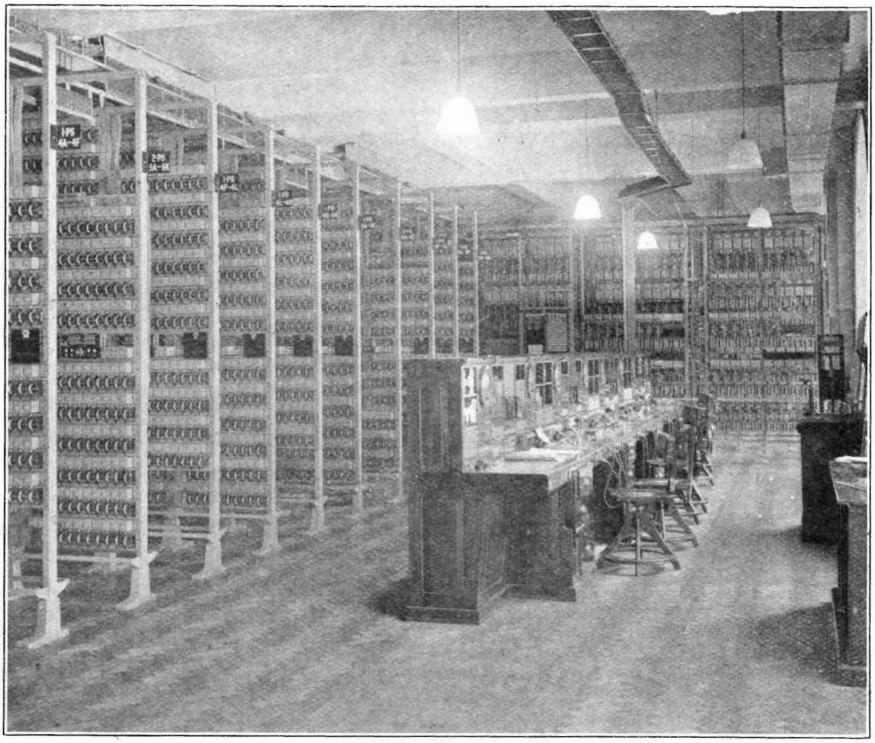


FIG. 2.—EDINBURGH CENTRAL EXCHANGE. 8 POSITION TEST DESK AND PRESELECTOR RACKS.

New buildings were provided for the satellites, of which that for Newington, shown in Fig. **1**, is typical.

The original arrangement of the Central Exchange building was :—

Ground floor ...	District Manager's Office.
First ,, ...	Staff dining rooms, Engineers' offices, etc.
Second ,, ...	Apparatus Room for Central & Museum, Traffic offices, etc.
Third ,, ...	Central and Museum Exchanges.

After careful investigation it was decided that by removing the District Manager to other quarters, sufficient equipment could be installed on the ground floor to accommodate the subscribers' lines remaining on Central after the re-distribution, and to provide for development until further plant could be installed when the second floor became available. It was also decided to instal a temporary manual board on the second floor in rooms formerly occupied by the Traffic Staff. The actual equipment installed on the ground floor is 8,300 lines, together with the 1st selectors for satellites, and for manual exchanges dialling in to the Edinburgh

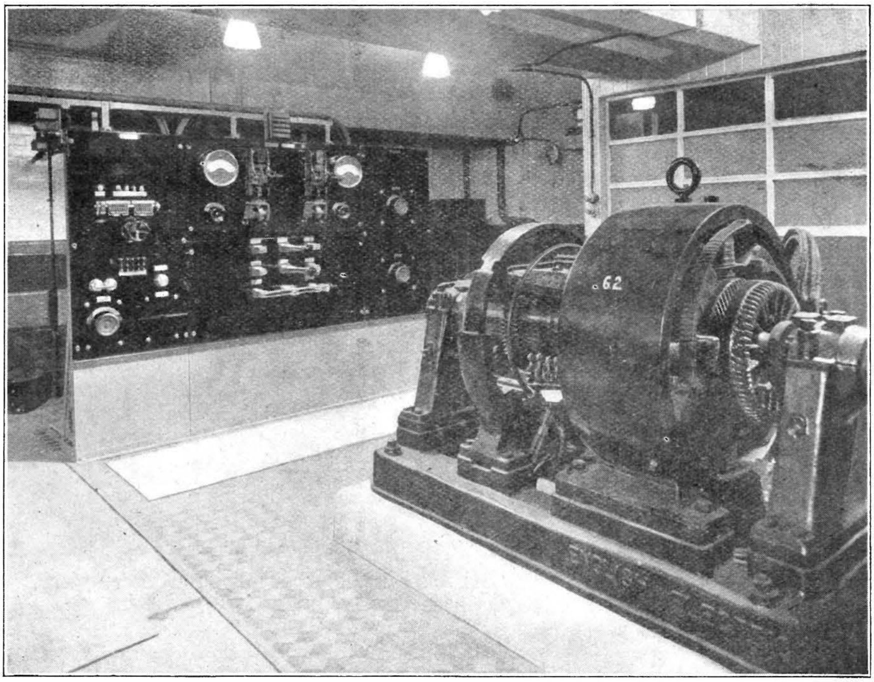


FIG. 3.—EDINBURGH CENTRAL EXCHANGE. CHARGING GENERATOR AND POWER BOARD.

area. Under this scheme the allocation of the building is as follows:—

Basement	...	Power plant and batteries.
Ground floor	...	Automatic plant, 1st Unit of 8,300 lines.
First ,,	...	Staff dining rooms and Repeater Station, etc.
Second ,,	...	Automatic plant, 2nd Unit.
Third ,,	...	Manual board (permanent) and operators' quarters.

Owing to greatly increased development, it is probable that the whole of the third floor will be required for the Manual Board, the operators' quarters being provided in an adjacent building.

The initial and ultimate equipment at the exchanges is as follows:—

	Initial.	*Ultimate.*
Central Unit No. 1	8,300	8,300
Unit No. 2	1,000	6,300
Morningside	2,500	4,400
Newington	2,100	3,600
Murrayfield	1,700	2,900

It is proposed to convert the sub-exchanges in the area to automatic working during the next few years. In the meantime, however, automatic subscribers obtain direct access to these exchanges by dialling special numbers. The initial and ultimate numbering schemes for the area are as follows:—

	Initial.	*Ultimate.*
Central 1st Unit ...	20,000—29,299	20,000—29,299
2nd Unit ...	30,000—30,999	30,000—36,299
Newington	41,000—43,099	41,000—44,599
Morningside	51,000—53,499	51,000—55,399
Murrayfield	61,000—62,699	61,000—63,899
Leith	7	71,000—73,499
Portobello	82	81,000—81,899
Granton	84	83,000—83,799
Corstorphine	85	85,000—85,499
Colinton	88	86,000—86,599
Davidsons Mains ...	89	87,000—87,499

The numbering scheme for the sub-exchanges was arranged as far as possible to allow of the level used for the dialling-out code to be made spare and connected to the Number Unobtainable Tone circuit, when an exchange is converted to automatic working.

The automatic plant installed in the area is Siemens No. 16 type equipment, which is now too well known to need any special comment. It is interesting to note, however, that the satellites are equipped with Discriminating Repeaters and Selectors. With each Repeater is associated a Junction Finder and a Selector Finder. When a subscriber calls, he is thus connected to an outgoing junction to the 1st Selectors at Central and to a Discriminating Selector. When the digits dialled determine the call to be local, the junction is released and becomes free to another calling subscriber. If the call is not local, the Discriminator Selector is released and the call completed over the junction to Central. Discrimination is effected on the first digit of the satellite number, *e.g.*, "4" in the case of Newington.

The circuit arrangements of the Discriminator circuits are those peculiar to Siemens No. 16 system, but the facilities provided are practically identical with those of the A.T.M. Co.'s Switching Selector Repeater at Leeds, which was described in the April, 1926, issue of this Journal.

Fig. **2** gives a general view of the Test Desks, 1st Preselectors, and 1st Selectors at Central.

Fig. **3** Charging Machine and Power Board at Central.

Fig. **4** 1st Preselectors, Incoming and Local 3rd Selectors, Newington.

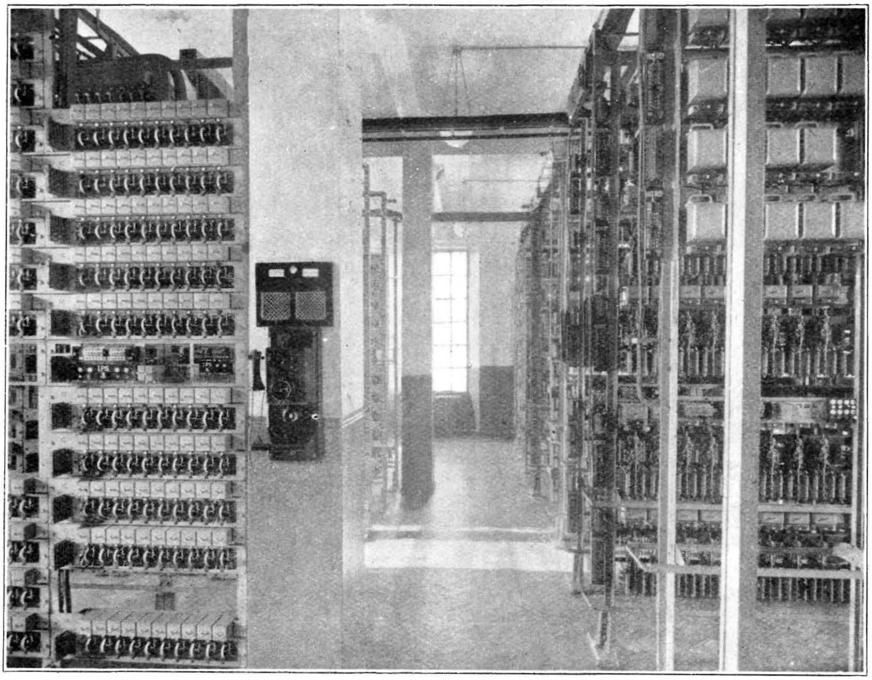


FIG. **4**.—GENERAL VIEW OF SWITCH ROOM, NEWINGTON AUTO. EXCHANGE.

Fig. **5** General View, Morningside.

Fig. **6** 1st Preselectors, Murrayfield.

The transfer was effected at 5 minutes past midnight on Sunday, October 3rd, 1926, traffic at that time being very light. Cutting out took place in the old apparatus room, some 42,000 heat coils being withdrawn in three minutes. The withdrawal of the wedges from the protectors on the new Main Frames was carried out rather more leisurely in order to avoid trouble due to displaced carbons, but the total time occupied in the transfer from first to last was approximately only $9\frac{1}{4}$ minutes. Immediately after the transfer a total of 81 P.G.'s at 1st Selectors was noticed, and within 10 minutes this number had fallen to 35.

Testing of subscribers lines began immediately, and the result of the test showed a total of 205 faults, representing 1.7% of the total number of lines. Approximately 50 of these were subsequently found to be ordinary day-to-day maintenance troubles, so that the percentage of faults arising out of the transfer was actually 1.3%. In view of the large number of circuits to be dealt with, this result cannot be regarded as other than excellent.

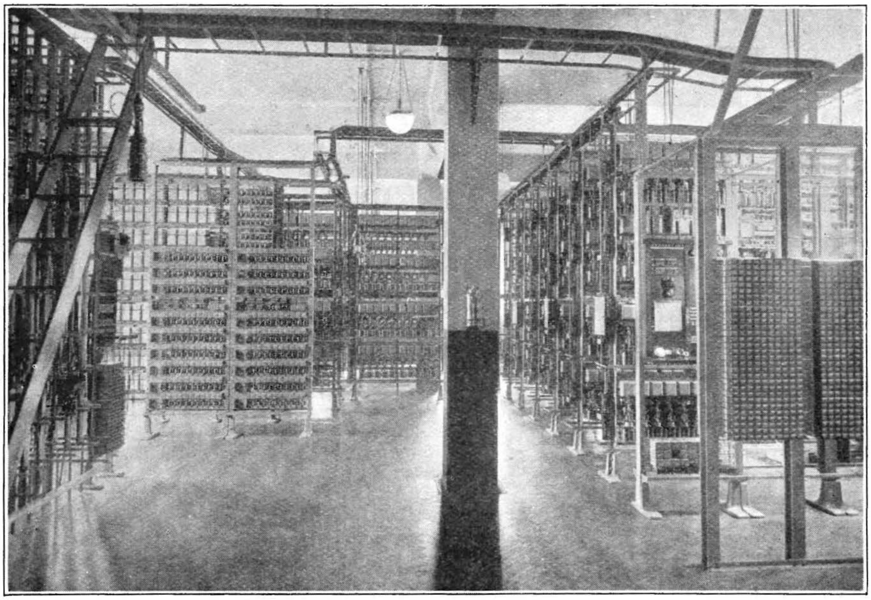


FIG. 5.—GENERAL VIEW OF SWITCH ROOM, MORNINGSIDE AUTO. EXCHANGE.

Telephone Engineers who have had experience of transfers will be able to visulize the careful organisation required for the vast amount of work involved in testing, and the detailed work in the keeping of records of lines, removals, ceases, etc., where nearly 12,000 subscribers lines are concerned. They will, therefore, be quick to appreciate the excellence of the transfer and the hard work and enthusiasm of the Edinburgh Engineering force in bringing about such a splendid result. An idea of the amount of testing work required in a large automatic area will be gained from the following summary of plant in the Edinburgh area :—

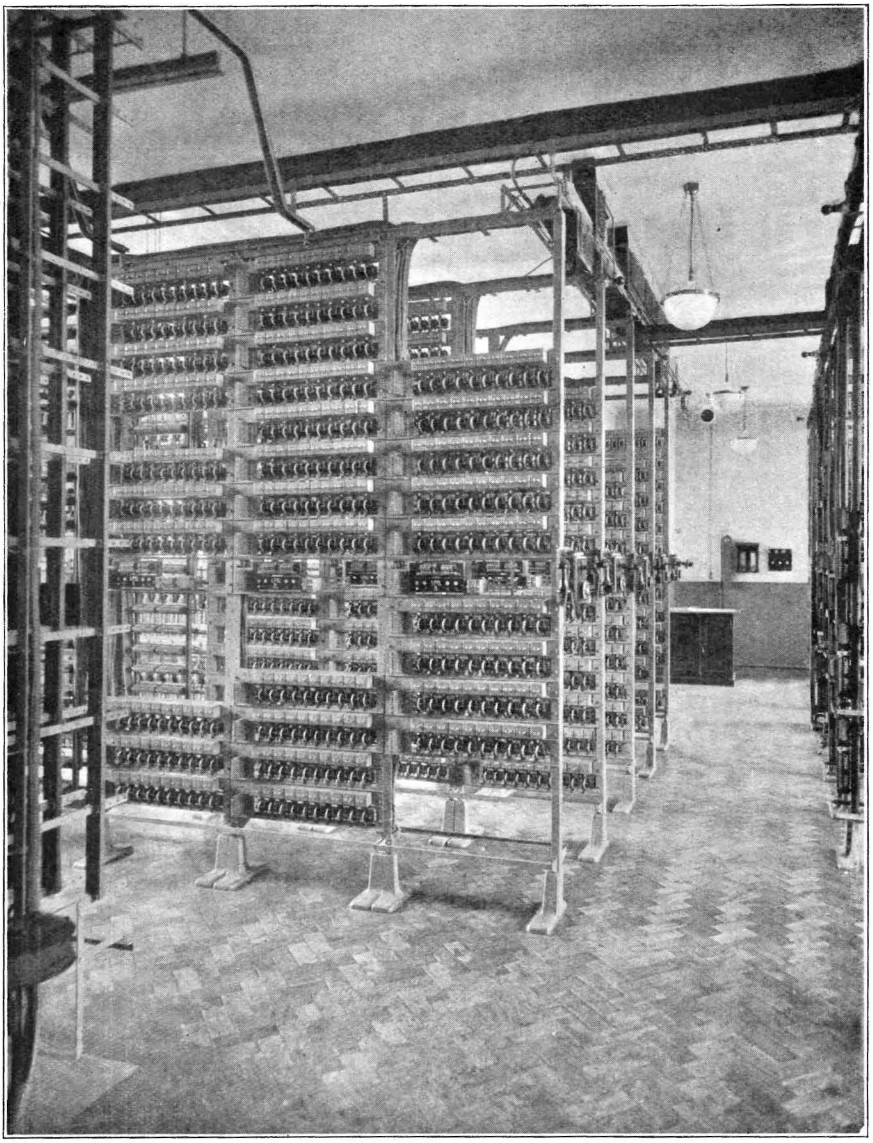


FIG. 6.—MURRAYFIELD AUTO. EXCHANGE. FIRST PRESELECTOR RACKS.

1st Preselectors	...	...	14,640
2nd ,,	...	...	1,920
1st Selectors	...	...	1,328
2nd ,,	...	...	1,196
3rd ,,	...	...	1,487
Final ,,	...	...	1,871

Discriminating Selectors	...	76
,, Repeaters	...	280
Miscellaneous Switches	...	335
Subscribers Meters ...	...	15,600

On the day following the transfer, the traffic flowed very smoothly, very little traffic congestion occurring, and the subscribers very quickly settled down to the new method of working. There seems no doubt that the conversion from C.B. working was a contributing factor to this, as it was possible of course to recover the existing telephones before the transfer.

The temporary Manual Board consists of:—

1 Cordless B position with Key Sender,
7 Trunk Signalling positions,
2 Special control ,,
5 Jack-ended junction ,,
15 A positions for "0" level calls,
1 Service P.B.X. position.
1 12 position Monitors Desk.

The permanent Manual Board will be installed in the old "Central" switchroom as soon as the old equipment has been recovered and the room prepared for the new plant.

The second Automatic Unit of 1,000 lines initial equipment will be installed in the old apparatus room when the old plant has been recovered and the necessary structural alterations made.

A Centralized Service Observation equipment will be installed also. This consists of a 2-position Desk at Central with equipment for observing service on 50 Central subscribers and on 25 subscribers at each of the Satellite Exchanges. With this latter equipment, one junction circuit between the distant exchange and the Service Observation Desk will allow the service of 25 subscribers to be observed.

Thanks are due to Messrs. Siemens Bros. & Co., Ltd., for the photographs with which this article is illustrated.

OPERATING TIME LAG OF RELAYS.

In Automatic Telephony the need of a more thorough knowledge of the principles governing relays and their operation is becoming more and more evident. Hitherto, a relay has been regarded chiefly as an electro-magnet which, when energised, was capable of opening or closing certain contacts, and the only information that was considered necessary was a knowledge of the limiting values of current which would cause it to operate or release. The ever-increasing complexity of automatic circuits, caused by the necessity of meeting more and more stringent requirements, has compelled circuit designers to ask for relays that function within fixed time limits as well as within fixed current limits. Hence it is that a knowledge of the operating and releasing lags of relays has become of primary importance. It should be remarked, however, that this development must be accompanied by increased accuracy of maintenance, since the time elements of a relay depend very much upon its adjustment and one of the problems that must be solved is a method of manufacturing and maintaining relays within close limits, both as regards operating currents and operating times.

The following extract from a paper by S. Raybould entitled, " The measurement of operating and releasing lags and relays by means of a Ballistic Galvanometer " (Annales des Postes, Télégraphs et Téléphones," March, 1926), is, therefore, of considerable interest :—

Certain electro-mechanical means can be used to determine the time periods of a relay, but unfortunately they necessitate the use of apparatus which is rarely available in a laboratory. For example, a Baudot distributor can be used. From one of the contacts (A) of the distributor, a current is completed for the winding of the relay under consideration, the operation of which closes the circuit of a telephone receiver connected to a moving contact (B). By displacing this contact one can find the point at which the relay operates. By dividing the arc which separates the contacts (A) and (B) by the angular speed of the distributor, the operating lag of the relay is found. Investigations have, however, led to the discovery of a simple and practical method of measuring time periods which gives very satisfactory results. This method, which can be varied to meet the particular case, is based on the following principles: the charge q received in a time t by a condenser of capacity C placed in a circuit of resistance R is given by the equation

$$q = Q\,(1 - \epsilon^{-\frac{t}{CR}}) \qquad \ldots\ldots(1)$$

If a scheme be devised in which the condenser is partially charged during the time which it is desired to measure, the measurement of q will enable the time to be calculated.

It may be necessary to know either the operating or the releasing lag of a relay, depending on the functions which in practice it will have to perform. The method will be explained by describing two cases.

Case 1.—To determine the time that elapses between the closing of the current in the winding of relay A (Fig. 1) and the instant at which the make contact is closed, it is necessary to have a constant voltage E, a well insulated condenser of capacity C, a high resistance r, and a ballistic galvanometer of resistance g. The connections are shown in Fig. 1. If key M be closed while keys N

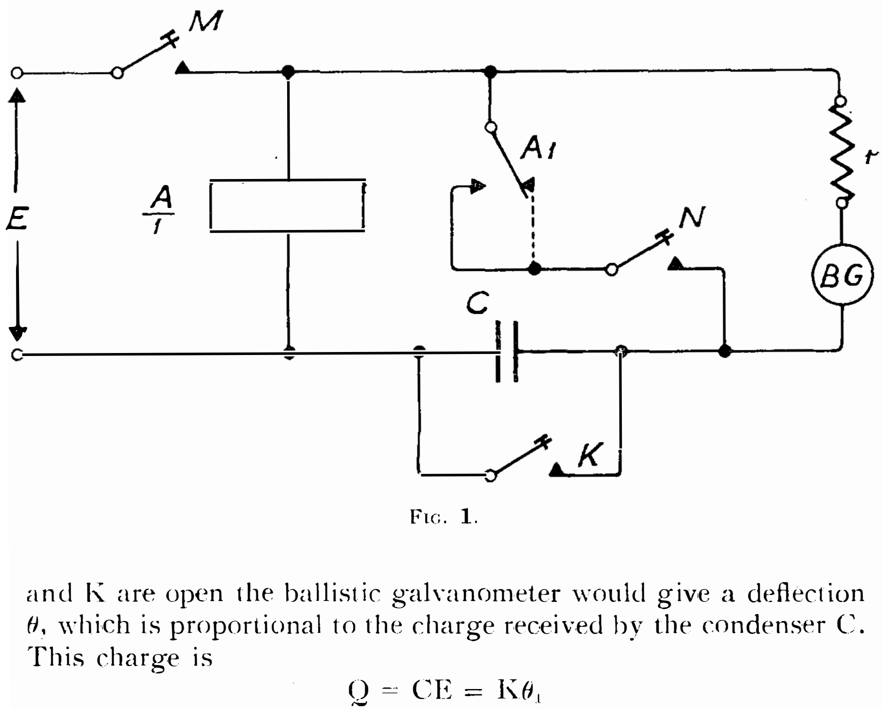


Fig. 1.

and K are open the ballistic galvanometer would give a deflection θ, which is proportional to the charge received by the condenser C. This charge is

$$Q = CE = K\theta_1$$

This is the ordinary equation of the galvanometer from which the constant K can be found. It will be referred to later. The following operations are then performed:—

(1) Key M is opened.
(2) Key N is closed.
(3) Key K is used to discharge the condenser, the discharge being shown by the return of the ballistic galvanometer to zero.
(4) Key M is closed.

The condenser is charged and the ballistic galvanometer gives a deflection θ_2 proportional to the charge that C receives during the time that elapses between the closure of M and the closure of the operated contact of the relay. This charge has a value

$$q = K\theta_2$$

Let us suppose that the condenser used has a very high internal resistance and that consequently its conductance is negligible. The resistance of the circuit is, therefore :—

$$R = r + g$$

as we have already seen

$$q = Q\left(1 - \epsilon^{-\frac{t}{CR}}\right)$$

from which we have

$$\frac{t}{CR} = \log_e \frac{Q}{Q - q}$$

and

$$t = CR \log_e \frac{Q}{Q - q}$$

by replacing Q and q by their value in terms of deflection

$$t = CR \log_e \frac{\theta_1}{\theta_1 - \theta_2}$$

The time will be expressed in seconds if C is in farads and R is in ohms.

By connecting the "make" and "break" springs (shown dotted in Fig. 1) the period of disconnection of the moving spring can be measured and by substracting this value from the result already obtained the electro-magnetic retardation of the relay can be found.

Case 2.—To determine the time which elapses between the instant at which the circuit of relay A is opened and the instant at which its armature returns to normal (Fig. 2).

In this case it is necessary to use an extra relay of which the operating lag has previously been measured.

The actual measurements in this case are made in exactly the same manner as in the first case, but it will be necessary to subtract from the result the delay introduced by the auxiliary relay before the required time period can be found.

The measurement can be simplified by the use of a well adjusted Baudot relay for the auxiliary relay, the lag which it introduces being usually less than one millisecond and therefore in most cases it can be neglected.

Accuracy of Measurement.—It can be shown that for maximum accuracy the following conditions should be aimed at—

$$T = C.R.$$

If this condition holds good, approximately an accuracy of about 3% can be obtained.

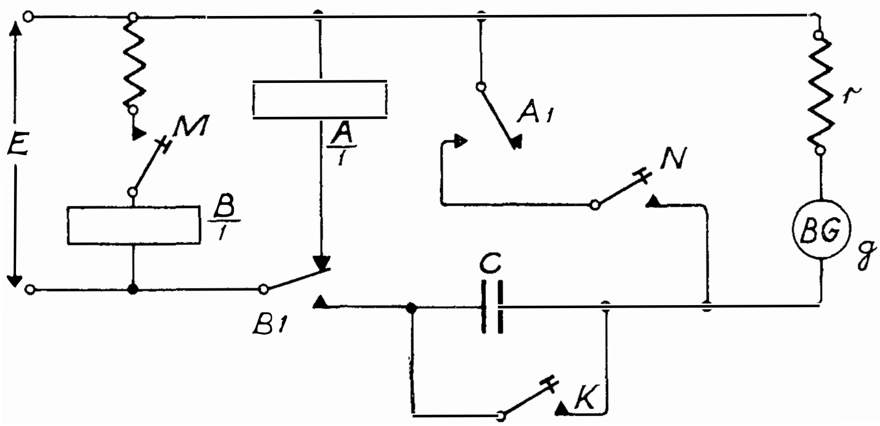


FIG. 2.

In the particular case of a relay possessing an operating period equal to CR seconds, the ballistic galvanometer gives a deflection

$$\theta_2 = 0.63 \times \theta_1$$

By using a variable resistance "r," this peculiarity can be made use of, for if by means of several measurements, the value of r can be adjusted such that

$$\theta_2 = 0.63\,\theta_1$$

Then $$t = C.r.$$

By this means the operating time can be obtained by direct reading.

F. I. RAY.

STRENGTH OF FLOORS IN TELEPHONE EXCHANGES.

By Capt. H. Hill, B.Sc., M.I.E.E.

In buildings specially erected for Telephone Exchange purposes, the floors of rooms planned for equipment are now usually of filler joist construction. Concrete slabs reinforced with rods or mesh are not used because of difficulty in cutting cable holes without unduly weakening the strength of the slab. Should the time ever arrive when the exact location of the cable holes can be determined before the floors are constructed this difficulty would not arise.

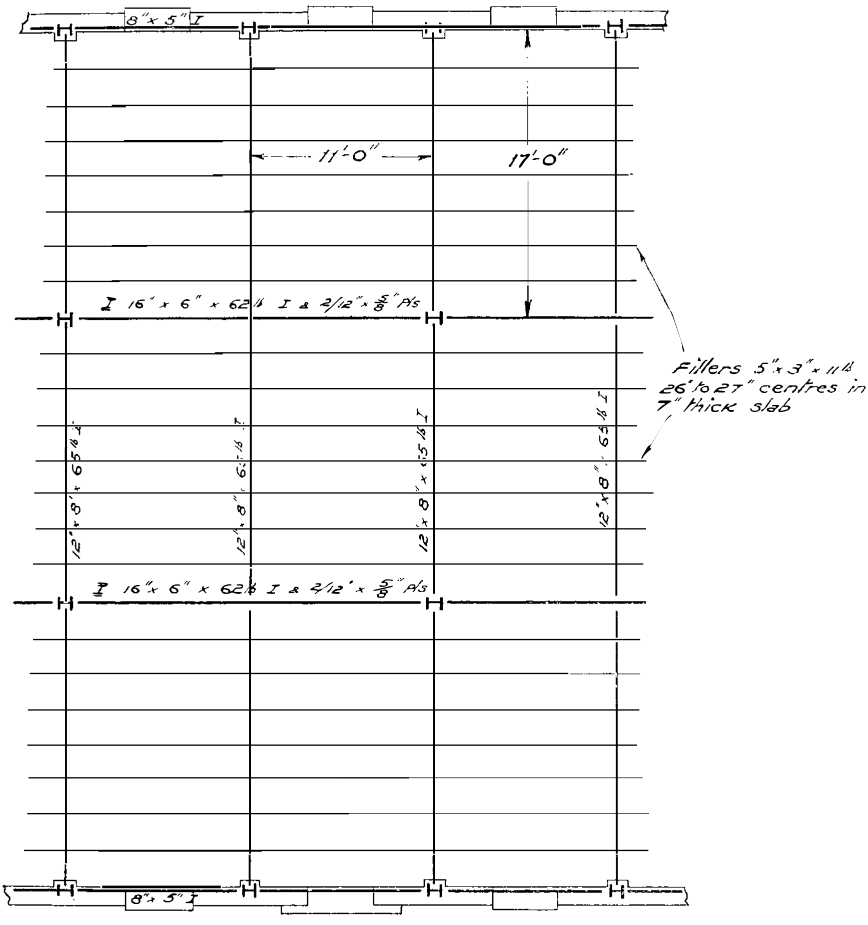


Fig. 1.

A plan of the steel work in a portion of a typical floor of filler joist construction is given in Fig. 1.

The method adopted to express clearly and simply the strength of any floor is to state that it is capable of carrying a certain uniformly distributed load per square foot. A floor having been designed to carry such a load, the question often arises as to the extent to which loads which are not uniformly distributed can be applied to the floor without overstressing it.

For example, let us suppose that in a room of 300 square feet area, with the floor designed to carry 150 lbs. per square foot, it be proposed to instal apparatus racks weighing in all 14,000 lbs., and that this load be applied to the floor through 12 footings having a total floor bearing surface of about 350 square ins.

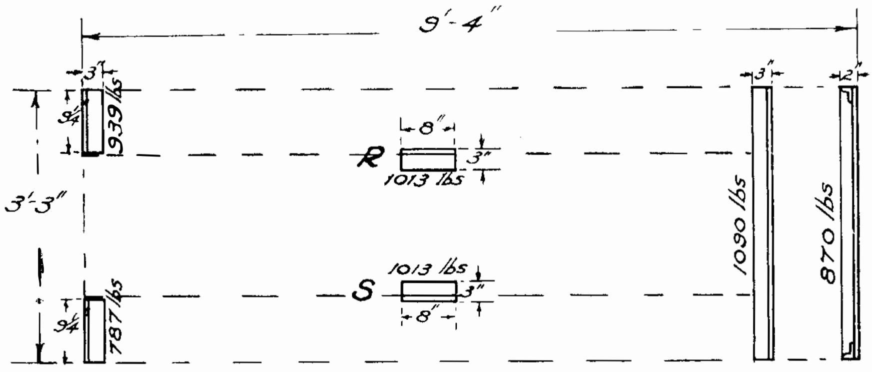


FIG. 2.

The average load on the floor is only $\frac{14000}{300}$ = 46 2/3lbs. per square foot, but it by no means follows that the floor will be strong enough owing to the fact that the manner of application of the load may cause greater stresses in some of the steel than would a load of 150 lbs. per square foot uniformly distributed. The concentrated load on the floor immediately beneath the footings is at the rate of $\frac{14000}{350} \times \frac{144}{1}$ = 576 lbs. per square foot. A floor designed for a uniformly distributed load of 150 lbs. per square foot might quite safely carry such concentrated loads provided the footings are large enough to keep the shearing stresses in the floor within safe limits. With all footings designed for apparatus racks and with the loads which they carry, it may be taken for granted that as the loading increases, a floor will first become overstressed due to the deflection of the steel while the shearing stresses are still within safe limits. It follows, therefore, that concentrated loads in the particular problem under review need only be considered in relation to the bending moments which they produce in the steel. It will now be gathered that neither the average loading, 46 2/3lbs. per square foot in the example above, nor the degree of concentration, 576 lbs. per square foot, is much guide in itself in determining whether a floor will be strong enough to carry apparatus.

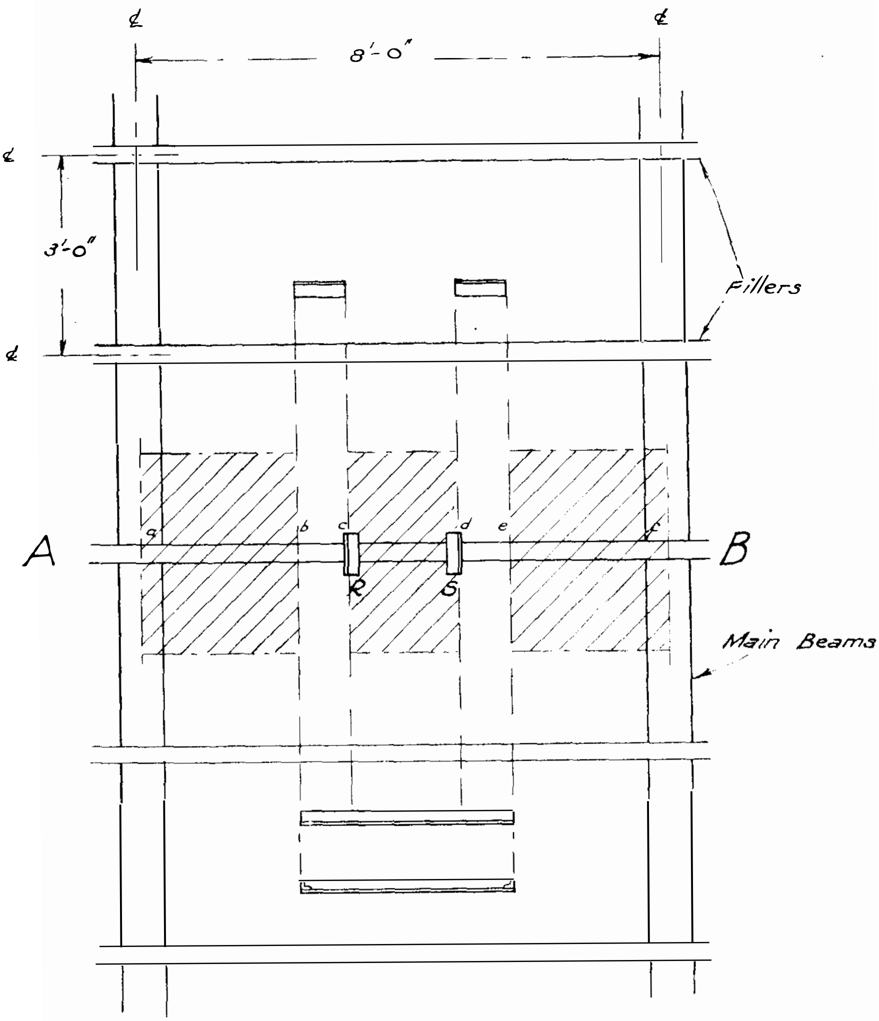


FIG. 3.

An example showing the method of determining the strength of floor necessary to carry apparatus racks may serve in clarifying ideas on the subject. A typical selector rack in an automatic exchange will be taken for illustration. Fig. 2 shows the floor bearing surfaces and the loads transmitted to the floor by the footings of the rack supplied by one particular contractor.

In the design of the rack it is provided that the load taken by each rack footing is well distributed over its bearing surface and that the area is sufficient to keep the shearing stresses in the floor within safe limits.

It would be impracticable to place automatic apparatus racks in any standard position relative to the steel in the floor and the floor must therefore be designed to carry the racks on the assumption that they may be placed in the position which imposes greatest stresses. In the case of the Selector Board a study of the stresses caused by various arrangements shows that the worst position is that in which loads R and S (Fig. **2**) lie directly over and symmetrical about the centre of a filler joist, as shown in Fig. **3**.

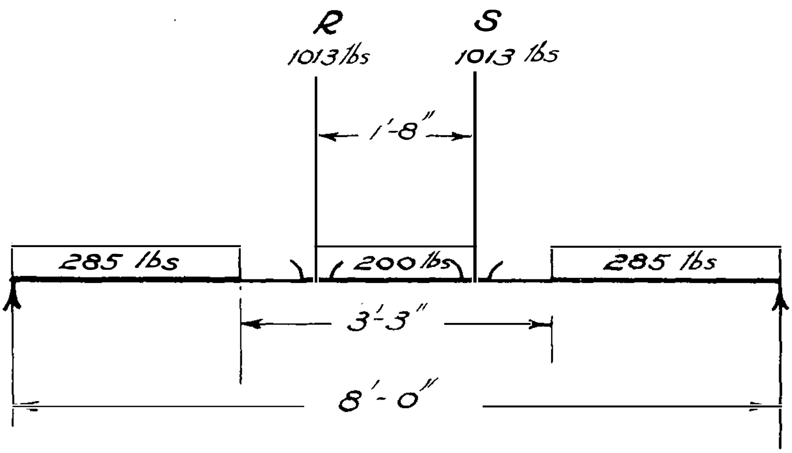


FIG. **4**.

As our problem is to find the equivalent uniformly distributed load it will be clear that the length of the filler joists and their distance apart will affect the result. If therefore we wish the result to cover all possible conditions we must again choose the worst case and in the following calculations it is assumed that this will be given by 8 feet fillers at 3 feet centres. The filler carrying the heaviest load will be AB in Fig. **3**, and its load will consist of the concentrated loads R and S and the proper proportion of the gangway loading between *a* and *b*, *c* and *d*, *e* and *f*, shown cross hatched. The filler is therefore loaded as shown in Fig. **4**. The two concentrated loads are due to the weight applied through the rack footings and the distributed loads to the allowance for gangway loading, which is taken as 40 lbs. per square foot.

The Maximum Bending Moment on the filler works out to 3910 ft. lbs. approximately.

The equivalent uniformly distributed load "ω" per foot run is given by

$$\frac{\omega l^2}{8} = 3910$$

$$\omega = \frac{3910 \times 8}{8^2} = 489 \text{ lbs.}$$

As the fillers are spaced 3 feet apart this reduces to $\frac{489}{3} = 163$ lbs. per square foot, which gives the uniformly distributed superimposed load per square foot for which a floor would have to be designed to provide for the possibility of placing selector boards in any position.

Similar consideration must be given to all other racks liable to be used in an automatic exchange and suitable additions made for cable runs before a standard strength can be determined.

The object of this article is simply to illustrate the relation between weights of equipment and floor strengths, and certain assumptions have been made which are not strictly accurate but serve the purpose in view.

A TELEPHONE REPEATER WITH REMOTE CONTROL.

By A. C. Timmis, B.Sc., A.M.I.E.E., and
H. G. Davis, A.C.G.I., B.Sc., D.I.C.

As a general rule, in this country at least, there are no circumstances which would prevent the control of a repeater at the point of its insertion in a circuit. The peculiar conditions necessitating the operation of a repeater from a distance were found in an attempt to improve speech transmission between the Orkney Islands and the North of Scotland.

Three submarine telegraph cables traverse the Pentland Firth, connecting Kirkwall with Dunnet Head on the Scottish Coast. A first experimental attempt was made to get telephonic communication established over the shortest of these lines, comprising 18.28 nauts of 107/150 cable having a resistance of 183 ohms. The attempt was so far successful as to provide reasonably good speech between Kirkwall and Thurso, and between Kirkwall and Wick. For communication to places beyond Wick, however, the circuit was not considered satisfactory. The Dunnet Head—Thurso and Thurso—Wick circuits were made up of open lines, partly 150 lbs. bronze and partly 150 lbs. copper, together with various short lengths of 10-lbs. underground cable. In order to improve the uniformity of the circuit and make it more suitable for the introduction of a repeater, several short lengths of underground cable were cut out. It was also found that, with a suitable transfer at Croxter Junction Pole, the Wick—Thurso circuit could be made 150 lbs. copper throughout and similarly the Thurso—Dunnet Head circuit 150 lbs. bronze throughout, thus considerably improving the uniformity. As regards the position of the repeater to be inserted, it was immediately obvious that the best position from the transmission standpoint was at Dunnet Head, where there is only a cable hut. The transmission equivalent of the submarine cable was about 12 S.M., and the equivalents of the open lines

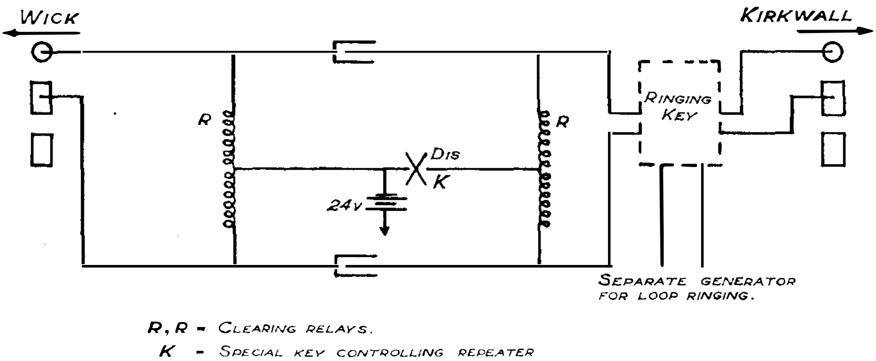


FIG. 1.—MODIFIED CORD CIRCUIT, THURSO.

4 S.M. and 5 S.M. respectively. No repeater being considered between Dunnet Head—Thurso and Thurso—Wick were about necessary for Thurso—Kirkwall calls, it remained to be arranged for the Dunnet Head repeater to be brought into circuit by the Thurso Exchange operator when Kirkwall was connected to Wick or places beyond. The method of doing this will be understood on reference to the diagrams, of which Fig. 1 shows the modification in the Thurso operator's cord circuit and Fig. 2 the arrangements at the repeater itself. Referring to Fig. 2, which shows the circuit as connected for Thurso—Kirkwall calls with the repeater inoperative, the valve filaments are connected in series with the contacts of a Relay 7A which, when operated, switches on the valves and also operates two Relays 7D, thereby bringing the repeater into circuit. Relay 7A is connected between the midpoint of the line transformer winding and earth, so that the application of $-24v$ to line will operate the relay and switch the repeater into circuit. This operating voltage is automatically applied to line from the battery in the ordinary C.B.S. cord circuit (Fig. 1)

when the Thurso operator puts Kirkwall through to Wick or places beyond. In the normal case, for Thurso—Kirkwall calls, a special cord circuit is used, having the battery feed disconnected as shown in Fig. 1.

The apparatus installed at the Dunnet Head cable hut consists of two Repeaters No. 3A associated with two Potentiometers 1A and the relays already mentioned. The line and balance transformers on the land line side are of type 16A, while on the submarine cable side two special transformers were wound with a step-down turns ratio from repeater to cable of 2.5 : 1. These transformers were made as nearly alike as possible but without gaps in the cores, such as are used in Transformers No. 16. There is little danger of change in the core of the cable transformer by ringing currents, and earth currents are eliminated by a 4 μf con-

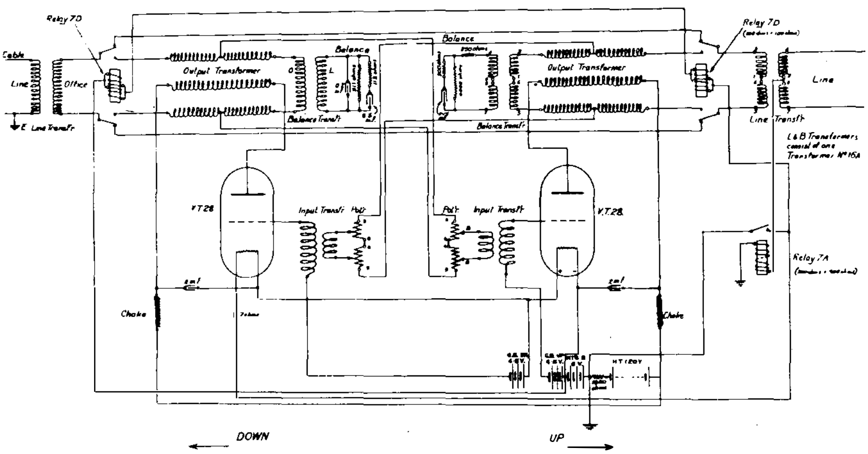


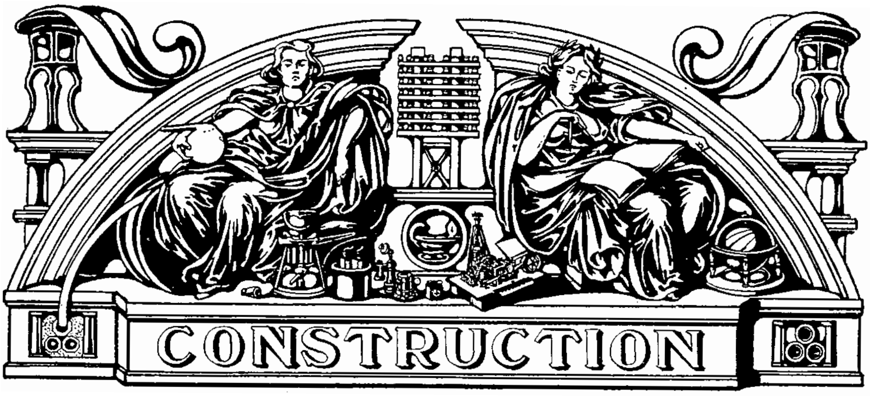
FIG. 2.—TWO-WIRE REPEATER WITH REMOTE CONTROL.

denser in series at the Kirkwall end of the cable. The balances are modifications of the type usually employed for unloaded lines. Under the special conditions of isolation obtaining, it was obviously necessary to depart from the usual practice as regards the valves used, and the repeaters were fitted with dull emitter valves (V.T. 28), operating on a voltage of 2.8 with filament current 60 *mA*. These valves have an amplification factor of about 6 and an anode impedance of about 20,000 ohms. Dry cells supply the anode voltage. A portable battery of three "Exide" DFG cells was supplied for the filament heating and relay current, these cells giving a satisfactory output under conditions of slow, intermittent discharge, and requiring little or no maintenance attention. This type of battery has given good results so far, removals for charging being necessary only about once in six weeks. The cable hut is, as might be expected, very damp, and the repeater with its relays, etc., was enclosed in a special box with quicklime as a drying agent, and well sealed with paraffin wax.

The only other modification of the apparatus previously used has been the provision of a special generator at Thurso, fitted for loop ringing only, to be used for ringing Kirkwall. This obviates the operation of the repeater control relay at Dunnet Head when the ordinary earthed generator is used. Subscribers at Kirkwall, a C.B.S. exchange, cannot operate the relay in clearing their calls, nor can Wick subscribers, as their magneto generators are fitted for loop ringing only.

The apparatus as installed has given satisfactory results, improvements of the order of 10 S.M. being regularly obtained. Very good volume from Kirkwall to Aberdeen has been obtained and, by the use of a cord circuit repeater at Inverness, Stromness in the Orkneys can get through to Edinburgh with good results. The introduction of the repeater has opened up new possibilities of communication to the Orkney Islanders, and the improved transmission is already widely known and appreciated.

The repeater was made up in the Research Laboratories, and the necessary line impedance measurements, etc., were made by Mr. R. B. Rae, Scot. E. District, whose co-operation contributed largely to the success of the undertaking.



THE ANGLO-BELGIAN (1926) CONTINUOUSLY-LOADED TELEPHONE CABLE.

By W. T. Palmer, Wh.Ex., B.Sc. (Hons.).

" There is no sound, no echo of sound, in the deserts of the deep;

. . . .

Hush! Men talk to-day o'er the waste of the ultimate slime,
And a new Word runs between: whispering 'Let us be one.' "

Just before dawn on the morning of July 30th, 1926, the connection of the largest telephone link between England and the Continent was completed in the grey waters of the North Sea by the cable ship " Faraday." This link—the Anglo-Belgian (1926) continuously-loaded, paper-core, submarine telephone cable—was manufactured at Woolwich by Messrs. Siemens Bros. & Co., Ltd., to whom the task of laying was entrusted.

The total length of cable manufactured consisted of five 10-naut lengths and one spare 5-naut length, which were joined together in the works to form two main portions for the purpose of laying—20 nauts being laid from La Panne (Belgium) and 35 nauts laid from Dumpton Gap (England)—approximately 6$\frac{1}{2}$ nauts being cut out and a joint made at sea. A cross-sectional view of the cable with the colour scheme is shown in Fig. 1. There are seven quads (28 conductors) making a total of 21 circuits—2 side circuits and 1 phantom for each quad. The constituent conductors are solid copper of 0.08 inch diameter. Each conductor is wound with a layer of 0.008-inch diameter special iron wire to increase its inductance, and insulated by four layers of paper. The cable core is surrounded by two seamless lead-coverings with a compound filling between. Over these two layers of bitumized paper, served with tarred jute, form a bedding for the armouring of 26 galvanised iron wires each 0.232 inch diameter. Above this lies a double layer of jute and compound coating. The total diameter of the cable is 2.58 inches and its weight $26\frac{1}{2}$ tons per naut. The length after laying was 48.40 nauts.

Owing to unfavourable conditions when the shore end of the cable was landed at La Panne, the end had to be left 240 yards from the hut. Until an extra length of 240 yards of cable was shipped from England and connected through a sea-joint on the beach to the cable hut, the necessary tests in co-operation with the cable ship were conducted from two bathing machines in which the cable end and apparatus were sheltered. See accompanying photographs. From these improvised testing places cross-talk measurements were taken on all quads, during the making of the joint at sea,

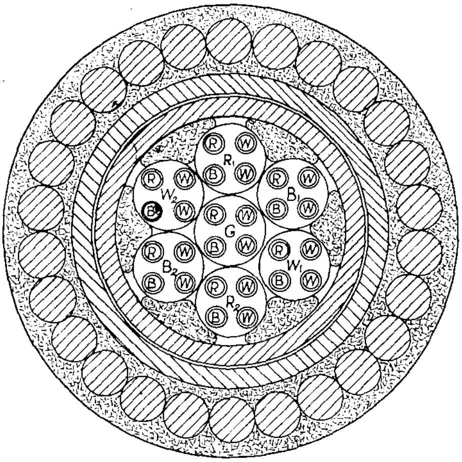


FIG. 1.—CROSS SECTION OF CABLE, FULL SIZE.
R_1 B_1 W_1 DISTINGUISHED BY ORANGE PAPER PACKING PIECES BETWEEN THEM.

by the aid of a switch on the "Faraday," which enabled, if necessary, the wires in a pair or the pairs themselves to be crossed for the purpose of reducing the cross-talk. The results of these tests not only showed that considerable reduction in the readings of the cross-talk meter could be obtained, in some cases, by a selection at this sea-joint, but also emphasised the liability to split pairs owing to the presence of two white cores in the same quad (Fig. 1).

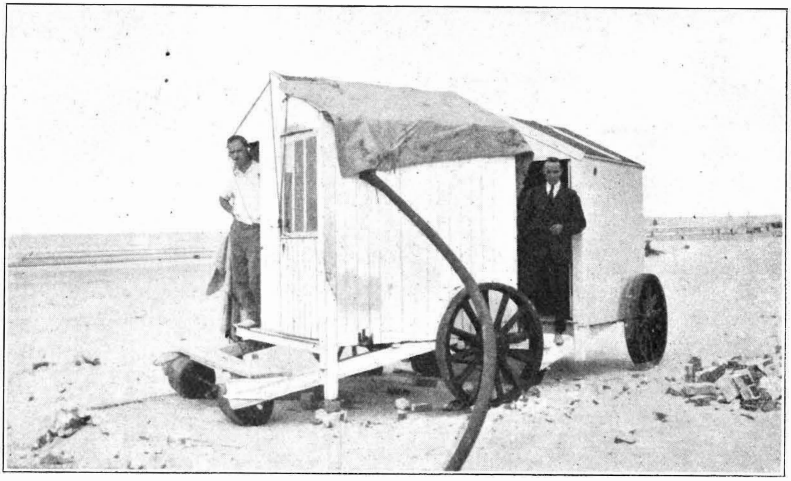
To facilitate the manipulation of the cores during work at sea on cables of this type and to get the best results, even where distinctive colours for each core in the quad may be used, the importance of a rigid programme, agreed upon by all those actually taking part in the tests, cannot be too greatly emphasised, and once drawn up *only unavoidable circumstances should interfere with this programme.*

From tests made on the cable after it was joined through to the hut at La Panne, the following results are taken :—

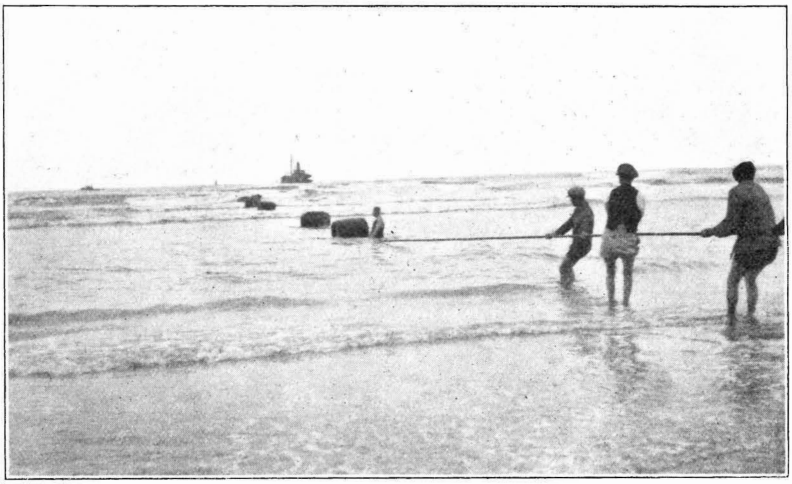
Direct Current Tests.

a. Mean conductor resistance of the 28 cores = 9.89 ohms per naut.

b. Mean insulation resistance, measured with 170 volts, between each core and all the other cores earthed and after 1 min. electrification = 32,000 megohms per naut.



Bathing Machines used as Test Hut. Dr. Rosen in shirt sleeves.



Floating in Shore End at La Panne.

FINAL PULL AT LA PANNE. LADIES NOT INTERESTED.

ALTERNATING CURRENT TESTS.

a. Transmission Efficiency and Distortion. Each circuit was measured for its attenuation constant and characteristic impedance from both ends with a testing current of 1 *m.a.* at a frequency corresponding to an angular velocity of 5,000 radians per second. The mean results are shown in Table I.

TABLE I.

ATTENUATION CONSTANT AND CHARACTERISTIC IMPEDANCE AT $\omega = 5000$ RADS./SEC. FOR LENGTH OF CABLE = 48.40 NAUTS. MEAN OF TESTS FROM EACH END.

Circuit.	Attenuation Constant per Naut. Loop $\equiv \beta$		Characteristic Impedance in Vector Ohms $\equiv Z_0 \angle \phi_0$	
	From La Panne.	From Dumpton Gap.	From La Panne.	From Dumpton Gap.
Average of the 12 pairs in the outer quads	.0275	.0276	$395 \angle 9^\circ 2'$	$388 \angle 9^\circ 0'$
Average of the 6 outer phantom circuits	.0331	.0332	$161.5 \angle 9^\circ 47'$	$158 \angle 9^\circ 18'$
Average of the 2 pairs of the centre quad	$.0273_5$	.0274	$391.5 \angle 9^\circ 0'$	$388 \angle 8^\circ 15'$
Phantom circuit of centre quad	.0332	.0332	$160 \angle 9^\circ 48'$	$158 \angle 8^\circ 32'$

From Table I. the side circuits of the cable are found to be approximately equivalent to 12.5 M.S.C. and the phantom circuits to 15.1 M.S.C.

The variation of the attenuation constant with frequency for a selected pair and phantom is shown in Fig. **2**. From the curves in this figure it can be shown that the mean distortion for the side and phantom circuits between $\omega = 2{,}000$ and $\omega = 12{,}500$ rads. per sec. is equivalent to a βl of approximately 0.322 or an equivalent distortion of nearly 3 M.S.C. in either case.

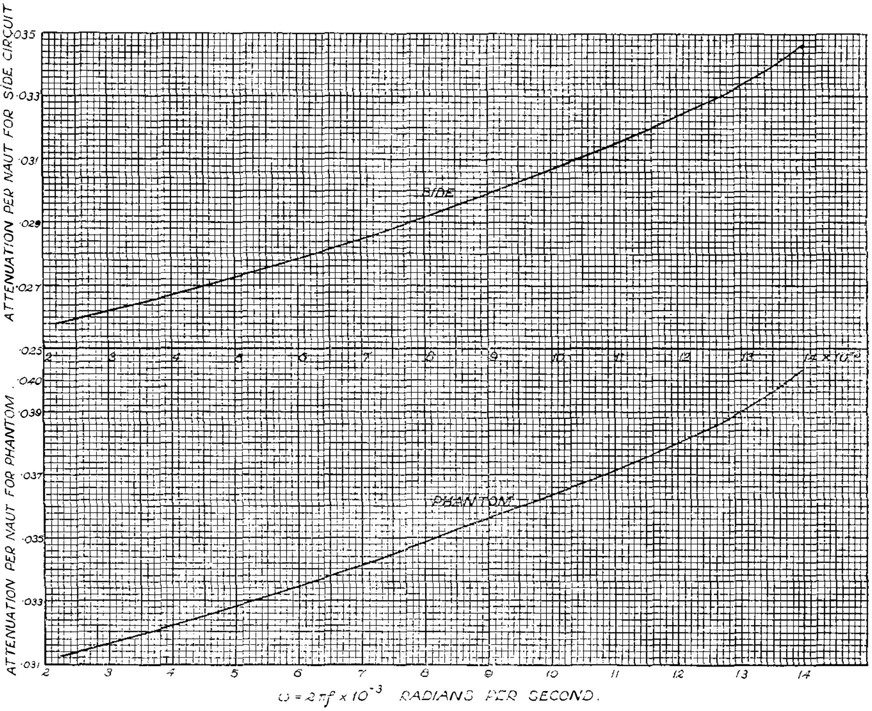


FIG. 2.—MEAN ATTENUATION-FREQUENCY CHARACTERISTICS FOR SIDE AND PHANTOM CIRCUITS OF THE ANGLO-BELGIAN (1926) SUBMARINE TELEPHONE CABLE.

The arrangement of the apparatus used to obtain the curves in Fig. **2** is given in Fig. **3** (see article by H. F. Mayer in " Elektrische Nachrichten-Technik," Vol. 3, No. 4, for April, 1926). This is a much simpler and quicker method than the " open and closed impedance " method, and check tests made by the latter agreed exactly with the results of the former. In Fig. **3** silence was obtained in the telephone by adjusting the frequency f and the resistance r. Then the following relation holds if the line is electrically long :—

$$e^{\beta l} = \frac{V_1}{V_2} = \frac{r + 2R}{r/_2}$$

where V_1 = voltage at sending end of cable.
V_2 = voltage at receiving end of cable.
β = attenuation constant per naut loop.
l = total length of circuit in nauts.

Hence $\beta = \frac{1}{l}\log_e\frac{2(r+2R)}{r}$

By reversing the connections on one pair intermediate values of ω can be obtained and assuming

$$\alpha \fallingdotseq 2\pi f\sqrt{CL} \fallingdotseq \omega\sqrt{CL}$$

where α = wave-length constant per naut loop.
C = capacity of cable, in farads, per naut loop.
L = inductance of cable, in henries, per naut loop.

We have the intervals ω_1 between the values of ω, for which silence is obtained in the telephone, given by

$$\omega_1 \fallingdotseq \frac{\pi}{\sqrt{CL}} \times \frac{1}{\text{length of circuit in nauts.}}$$

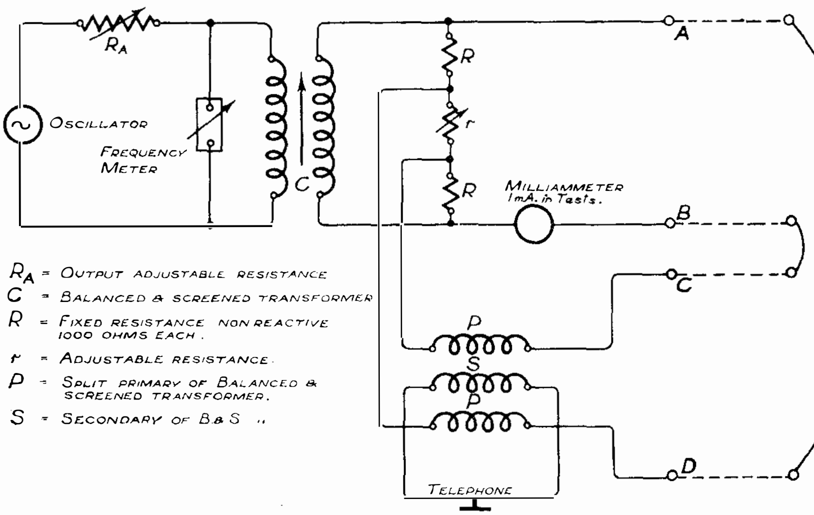


Fig. 3.

The advantages of this method are:—

(1) It can be used on lines too long for the application of the open and closed impedance method.

(2) The value of β is easily calculated and the required curve drawn whilst the test is in progress.

(3) The value of the frequency does not enter into the calculation for β and need not be known with extreme accuracy.

b. Uniformity of Electrical Constants. The uniformity of electrical constants—resistance, inductance, capacity and leakance—can be investigated by plotting the impedance-frequency curve of each circuit and noting how far this curve deviates from a smooth mean curve drawn through it. A sudden change in the value of one or more of the constants will result in reflection of the current and voltage waves at the change of impedance and, if the change be big enough, will cause the impedance-frequency curve to be undulated.

In the case of tests made on this type of cable the mean impedance-frequency curve of each circuit has, generally speaking, a "falling" characteristic, *i.e.*, one in which the impedance decreases with frequency. The explanation of this is considered in an Appendix, where it is shown that the characteristic imped-

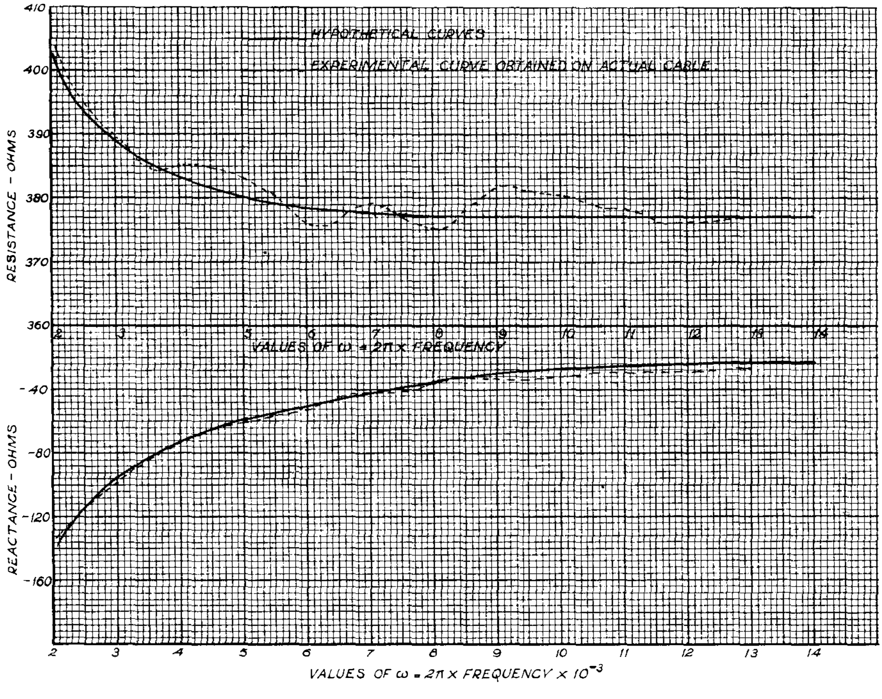


FIG. 4.—HYPOTHETICAL IMPEDANCE-FREQUENCY CHARACTERISTICS FOR SIDE CIRCUITS OF ANGLO-BELGIAN (1926) CABLE.

ance Z_0 of a hypothetical loaded cable having uniform constants throughout its length has a magnitude given by the formula:

$$Z_0^4 = \frac{M}{\omega^2} + N \quad \ldots\ldots\ldots\ldots (1)$$

where M and N are constants for the cable under consideration and $\omega = 2\pi \times$ frequency of testing current. From this expression it is evident that as ω increases, Z_0 decreases.

Further, the angle ϕ_0 of the vector impedance Z_0 is given very closely by the expression

$$\text{Tan } 2\phi_0 = -\frac{b}{\omega L} \quad \ldots\ldots\ldots\ldots (2)$$

where L and b are constants of the cable.

From equations (1) and (2) the resistance and reactance components have been caluculated for a hypothetical cable having the average constants of the side circuits of the Anglo-Belgian (1926) Cable, and are shown in Fig. **4**, together with similar curves obtained by measurement on the actual cable. It will be seen that the hypothetical curves form good means of the actual curves.

From tests made upon the separate 10-naut manufactured lengths it was known that the 20 nauts on the Belgian side of the sea-joint have a slightly higher average capacity than the length of cable on the English side of the joint. This discontinuity of

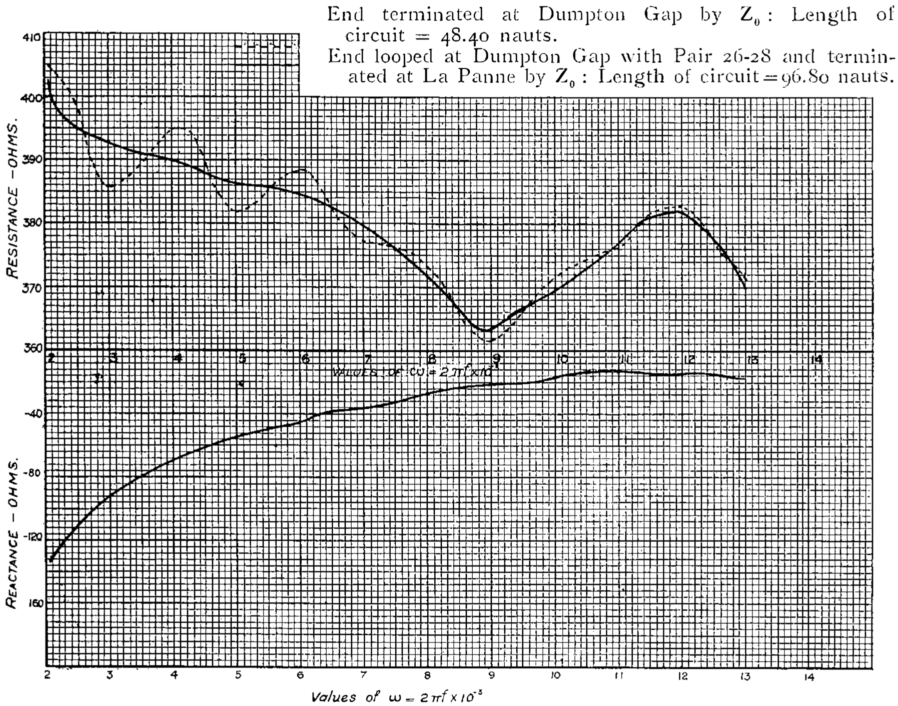


FIG. **5**.—IMPEDANCE-FREQUENCY CHARACTERISTICS OF PAIR 25-27 TAKEN FROM LA PANNE WITH TESTING CURRENT OF 1 M.A.

uniformity has affected the impedance-frequency characteristics of the circuits by producing an undulation which in some cases is ill-defined, but in others, especially from La Panne, is quite distinct. All the circuits were tested for impedance over a range of ω from 2,000 rads. per sec. to 13,000 rads. per sec., and as typical examples, Figs. **5**, **6**, **7** and **8** are given. Fig. **5** refers to the centre quad and the dotted curve shows the result of testing with pair 25-27 terminated at Dumpton Gap by a resistance adjusted to be equal to the real part of the characteristic impedance, and giving a circuit only 48.40 nauts in length—approximately

12.5 M.S.C. It will be seen that this dotted curve has "bumps" with a period of roughly $\omega = 2{,}000$ radians per second, which indicates reflection at about 48 nauts from La Panne,* *i.e.*, at Dumpton Gap, and is due to the absence from the termination of the reactive portion of the characteristic impedance—the ratio of the reactance to the resistance portion being of the order of 20% at the lower frequencies where the amplitudes of the "bumps" are greatest. The full curve was obtained by looping pair 25-27

FIG. 6.—IMPEDANCE-FREQUENCY CHARACTERISTICS TAKEN FROM LA PANNE ON PAIR 1-3 WITH A TESTING CURRENT OF 1 M.A.

to pair 26-28 at Dumpton Gap to give a circuit 96.80 nauts in length (approximately 25 M.S.C. and approaching the infinite line condition), whilst pair 26-28 was closed at La Panne through a resistance which was varied with the frequency to be equal to the real part of the characteristic impedance. It is interesting to note that the bigger undulation has roughly a period of $\omega = 5{,}000$ rads. per sec., which indicates reflection at a distance nearly 19 nauts from La Panne, *i.e.*, near the sea-joint, and it is in that region where the change of average cable capacity, already referred to, takes place.

Figs. **6** and **7** refer to tests on pair 1-3 looped to pair 2-4

* See Paper No. 76 of the I.P.O.E.E., by Robinson and Chamney, p. 112.

(circuits in an outer quad) taken from La Panne and Dumpton Gap.

Fig. **8** gives the resistance-components of the phantom circuits for the centre and one outer quad.

These curves are drawn to a large scale and in Figs. **6** and **7** the maximum deviation of each from a mean curve is less than ± 2%, whilst in no case did the variation exceed ± 5%, the figure guaranteed by the Makers.

c. Interference between Circuits. Cross-talk measurements were made on an equivalent current basis (1) with the P.O.

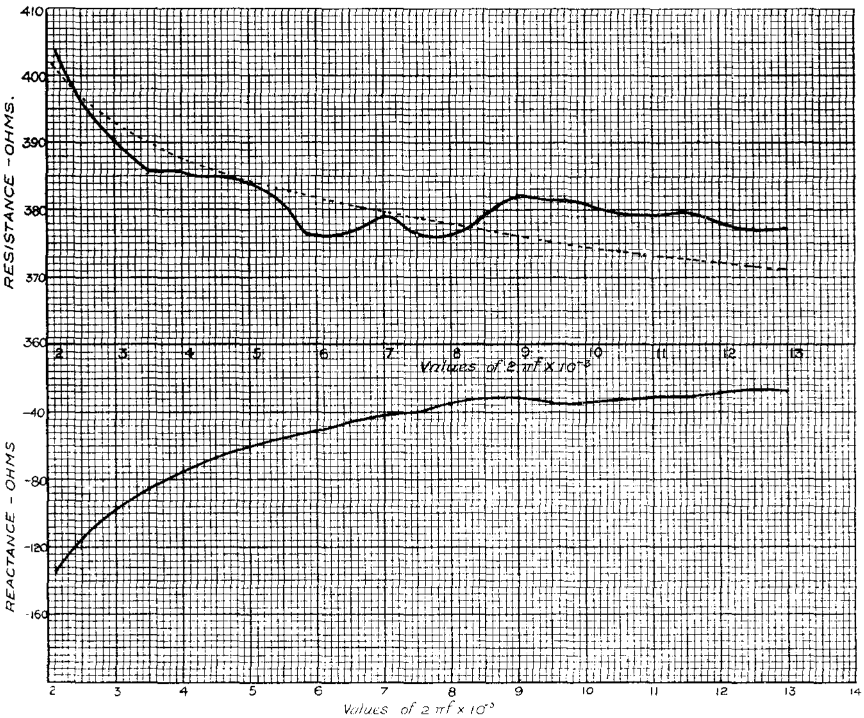


FIG. 7.—IMPEDANCE-FREQUENCY CHARACTERISTICS TAKEN FROM DUMPTON GAP ON PAIR 1-3 WITH A TESTING CURRENT OF 1 M.A.

apparatus using a Western Electric Cross-Talk Meter, which expresses the induced current in millionths of the inducing current, and (2) with the Siemens and Halske apparatus, which expresses the interference between circuits in βl-units. In both of these methods, if the true value of the interference be required, it is necessary to make allowance for the effect of the end apparatus and for the difference in impedance between the disturbed and the disturbing curcuits.

One of the chief objections to measuring interference with speech or reed hummer (largely counterbalanced by the celerity and simplicity of the method) is due to the fact that very often the observer has to judge equality between two sounds of different timbre. This difference may be so great that even experienced observers will record different results. To give examples of the difference the results of two such observers, X and Y, are given in Tables III. and IV.

(1) *Tests with P.O. Apparatus.* The cross-talk between circuits within each of the seven quads was measured, using speech as the source of disturbance—See Table II.—and also with a reed hummer for the disturbing source—See Table III.

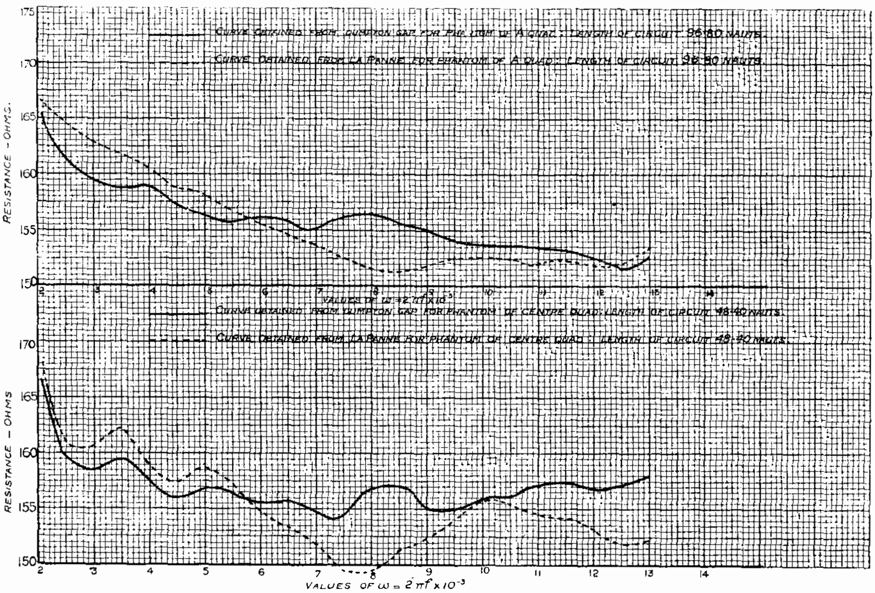


FIG. 8.—RESISTANCE COMPONENTS OF IMPEDANCE-FREQUENCY CURVES FOR PHANTOM CIRCUITS OF "A" QUAD AND G (CENTRE) QUAD, TAKEN FROM BOTH ENDS OF THE CABLE.

The results in Table II. are simply the meter readings, but in Table III. the actual readings have been corrected to allow for the effect of external apparatus and for difference in impedance between the disturbed and disturbing circuits* and then converted to βl-units.

The maximum cross-talk reading obtained between circuits in different quads with speech did not exceed 130 and in most cases the reading was less than 20.

* See Paper by A. Rosen, *Journal I.E.E.*, p. 840, Vol. 64, August, 1926.

(2) *Tests with Siemens and Halske Apparatus.* Cross-talk results obtained with this apparatus are measured directly in βl-units.

A reed hummer was used as the source of disturbance and Table IV. gives the results obtained for side to side and phantom to side cross-talk in each of the seven quads, corrected to allow for end apparatus and for different circuit impedances.

The corrected figures in Tables III. and IV. agree fairly well, and most of the existing differences are probably due to the difficulty mentioned above.

Table II.

CROSS-TALK WITHIN QUADS MEASURED WITH P.O. APPARATUS.

Meter readings taken with the distant end of the cable closed through repeating coils by its characteristic impedance. Meter in parallel.

RW_1 ≡ Red—White pair of the quad.
BW_2 ≡ Blue—White ,, ,, ,, ,,
+ ≡ Phantom circuit ,, ,, ,,

SOURCE OF DISTURBANCE—SPEECH.

Tests from La Panne (Hut).					*Tests from Dumpton Gap (Hut).**				
Speaking on :—		Listening on :—			Speaking on :—		Listening on :—		
Quad.	Cct.	RW_1	BW_2	+	Quad.	Cct.	RW_1	BW_2	+
G (Centre)	RW_1	—	100	700	G (Centre)	RW_1	—	200	550
	BW_2	100	—	600		BW_2	190	—	370
	+	800	900	—		+	800	430	—
A	RW_1	—	140	1000	A	RW_1	—	130	1200
	BW_2	140	—	800		BW_2	130	—	350
	+	1400	1000	—		+	1400	550	—
B	RW_1	—	170	1000	B	RW_1	—	300	600
	BW_2	170	—	600		BW_2	280	—	600
	+	1500	700	—		+	800	700	—
C	RW_1	—	100	700	C	RW_1	—	230	700
	BW_2	100	—	1000		BW_2	260	—	450
	+	1000	1400	—		+	900	600	—
D	RW_1	—	130	800	D	RW_1	—	140	480
	BW_2	130	—	800		BW_2	140	—	800
	+	1000	2000	—		+	700	1200	—
E	RW_1	—	130	500	E	RW_1	—	90	1100
	BW_2	130	—	600		BW_2	80	—	450
	+	700	800	—		+	1600	750	—
F	RW_1	—	130	800	F	RW_1	—	280	500
	BW_2	130	—	800		BW_2	280	—	400
	+	1000	1000	—		+	700	450	—

* During the laying operations, 500 yards were cut from the English end and this is probably the cause of the fact that the average side to side cross-talk figures from Dumpton Gap are higher than those taken either in the Works or at La Panne.

TABLE III.

CROSS-TALK WITHIN QUADS MEASURED WITH P.O. APPARATUS.
SOURCE OF DISTURBANCE—REED HUMMER.

Testing Conditions as in Table II.

Quad.	Red—White to Blue—White.				Phantom to Red—White Pair.				Phantom to Blue—White Pair.			
	Meter Reading.		Corrected βl-units.		Meter Reading.		Corrected βl-units.		Meter Reading.		Corrected βl-units.	
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
G	70	50	9.9	10.1	1200	1300	7.5	7.5	1400	1500	7.4	7.3
A	200	250	8.8	8.5	900	1200	7.8	7.5	1700	2000	7.2	7.0
B	150	200	9.0	8.5	1600	2000	7.2	7.0	1200	1200	7.5	7.5
C	100	100	9.4	9.4	1000	1400	7.7	7.4	1200	1600	7.5	7.2
D	120	100	9.3	9.4	800	800	7.9	7.9	2500	3000	6.8	6.6
E	130	130	9.2	9.2	1400	1400	7.7	7.7	1200	1100	7.5	7.6
F	130	160	9.2	9.0	2000	2500	7.0	6.8	2500	2500	6.8	6.8

TABLE IV.

CROSS-TALK WITHIN QUADS MEASURED WITH SIEMENS & HALSKE APPARATUS.

SOURCE OF DISTURBANCE—REED HUMMER.

Resistances Used at Sending End instead of Repeating Coils: P.O. Distant End Sets used.

Quad.	Red—White to Blue—White.				Phantom to Red—White Pair.				Phantom to Blue—White Pair.			
	Meter Reading.		Corrected βl-units.		Meter Reading.		Corrected βl-units.		Meter Reading.		Corrected βl-units.	
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
G	10.0	9.5	9.7	9.2	9.3	9.2	7.6	7.5	9.2	9.2	7.5	7.5
A	8.7	8.8	8.4	8.5	9.4	9.4	7.7	7.7	9.0	9.1	7.3	7.4
B	9.0	8.9	8.7	8.6	8.9	8.9	7.2	7.2	9.3	9.2	7.6	7.5
C	9.7	9.7	9.4	9.4	9.4	9.4	7.7	7.7	9.1	9.3	7.4	7.6
D	9.5	9.6	9.2	9.3	9.6	9.5	7.9	7.8	8.6	8.7	6.9	7.0
E	9.3	9.4	9.0	9.1	9.1	9.3	7.4	7.6	9.5	9.5	7.8	7.8
F	9.1	9.0	8.8	8.7	8.8	8.8	7.1	7.1	8.8	8.9	7.1	7.2

d. Magnetic Stability. A direct current of 100 milliamperes sent through one core in a quad produced an approximate increase of inductance of only 0.2%.

A repeater station is being constructed at La Panne in which this Anglo-Belgian cable will be terminated and from which will radiate continental land circuits, further repeatered, each many hundreds of miles in length. From Dumpton Gap the cable will be joined through to a repeater station at Canterbury by means of 18½ miles of land cable of similar construction to the sea length (except for the armouring) and having the same electrical characteristics. This land cable has been separately tested and found to be satisfactory, and further tests on the completed cable from Canterbury to La Panne will be made as soon as the jointing operations are completed at Dumpton Gap.

APPENDIX.

RELATION BETWEEN THE CHARACTERISTIC IMPEDANCE OF A CONTINUOUSLY-LOADED CABLE AND THE FREQUENCY OF TESTING CURRENT.

In the case of a hypothetical cable having perfectly uniform electrical constants throughout its length, the characteristic impedance, expressed in vector ohms, is given by the expression—

$$Z_0 \underline{|\phi_0} = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

where $\omega = 2\pi \times$ frequency of testing current.

R = resistance per unit length of circuit in ohms.

L = inductance ,, ,, ,, ,, ,, henries.

G = leakance ,, ,, ,, ,, ,, mhos.

C = capacity ,, ,, ,, ,, ,, farads.

Z_0 = the magnitude of the vector and is given numerically by

$$Z_0 = \sqrt[4]{\frac{R^2 + \omega^2 L^2}{G^2 + \omega^2 C^2}} \quad \text{.......(1)}$$

ϕ_0 = the angle of the vector and is found in magnitude and sign from

$$\operatorname{Tan} 2\phi_0 = \frac{\frac{\omega L}{R} - \frac{\omega C}{G}}{1 + \frac{\omega^2 LC}{GR}} \quad \text{.......(2)}$$

We can obtain Z_0 and ϕ_0 in terms of ω from equations (1) and (2) with sufficient accuracy by substituting for R, L, G and C the following expressions obtained by observation on continuously-loaded cables already manufactured:—

$$R = a\omega^2 + b$$

and $G = d\omega$ for values of ω throughout the audio-range and where a, b and d are constants for the particular cable under consideration.

L and C may be considered as constant within the audio-range of frequencies. Hence:—

$$Z_0 = \sqrt[4]{\frac{(a\omega^2 + b)^2 + \omega^2 L^2}{d^2\omega^2 + C^2\omega^2}}$$

$$\text{and } \therefore Z_0^4 = \frac{M}{\omega^2} + N + Q\,\omega^2 \quad \text{.......(3)}$$

where M, N and Q are constants; $M = \frac{b^2}{C^2 + d^2}$, $N = \frac{2ab + L^2}{C^2 + d^2}$ and $Q = \frac{a^2}{C^2 + d^2}$.

By differentiation of the right hand side of (3) with respect to ω it will be seen that the slope of the impedance-frequency curve will be negative for values of ω up to $\omega = \sqrt{\frac{M}{Q}}$. In practice, the value given by $\omega = \sqrt{M/Q}$ is always far beyond the upper limit of important speech frequencies and further, the value of $Q\omega^2$ in comparison with M/ω^2 may be neglected. *Hence we may say that in a continuously-loaded cable the value of the characteristic impedance decreases with increase of frequency very nearly according to the law*—

$$Z_0^{\,4} = \frac{M}{\omega^2} + N \quad \text{.....(4)}$$

Equation (2) can be written

$$\text{Tan}\, 2\phi_0 = \frac{\dfrac{\omega L d}{a\omega^2 + b} - C}{d + \dfrac{\omega LC}{a\omega^2 + b}} \quad \text{.....(5)}$$

Differentiating with respect to ω

$$\therefore \frac{d\,(\text{Tan}\, 2\phi_0)}{d\omega} = \frac{L\,(C^2 + d^2)\,(b - a\omega^2)}{(\text{denominator})^2}$$

This last expression is +ve if $b > a\omega^2$. In practice b is always much greater than $a\omega^2$ within the audio-range of ω, and therefore *the characteristic angle ϕ_0 (as given by equation 5) increases in a +ve direction as ω increases.*

As a further close approximation for the angle ϕ_0 the terms containing d and a in equation (5) may be neglected, giving

$$\text{Tan}\, 2\phi_0 \fallingdotseq -\frac{b}{\omega L} \quad \text{.....(6)}$$

From (6) for small values of ϕ_0 we have

$$\phi_0 \propto \frac{1}{\omega} \text{ approximately.}$$

Example:—Using equations (4) and (6) the hypothetical resistance and reactance components ($Z_0 \cos \phi_0$ and $Z_0 \sin \phi_0$ respectively) for the chracteristic impedance of the side circuits of the Anglo-Belgian (1926) Submarine Telephone Cable have been calculated and are given in the Table below. They are shown plotted in Fig. **4** together with similar curves obtained by measurement on the actual cable. The values of the constants for this cable are as follows :—

$$a = 0.025 \times 10^{-6}$$
$$b = 20.2$$
$$C = 0.089 \times 10^{-6}$$
$$d = 4.0 \times 10^{-10}$$
$$L = 12.7 \times 10^{-3}$$

From which we have

$$M = 5.151 \times 10^{16}$$
$$N = 2.002 \times 10^{10}$$
$$Q = 0.05051$$

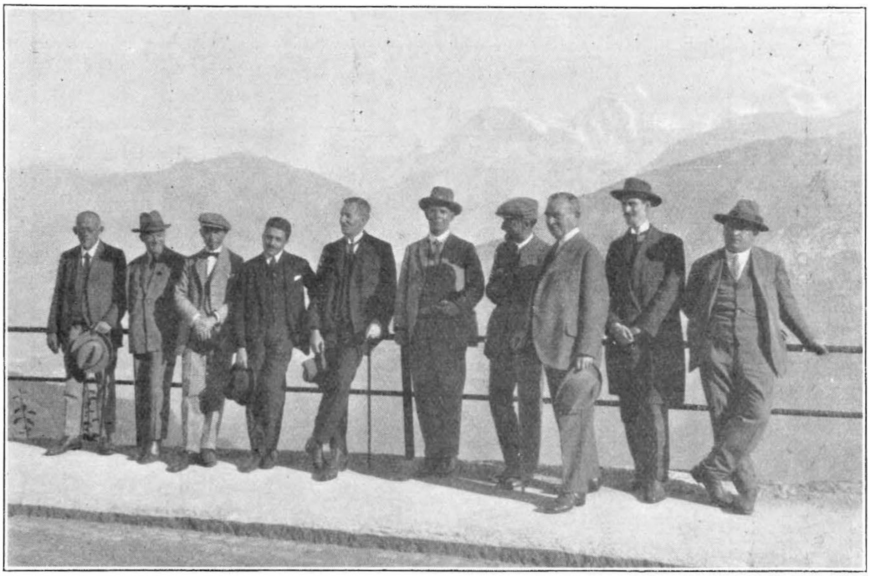
TABLE SHOWING HYPOTHETICAL IMPEDANCE COMPONENTS FOR ANGLO-BELGIAN (1926) SIDE-CIRCUITS.

ω	2000	3000	4000	5000	6000	8000	10000	12000	14000
Z_0	426	401	391	386	383	380	378	378	377
ϕ_0	$-19^\circ\ 15'$	$-13^\circ\ 58'$	$-10^\circ\ 52'$	$-8^\circ\ 50'$	$-7^\circ\ 26'$	$-5^\circ\ 37'$	$-4^\circ\ 31'$	$-3^\circ\ 47'$	$-3^\circ\ 15'$
R_0	402	389	384	381	379	378	377	377	377
X_0	−140	−96	−73	−59	−49	−37	−30	−25	−22

CORROSION OF LEAD-COVERED CABLES BY ELECTROLYTIC AND CHEMICAL ACTION.

A SUB-COMMITTEE or the Comité Consultatif International des Communications Téléphoniques à Grande Distance (the C.C.I.) met at Berne, Switzerland, on the 13th September, 1926, to prepare reports on the above subjects for presentation to the plenary meeting of the full Committee held in Paris on 29th November, 1926. The Sub-Committee consisted of Engineers from the Telephone Administrations of France (3), Germany (2), Switzerland (3), and Great Britain (1), the Chairman being Dr. Bresig, Germany. The Committee also had the assistance of M. Bourquin, an engineer attached to the Swiss Permanent Commission on Corrosion, a body concerned solely with the prevention and mitigation of the effects of electrolytic action by stray current from electrical systems. This Commission is composed of representatives from the Swiss Society of Gas and Water Industries, the Swiss Union of Secondary Railways, the Swiss Association of Electricians, and the Swiss Direction General of Telegraphs. Agreed regulations of a comprehensive character have been drawn up by the Commission and special investigations are carried out as required by its engineers.

The Sub-Committee was very fully engaged for 6 days thrashing out the subjects and preparing the reports, but had a little relaxation one afternoon when, as the guests of the Swiss Telegraph Administration, they were taken for a motor trip to Beatenberg, above Lake Thun. The group photograph on this page was



Left to right:—M. Trechsel (Switzerland), M. Bourquin (Switzerland), Dr. Jaeger (Germany), M. Valensi (Secretaire-General C.C.I.), M. Muri (Switzerland), M. Bartholomew (Great Britain), M. Milon (France), Dr. Breisig (Germany), M. Collet (France), Dr. Forrer (Switzerland).

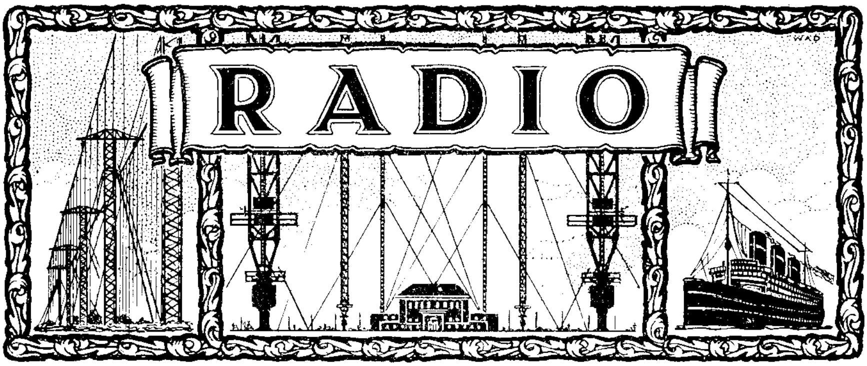
taken at Beatenberg and shows the members of the Sub-Committee with the Eiger, Monch and Jungfrau in the background. The trip was most enjoyable, the weather being perfect and the arrangements made by the Swiss hosts for the comfort of their guests were most excellent.

Mr. S. C. Bartholomew, the representative of the British Post Office, unfortunately met with an accident on the day he was returning to London, when, owing to the sudden stopping of a train, he was thrown along the corridor and broke several ribs.

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 20TH SEPTEMBER, 1926.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District.	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
504,809	568	4,181	53,901	444	London	23,780	58,430	1,747,012	69,061
61,502	1,881	21,450	60,247	1,785	S. East	3,827	39,424	130,703	16,271
66,211	4,496	27,752	48,572	2,183	S. West	15,114	7,298	111,704	55,937
48,487	8,391	32,764	45,233	3,254	Eastern	13,872	29,043	74,839	65,676
84,688	8,635	42,097	53,793	3,868	N. Mid.	22,658	41,544	176,299	124,076
63,566	4,872	28,346	61,843	3,771	S. Mid.	12,554	18,264	124,748	84,845
54.184	4,851	29,085	47,451	2,158	S. Wales	5,522	21,198	94,596	69,615
88,294	8,277	24,885	45,812	4,983	N. Wales	12,596	36,876	191,905	55,971
139,359	1,585	17,165	42,481	2,821	S. Lancs.	12,662	74,448	407,613	43,366
82,148	6,053	30,865	43,302	2,963	N. East	10,158	37,985	188,199	43,329
56,047	3,645	24,178	35,443	1,745	N. West	8,586	31,376	130,584	37,180
42,013	2,312	15,728	23,386	2,480	North	4,493	10,106	81 848	55,348
19,292	4,811	6,427	12,573	278	Ireland N.	142	251	35,562	712
58,182	5,356	23,525	34,672	1,269	Scot. East	2,673	8,971	114,806	50,944
78,346	7,436	23,806	40,834	812	Scot. West	12,258	22,543	200,253	33,407
1,447,128	73,169	352,254	649,543	34,814	Totals.	160,895	437,757	3,810,671	805,738
1,424,786	73,131	349,769	645,430	36,056	Figures on 30th June, 1926.	157,729	419,852	3,654,998	725,002



THE RUGBY RADIO STATION.

By E. H. Shaughnessy, O.B.E., M.I.E.E.

The Rugby Radio Station of the British Post Office is situated at Hillmorton, about 4 miles south east of Rugby, and occupies a site about 1½ miles long by 1 mile wide. The station buildings are erected at about the middle of the site (see Figs. **1** and **2**).

Power Supply.

The relative advantages of either installing prime movers or purchasing a bulk supply of power were investigated, with the result that it was decided to obtain a bulk supply from the Leicestershire and Warwickshire Electric Power Co. The incoming supply is three-phase, 50 cycle, alternating current, having an earthed neutral and 12,000 volts between phases. Duplicate Underground Mains are provided between the Company's sub-station at Rugby and the Radio Station. The decision to use water-cooled three-electrode valves rendered it necessary to change the incoming alternating current supply into a high tension direct current supply of the order of 10,000 volts and, after considering the merits of mercury-arc rectifiers, thermionic valve rectifiers and motor generators for this purpose, it was decided to instal the latter. The main machinery hall, Fig. **3**, is 185 feet long by 47 feet wide, spanned by an 11-ton overhead travelling crane. The height of the room is 32 feet. Parallel with this main hall is an annex, the lower portion of which contains a battery room and six transformer rooms; the upper floor is a switch gallery open to the main machinery hall. This gallery contains the high and low tension A.C. switchboards, high tension A.C. starting cubicles for the main motor generators, and the low tension D.C. switchboard.

In the machinery hall are three main motor-generator sets for providing high tension direct current to the valves, two frequency converter motor-generators for heating valve filaments, together with motor starting cubicles and alternator control panels, and also two motor-generator and booster sets for battery charging and low tension D.C. supply. All power, other than that required for the main motor-generators, is supplied by two auxiliary step-down transformers (12000/416 volt) of 450 KVA output through the main low tension A.C. switchboard.

The extra high tension A.C. switchboard is a 6-panel board, consisting of 5 truck cubicles and a Company's metering cubicle.

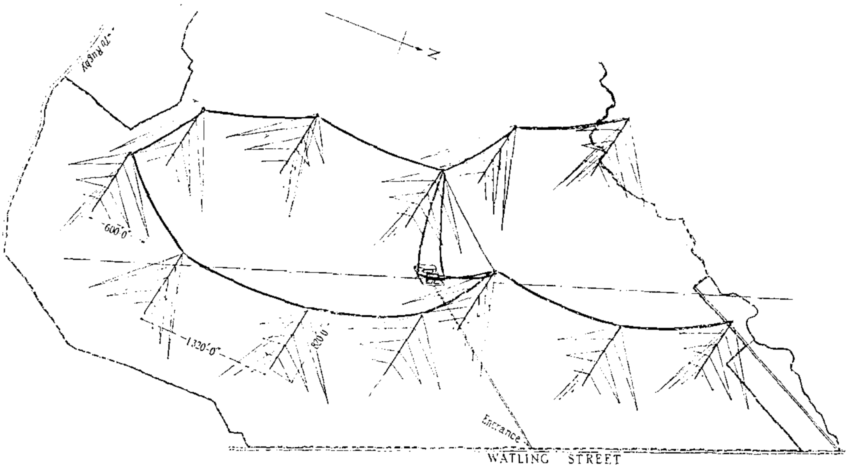


Fig. 1.—Isometric View of Station.

One panel is used for the Department's metering; two panels are connected to the auxiliary 450 KVA transformers situated immediately below the switchboard; the fourth panel of 2,000 k.w. capacity controls the supply to the main motor-generator starting cubicles and one is spare and interchangeable with the others. The low tension A.C. 416 volt switchboard is of the normal slate pattern, containing 16 panels. The requirements of the high frequency valve generator equipment called for the supply of direct current power of from 1,000 k.w. to 1,500 k.w. at a potential of from 8000 to 18000 volts with the negative side at earth potential. Owing to possible failure of valves, the source of supply has to be capable of standing a dead short-circuit with impunity and operate under rapidly fluctuating loads, low self inductance and absence of voltage ripple.

To meet this requirement the high tension D.C. supply to the valves is provided by means of motor-generator sets operating in series as required. The sets, Fig. 4, were made by the British Thomson-Houston Company at their Rugby Works. Each set consists of one synchronous motor, 640 KVA, wound for 2200 volts between phases, driving two 3000 volt single commutator 250 kilowatt generators joined in series and two pedestal exciters. The main exciter is 8.5 kilowatts at 110 volts and provide field current for both the high tension D.C. generators and for the field of the other exciter, the latter provides current for the field of the synchronous A.C motor. The speed of the set is 750 revs. per

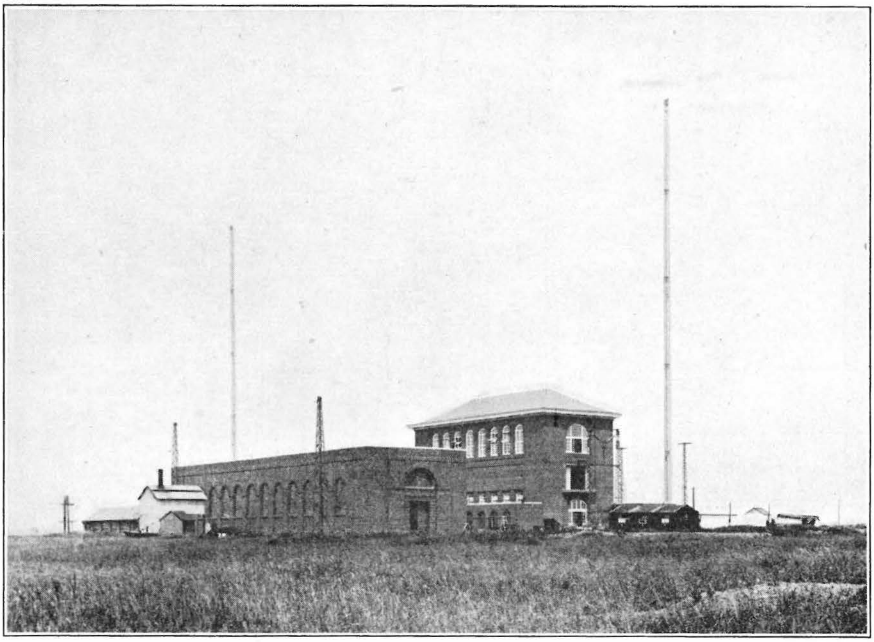


FIG. 2.—RUGBY RADIO STATION.

min. The five machines of each set are mounted on one bedplate, which is insulated from earth by being mounted on groups of porcelain insulators. The neutral point of the motor stator and the mid point between the two D.C. generators are connected to the base plate. By this means the potential of any portion of the set relative to the frames is limited to 3000 volts D.C. For convenience, the D.C. controls of each set are mounted on an auxiliary insulated base plate, which carries generator field rheostats and shunt field rheostats for the main exciter and the motor exciter. Both base plates of the set are connected together.

Each set can give an output of 500 k.w. at 6000 volts and one, two or three sets may be joined in series. A separate starting cubicle and separate transformer is provided for each set; this avoids the use of insulated couplings between motors and generators.

Each main base-plate carries two high-speed circuit breakers, each connected in series with a generator armature. The breaker is set for instantaneous tripping at about 5 times full load current, and inserts a blocking resistance and at the same time trips the generator field contactor; on operation the contacts are fully opened in 0.02 sec.

To start the motors, the 12,000 volts A.C. is connected in star to the primary of the transformer delivering 1,270 volts between phases to the motor, a change-over switch then connects the

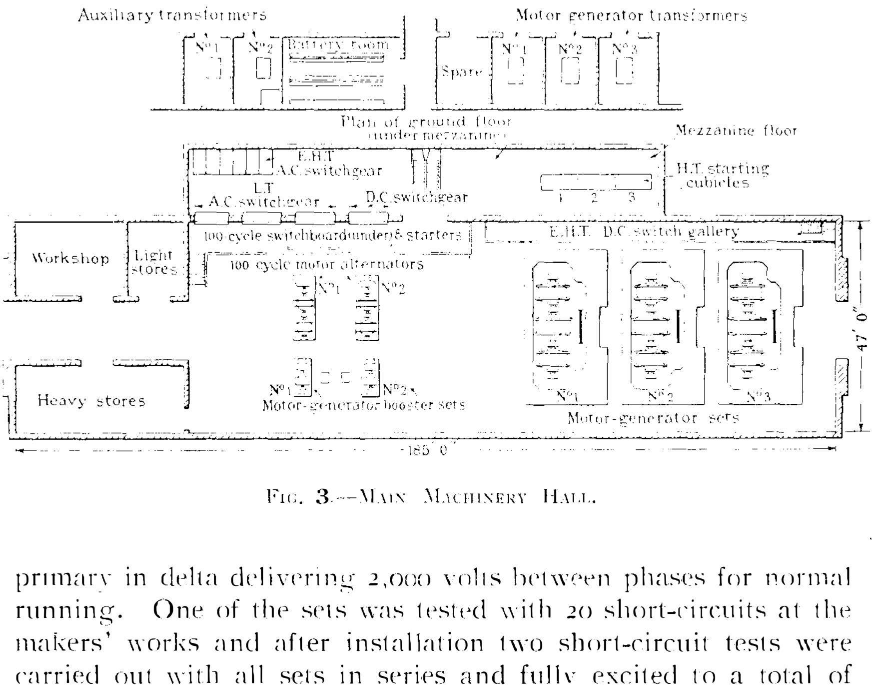


FIG. 3.—MAIN MACHINERY HALL.

primary in delta delivering 2,000 volts between phases for normal running. One of the sets was tested with 20 short-circuits at the makers' works and after installation two short-circuit tests were carried out with all sets in series and fully excited to a total of 18,000 volts D.C. with satisfactory results.

The 100 cycle frequency supply is obtained from a three-phase, 416-volt, 50-cycle synchronous motor coupled direct to a three-phase 416-volt 100-cycle 200 KVA alternator provided with a Tirrill regulator to limit A.C. voltage fluctuations.

Continuous current at 240 volts is furnished by means of 30 k.w. 416-volt induction motor-driven generator and booster sets in duplicate, in conjunction with a battery of 120 cells 200 ampere-hours. This D.C. supply is provided for excitation of motors, controls and emergency lighting.

Power for mast lift motors, lighting, pumps for air and water circulation, etc., is taken from the main low tension A.C. bus bars.

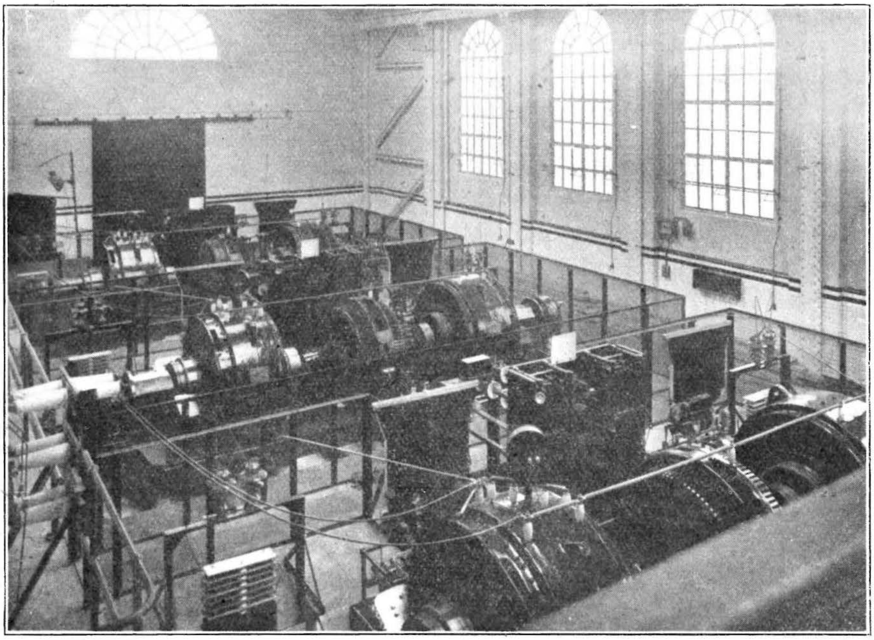


FIG. 4.—MOTOR-GENERATOR SETS.

HIGH FREQUENCY GENERATING VALVE PLANT.

The main wireless building is 103 ft. long by 42 ft. wide, and consists of two floors. The height of this building is 50 feet. (Fig. 5).

The high frequency generating valve plant utilises water cooled

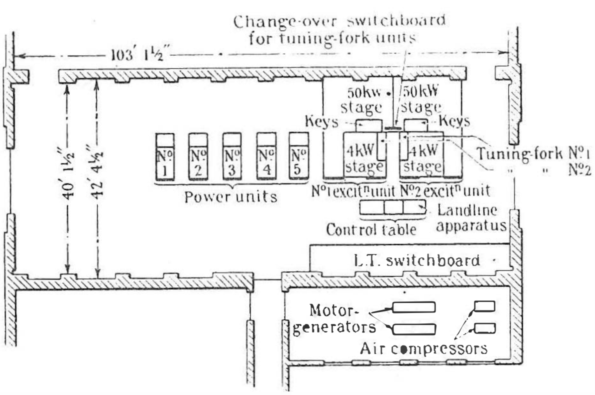


FIG. 5.—H.F. GENERATING PLANT LAYOUT.

thermionic valves and is capable of dealing if necessary with an output of 540 k.w. continuously under commercial conditions.

The general scheme of producing the high power is to generate oscillations of constant frequency at low power and proceed by definitely designed stages of amplification up to the maximum required for fully energising the aerial.

In order to reduce the possibility of interference from the high power transmissions and to permit the use of highly selective receivers, special precautions are taken to maintain a constant frequency. The primary oscillations are obtained from a tuning fork maintained in oscillation by means of a D.E.R. thermionic valve. The tuning fork vibrates at about 1,777 per second and

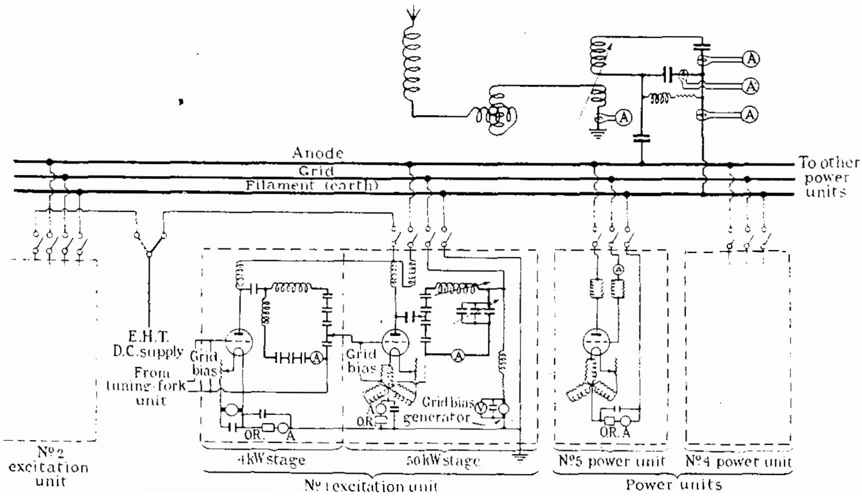


Fig. 6.—Diagram Showing Method of Feeding H.T. D.C. Supply to Power Units.

by means of a chain of small valves and filter circuits the ninth harmonic, a frequency of 16,000, is selected and amplified up to a power of about 100 watts. The stages in this chain of filter circuits and valve amplifiers are carefully copper screened from each other and from any external influences and constitute what is called the "Tuning Fork Unit."

The 100-watt output from the tuning fork unit at the station's signalling frequency is amplified three times before it is delivered to the aerial circuit, the successive stages being designed to deal with input powers of the order of 4 k.w., 50 k.w., and 1,000 k.w. respectively and giving output powers of 2 k.w., 30 k.w., and 540 k.w. respectively. These are referred to as the 4 k.w. stage, the 50 k.w. stage, and the "power units" respectively. Each stage includes a low decrement tuned circuit. The combination of the 4 k.w. stage with the 50 k.w. stage forms the "excitation unit." The tuning fork units and excitation units are provided in duplicate and are interchangeable. All the stages are enclosed in high tension enclosures.

The final stage of amplification (the power units) is not provided in complete duplicate. The power station practice of having a number of units capable of being worked in parallel on common bus bars has been adopted. The principal advantages of this are that it permits an easy flexibility as regards power required for a particular transmission at a particular time of the day, it provides a simple method of repairing a faulty unit or of replacing worn-out

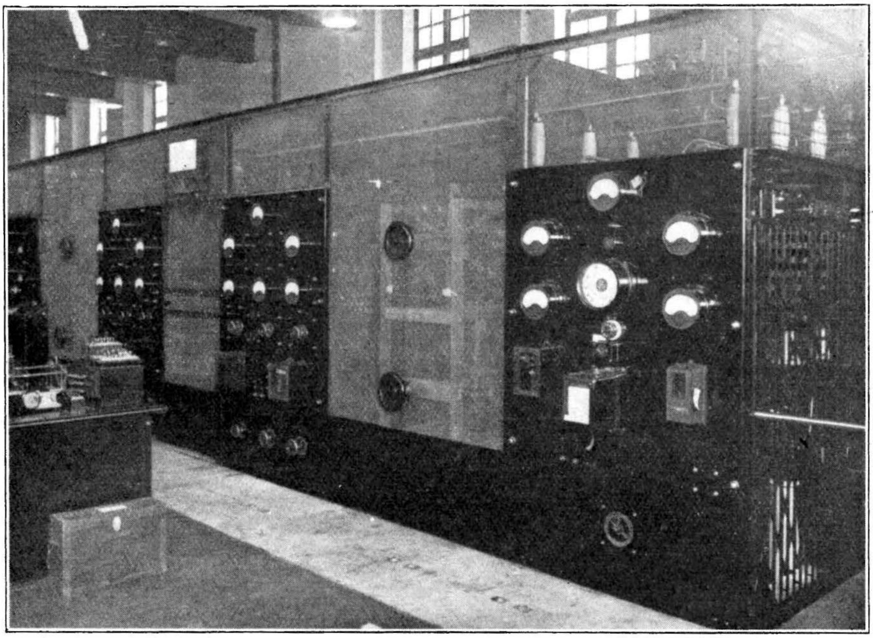


FIG. 7.—EXCITATION UNITS.

or faulty valves while the station is working. The installation can be easily adapted to provide two simultaneous transmissions on separate aerials and it gives facilities for testing different types of valves.

Fig. 6 is a schematic diagram showing the method adopted for feeding the high tension D.C. supply through a selected "excitation unit" to the power units by means of the bus bars and the method of paralleling the power units by means of the same bus bars. It will be seen that there are three bus bars running the length of the installation for anode, grid and filament (earth) respectively, and that to bring a particular power unit into operation in parallel with others it is only necessary to connect it to the bus bars by one 3-pole switch and light the filaments by means of the filament switch. In order to simplify this system of paralleling all apparatus proper to the final stage of amplification formed by the "power units" in use, such as anode choke, grid leak, etc., are placed inside the excitation units. The 4 k.w. stage employs glass valves and the 50 k.w. stage employs three water-cooled valves. The excitation units are screened from each other and the rest of the installation by an enclosure of copper mesh suitably mounted. (Fig. **7**).

The valves used in the power units are capable of dealing with

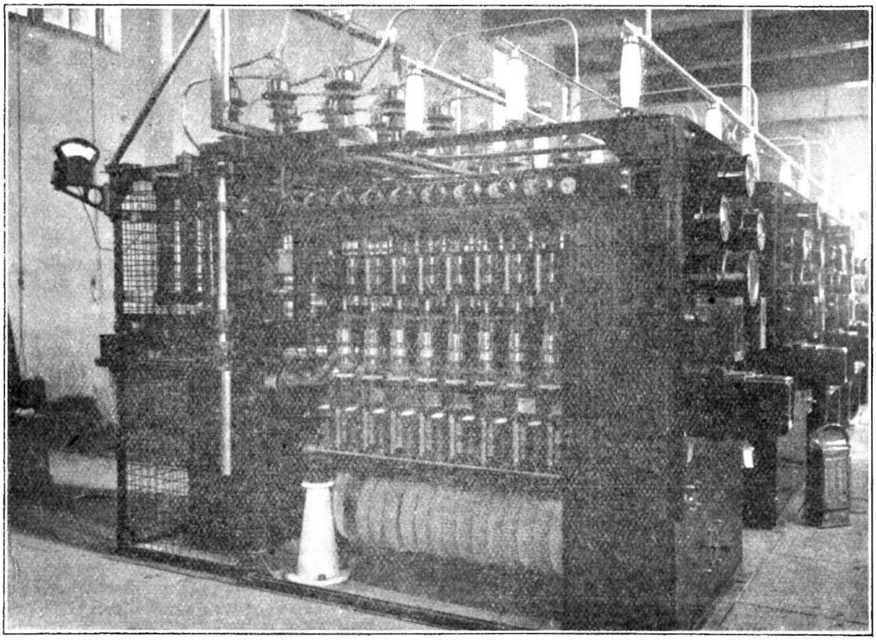


FIG. 8.—POWER UNITS.

an input of 20 k.w., of giving an output of 10 k.w. and continuously dissipating 10 k.w. when properly water-cooled and when operated at a D.C. anode voltage of 10,000 volts. The filament takes 41 amperes at 22 volts. These valves were made by The Standard Telephones & Cables, Ltd.

Five power units are provided. Each unit is equipped with 18 water-cooled valves, capable of an output of about 180 k.w. of high frequency power. With this equipment three power units will give an output of about 540 k.w. and leave two units spare.

The power unit (Fig. **8**) is a rectangular enclosure arranged with nine valves mounted on each side and a front slate panel containing the meters. At the top of the power unit is the three-pole switch for connecting the unit either to the three bus bars or to earth. The valve panel contains the separate filament resistances, overload relays and other safety devices associated either with individual valves or the panel as a whole.

The distilled water used for cooling the valves is fed in each power unit to copper tube inlet and outlet headers through 30 ft. of 2″ diameter rubber hose mounted on a wooden reel at the lower part of the panel. From the unit the distilled water passes through metal pipes to a "cooler," the latter being cooled by means of a separate circulation of water obtained from a cooling pond. The

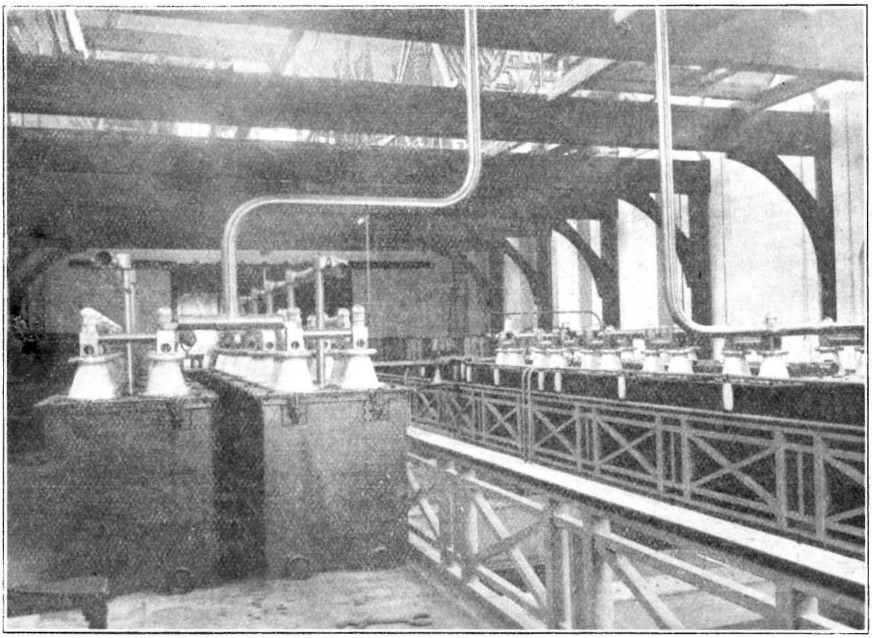


FIG. 9.—PRIMARY CIRCUIT CONDENSERS.

cooling pond has been built about half a mile from the station buildings and is filled from a stream which has been dammed and which runs through the site.

The high frequency output from the power units is fed into a primary circuit (Fig. 9) made up of mica condensers immersed in oil and a tuning inductance made of cable containing 6,561 separately insulated wires, mounted in spiders of American whitewood. The coil is in the form of a hexagon with 7 ft. external sides. The actual measured resistance of the primary circuit at 16,000 cycles is .088 ohm.

The circuit is inductively coupled to the aerial circuit. The aerial tuning coil, which has a maximum width of 14′ 6″, is made of similar cable to that used for the primary circuit, wound on whitewood spiders in the form of a hexagon with 7′ 9″ external sides. The measured resistance of the aerial tuning coil at 16,000 cycles is .11 ohm.

The method of keying the whole installation is by means of making and breaking the circuit between the output from the "tuning fork unit" and the input to the "excitation unit." The whole of the wireless installation was erected by Post Office workmen under the direction of Dr. Hansford and Mr. Faulkner.

The aerial is supported on 12 masts, each 820 ft. high, and is so arranged that it can be suitably divided at the leading-in points into two separate aerials, one much larger than the other. The whole aerial is used for telegraph purposes and using three power panels with 54 valves in use an aerial current of 740 amperes is obtained. With this current the voltage on the antennæ is about 175,000 volts.

For experimental telephony the smaller section of the aerial is used and the reduced telegraph aerial is then worked with an aerial current of about 600 amperes.

The masts and external work were described in an article by Mr. Walmsby, in Vol. 18, Part 1, April, 1925, of this Journal.

THE FELLING OF THREE RADIO MASTS AT DEVIZES.

Iron and steel will bend and bow,
Wood and clay will wash away,
Build it up with stone so strong;
Huzza! 'twill last for ages long.

From the Ballad of
"London Bridge is broken down."

On the side of a hill near the old market town of Devizes and a few miles from the ancient village of Avebury, six tall steel masts have formed a conspicuous landmark for many years. The number has now been reduced to three.

In the early part of September, three crashed to the ground, sacrificed on the Altar of Progress. It seems peculiarly fitting that this site should have been chosen for the scene of destruction; the offspring of the most modern branch of Engineering laid low amidst the ruins of the most ancient! Local antiquaries will tell you, if you are interested, of the great feats of those Neolithic Engineers who, at Avebury, ages before men learnt to use iron implements, built those huge circles of stone within whose confines sun worshippers conducted their religious rites. They will speak with enthusiastic voice of the mighty deeds of the civil engineers of ancient times, who, to restrain the predatory encroachments of hostile Lords, excavated the great dyke that skirts the boundary of the Radio Station site. These deep ruts crossing the line of masts, mark the road made by Roman military engineers, and many an invading chariot has passed this way in the great days of old.

The trails of the engineer have left their mark unobliterated even by the passing of Time! Many other tales will be told, but

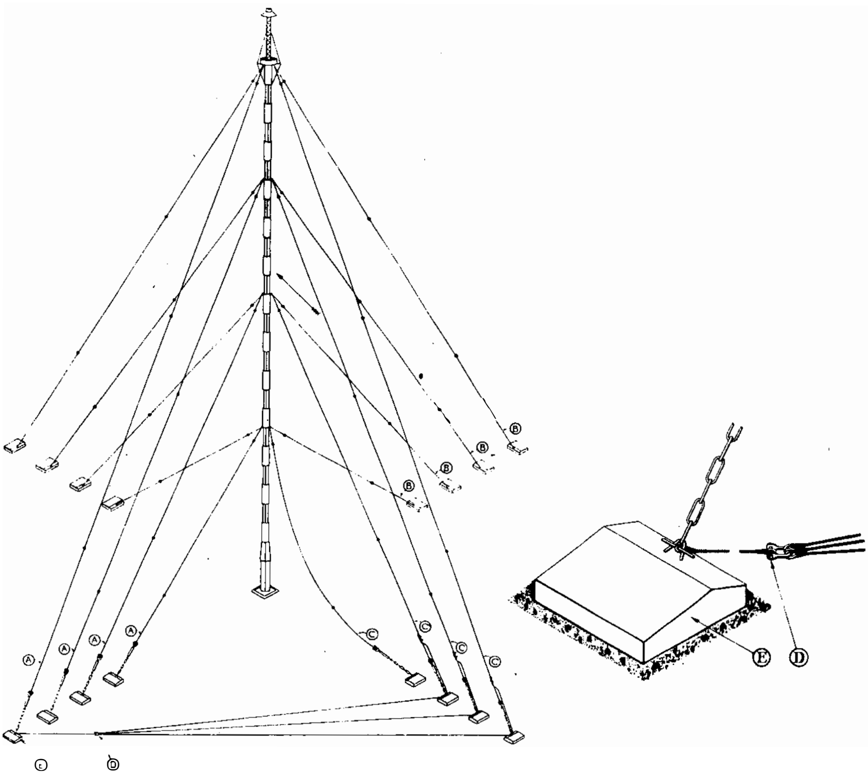


FIG. 1.—METHOD OF RELEASING STAYS.

if you pass down from the hill into the villages below the story you will hear most often concerns the sad passing of those 300 feet masts. Lest the details may be warped, the true account is given here. Each mast is held by 16 steel stay ropes, arranged in four groups. At the bottom of each stay and near the concrete anchor block, a "bottle" screw enables adjustment of stay tension. By turning the screw sufficiently, the stay becomes entirely detached from the anchorage. It might be thought that to cause a mast to fall, one merely has to screw round the "bottles" and so detach the stays from the anchorages. The problem, however, is not so simple as this. The mast might fall at an inopportune moment and in a wrong direction. Trailing stays might whip some unfortunate worker. As the masts are composed of bolted sections, they could, of course, have been taken down piece by piece, starting form the top. Such a method, however, would have been too expensive. It would have been necessary to loosen many hundreds of bolts and to lower some thirty tons of material for each mast so dismantled.

The method adopted as being at once the cheapest, simplest and quickest is illustrated in Fig. 1. Four sets of stays are arranged at right angles. If one set of stays, those for example on the right

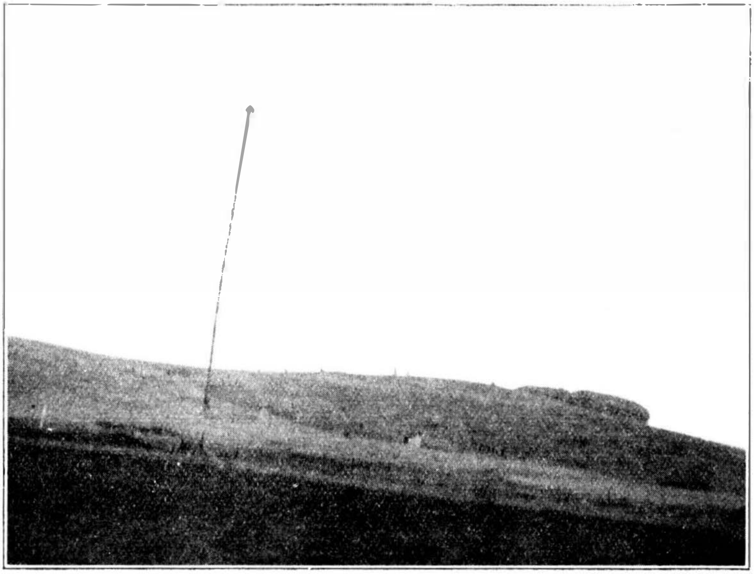


FIG. 2. A MAST STARTING TO FALL.

of the Fig., were released simultaneously, there would then be an unbalanced pull in the direction of the arrow, due to the tension of the stays immediately opposite. The ropes AAAA and BBBB, being fixed in one plane both to their anchorages and the mast, would prevent any movement of the mast except in the direction of the plane at right angles. Thus the mast would fall in the direction of the arrow. To ensure that all the tensions in one set of stays were released simultaneously, steel ropes were fixed temporarily to the three stays CCC above the "bottle" screws. The fourth and inner stay had previously been released, since this could be done with safety. Each of the three steel ropes was passed through an eye in its own anchorage and pulled out to a common shackle at D. A steel sling was attached to the junction D and also to an inverted V-shaped bar fixed in the concrete block E. Thus one end of the sling held the three steel ropes, whilst the other was attached to the block at E. By tensioning each of the three ropes in turn and by removing the "bottle" screws at CCC, the pull of the three stays was resisted by the single sling. Some attention must now be given to the method of fixing the sling to the V iron. The sketch in the lower portion of Fig. 1 will explain matters. The terminating eye of the sling was passed through

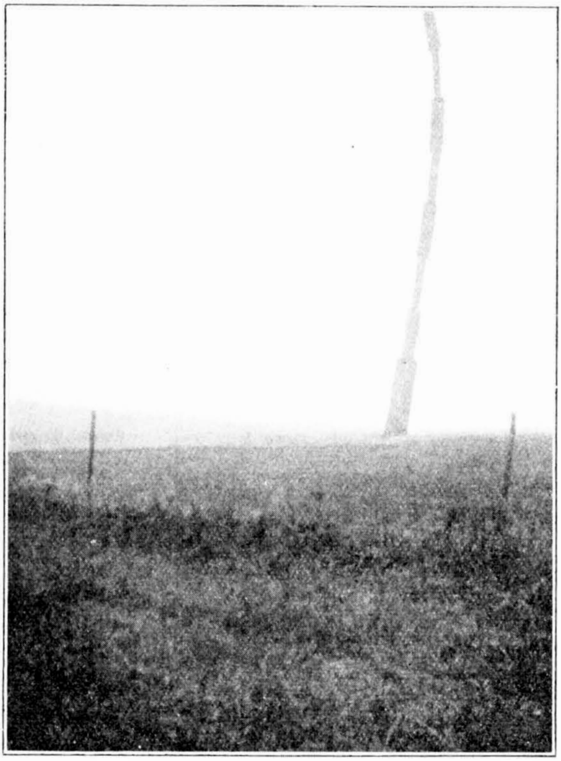


FIG. 3.—A FURTHER STAGE, SHOWING THE HUMP FORMING IN THE LOWER SECTION OF A MAST.

the inserted V. A short steel rod was thrust through this eye and allowed to rest on the legs of the V. In this way the pull of the three stays was communicated to the three ropes and a single sling, which was held firm by the thrust between the V and the pin. The nuts at the base of the mast having been removed, all was ready for the final act. Picture the scene as the anxious moment arrived to put the scheme to test! Holding a sledge hammer aloft, the executioner stands above the pin. A word of command and the heavy tool swings quickly down. The pin flies out, the stays slacken and fall in towards the mast. For a moment the " stately and air-braving tower " remains erect, and then a great shout goes up, " She's falling ! she's toppling over ! " Slowly at first, but with ever increasing speed, the structure heels about the base. The higher sections of the masts describe a larger arc than the lower and thus accelerate at a greater rate. Unequally distributed forces are therefore brought into being, the loading progressively increasing from the base upwards. For a brief period the mast successfully resists these unequal forces, retaining a stiff steel backbone. Soon, however, the uneven contest ends and when about 10° of heel have been attained the great structure bends and bows in a curve of increasing curvature, the convex side upwards. The metal yields and on the tension side only large steel bolts stretch and snap. Then, with a thud

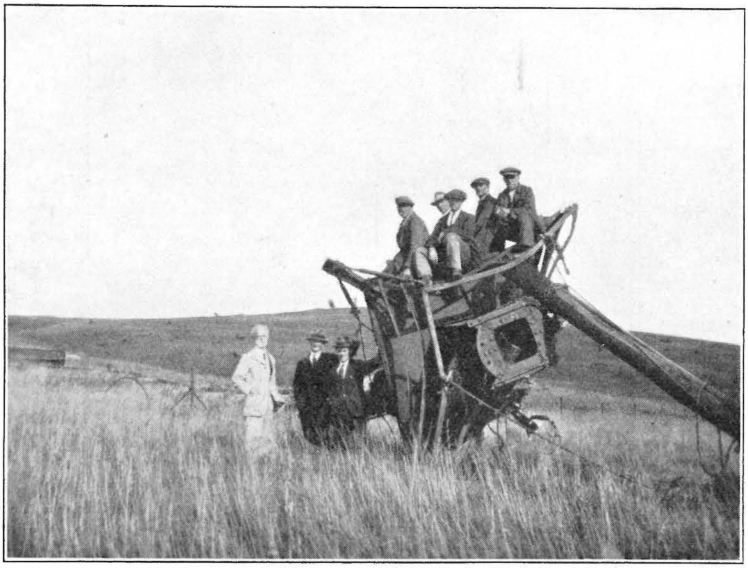


FIG. 4.—THE HEAD OF ONE OF THE MASTS.

heard miles away, the head crashes to the ground. The struggle is not quite over. Two thirds of the length of the mast lay stretched upon the ground, unsevered on the compression side from the remainder. At the base a great hump, 60 feet high, stands motionless for a few seconds, then slowly turns over to rest upon the ground. All is over ! And not one alone of the witnesses experienced " a pang as great as when a giant dies."

An examination of the first fallen mast revealed many interesting facts. To pull apart the nine bolts that failed in tension in the horizontal flange would necessitate a force of about 350 tons. Generally the section of the mast retained its original circular section. At some sections, however, the bolts in the horizontal section remained intact and the material of the tubes failed. There is thus good evidence of the equality of strength of bolts and mast section. In a few places only the tube section had become elliptical due to the partial collapse of the walls on the compressive side.

No stays were damaged except in those cases where a blow had been dealt. The steel masts have been cut into small sections by means of an oxyhydrogen flame. And now the story of the passing of the masts is told. If, on that mid-September night when the last mast fell, you had chanced to pass by the great stones in the quiet village of Avebury, you would have seen —as the moon rose—small dark figures flitting about the ground,

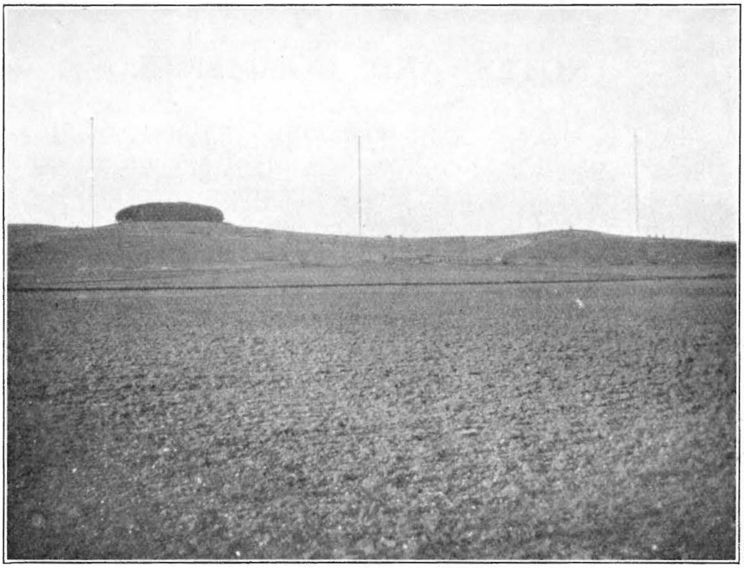


FIG. 5.—THE THREE REMAINING MASTS.

and heard a whispering sound rising and falling in gentle cadence. You and I, cold matter-of-fact engineers, would have dismissed the matter with some crude remark about shadows, and wind blowing leaves about. But the Poet, with wiser discernment, will tell you that these were no shadows caused by the rustling leaves, but elves and goblins jauntily capering around the great hoary stones, chanting joyously their triumphant song.

Iron and steel will bend and bow,
Wood and clay will wash away,
Build it up with stone so strong;
Huzza! 'twill last for ages long.

NOTES & COMMENTS

NOTES AND COMMENTS.

Mr. W. J. Medlyn, Superintending Engineer, South Lancs. District, occupies the chair for the current session at the North Western Centre of the I.E.E. In his chairman's address under the heading of "Electrical Communications, and the Spirit of Public Service," delivered at Manchester on the 2nd November last, Mr. Medlyn gave a very interesting review of the development and progress of the electrical industry generally and of electrical communications in particular.

The first important application of electricity was the introduction of the telegraphs in 1837. The Society of Telegraph Engineers was founded in 1871 and in 1883 it became the Institution of Electrical Engineers. In the course of his address Mr. Medlyn traced the rise of electrical engineering and said the electrical industry had become a public necessity, applied electricity and civilisation had become synonymous terms. He gave an imposing array of figures covering the plant and the capital invested in the business. In tracing the improvements in transmission introduced by the application of scientific methods, Mr. Medlyn gave some interesting facts and figures relating to the London-Manchester cable, completed and brought into use in April, 1922. The cable contains 160 pairs of 40 lb. conductors, 104 pairs telephones and 56 pairs telegraphs. By means of phantoms the 104 telephone pairs can give 156 trunks. The length of the cable is nearly 200 miles, and if it were not loaded and equipped with repeaters, the equivalent grade of speech now obtained would have been possible over some 13 miles only. To give equal speech over the 200 miles, copper wires weighing 400 lbs. per mile carried upon six lines of poles would be required, and an additional line of 56 wires of

150 lbs. would have been needed for telegraphs. These routes would have cost at least £1,500,000 more than the cable and to accommodate the lines it might be necessary to buy or rent a fenced-off strip of land, say, 20 feet wide, for a great part of the distance.

In the latter portion of his address Mr. Medlyn emphasised the necessity for peace in industry, and said we must have the co-operation of all grades of workmen in securing maximum production for the common good. He concluded as follows:—It is encouraging to note that the economic laws which govern our present life and civilisation are gradually becoming better known and appreciated by thinkers and leaders of all classes and all shades of public opinion, and the knowledge is spreading to all classes of the population. There is, therefore, good ground for the hope that the solution of our industrial problem will ultimately be found in the general recognition that, fundamentally, industry is a form of service to the whole nation; and, hence, good team work between all classes of organisers and workers engaged in the production and distribution of commodities is the best and surest way to improve the standard of living to the advantage of everybody concerned. Personally, I am convinced that the encouragement of this principle is the highest form of patriotism, because it is calculated to advance the industrial efficiency and the well-being of all members of the community and the general welfare of the British Empire.

In an address on "The Advancement of Electrical Engineering," Mr. Medlyn also delivered a useful and instructive exhortation to the students of the North Western Centre. At the outset he declared that the honour, the prestige and the progress of any body of men or association of men was the integral of the units composing that body.

He then passed on to consider the beneficent effects of maintaining a live interest in the particular work in hand and in the profession of electrical engineering generally. The value of proper perspective was emphasized, and it was pointed out that there was some danger in becoming so absorbed in one's own corner of Electrical Engineering as to lose sight of its relation to the world at large. In this way a narrow, cramped outlook would replace the breadth of vision which was essential for all positions of supreme control.

Mr. Medlyn then laid down the principle that the surest way to obtain material progress was to secure close co-operation between all classes engaged in the national industries. The resulting harmonious working would react to the benefit of the whole community, and consequently this spirit ought sedulously to be cultivated to replace the bitterness that so often manifested itself between the various partners in the production of commodities. It was not easy, he said, to reconcile the many divergent views as to what was best for mankind, but there was a growing opinion amongst the majority of serious thinkers that economic peace between classes was as necessary to the future life of the world as political peace between States. But the object of all our work was to add to the amenities of civilization and the well-being of humanity in general.

A plea was here introduced for a sympathetic understanding not only of the minds of the workmen whom the young engineer was called on to control, but of the Chiefs whom he served. Adding, that it was only in this way that happy, harmonious, co-operative working, which was only another term for efficiency, could be achieved, he said the engineer of the future must, if he is to occupy a position of administrative control, not only know his work, but he must know his men. He must develop, along with his professional knowledge and experience, the knowledge of his fellow men. And all this must be correlated to the economics of his sphere of activity. The young engineer who kept those principles well to the fore and could " fill the unforgiving minute with sixty seconds worth of distance run," would not only command and attain the highest rewards of his profession, but he would attain the very highest plane of mental development and happiness in life.

In service to the community—which included his chiefs and subordinates—lay every material and moral advantage. He who served his day and generation best would surely best serve himself. His slogan should be " How best can I serve the community ? " *not* " How much pelf or kudos can I extort ? "

Mr. Medlyn next instanced the value of order and method, and suggested that deficiencies in this direction were generally due to disorderly thinking, and that this in turn was caused by lack of perspective in that the relation of the work in hand to the complete organisation was not fully appreciated.

The seriousness of errors of judgment in dealing with human problems was emphasized. Injustice rankled severely, and, like a contagious disease, spread around by contacts. The Electrical Engineering profession would advance at the rate that the coming generation advances, and he had, therefore, deemed it worth while to call specific attention to the things which would serve to develop the administrative powers of engineers. It certainly did not follow that every professional man had administrative ability simply because he was a professional man. These remarks were made from the point of view that in so many young engineers there was a tendency to treat with contempt the business aspect of their work, and Mr. Medlyn expressed the hope that he had applied a small corrective of a wrong, but somewhat prevalent view point.

On the conclusion of the address the Chairman asked permission to discuss it. This Mr. Medlyn readily accorded, whereon twelve of the students took part in the ensuing debate. In general the very live discussion resolved itself into emphasis and extension of the principles laid down. Finally a very enthusiastic vote of thanks was accorded to Mr. Medlyn for one of the most interesting addresses with which the students had been favoured.

T.E.H.

FROM GAOL TO BROADCAST STATION.

The steady improvement in Irish conditions is reflected in the announcement that Standard Telephones and Cables, Limited, of London, have been commissioned by the Irish Post Office to supply a Broadcasting Station for Cork, and this will be located in the Gaol, now fortunately unrequired.

The Station will be of a similar type to that now in operation at Birmingham, but of an approximate 3 K.W. Geneva Rating.

The Annual Report for 1925 of the Rotterdam Municipal Telephone Service, which has recently been received, includes much valuable information. Rotterdam will be remembered as one of the first cities to make a trial of the ingenious automatic system manufactured by Messrs. Ericsson, of Stockholm.

The total number of lines on the 31st December, 1925, was 18,803, distributed among three exchanges—Botersloot, with 12,360; Korenaarstraat, with 3,943; and Vlaggemansstraat, with 2,500. At the last two exchanges, 1,905 and 2,081 lines respectively, are working on the full automatic principle. The number of stations at the same date was 29,881. Vlaggemansstraat exchange was opened on the 25th March, 1925.

No serious fault has occurred on the automatic equipment, the working of which is giving complete satisfaction. The new building for the Botersloot exchange, which is also to be converted to automatic working, has been commenced.

During the year under review the local traffic exceeded that for the previous year by 4.9 million calls, or 6.9%, as compared with an increase of 22.5% in 1924 over 1923. Traffic to and from other cities amounted to 3,225,545 calls—an increase over the previous year of 0.9%.

International traffic was responsible for several hundred thousand calls, the principal components being the following :—

With	Germany	244,780,	as against	224,353	in 1924.
,,	Belgium	122,848,	,, ,,	126,904	,,
,,	England	42,195,	,, ,,	24,189	,,
,,	France	2,569,	,, ,,	3,655	,,

For the busiest two-week period in the year—the week before and the week after Christmas—the average day calling rate per line was about 18 for the main exchange and 4 for the other two. During the same period the ratio of day to busy hour averaged about 8.

The number of public call offices numbered 113, and of coin-boxes in shops, etc., 88.

Requests for the correct time averaged 1,086 per week-day, 1,007 per Saturday, and 841 per Sunday.

The result of the year's working was a credit balance of nearly 874,000 florins.

In recent years sick absence has been steadily declining, the figure for the year under review being 3.09%.

These few particulars are culled from a large amount of interesting material in the report.

G.F.O.

CARRIER-CURRENT COMMUNICATION ON SUBMARINE CABLES.

The Journal of the American Institute of Electrical Engineers for October, 1926 (Vol. XLV., No. 10), contains a detailed description by H. W. Hitchcock, of the Southern California Telegraph and Telephone Coy., of a recent application of the principle of Carrier-Currents, which is of considerable interest.

Catalina Island, on the west coast of California, is separated from the mainland by a channel 23 nautical miles in width, and prior to 1920 the Island was not in telephonic communication with the mainland. A radio system was then established, the circuit being extended by wire between Avalon and Los Angeles. Owing partly to increasing interference from ships' transmitters and also to the growth of work, this circuit was replaced in 1923 by two single-conductor submarine cables, each of which was used as a single-wire telephone cricuit.

The further growth of traffic having necessitated additional channels, it was decided to instal the carrier system, and on the 15th May, 1926, six carrier telephone circuits were brought into operation on one of the cables. This cable now carries therefore seven telephone circuits and one telegraph circuit.

The arrangement is interesting, not only because it is the first case of application of carrier telephony to deep sea cables, but it is the shortest carrier system (26 miles) in commercial operation. It provides more carrier channels than has previously been attempted, and it differs in several important respects from other systems.

METALLIC POLAR-DUPLEX TELEGRAPH SYSTEM FOR LONG SMALL-GAUGE CABLES.

The engineers of the Bell Telephone Company in the States have devised a complete telegraph system for use on the telephone toll cables of that organisation. Our old friend, and one time Secretary of the I.P.O.E.E., Mr. John H. Bell, with Messrs. R. B. Shanck and D. E. Branson, describes the system in a Bell Technical pamphlet. The following are some of the outstanding features:—Sensitive polarised relays, with closely balanced windings and in some cases with vibrating coils, are employed in the metallic circuit, and working currents of four or five milliamperes, obtained from 34 volt line batteries, while sufficient to operate the relays do not introduce appreciable disturbance in adjoining telephone circuits. Repeaters are spaced about 100 miles apart. Superposition is accomplished by the compositing method. The metallic system is suitable for providing circuits up to 1000 miles or more in length, the grade of service being better than that usually obtained from earth-return lines for such distances. About 55,000 miles of this type of telegraph circuit are in service.

NEUTRALISATION OF TELEGRAPH CROSSFIRE.

A Bell System Technical pamphlet describes the methods that have been adopted recently to neutralise mutual interference between parallel telegraph circuits, and by which, it is claimed, a reduction to 10 to 20 per cent. of the original values has been secured. The principle used is to connect circuits on which mutual induction exists by means whereby a neutralising impulse can be sent direct on the disturbed circuit at the same instant and with approximately the same value as the impulse produced by the mutual capacity coupling of the lines. This direct connection takes the form (*a*) of a small condenser fitted with a timing series resistance, joined at the beginning of the compensation circuit, (*b*) of a transformer with one winding in each battery to line circuit, or (*c*) in the case of phantom groups a balanced capacity Wheatstone bridge arrangement with the apexes joined to the compensation circuits of the composited telegraph circuits. Due to reduction of crossfire it is usually possible to secure a much better duplex balance after the neutralisers have been applied. The application of the anti-crossfire condensers, which have appreciable capacity to earth, requires a different setting of the balance. It is said that no disturbance takes place in the circuits when parallel wires are idle.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENT.

The following works have been completed:—

Exchange.	Type.	No. of Lines.
West Hartlepool	New Auto	1120
Blackburn	Extn. Auto	1000
Farnworth, No. 10 C.B....	New Manual	500
Upton ,, ...	,,	420
Gravesend ,, ...	,,	1300
Bexley Heath ,, ...	,,	780
Shipley ,, ...	,,	1080
Camberley ,, ...	,,	740
Seven Kings ,, ...	,,	1370
Dumfries	,,	700
Bournemouth	Extn. Manual	1680
Romford	,,	320
Chester	,,	460
Mansfield	,,	220
Mountview	,,	1900
Trafford Park	,,	520
Leith	,,	260
West Bromwich Union ...	P.A.B.X.	40
Morris Cars	,,	70
Formans	,,	60
Bristol Times	,,	40
Phillips	,,	30
Transport and General Workers	,,	80
Gestetner, Ltd.	,,	40
Weymouth Corporation ...	,,	30
Producers Distributing ...	,,	30
Edmonton Guardians ...	,,	100
Rowe Bros.	,,	30
Ormerods, Ltd.	,,	30
Heywood (M/R)	,,	70
Burnley Corporation ...	,,	100
Manchester and Salford ...	,,	50
Wright & Sons	,,	30
Riseley & Sons	,,	30
Metal Agencies	,,	70
Equitable Trust	,,	50
Glasgow Housing ...		50
Rylands	,,	60

Orders have been placed for the following new Exchanges:—

Exchange.	Type.	No. of Lines.
East Finchley, No. 1 ...	Manual	3500
Colne, No. 10	,,	620
Blackley Co-op.	P.A.B.X	30
Calico Printers	,,	40
Heatons (Leeds), Ltd. ...	,,	30
Shell Mex (Strand) ...	,,	30
Droylesden Co-op. ...	,,	30
United Dairies, Ltd. ...	,,	50
Bowater & Sons	,,	30
Crawford & Sons ...	,,	60
International Combustion..	,,	70
Barrow, Hepburn & Gale..	,,	60
Shell Mex (Leeds) ...	,,	30
Castner Kellner Alkali ...	,,	70
Shell Mex (Leicester) ...	,,	30
Stott & Smith	,,	30
Bury Corporation ...	,,	40
F. R. Simpson	,,	20
Greenock Corporation ...	,,	80
Jas. Hare, Ltd.	,,	30
Earl of Dudley's Works...	,,	70
Moss Gear, Ltd.	,,	40
Conolly's, Ltd.	,,	30
Plymouth Corporation ...	,,	210
Van Moppes & Sons ...	,,	30
J. Benn & Sons	,,	30
Watney, Combe, Reid ... (Tie Line Equipment)	,,	—

Orders have been placed for extensions to existing equipments as follows :—

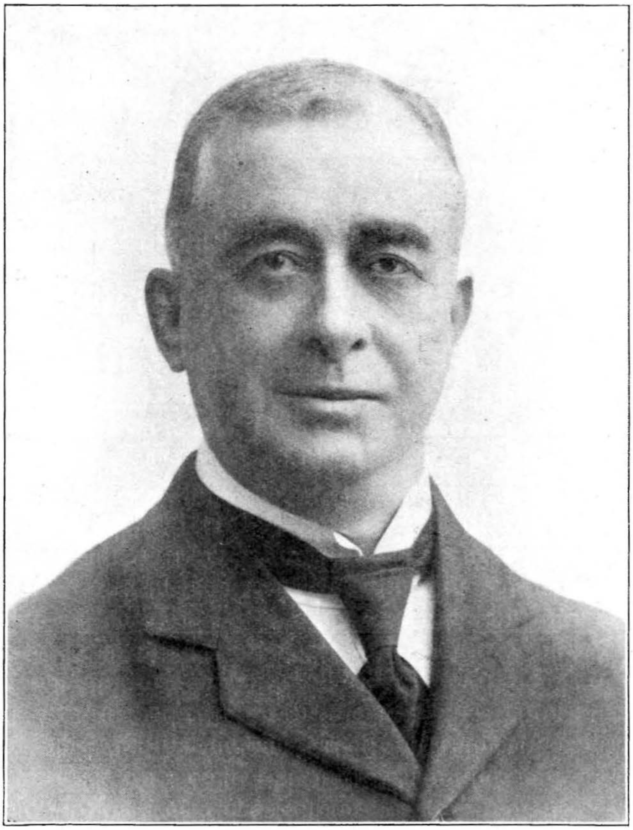
Exchange.	Type.	No of Lines.
Carlisle, No. 10	Manual	400
Streatham	,,	1480
Tottenham	,,	1260
Weston-Super-Mare ...	,,	460
Willesden	,,	1700
Bradford	,,	560
Cambridge	,,	Rearrangements
Reigate	,,	1400
Palmers Green	,,	1640
Sevenoaks	,,	740

MR. F. L. HENLEY, M.I.E.E.,

Chairman I.P.O.E.E. 1925-26.

Mr. Frank Henley, Staff Engineer of the Test Section, who retired 11th September last, entered the service in 1881 at the Central Telegraph Office, where he soon became known as an expert operator. His skill resulted in his being sent to the Stock Exchange Office, where, on a famous occasion, he was one of four men who, between them, despatched by Morse key 500 messages in one hour. Even allowing for the exceptional conditions at the Stock Exchange office, the feat was a remarkable one and it gained the thanks of the Postmaster-General.

In those days he was a useful boxer and a distinctly good swimmer, but his attachment to these sports did not interfere with the prosecution of his study of the pianoforte at the Guildhall School of Music, where he gained the School's Certificate of Merit.



MR. F. L. HENLEY.

An accomplished pianist he was greatly in request to play at staff social gatherings and concerts, and was obtaining much semi-professional work when a chance conversation led him to join the technical classes of Mr. (now Sir William) Slingo, and probably changed his whole career. Into the work of these classes he threw the energy and ability which have been the outstanding characteristics of his life, and in 1895 gained the 1st or Controller's prize, which is awarded to the student obtaining the highest aggregate number of marks in all subjects. Probably as a result of this success he was sent, a few months later, to the Testing Branch of the General Factory, at Mount Pleasant. Here he joined Messrs. G. F. Mansbridge, W. H. Winny, H. H. Harrison and others and soon made good.

Entering the evening classes at Finsbury Technical College he took the 1st prize in Inorganic Chemistry, and continued with organic work, finishing up with laboratory tests of rubber and gutta percha. In 1903 the Testing Branch passed to the control of the Engineering Department; Mr. Henley was placed in charge and promoted to 1st Class Engineer. In 1904 he matriculated at London University and shortly afterwards having passed the Civil Service Commissioners' Examination for 2nd Class Staff Engineer, was transferred to headquarters and posted to the Examinations Section under Mr. Hartnell. His studies at Finsbury College continued, and in 1906 he gained the 1st prize in Advanced Mechanical Engineering.

In 1910 he was a delegate, with Major H. Brown, to the Paris Conference of Telephone and Telegraph Administrations, to which he presented a paper on "Some recent tests on Creosoted Poles," containing much interesting original matter. In 1919 he was appointed Staff Engineer in charge of the Test Section, in succession to Mr. J. R. Gall, who had been transferred to the Designs Section. The work of the Department and consequently of the Test Section was developing, and it fell to Mr. Henley to extend the Testing Branches in London and Birmingham, and to open a small testing station at Edinburgh. The branch at Birmingham, hitherto in charge of an Assistant Engineer, was now allotted an Executive Engineer, and the staff at both branches steadily increased to meet the ever increasing volume of work. Many new tests were introduced to meet the requirements of new items, *e.g.*, audio frequency bridge test, special automatic testers, etc. Paper-core submarine cables were introduced and much testing and consultative work was undertaken for the various Dominions Governments. As showing the increase of work between 1919 and 1926, it may be mentioned that the value of the stores tested in 1925-26 was double that of 1919-20.

In 1921, Technical Instruction VIII., on his initiative, was compiled under his supervision, and issued to the Staff. In 1923 he published, through Messrs. Longmans, his Telephone Manual, entitled "The Inspection and Testing of Materials, Apparatus and Lines," a valuable handbook for post office men employed on inspection duties. Some reference must be made to the vast amount of labour and time expended on Committees of one kind or other. Mr. Henley served on very many of these bodies, among them being :—

The Interdepartmental Committees No. 2, Materials; No. 5, Power Cables; No. 6, Telephone and Telegraph Wires and Cables.

As chairman of the last-named, he represented it on the B.E.S.A. Committee which issued Standard Specifications Nos. 174-184.

The Committee of the Department of Industrial and Scientific Research on the Preservation of Timber.

The Committee of the British Electrical and Allied Trades Research Association on Composite Insulating Materials, Mica, etc.

The Committee of the B.E.S.A. which published the Standard Specification for Vitrified Ware Pipes.

Major McClintock's Committee on Fire Emergency in the Central Telegraph Office.

This gives but a slight idea of the Committee work he performed, for he did not spare himself, and made important contributions to each and all of them. From the time he took charge of the Section, in 1919, his relations with the Staff were of a most friendly nature. He always felt his responsibility for them and used all legitimate means to further their interests. Personally, I found him an understanding and sympathetic chief and a good friend. It may be said that he knew what was good, did justly, and never strained the quality of mercy.

He has always retained an interest in sport and has generously marked his retirement by presenting a silver cup to be competed for annually by football teams chosen from the London and Birmingham Testing Branches, and this, and the now well-known Telephone Manual, will help to keep his memory green.

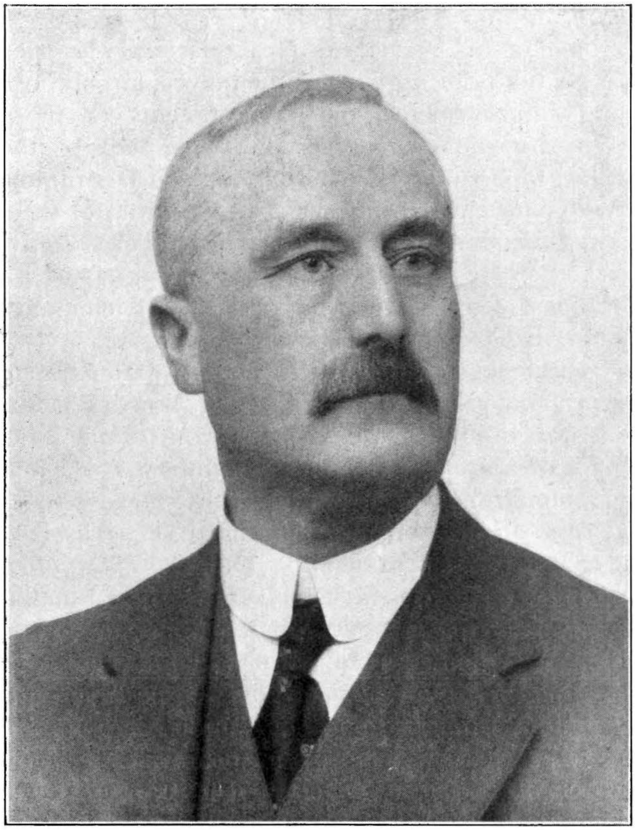
Mr. Henley is married and has two daughters; he suffered the grievous loss of his only son in the war, in 1916. His positive and striking personality will be greatly missed. He takes into retirement the warm good wishes of his many colleagues and friends, and, judging from his excellent health and vigour, it is reasonable to hope he has many pleasant years in front of him. Mr. Henley is prominently engaged in church work and his recreations include higher mathematics and mental and moral philosophy.

F.H.B.

MR. EDWIN LACK, M.B.E.

By the retirement of Mr. Lack, under the age limit rule on the 12th September, the Department lost one of the best known figures in the English Telegraph world.

In January, 1882, he was appointed S.C. & T. at Hull—an office which is notable for the number of men who have joined the Engineering Department. It is thought indeed that Hull has furnished more officers for the Engineering Department than any other city or town in the United Kingdom at which there has not been a Superintending Engineer's Headquarters. One can recall the names of Harrison, Smart, West, Youngs, Johnson, McInnes, Tinsley, Richardson, Anson, Burton, Statters, Platt, Hammond, Vickery, Tanner, Kemplay and others who have attained high rank in the Engineering Department.



Mr. Edwin Lack, M.B.E.

Mr. Lack took a great part in the formation of electricity and magnetism and telegraphy classes, of which he proved a very successful teacher, and several of the men whose names are mentioned above were his pupils. He also took an active part in the formation of the Signal Section of the Hull Rifle Volunteers (a rare luxury in those days) and became its first Corporal.

He joined the Engineering Department as a Relay Clerk in

November, 1893, and after service at East Dean and Lowestoft was appointed Second Class Engineer at Dundalk in November, 1899. Like other men who have had service in Ireland, he brought back not only experience but a fund of good stories. He was transferred to Brentwood in December, 1900, to Chelmsford in December, 1904, and appointed First Class Engineer in London in November, 1906, where he had charge of the Victoria Section and afterwards of the combined Victoria and Mayfair Sections. He was appointed Staff Engineer, Second Class, and attached to the Telegraph Section in April, 1909, and Assistant Staff Engineer in July, 1911.

The whole of his service at Headquarters was spent in the Telegraph Section, during which time he was largely instrumental in devising improvements and developments in the telegraph service. In 1910 he was appointed a member of the Anglo-German Telegraph Commission, which met at Berlin, and was the Engineer-in-Chief's representative at the opening of the cable laid by the Post Office for the Anglo-Norwegian Telegraph Service in the same year. He introduced the present system of morning testing of lines, after serving on the Testing Committee under Mr.—afterwards Sir William—Slingo in 1913-14.

At the outbreak of the Great War, Mr. (afterwards Lt.-Col.) Booth was appointed Assistant Director of Army Signals, and Mr. Lack took charge of the Telegraph Section for the whole period of the War. Among other things, he was responsible for equipping submarine cables from Beachy Head to St. Nazaire (France), from Peterhead to Alexandrovsk (Russia) and the Imperial cable from Penzance to Halifax, Nova Scotia. He established duplex repeaters at Dieppe for duplex Baudot working for the service between London and Paris, and equipped with telegraph apparatus Lord Haig's train for his movable headquarters. During the Irish troubles he carried out the transfer of the Direct United States Cable Office at Ballinskelligs.

For his services during the war he had conferred on him the honour of a Member of the newly created Order of the British Empire in January, 1918.

Among other improvements he arranged the application of the Gulstad vibrating relay arrangement to the Post Office standard relay, now known as the "G" Relay. By this arrangement many circuits which formerly had to be worked through repeaters can be worked direct.

In 1924 he went on two occasions to the West Indies in connection with the laying of the new telegraph cables between Turks Island, Barbadoes, Trinidad, and Demerara.

In the installation and adjustment of troublesome apparatus Mr. Lack is an acknowledged master, and Telegraphists or Engineering Officers in difficulties always received from him not only capable but also the most friendly assistance. He never put on the attitude of superior knowledge, and his great experience and skill were always at the disposal of his colleagues.

He was particularly fond of cricket, boating, fishing, etc., and in his later days has taken great interest in the game of bowls.

On his retirement he was presented with a 3-valve Radio set with loud speaker by his colleagues at Headquarters, and with a travelling bag by colleagues (chiefly old pupils) in the North Eastern District.

His genial presence and friendly comradeship will be greatly missed, and all his friends will join in wishing him and Mrs. Lack many years of comfort and good health in his retirement.

T.B.J.

H. P. FEW.

On 14th September passed away, after a lengthy illness which had involved his premature retirement, Herbert Percival Few, late Staff Officer, Engineer-in-Chief's Office, aged 50 years. The interment took place at Pinner Cemetery.

He entered the Engineering Department in 1902 from the London Postal Service and was engaged principally on Staff Establishment and accounts work in the Headquarter office. Although of a retiring disposition he was known and esteemed for his sterling qualities by a large circle of office colleagues.

Outside the Engineering Department he is perhaps better known by his text books in technical Telegraphy and Telephony and Mathematics, which works have found their way into all parts of the British Empire.

He leaves a widow and a son of 18 years of age.

ALEXANDER E. KEITH.

Telephone engineers of all grades have received the news of the passing of Alexander E. Keith with universal regret. He died on September the 24th last, at Chicago, in his 66th year.

Automatic Telephony has lost an outstanding personality and a real pioneer, as Mr. Keith was associated with the primary development of the Strowger system in America as long ago as 1893. From that time onwards he has consistently directed his energies to the perfection of machine switching in telephony, and his name has been identified with many of the major advances in this extensive field.

In the course of his long career Mr. Keith has filled many important engineering and executive posts; it is in no small measure due to his efforts, that the Automatic Electric Inc. of Chicago, is the vast and flourishing organisation it is to-day. In this country he is best known by the " line-switch " bearing his name. Prior to the invention of this earliest " preselector " type switch by Mr. Keith, the Strowger system, on its original basis of " one connector per subs. line," was little more than an interesting mechanical experiment. The cost of providing a telephone service on the basic Strowger two-motion switch plan, was prohibitive. The Keith Line Switch revolutionised this, and machine switching was thereby enabled to commence its long, uphill struggle against prejudice and convention, with its most serious handicaps, that of excessive initial plant costs, practically removed at the outset. Competition with the many manually operated systems that held the arena with such apparent security became an accomplished fact. It can, perhaps, be claimed that this invention of Mr. Keith is the most important contribution the science of automatic telephony has yet received, despite the fact that it was one of the earliest.

Undoubtedly, many of our modern conceptions, such as trunking and grading, have their genesis in this the first preselector switch.

Simplicity is an attribute of genius—in invention, as in other things, and this is aptly exemplified in the Keith line switch. Just a line relay, a two-coil, single core electromagnet, attracting an armature carrying a pivoted plunger to engage the bank contact springs. Quite simple, almost elementary, but it did its job and is, at the present time, doing it well. Nearly twenty thousand " Keith " Line Switches are " plunging in " on the service of British telephone subscribers. At least half of this number have stood the acid test of working conditions for nearly ten years. And the Keith Line Switch is not quite so prehistoric as many of us may imagine. What is the two-step relay but a variant of the combined pull down and bridge cut-off? The principle is there, if the application be different.

The Keith Line Switch had its limitations. Mr. Keith himself was among the first to acknowledge them and to suggest alternatives. It has now been supplanted by the rotary type of preselector. Progress in a healthy industry inevitably imposes revolution of this nature. The cherished notions of to-day become the history of to-morrow. This is but the natural outcome of a ceaseless striving after perfection. It was this that produced the Keith Line Switch, and laid the foundation of Automatic Telephony as we know it to-day.

A fitting tribute to the memory of A. E. Keith is the fact that the experience which has led to the evolution of the Director, the Discriminator, and other of our modern complexities has been gained largely on installations equipped with the Keith Line Switch. F.J.G.

Mr. L. M. Ericsson, the Swedish Telephone Engineer and Manufacturer, died on Friday, the 17th December.

Mr. Ericsson was the founder in 1876 of the organisation bearing his name and therefore was the World's pioneer manufacturer of the Commercial Telephone. He commenced business in a very modest way, but being a man of keen intelligence and foresight his business rapidly grew until to-day it is the largest telephone manufacturing concern in Europe. In this and other Countries the Ericsson concern employs many thousands of workpeople.

THE ROMANCE OF THE FORTY THIEVES.

(Modern Version).

Ali Baba in years gone by uttered the magic words "Open Sesame," and behold the treasures of the world were revealed to him.

The romance of the modern forty thieves and the treasure they found is well worth recording, and it will have served its purpose if it stirs the young men in the Post Office Engineering Department to the chances open to them and the positions in the service to which they can attain if they only work for them.

Just over three years ago the Research Section, Dollis Hill, required officers for Main Cable Testing work. The question was: "Can we obtain suitable men from the rank and file?" The answer was: "Try." An examination* was held and about 300 young men sat for it. Of these, 40 were chosen—most of them Unestablished Skilled Workmen and Youths—and they set out for Dollis Hill to commence the training course.

There were tall men, small men, stout men and thin men; in one corner could be heard the Cockney dialect, in another the Yorkshire, in another the Lancashire and in another the Scottish—a modern Babel indeed—but there was one thing these young men had in common, and that was the ambition to succeed.

The class started in July 1923, and the fact that these young members of the staff were very keen on their work soon drew attention from other members of the staff and some one in jest

* Messrs. A. B. Morice and A. Morris. "The Training of Officers of the British Post Office Engineering Department in Precision Testing of Underground Cables": Journal *P.O.E.E.*, July, 1926, Vol. 19, Part 2, p. 196.

nicknamed them "The Forty Thieves." Thieves, in a sense, because knowledge was the plunder, and, as will be seen later, the spoils were very evenly divided. The name "Forty Thieves" has endured, so much so, that individual members of the class are now labelled as one of the "Forty Thieves."

At the end of a seven weeks' course, 23 members of the class were selected for the work on hand, and the remaining 17 were—after a period of practical training—returned to their districts to act as reserves. All members of this class were given the temporary rank of Acting Inspector.

Three years have passed and these men—the greater number still on the best side of thirty—are now for the most part in the major ranks of the service.

Here are the figures :—

Assistant Engineers	14
Inspectors	12
Acting Inspectors	4
Returned to District	2
Traffic Appointments	2
Left Service	6
	40

I am sure that now the tale has been told there is no one but will agree there is some romance even in this practical service of ours. The chance still remains—examinations for Inspectors and Assistant Engineers are still being held—and every eligible youngster should try to follow the footsteps up the hill and prove that there are more good fish in the sea than have ever been taken out of it.

No. 5.

LONDON DISTRICT NOTES.

DURING the quarter ended September 30th, 1926, the number of exchange lines, internal extensions and external extensions provided and recovered were as follows :—

	Exchange lines.	Internal Extensions.	External Extensions.
Provided ...	9,063	5,276	916
Recovered ...	3,256	3,088	531
Net increase ...	5,807	2,188	385

EXTERNAL CONSTRUCTION.

Mileage Statistics.

During the three months ended 30th September, 1926, the following changes have occurred:—

Telegraphs.—A net decrease in open wire of 52 miles and a net increase in underground of 326 miles.

Telephones (Exchange).—A net decrease in open wire (including aerial cable) of 156 miles and a net increase in underground of 42,481 miles.

Telephones (Trunk).—A net decrease in open wire of 2 miles and a net increase in underground of 1,199 miles.

Pole Line.—A net increase of 97 miles, the total to date being 5,549 miles.

Pipe Line.—A net increase of 447 miles, the total to date being 7,233 miles.

The total single wire mileages at the end of the period under review were:—

Telegraphs	25,120
Telephones (Exchange)	1,801,700
Telephones (Trunks)	63,853
Spares	69,504

INTERNAL CONSTRUCTION.

New Exchanges.

Rodney Exchange, C.B. No. 1 (Peel-Connor), of 3,900 capacity fully equipped, was opened on October 2nd to serve a portion of the Walworth Area. *Reliance* Exchange is being accommodated on this equipment temporarily.

The old Kellogg Exchange at *Battersea,* with its relief exchange of *Latchmere,* was replaced by a 10,000 line C.B. No. 1 type Exchange (General Electric Co.) on the 16th October. The present fitted capacity is for 1,740 direct lines.

A C.B. No. 10 Exchange with 6-panel multiple, installed by Messrs. Siemens, replaced a magneto exchange at *Bexley Heath* on November 6th. It is a 3,000 line switchboard, the present equipment being for 1,100.

A new C.B. No. 1 Exchange has been installed at *Burgh Heath* by Messrs. Ericsson. It has an ultimate capacity for 4,500 lines; the present fitted capacity is for 1,740 direct exchange lines.

Seven Kings was opened as a hypothetical Exchange on Ilford in July. The new Exchange (Siemens C.B. No. 10, 1,500 lines) was opened on December 2nd.

Wallington New Exchange (C.B. No. 1) is nearing completion and will be opened in the first quarter of 1927. This is a

Peel-Connor Exchange and the present equipment is for 2,900 lines.

Automatic Exchanges. Progress is being made with the installations at Mechanical Tandem, Bishopsgate, Holborn and Sloane.

C.C.I. The group of Coder Call Indicator Positions in the 1st Zone, comprising Addiscombe, Thornton Heath and Croydon Exchanges, have been tested out in readiness for use on the opening of the Mechanical Tandem Exchange at Holborn.

Hall Multi Coin Boxes. Coin Boxes of this type are gradually taking the place of the Coin Collecting Boxes in the Inner London Area. Call Offices in the Paddington and Gerrard Exchange Areas have been converted, and Royal and Museum Areas are in hand. It is expected that 2,000 of the Prepayment boxes will be fitted within the next year.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

ELECTION OF COUNCIL FOR YEAR 1926-7.
REPRESENTATIVE OF ASST. & 2ND CLASS ENGINEERS.

THE result of the election in respect of the above representative is as follows:—

*Hay, P. G.
Gear, W. J.
Gray, H. C.

The names are arranged in the order of votes polled and the successful candidate is indicated by an asterisk.

LOCAL CENTRE NOTES.

LONDON CENTRE.

SESSION 1926-27. (FIRST HALF).

THERE has been a steady increase in the Membership during the current year, and it is pleasant to record that there was a gratifying response to the application for papers for the general meetings.

The Session was opened by an address from the Chairman, Lieut.-Col. E. G. Lee, M.C., B.Sc., M.I.E.E., the subject chosen being "Transatlantic Telephony." As was anticipated, the attendance reflected the great interest which is taken in Wireless

Telephony in these days, there being 202 present. The address, which dealt with up-to-date developments of Radio Communication between this country and America, was supplemented by slides showing the Rugby Wireless Station and some highly interesting curves illustrating the effect of atmospherics on audibility at different periods of the day.

On the 9th November, Mr. W. Day, M.I.E.E., read a paper on "Phases in Automatic Telephony." The paper dealt with the subject under the following headings:—

Numbering schemes in Multi-Office Areas; Fundamental considerations concerning traffic discrimination; Statement of Principles embodied in existing types of discriminating switches; Common defects; Characteristics of an ideal discriminator; a P.O. Traffic Discriminator for Director areas; A limit to the economic use of common plant; Notification of abnormal plant conditions; Nature and effect of irregularities; Methods of control and indication in Main Exchanges; Transmission of emergency alarms from unattended Satellites to their Parent Exchange.

In view of the popularity of automatics there was no dearth of speakers, some of whom provided the light relief so necessary in a weighty subject of this nature by allusions to the word "phase" and its various definitions. It is not at present proposed to print this paper, but a copy has been deposited with the Librarian for reference by the Members.

On the 14th December Mr. H. Kitchen, M.I.E.E., read a long-awaited paper on "Economics of Line Plant Provision." This highly interesting contribution dealt with such subjects as comparative capital and annual costs for underground and overhead systems, apparatus for thrust boring, contract works, automatic layouts for multi-office areas, determination of practical telephone centres, and the controversial question of "teeing." A spirited discussion was opened by Capt. J. G. Hines and representative opinions were obtained from Major H. Brown and others. Mr. W. B. Crompton gave an explanation of the simplicity of the "teeing" arrangements. It is unfortunate that the discussion had to be somewhat curtailed owing to the late hour.

In continuance of its policy, the Committee have arranged for a series of informal meetings, and the first of these was held on the 26th October, when Mr. G. F. O'dell, B.Sc., A.K.C., M.I.E.E., opened a discussion on "The growth of American Influence in the Post Office." The record attendance at this meeting must have been very gratifying to the author. May one dare to suggest that the large attendance may not have been wholly due to the popularity of Mr. O'dell, but might in some measure be explained by the fact that the subjects dealt with represented only about 10 per cent. telephones?

The second informal meeting was held on November 23rd, when Mr. W. Dolton, M.I.E.E., offered some observations on "Electrolytic Damage in the London District." It is unfortunate that so many members were unable to be present at this meeting as Mr. Dolton had evidently taken a great deal of trouble to prepare his subject matter and erect the demonstration apparatus, the result being a highly interesting and instructive address. It is, however, very nice to record that the majority of the members present entered keenly into the discussion.

Arrangements were made for a visit to the Standard Telephone Company's Hendon Works on the 28th September. The number of members wishing to attend was so large that a ballot was necessary, and the successful 140 had a most enjoyable time. The party were conducted round the Works in a manner which reflected great credit on the Standard Company's organisation. The Committee would like to take the opportunity of thanking the Managing Director and his Staff for the excellent programme arranged for the visitors.

It is proposed to visit the G.P.O. Holloway Factory early in January.

F.W.F.

EASTERN CENTRE.

The following is an extract from a paper read before the Eastern District, I.P.O.E.E., Local Centre, by Mr. C. J. Jones, Officer-in-Charge Fenny Stratford Repeater Station, at the Majestic Cinema, Fenny Stratford.

The paper was excellently illustrated by slides.

Mr. J. F. Lamb, M.I.E.E., Superintending Engineer, presided, and was supported by Major Bachelor, D.S.O., Assistant Superintending Engineer, Mr. A. J. Sharpley, Sectional Engineer, St. Albans, Mr. W. Cruickshank, M.I.E.E., and Mr. E. S. Ritter, D.F.H., A.M.I.E.E., and other officers from E.-in-C.'s office, Mr. S. W. Bassett, Technical Section, Cambridge, and many other engineers and officers of the Eastern District.

A very intelligent interest was displayed by the Eastern District and a good attendance resulted, approximately eighty members and associates being present.

Mr. Lamb proposed a vote of thanks to Mr. C. J. Jones, who suitably replied.

Owing to lack of time no discussion took place, but the meeting adjourned to the Repeater Station, where one of the engines was started to enable the party to watch operations on the spot. The party was made up into four groups and conducted round the station, while a detailed explanation of the plant was given by Mr. C. J. Jones, ably assisted by three of his staff.

The photos are by Mr. J. E. Statters, Messrs. Bed.'s Times Publishing Co., and Mr. W. G. Berrill, a member of the Repeater Station Staff.

FENNY STRATFORD REPEATER STATION.

By C. J. JONES.

Repeaters were first installed at Fenny Stratford in the year 1919. The installation was carried out by the local staff, under the supervision of the E.-in-C.'s Office, Telephone Section. These repeaters were known as the 21 type, *i.e.*, "Two-way, one valve, one stage." They were installed in the old Main Line Test Hut, and the circuits in which they were inserted were 7 phantom unloaded circuits in the TSX—BM—LV cable. These circuits have since been loaded and the cable put straight through without repeaters.

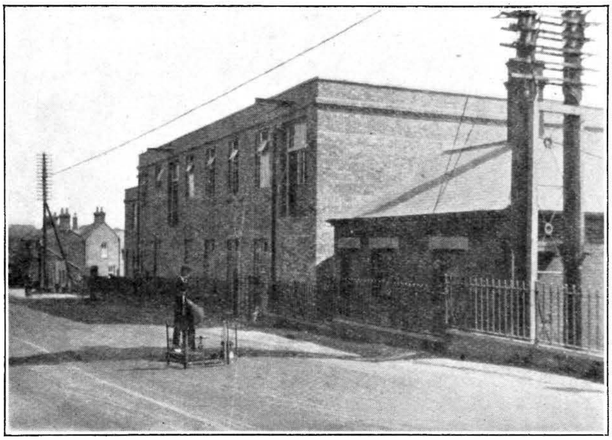


FIG. 1.—FENNY STRATFORD REPEATER STATION.

When the London—Manchester Cable was laid, in 1921, a temporary Repeater Station, equipped with 40 22-type repeaters, was installed in the Test Hut and a temporary hut erected to house the Power Plant, consisting of a 10 H.P. oil engine and the necessary batteries for the filament plate and grid circuits. This plant was in use up to the time of the transfer of the Manchester Cable into the new Repeater Station in June, 1925. The temporary Repeater Plant is being transferred to Manchester and the Power Plant has been transferred to Marks Tey Repeater Station.

The new Repeater Station is situated where the main Watling street crosses the Grand Junction Canal and is adjacent to the "Old Main Line Test Hut." Those officers of the department who served with the Royal Engineers doubtless remember the place well.

Fig. 1 shows side view on Watling Street.

The distance from London is 46 miles and from Derby 82 miles. The building is of brick with reinforced concrete floors. The roof is flat, being so designed for the extension of the building upwards. It is at present a two-storey building and the layout is as follows:—

Basement.—A cable chamber where the Trunk cables enter the building; Heating Installation chamber.

Ground Floor. Power Room, Battery Room, Linemen's Room, and Lavatories.

First Floor. Repeater Room, Inspectors' Office and Linemen's Room.

The building was designed to accommodate 1000 repeaters (ultimately).

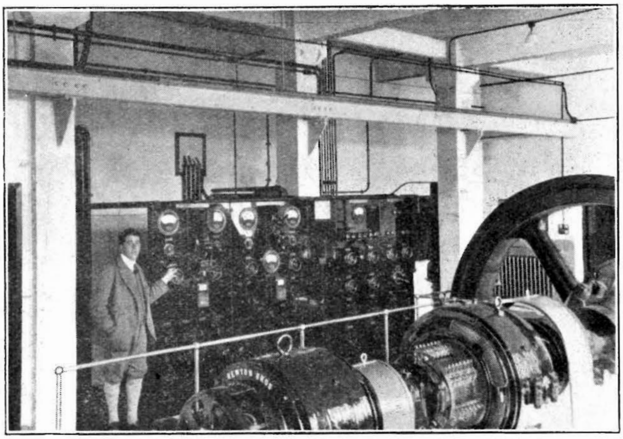


FIG. 2.—FENNY STRATFORD POWER BOARD.

Power Plant (*Engine Room*).—The plant consists of the following:—

2 80 BHP semi-diesel engines.
2 32 Kilowatt Machines (for charging filament A batteries).
2 11 Kilowatt Machines (for charging plate B Batteries).
2 Ringing Dynamotors for 17 cycle ringing circuits.
2 Electric Motors, 5 H.P., for driving compressors.
2 Electric Motors, $2\frac{1}{2}$ H.P., for driving fuel pumps.
2 Electric Motors, 2 H.P., for driving cooler pumps and fans.
2 Heenan Water Cooling Plant for Engines.
2 Air compressor pumps for charging containers.

1 Power Switch Board of 4 panels, equipped with the necessary switches, circuit breakers, and testing instruments.

1 Travelling Crane for lifting weights up to 25 cwt.

Fig. **2** shows the Power Switchboard.

The engines are direct-coupled; one 32 Kilowatt Generator, 32 volts at 1,000 amps., for charging A Batteries, and one 11 Kilowatt Generator, 200 volts at 50 amps., for charging B Batteries. The air compressors, motors, and cylinders are used for starting the engines. A safety device, the Moniton Valve, is associated with the water cooling system. The fuel used is crude

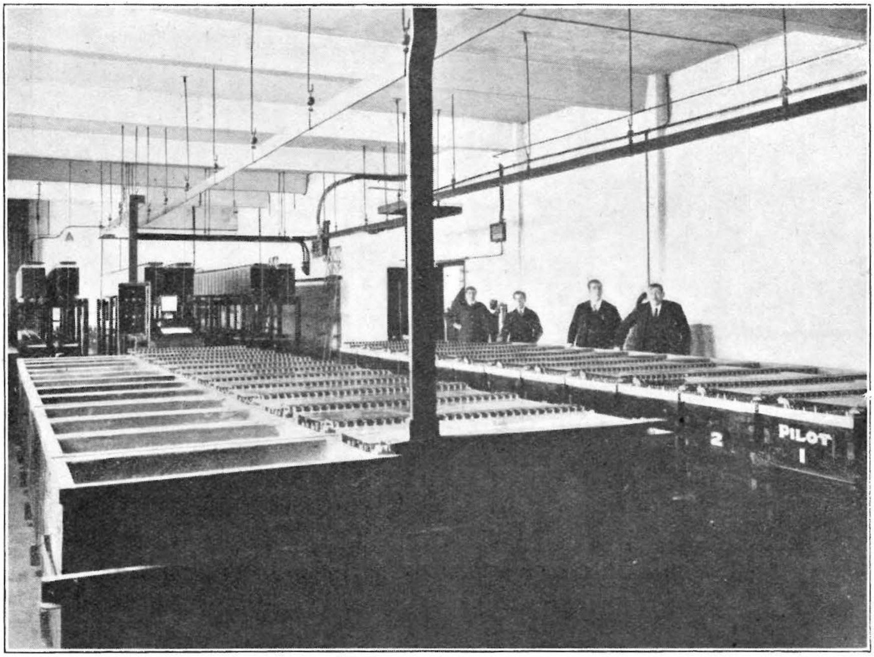


FIG. **3**.—FENNY STRATFORD BATTERY ROOM.

oil of a specific gravity .93. The oil is stored in two 2,500 gallon tanks situated under the front entrance. The oil is conveyed to the subsidiary tanks by electrically driven rotary pumps. A few details with respect to the Engines and Power Plant may be of interest.

Weight of flywheel = 6 tons 14 cwt.
Height ,, = 9 ft. 2 ins.
Width ,, = 1 ft. 4 ins.
Cost of fuel per unit generated = $\frac{1}{2}$d.
Makers: Messrs. Ruston and Hornsby, Lincoln.

Machine and Power Cables were supplied and installed by Messrs. Newton Bros., Derby, both firms being sub-contractors to Messrs. The Automatic Telephone Coy., Liverpool, who were the main power plant contractors.

Power Plant (Battery Room. Fig. **3**).—The Batteries were installed by the makers, the Alton Battery Coy., Alton, Hants, who were sub-contractors to The Automatic Telephone Coy., and consist of the following:—

2 ("A") Filament Batteries, 24 volts of 5,075 amp. hr. capacity, with an ultimate capacity of 9,450 amp. hr These capacities are calculated at the 10 hr. rate.

Weight of 1 Cell = 2 tons 4 cwt.
Total weight of "A" Batteries = 52 tons 16 cwt.

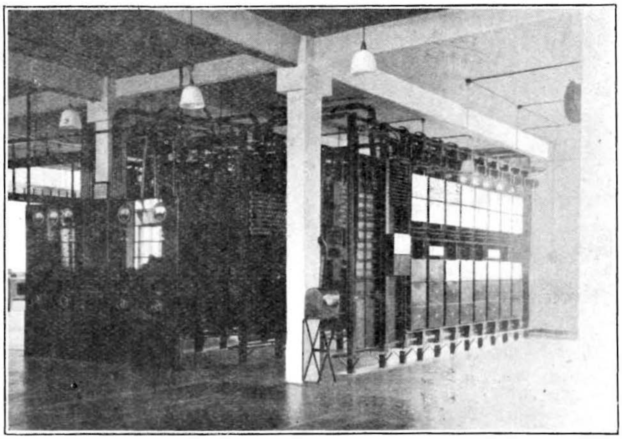


Fig. **4**.—Fenny Stratford 2-Wire Repeater Racks.

"B" Plate Batteries. There are 3 sets of 75 cells, *i.e.*, 150 volts of 300 amp. hr. capacity, and are utilised as follows:—

1 set on Plate circuits of Repeaters.
1 ,, ,, Electric Light circuits (123) and Auxiliary Motors.
1 ,, ,, Charge, or in reserve.
5 Regulating Cells for use in Electric Light circuits.

"C" Grid Batteries. 2 sets of 5 cells, each 10 volt 20 amp. hr. capacity for priming the Grid circuits.

"D" Counter E.M.F. 2 sets of 10 cells, each 20 volt for opposing the "B" battery to give a terminal voltage of 130 volts for the plate circuit.

Total number of cells in Battery Room = 284.

Peak load "A" Battery = 100 amps.
,, ,, "B" ,, = 2.5 ,,

Repeater Room.—The cables serving the building are the TSX.MR cable 160/40 and the TSX.DY cable 88/40 and 156/20.

All cables pass to the Repeater Room from the cable chamber *via* the cable chute and are terminated on Tablets, TK Test, 18 circuit.

A Cable Test Desk equipped with a precision test set is provided for dealing with incipient faults.

From the line transformers the circuits are cabled to the Cable Distribution Frame, where they are cross-connected to the Repeater Units.

Fig. **4** shows a general view of the 2-wire Repeater Racks, with the Voltage Control Boards in the foreground. Two additional racks have been installed since this photograph was taken.

Four-wire repeater units have been installed by the G.E.C. This equipment is of a temporary nature and is known as the Fire Emergency Equipment. On the completion of the 4-wire equipment now being installed by the Standard Telephones and Cables Ltd., the temporary 4-wire equipment will be recovered, and stored for use in emergency.

The station at the time of writing has 146 Repeaters working, and is equipped with the following :—

268	2-wire repeaters	=	536	valves
54	4 ,, ,,	=	216	,,
13	4 ,, ,,	=	53	,,
	Total ...		804	,,

A Repeater Test Desk equipped with an impedance bridge, gain set, and equipment for connecting lines to other stations and Repeater Racks, will be installed shortly. The whole of the Repeater and associated apparatus was installed by the Standard Telephones and Cables Ltd. with the exception of the temporary 4-wire equipment.

NORTHERN CENTRE.

The Session opened on the 20th October, when the Vice-Chairman of the Centre, Mr. F. G. C. Baldwin, M.I.E.E., introduced a paper on " Scientific Organisation and the P.O. Engineering Department," which was taken as read in order to afford sufficient time for discussion. The paper dealt in a general way with scientific management in relation to the work of the Department and of the individual worker and gave illustrations of the application of scientific organisation with satisfactory results to certain aspects of the work in the Northern District, *e.g.*, Repairing of Telephone Switchboard Cords, The Handling of Stores, etc. Composite Works and their organisation, and the relationship of Planning to the Execution of Works were also subjects of detailed consideration, and the paper concluded with the suggestion that the subject of scientific organisation should be " included in the curricula of all our educational establishments as an essential companion to the pure and applied sciences and provided for in the syllabus of our examining bodies," the author's opinion being that " the planning of works in a scientific manner, the preparation and use of comprehensive works instructions, the organisation of works and the exercise of scientific methods generally as labour saving and economic measures can all be developed to a much higher state of perfection with very important advantages to the Engineer and the Department generally."

The second meeting of the Session was the occasion when Mr. J. Lane's paper on " The Control of Advice Note Work " was the subject of consideration and discussion, the paper being accepted as read. The paper covered the specified ground in a very complete and adequate manner and will be a valuable " vade mecum " to all members interested in this phase of the Department's work. In the opening paragraphs of the paper Mr. Lane stated that " the provision of additional telephone facilities is second in importance only to the maintenance of the service to existing subscribers and in the same way as everyone realizes the necessity for, and takes a pride in, restoring the service without delay in the case of breakdowns, so special efforts should be made to complete quickly orders received for new subscribers. Further, the staff comes into immediate contact with the public and the credit of the Department is closely associated with the speedy execution of this class of work, and in addition it is highly desirable that non-revenue earning plant should be brought into operation as quickly as possible. The Secretary to the Post Office very strongly supports the view that nothing more seriously tends to discredit the administration of the telephones than delay in providing service, and the object of this paper is to illustrate and facilitate the control of Advice Note work."

The members of the Centre have been invited by the Institution of Electrical Engineers to attend the Faraday Lecture by Professor Thornton, O.B.E., D.Sc., M.I.E.E., on the 24th November, the subject being " What is Electricity? "

West Hartlepool Exchange Transfer.

On the 25th September last another link with the past was severed when the subscribers at West Hartlepool were transferred from the old Magneto Exchange to the new Siemens' No. 16

Automatic Exchange. The subscribers at Hartlepool were transferred at the same time—Hartlepool being a satellite Exchange.

The installed capacity of the new Main Exchange is:—

		Ordinary Subs.	*Coin Box Lines.*
Initial Equipment	...	1100	30
Ultimate ,,	...	1700	50

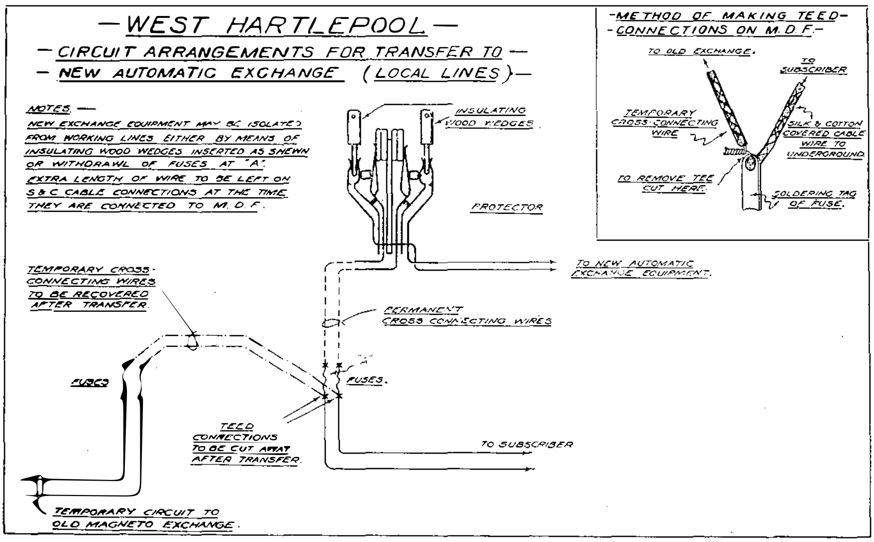
with M.D.F. equipment for 3,080 lines.

The capacity of the Satellite Exchange at Hartlepool is:—

		Ordinary Subs.	*Coin Box Lines.*
Initial Equipment	...	170	10
Ultimate ,,	...	200	10

with M.D.F. equipment for 480 lines.

The Main Exchange is accommodated in a substantial building purchased by the Department and adapted by the Office of Works for the purpose. It is situated about 400 yards from the old Exchange.



Owing to the situation of the Exchange with respect to the cabling and also due to a development scheme being carried out at the same time as the transfer arrangements, it was found possible, by utilising the spare wires, to loop all the working circuits through the new Exchange M.D.F. and back to the old Exchange. The arrangements made were such that there were no external tees either underground or open. In all cases the tees were made on the new Exchange M.D.F. in the manner shown on the accompanying diagram.

When the external cables were terminated on the new Exchange M.D.F. a $\frac{3}{4}$ inch extension was left on every S. & C.C. wire end. To these extensions the temporary jumpers carrying the circuits back to the old Exchange were soldered as shown in inset on diagram. The temporary jumpers were not passed through the jumper rings, but were tied together outside the rings. This was in order to avoid interference with the permanent jumpers and to facilitate speedy removal after the transfer. After all the jumpering had been completed the S. and C.C. wire extensions not required for cross-connecting were cut away.

Except for testing purposes the fuses were not inserted at " A " until the day previous to the transfer, prior to which the new exchange equipment had been insulated by means of sash line inserted between the Test Springs of the Protectors.

Special telephone circuits were provided from the Auto Exchange to the principal points affected by the transfer, and in these cases a loop was made in the sash line so as not to insulate the Test Springs of the Protectors concerned.

At the old Exchange the usual arrangements were made for transfer by withdrawing the Heat Coils, prepared linen tape 7/8" wide folded to 7/16" being inserted behind the Heat Coils on both sides of each 50 line strip, the tape being looped at the bottom.

At Hartlepool Exchange the new Automatic Exchange was installed in the same building at the Magneto Exchange, and in this case the Auto Equipment was terminated on duplicate protector apparatus on the M.D.F. The method of transfer was first to insert wedge-shaped hardwood strips in the line springs of the protectors serving the old Exchange Equipment and then to withdraw the sash cord from the line springs of the protectors serving the new equipment.

Half the trunks and junctions were transferred in advance at 1.0 p.m. To enable this to be done, instead of sash cords, wood wedges were used for insulating the Test Springs of the Protectors, those in the Junctions transferred in advance being withdrawn separately. The remainder of the wood wedges in the Junction circuits were threaded with whip-cord and were dealt with at the same time as the Main transfer.

At 2.0 p.m. the signal was given for the transfer to be carried out; the Heat Coils were withdrawn at the Old Exchange, after which the wood wedges and sash cords were withdrawn at the New Exchange—the transfer at Hartlepool proceeding simultaneously. The whole period occupied by the transfer was only 35 seconds, after which the Traffic Staff immediately commenced to test out.

The actual number of working lines transferred was:—

Direct Exchange Lines ...	1111
Junction Lines	12
Trunk Lines	61
	1184

The number of faults after the transfer being:—

Line	3
Exchange	5
Subs. Apparatus	3
	11

or approximately 1%.

After the testing out had been completed, the whole of the tees were cut away and the temporary jumpers removed from the M.D.F., this work being completed before 9.0 p.m.

In order to avoid interference from the subscribers' magneto apparatus the work of cutting away the old apparatus and completing the permanent connections on the auto apparatus was immediately commenced, and this work was completed by the end of the following week, the apparatus being afterwards collected by motor van.

It should perhaps be mentioned that although it was necessary after the transfer to open joints at certain points in order to restore spares to their respective D.P.'s the work carried out was on spare wires only and there was no interference with any working circuit.

J.J.S.

SOUTH LANCS. CENTRE.

The Session was opened on the 18th October with an address by the Chairman, Mr. W. J. Medlyn, outlining the "Progress and Development in the Post Office Engineering Department" during the preceding year. The annual resumé of the Department's activities is highly appreciated by the membership and on this occasion the address surpassed in interest those of previous years.

The lecturer for the second meeting of the Session held on November 15th was Mr. A. Magnall, until recently Sectional Engineer of the Manchester West Section. The subject selected by the lecturer was his "Reminiscences." A brief review of his career was given which proved both interesting and instructive. He described how starting on the lower rung of the ladder he had climbed to the position of Sectional Engineer and ascribed his success mainly to hard work. Many problems with which he had been confronted over his long experience, as telephone engineering practice developed, were described and were illustrated by a number of lantern slides. Some instances in which, in pursuance of his duties, he had found himself in difficult and dangerous positions, were related, and the manner in which he extricated himself bore witness to his capacity, well known to his colleagues, for overcoming difficulties which to many would have appeared insurmountable. The lecture was interspersed with a lively humour and the reminiscences of one who by sheer hard work and determination has made good, should prove an inspiration to the younger members of the Institution.

A pleasing feature of the occasion was the presence of colleagues with whom the lecturer had been associated in the earlier stages of his engineering career. Among these was Mr. J. M. Shackleton, who proposed the vote of thanks, and Messrs. J. Nevin and J. Parker, who preceded Mr. Magnall in retiring from the strenuous life of the Post Office Engineering Department for, it is hoped, a long period of leisure. A separate article dealing with Mr. Magnall's retirement will be found below.

Mr. Alfred Magnall.

The 17th October, 1926, marked the retirement from the service of Mr. Magnall, Sectional Engineer, Manchester West Section. It is with very genuine regret that we record the official passing of our old friend, for his sterling qualities of heart and mind had endeared him to everyone.

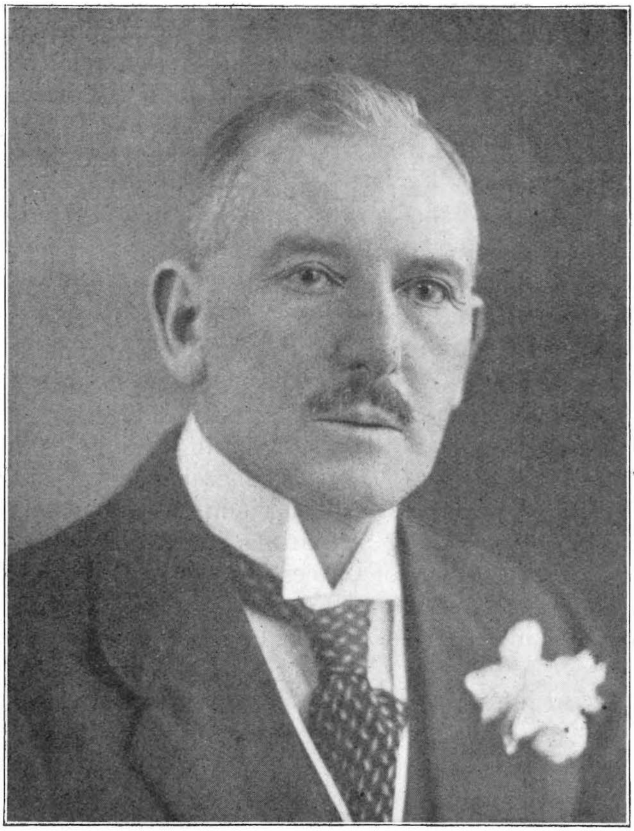
Mr. Magnall's service extends over 43 years, commencing with the Lancashire and Cheshire Telephone Co., which he joined in Liverpool in 1883. He rose rapidly from Lineman to Inspector and then to District Manager, Warrington. But in this last capacity his engineering abilities were somewhat wasted and he was very soon promoted to be Engineer at Manchester with a large and doubtless welcome addition to his salary. He entered on his new duties with an enthusiasm which never waned. He was always generous in giving the results of his vast experience to his colleagues and he has many lectures and papers to his credit. It would, moreover, be fair to describe Mr. Magnall as one of the pioneers in the development of modern external plant.

In 1911 Mr. Magnall was responsible for the lay-out of the new telephone system in Constantinople, and it must be a source of pride to him to know that his forecasts have been fully justified in the years which have elapsed.

With the transfer of the local telephone systems to the State, Mr. Magnall became a civil servant and very soon earned the affectionate regard of everyone. If reason for this be demanded, then it is to be found in a vivid personality allied with transparent honesty in all his dealings and directed by a kindly heart.

Owing to the uncertainty of Mr. Magnall's future plans the presentation, made to him on the 18th October, had, perforce, to take the form of a well lined case of Treasury Notes. The meeting was presided over by Mr. Medlyn and the presentation made by Mr. T. E. Herbert, who claimed Mr. Magnall as a friend of 30 years' standing.

T.E.H.



MR. ALFRED MAGNALL.

NORTH WESTERN CENTRE.

The opening meeting of the 1926-27 Session was held in the Lecture Hall of the Preston Scientific Society, Preston, on the 11th October, 1926, when a paper entitled " A Comparison of Desiccation Methods " was read by Mr. E. Hopper.

Mr. Shackleton presided, and in his opening remarks referred to the interesting programme arranged for the Winter Session.

Mr. Hopper opened his paper with an explanation of the physical considerations involved in the process of desiccation and proceeded to explain the application of Dalton's, Boyle's and Charles' laws. The questions of pressure and temperature were dealt with at length, the advantages of the use of Carbonic Acid Gas, Compressed Air, etc., compared, and the treatment of isolated joints touched upon. The paper was illustrated by special apparatus and diagrams and was followed by a useful discussion.

The second meeting of the 1926-27 Session was held in the Lecture Hall of the Preston Scientific Society on the 2nd November, 1926, when a good attendance of members assembled to hear a paper entitled "Local Line Plant Economics" by Mr. H. Kitchen, of the Engineer-in-Chief's Office. Mr. Shackleton presided, and before the proceedings commenced the members present stood in silence as a mark of respect for Captain A. W. Sirett (Executive Engineer, Preston External Section), who had passed away since the last meeting of the Centre.

The Chairman explained that owing to unavoidable circumstances it was not possible for Mr. Kitchen to attend in person to read his paper, but that Mr. W. B. Crompton, of the Local Lines Section at Headquarters, had kindly consented to come to Preston and read the paper in Mr. Kitchen's stead.

The paper opened with a reference to the subject of expenditure on local line plant, and statistics illustrating the financial position of the service were presented. The general question of economics was then dealt with and the following items were covered:—Ducts, Wood Troughing, Boring Apparatus, Contract Work, Teeing Systems, Records, Types of Cables, Overhead Work, Lay-out of areas, Junction & Line Plant, Transmission, etc. The paper was illustrated by lantern slides.

A hearty vote of thanks was accorded to Mr. Kitchen for his interesting and informative contribution and to Mr. Crompton for his kindness in reading the paper and for his lucid exposition of the various details. A number of points were raised in the discussion to which Mr. Crompton replied at length.

A meeting of the Centre was held at Preston on the 6th December, 1926, when a paper entitled "Ways and Means in an Engineering Section" was read by Mr. S. Upton, A.M.I.E.E.

Mr. Shackleton presided over a good attendance.

Mr. Upton opened his paper with a review of the scope of the subject and proceeded to deal with the following points:—Staff, Works, Faults, Correspondence, General Office Work, Recruitment and Training. The paper was illustrated by specially prepared diagrams.

Upon the proposition of Mr. W. J. Finlayson, seconded by Captain Buchanan, and supported by other speakers, a hearty vote of thanks was conveyed to Mr. Upton for his interesting paper. An animated discussion followed and many points were raised to which Mr. Upton replied.

D. BARRATT.

CAPTAIN ALBERT WILLIAM SIRETT, R.E. (T.), A.M.I.E.E.

The friends throughout the service of Captain A. W. Sirett will regret to hear of his premature death at his home in Fulwood, Preston, on the 23rd October. Captain Sirett, who was in his fifty-seventh year, entered the Post Office service on the 1st April, 1885, as a telegraphist at Manchester, where his father was Superintendent of Telegraphs. In September, 1891, he was transferred to the Engineering Department as a 2nd Class Junior Clerk, and after service in that capacity and as 1st Junior Clerk, first at Manchester under the late Mr. John Doherty, and afterwards at Cork and Newcastle, he was appointed 2nd Class Engineer on the 1st May, 1897, with headquarters at Coventry. On promotion to a 1st Class Engineership Captain Sirett removed to the South Wales District in April, 1906, and was stationed at Gloucester as Sectional Engineer, where in due course he passed to the new class of Executive Engineer on the 1st July, 1911.

Captain Sirett was a keen Volunteer and Territorial soldier, having served successively in the 5th (Ardwick) V.B. Manchester Regiment, Newcastle-upon-Tyne Royal Engineers, 2nd V.B. Warwickshire Regiment and 5th V.B. Gloucestershire Regiment. He joined the first-named Corps, with which the whole of the male members of his family had been associated since its formation in 1859, in 1888 and rapidly rose to the rank of Sergeant. His removal to Newcastle entailed severance from that Corps, but he immediately joined the Newcastle Engineers and was promoted to Sergeant within a month of attestation, after having passed through the qualifying examination in Military Engineering, a testimony to his interest and thoroughness in the Volunteer movement. During his service with the Warwickshire Regiment he rose to the rank of Colour Sergeant and became one of the leading shooting men of the County of Warwickshire. He was the "best shot" of his battalion, and was chosen to go to Bisley to represent it in the National Competitions and was elected a member of the English Twenty Club, a high honour amongst shooting men. He finished his Territorial peace time service in the Gloucestershire Regiment in December, 1911, with the rank of Quartermaster and Honorary Lieutenant, having received the Volunteer Long Service Medal and the Coronation Medal (King George V.).

On the outbreak of the Great War, Captain Sirett immediately volunteered for service and on 1st July, 1915, he was gazetted 2nd Lieutenant in the Royal Engineers Signal Service, the same Gazette announcing his promotion to Lieutenant. He was posted to the Divisional Signal Company of the 2/1 Welsh Division, joining the Division in North Wales after a short course of training and was there appointed Acting Captain. Early in 1916 he was sent to Farnham to raise and train the 71st Divisional Signal Company. He took this Company through the whole course of their training, proceeding with them to Colchester and Haynes Park and received gratifying reports from his superior officers upon the methods and success of his work. Towards the end of 1916 he was ordered to France, where he joined the Headquarters of the famous Anzac Corps and remained on the lines of communication until the Armistice. During this period he was second in command of "L" Company, Royal Engineers Signal Service, at G.H.Q.

Captain Sirett was demobilized on the 26th January, 1919, and on resuming his civil duties was transferred to the North Western District in charge of the Preston Section and there he remained until after only a fortnight's illness he succumbed to an attack of pneumonia.

Captain Sirett was interred with military honours in the quiet churchyard at Broughton, near Preston, on the 27th October, when a representative gathering of his late colleagues and friends attended to pay their last respects to his memory. A party from the East Lancs. Regiment, accompanied by his friend Lieut.-Col. Cranston, O/C Fulwood Depot, fired three volleys over the grave, followed by the sounding of the "Last Post" and the "Reveille."

In addition to his military activities already noticed, Captain Sirett was greatly interested in all forms of sport and particularly in Rugby football. He was treasurer of the Preston Grasshoppers R.F.C. and County representative, and a member of the West End Tennis Club and of the Broughton and District Social Club. He also took a prominent part locally in all movements for helping ex-service men and was treasurer of the Preston United ex-Service Men's Committee (War Widows and Orphans). R.I.P.

R.A.J.

SCOTLAND WEST CENTRE.

The first meeting of the current Session was held in the Royal Technical College on Monday, 4th October. In the unavoidable absence of Mr. Aitken the chair was taken by Mr. Hardie. The lecturer for the day was Mr. Vincent A. M. Bulow, of the British Broadcasting Coy., and the subject treated was "Some Links in the Broadcasting Chain."

The links considered were :—

Studio. General requirements; Resonance and damping; Methods adopted to improve the natural acoustics; Artificial echo.

Microphones. Discussion of various types of pick-up device used by B.B.C.

Amplifiers. General description of the various amplifiers used, including Line Correctors, and giving the average figures for gain or loss in the various pieces of apparatus.

Transmitters. Brief description of the transmitting apparatus at Main and Relay Stations.

Receivers. Brief statement of requirements.

The lecture was fully illustrated by lantern slides. On conclusion a hearty vote of thanks was accorded to the lecturer.

NORTH WALES CENTRE.

The first meeting of the 1926-27 Session was held at Shrewsbury on 13th October, 1926, when to an audience of about 75 members Mr. G. H. Carrier read a paper entitled " The Control of Expenditure by Supervising Officers." Mr. Carrier after outlining responsibilities of supervising officers in the matter of control went on to describe the headings under which funds are estimated and allocated, and to detail the methods of keeping records of allocations commitments and expenditure under the various classes of work. Finally the methods of record by the Inspector and the following up of progress were gone into very fully, and slides of the various printed forms used in these directions were shown on the screen.

The second meeting was held at Birmingham on 11th November, when a visit was paid to the Birmingham Telephone Repeater Station. There was an attendance of 97 members who were made up into conveniently sized groups as they arrived at the entrance, and taken on a tour of inspection by members of the repeater station, and of the Power Section Staffs, who explained clearly the functions of every piece of apparatus. The arrangements were so carefully made, that each member had an opportunity of seeing and understanding every unit in the whole installation, and general appreciation of the arrangements was expressed as the various groups completed their visit. Later on the same afternoon a meeting was held at the Birmingham Technical Schools, when Mr. R. P. Collins read a copiously illustrated paper entitled the " Birmingham Telephone Repeater Station." The arrangements of two and four valve repeaters were fully explained, and the whole lay-out of the Birmingham Station described. The lecturer described also in a very interesting fashion the maintenance testing and staffing arrangements which had been made at Birmingham.

The third meeting was held at Shrewsbury on 8th December, 1926, when J. B. Salmon read a paper on "Ferro Concrete Construction" to an audience of 75. After referring briefly to the general characteristics of concrete, the lecturer went on to the great extension in the use of concrete in building construction, and its utility in Departmental work.

Mr. Salmon, not satisfied with searching out and marshalling an imposing array of facts and figures not available to the ordinary member, had visited the Ship Canal Portland Cement Manufacturers works at Ellesmere Port, and had secured a large number of photographs of the processes of manufacture which were projected in illustration of his lecture.

Mr. Salmon exhibited also a number of specimens of the various constituents of Portland Cement, and of samples prepared for compression and tensile tests and after the lecture had terminated the members adjourned to an adjoining laboratory where a tensile testing machine was exhibited, and several samples were tested to destruction.

BOOK REVIEWS.

"Practical Physics." By T. G. Bedford, M.A., F.Inst.P. Longmans, Green & Co., Ltd. 10/6 net.

The volume is based upon the experimental work carried out by junior students at the Cavendish Laboratory, Cambridge University, but these experiments have been supplemented by accounts of other work not actually covered by the course conducted by the author.

The matter is divided into five parts: (1) Mechanics and Properties of Matter; (2) Heat; (3) Light; (4) Sound, and (5) Magnetism and Electricity. One hundred and fifty experiments are described, and in most cases the object of the experiment is explained and the precautions necessary for accuracy elaborated.

As the author admits, the book is intended to supplement and not to replace oral instruction, but it will form a valuable reference for others than students and teachers. Lecturers and demonstrators of physical sciences will find it very useful.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

Promotions.

Name.	Grade.	Promoted to.	Date.
Murray, J. K. ...	Executive Engineer, Scot. E. District.	District Manager, Scotland W. Telephone District.	29-9-26
Warner, A.	Assistant Engineer London District	Executive Engineer, London District.	11-10-26
Hammond, G. W. ...	Assistant Engineer N. East District	Executive Engineer, London District.	17-10-26
Bell, J. H.	Assistant Engineer London District	Executive Engineer, London District.	11-10-26
Stewart, W.	Assistant Engineer Scot. W. District.	Executive Engineer, Scot. East District.	31-10-26
Fletcher, Capt. J. E....	Assistant Engineer N. East District.	Executive Engineer, S. Lancs. District.	24-10-26
Dunlop, A.	Second Engineer, H.M.T.S. Monarch.	Chief Engineer, H.M.T.S. Monarch.	26-9-26
Middleton, W.	Third Engineer, H.M.T.S. Monarch.	Second Engineer, H.M.T.S. Monarch.	26-9-26
Thomson, A. J. ...	Fourth Engineer, H.M.T.S. Alert.	Third Engineer, H.M.T.S. Monarch.	7-11-26
Paines, A. V.	Fourth Officer, H.M.T.S. Monarch.	Third Officer, H.M.T.S. Alert.	7-11-26
Beer, H. G.	Prob. Asst. Engineer.	Assistant Engineer.	1-9-26
Britton, F. T. ...	,,	,,	,,
Moffatt, C. E.	,,	,,	,,
Ryall, L. E.	,,	,,	,,
Semple, L. G. ...	,,	,,	,,
Manning, F. E. A. ...	,,	,,	,,
Bryden, J. E. Z. ...	,,	,,	,,
Brent, W. H.	,,	,,	,,
Gemmell, W. T. ...	,,	,,	,,
Davies, T. A.	,,	,,	,,
Bewick, W.	,,	,,	,,
Barker, P. L.	,,	,,	,,
Loftus, R. W. ...	Chief Inspector, London District.	Assistant Engineer. London District.	24-11-26
Graham, R. B. ...	Chief Inspector, S. Lancs. District.	Assistant Engineer. N. East District.	To be fixed later.
Barlow, T. F.	Chief Inspector, N. East District.	Assistant Engineer. N. East District.	24-11-26
Graham, C.	Chief Inspector, S. East District.	Assistant Engineer. S. East District.	To be fixed later.
Keeble, A. G.	Chief Inspector, Testing Branch.	Assistant Engineer. Testing Branch.	24-11-26
Hooper, W. N ...	Skilled Workman, Class I., S. West District.	Inspector, S. West District.	8-1-26
Colbourne, R. W. ...	,,	,,	1-3-26
Davey, W. H. ...	,,	,,	6-4-26
Ferris, J. T.	,,	,,	10-1-26
Evans, R. B.	,,	,,	1-3-26
Morgan, C. R. ...	,,	,,	1-3-26
Harris, A. E.	,,	,,	1-3-26
Moss, J.	,,	,,	6-11-25
Shaw, J.	,,	,,	29-4-26
Woodley, E. T. M. ...	,,	,,	1-3-26
Coles, F. S.	,,	,,	1-3-26
Woods, D. T.	,,	,,	20-9-26
Swan, R. J.	Skilled Workman, Class I., Eastern District.	Inspector, Eastern District.	19-5-26

PROMOTIONS—continued.

Name.	Grade.	Promoted to.	Date
Mentasti, R. G. B. ...	Skilled Workman, Class I., S. Lancs. District.	Inspector, S. Lancs. District.	1-7-26
McNamara, H. J. ..	Skilled Workman, Class I., Scot. West District.	Inspector, Scot. West District.	11-1-26
Chubb, E.	Skilled Workman, Class I., E.-in-C.O.	Inspector, E.-in-C.O.	24-8-25
McFarlane, A. E. ...	Skilled Workman, Class I., E.-in-C.O.	Inspector, E.-in-C.O.	5-6-26
Rule, C.	Skilled Workman, Class I., Met. Power District.	Inspector, Met. Power District.	8-3-25
Grigg, G.	Skilled Workman, Class I. S.Mid. District.	Inspector, S. Mid. District.	11-5-25
Webster, C. J. ...	Skilled Workman, Class I. S. Mid. District.	Inspector, S. Mid. District.	13-11-26
Reardon, J.	Telegraphist, C.T.O.	Repeater Officer, Class II., S. West District.	7-3-26
Topham, C. L. ...	S.C. & T., Leeds.	Repeater Officer, Class II., N. Wales District.	29-8-26

RETIREMENTS.

Name.	Grade	District.	Date.
Shorrocks, F. W. ...	Asst. Staff Engineer.	E.-in-C.O.	19-10-26
Magnall, A.	Executive Engineer.	S. Lancs.	17-10-26
Beasley, B. J. ...	Executive Engineer.	E.-in-C.O.	21-10-26
Hill, G. J. W. ...	Assistant Engineer.	Testing Branch.	27-10-26
Nevin, J. A.	Assistant Engineer.	S. Lancs.	9-10-26
Thorogood, S. W. ...	Chief Inspector.	S. Wales.	18-8-26
Pulford, A. R. ...	Chief Inspector.	N. Ireland.	14-11-26
Saville, D. B. S. ...	Chief Engineer	H.M.T.S. Monarch.	25-9-26
McNeil, A.	Inspector.	N. Western.	1-9-26

DEATHS.

Name.	Grade.	District.	Date.
Sirett, A. W.	Executive Engineer.	N. Western.	23-10-26

TRANSFERS.

Name.	Grade.	Transferred. From.	Transferred. To.	Date.
Holland, A. E. ...	4th Officer.	"Alert"	"Monarch"	7-11-26
Day, W.	Assistant Engineer.	E.-in-C.O.	London District.	1-12-26

STAFF CHANGES.

CLERICAL ESTABLISHMENT.

PROMOTIONS.

Name.	Grade.	District.	Date.
Medland, G. F. ...	Executive Officer. E.-in-C.O.	Staff Officer. E.-in-C.O.	12-8-26
Malkin, J. L.	,,	,,	12-8-26
Oldfield, G.	,,	Acting Staff Officer, E.-in-C.O.	12-8-26
Stephenson, W. H. ...	,,	,,	12-8-26
Taylor, A. J.	Clerical Officer, S. Wales District.	Higher Clerical Officer, S. Wales District.	3-10-26
Turner, F. W. ...	Clerical Officer, N. Wales District.	Higher Clerical Officer, Scot. West District.	To be fixed later.
Williams, J. T. ...	Clerical Officer, S. East District.	Higher Clerical Officer, N. East District.	do.
Penfold, F.	Clerical Officer, S. East District.	Higher Clerical Officer, Scot. West Dictrict.	do.
Goode, W.	Clerical Officer, E.-in-C.O.	Executive Officer, E.-in-C.O.	12-8-26

TRANSFERS.

Name.	Grade.	From.	To	Date.
Coleman, A. T. ...	Higher Clerical Officer.	South Wales.	South West.	3-10-26

RETIREMENTS, ETC.

Name.	Grade.	District.	Date.	Remarks
Eaton, J. C. ...	Higher Clerical Officer.	South Mid.	14-11-26	Retired.
Thorne, A. E. ...	Executive Officer.	E.-in-C.O.	10-11-26	Deceased.
Lilburn, G. L. ...	do.	do.	3-10-26	do.

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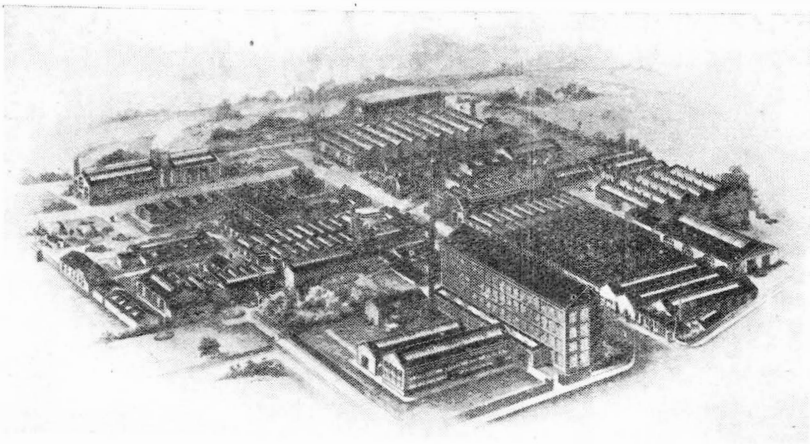

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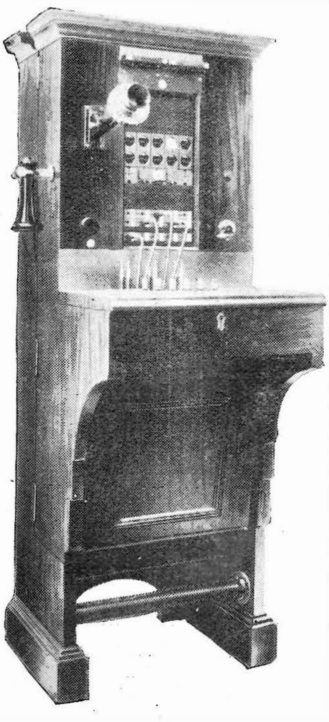

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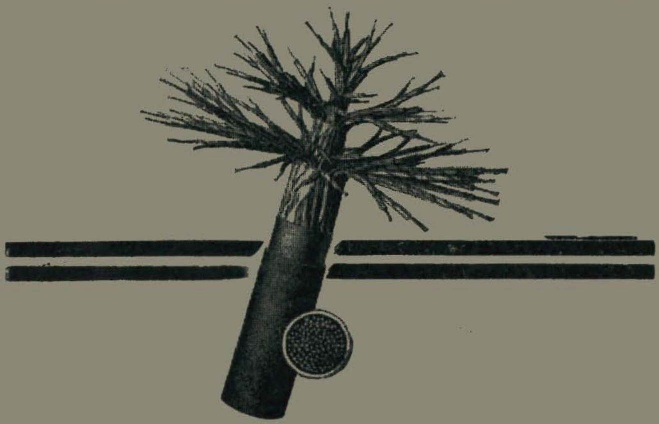

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