THE
Post Office Electrical Engineers' Journal

THE EQUIPMENT OF THE AGRA TELEGRAPH OFFICE.

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IN a previous number of the Journal (Volume 22, Part 2, page 79) giving a description of the equipment of the Central Telegraph Office, New Delhi, it was mentioned that an adjacent office would be fitted on the same principle of test room working, and this has since been done at Agra.

In designing the equipment for Agra, opportunity was taken to review and improve the New Delhi arrangements; the following notes indicate the chief alterations which were made. The Agra installation is a larger one than that of New Delhi and, in addition to circuit modifications, the lay-out of the plant was also influenced by the fact that most of the load of the Agra Telegraph office is transit traffic.

The trunk test boards, composite set arrangements and testing apparatus are similar to those used at New Delhi (Fig. 1). Closed circuit Morse sets are also arranged in a like manner. Duplex Morse sets, of which 40 have been installed, have been modified in some ways; the circuit (Fig. 2) has been simplified, eliminating the "R/R" key previously fitted, and, in addition, the cross-connection arrangements for repeater working, forked working, etc., are made more convenient. All duplex sets likely to be used for repeater work have been fitted with thermostat alarms allowing distant stations to

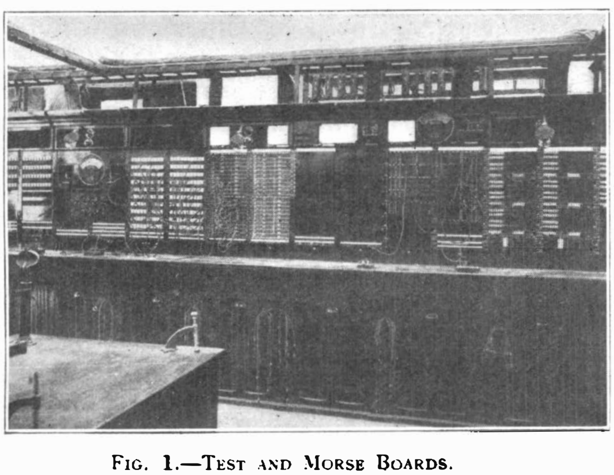


FIG. 1.—TEST AND MORSE BOARDS.

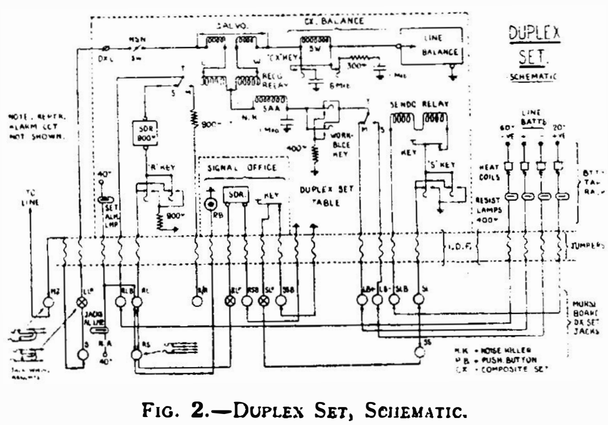


FIG. 2.—DUPLEX SET, SCHEMATIC.

call the supervisor's attention as soon as required.

The Baudot set arrangements have been modified and improved to a greater extent. The sets have been fitted six per table, the distributors and line apparatus being mounted in the centre. The ends of the tables are occupied by the test keyboards, test receivers and small control switchboards (Fig. **3**). The latter are fitted with

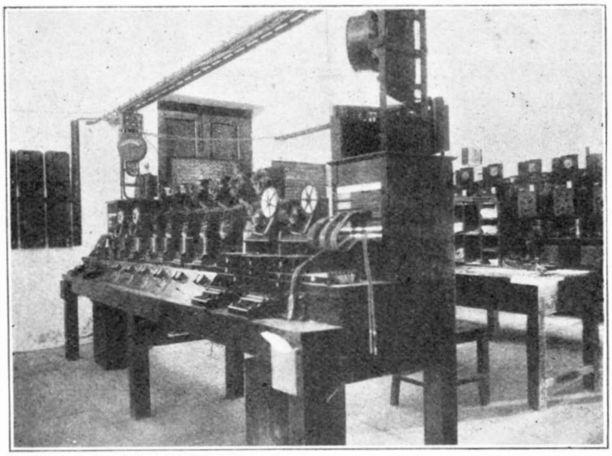


Fig. **3**.—Baudot Set Table.

20-way five-point break jack strips interposed between the distributors and the Baudot Test Boards which form part of the main switchboard of the test room. The wiring arrangement is shown in a schematic form in Fig. **4**. The test

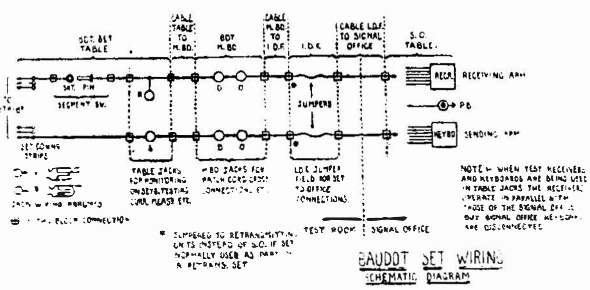


Fig. **4**.—Baudot Set Wiring.

receivers and keyboards are jack-ended on the control switchboards and can be plugged into the sets with five-way patch cords as required. The control switchboards are used by the Baudot supervisors in attending to set adjustments and faults. The main Baudot test boards contain the jack fields for making all forms of set cross-connections, provision being made to allow as full a flexibility of set and office arrangements as possible. It may be noted that from the series arrangement of jacks used on the control and main test boards, connections made on the latter, whatever they may be, do not influence the regular test procedure on the control boards, thus making the system a simple one to operate. As in the New Delhi office, jacks strips are coloured to further simplify the handling of circuit arrangements. An indication of the results which are obtained from this system may be of interest:—

(1) Any office position can work on any distributor, and working positions can be concentrated in any portion of the office as required.

(2) The keyboards (or transmitters) and receiving arms of all sets can be freely interchanged and apparatus thereby released for investigation of faults.

(3) Keyboards and receivers, distinct from the office equipment, are used for all testing and adjusting of sets, facilitating the location of faults in office apparatus.

(4) Sets can be changed from "correcting" to "corrected," or *vice versa*, without change of office sending and receiving positions.

(5) Two or more copies of the same incoming message can be printed in the office as required.

(6) Any set can be duplexed as required.

(7) Any two sets can be used as a re-transmitting set by locally synchronising them and cross-connecting the two distributors to re-transmitter relays. They can be used with or without a receiving arm connected to the office.

(8) One keyboard (or transmitter) can be used to send simultaneously on a number of sets for transmission of long press messages.

(9) Re-transmitting sets can quickly be arranged for up and down or uni-directional working as required by traffic conditions.

(10 Sets normally worked as re-transmitters can be used as two office terminal sets by cross-connecting to spare office positions.

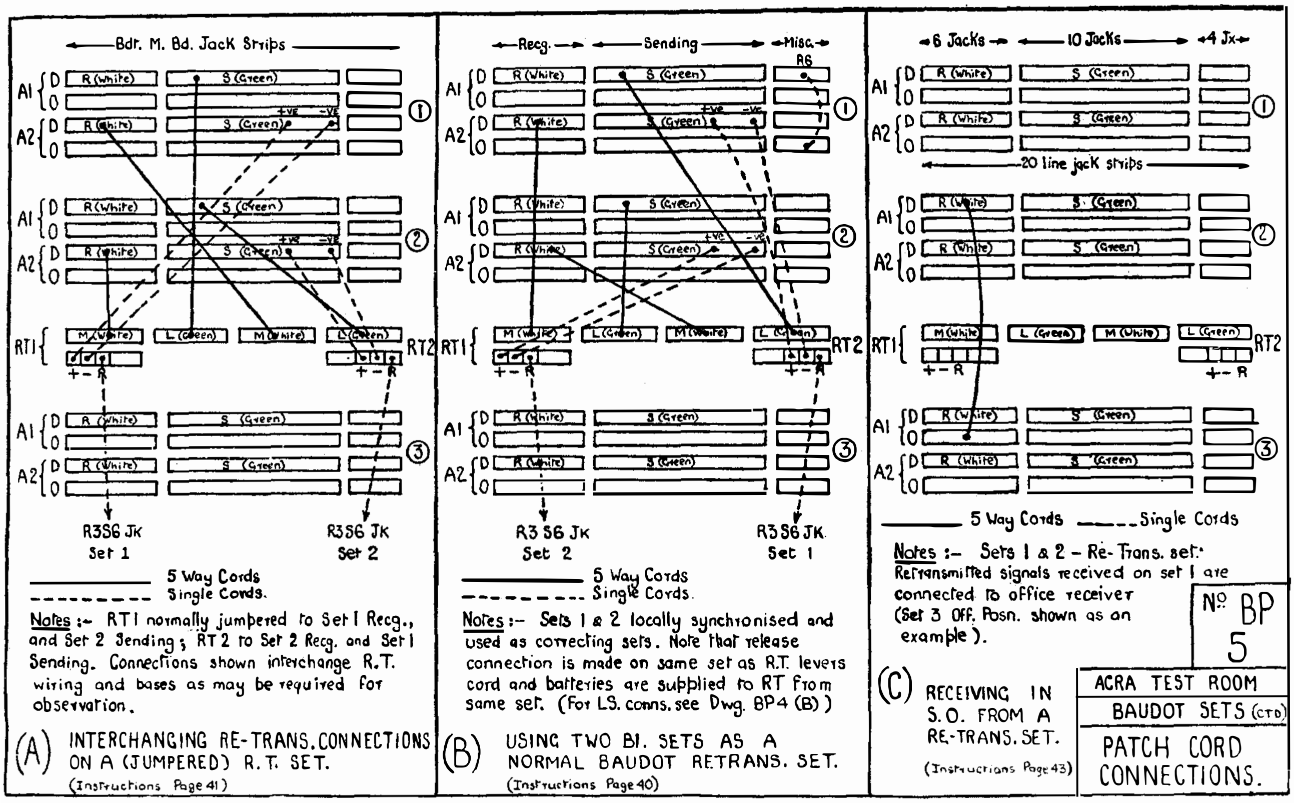


FIG. 5.—PATCH CORD CONNECTIONS.

(11) A number of combinations of forked working with re-transmitter working, etc., can be built up with patch cord connections and a number of extra testing facilities are available.

An example of a patch cord connection diagram (Fig. 5) shows how set cross-connections are made.

The procedure of control of the test room apparatus, alarm working, etc., is similar to that used in New Delhi. The two stations are also linked with a test wire (provided by a composite set) from one test room to the other, giving a direct means of communication for service orders.

FACSIMILE TRANSMISSION IN THE UNITED KINGDOM.

A. T. J. Beard, A.M.I.E.E.

THE chief systems of Facsimile Transmission in use in the United Kingdom are the Siemens Schuckert, Belin, American Telephone & Telegraph Co., Marconi and Fultograph systems.

Newspapers and the General Post Office are the principal users of the first three systems and use them practically entirely for the facsimile transmission of pictures, the Siemens Schuckert and Belin systems being used for both inland and continental transmissions, and the American Telephone & Telegraph Co. system for inland transmissions only.

Trans-Oceanic communication companies are the principal users of the Marconi system and use it for the facsimile transmission of diagrams and dual coloured matter in which there is no shading.

The Fultograph system is used by various authorities for the facsimile transmission of scientific data and to a lesser extent by news-agencies for the facsimile transmission of pictures.

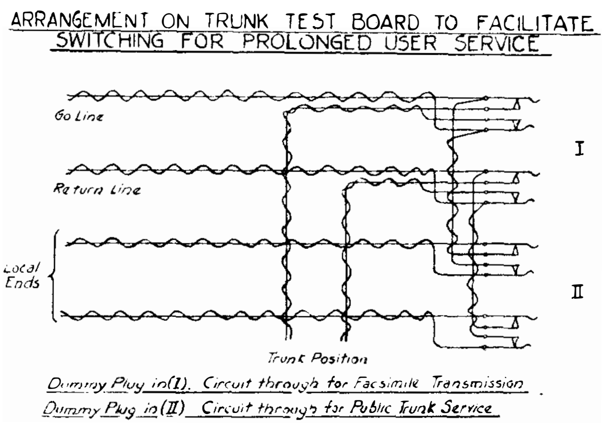


Fig. 1.

The land lines required for each of the systems are rented from the General Post Office. Four-wire circuits are generally provided and these are provided on both private wire and prolonged user basis. Private wires are rented between London and Manchester, London and Glasgow, London and Leeds, London and Bristol, London and Liverpool, London and Edinburgh, Manchester and Glasgow, Newcastle and Glasgow, Bristol and Cardiff, etc., the total mileage of circuit provided being approximately 3,000 miles. Prolonged user circuits are rented as required by newspapers and news-agencies between the scenes of special events and the town in which their receiving apparatus is located. The terms " Private Wire " and " Prolonged User " refer to the main portions of the circuits only, the local ends of facsimile transmission circuits are always rented on a private wire basis.

The various systems operate over a frequency range of from 500 to 2,400 periods per second, the frequency band occupied generally being 600 periods per second or less. Wherever possible, in order to keep the equalisation required at a minimum, the Department supplies 4-wire repeatered underground circuits which can be equalised up to 3,000 periods per second; while to keep the circuits as free as possible from cross-talk and interference the main cable portions between terminal trunk exchanges are lined up to zero transmission level.

Prolonged user circuits are chosen from the most suitable trunk circuits on the route concerned and usually have a transmission equivalent of about five decibels. The local ends from the Trunk Exchange to the renter's office are routed *via* local cables and usually have a transmission loss of not more than one decibel. Amplifiers are fitted at the renter's office, but these are used solely for compensating for any loss introduced by the sending or receiving apparatus.

Prolonged user service always obtains for Continental transmissions, the most suitable Continental trunk circuit being released for the facsimile transmission by mutual arrangement between the Administrations concerned.

Pictures are frequently transmitted to more than one receiving station. Two schemes are used, one in which the receiving sets are worked in cascade and the other in which a forked amplifier is used, the receiving stations being joined to either leg of the fork.

Facsimile transmission circuits are not always used solely for the transmission of pictures. Many renters alternate the transmission of pictures with verbal messages and messages transmitted by voice frequency telegraphy.

The present agreement between renters and the General Post Office does not permit the simultaneous use of a facsimile transmission circuit for facsimile transmission and voice frequency telegraphy. Experiments over circuits allocated for facsimile transmission have proved that by the use of suitable filter networks, no difficulty is experienced in transmitting six channels of voice frequency duplex telegraphy or two channels of voice frequency duplex telegraphy and one channel of duplex facsimile.

The slightest interruption to a circuit during the transmission of a picture or the variation of transmission level between the transmission of pictures usually means the spoiling of the picture. Trouble due to interruptions is minimised by the special marking of the associated apparatus at Repeater Stations and other places where the circuits are led out, and by testing circuits only with the concurrence of the renter. Variation in transmission level is kept at a minimum by daily single frequency repeater gain tests, weekly end to end single frequency attenuation tests and monthly valve rejection tests and end to end attenuation tests over a range of frequencies. On routes where spare cable pairs and repeater apparatus exist, emergency facsimile transmission circuits are set up and maintained as real facsimile transmission circuits.

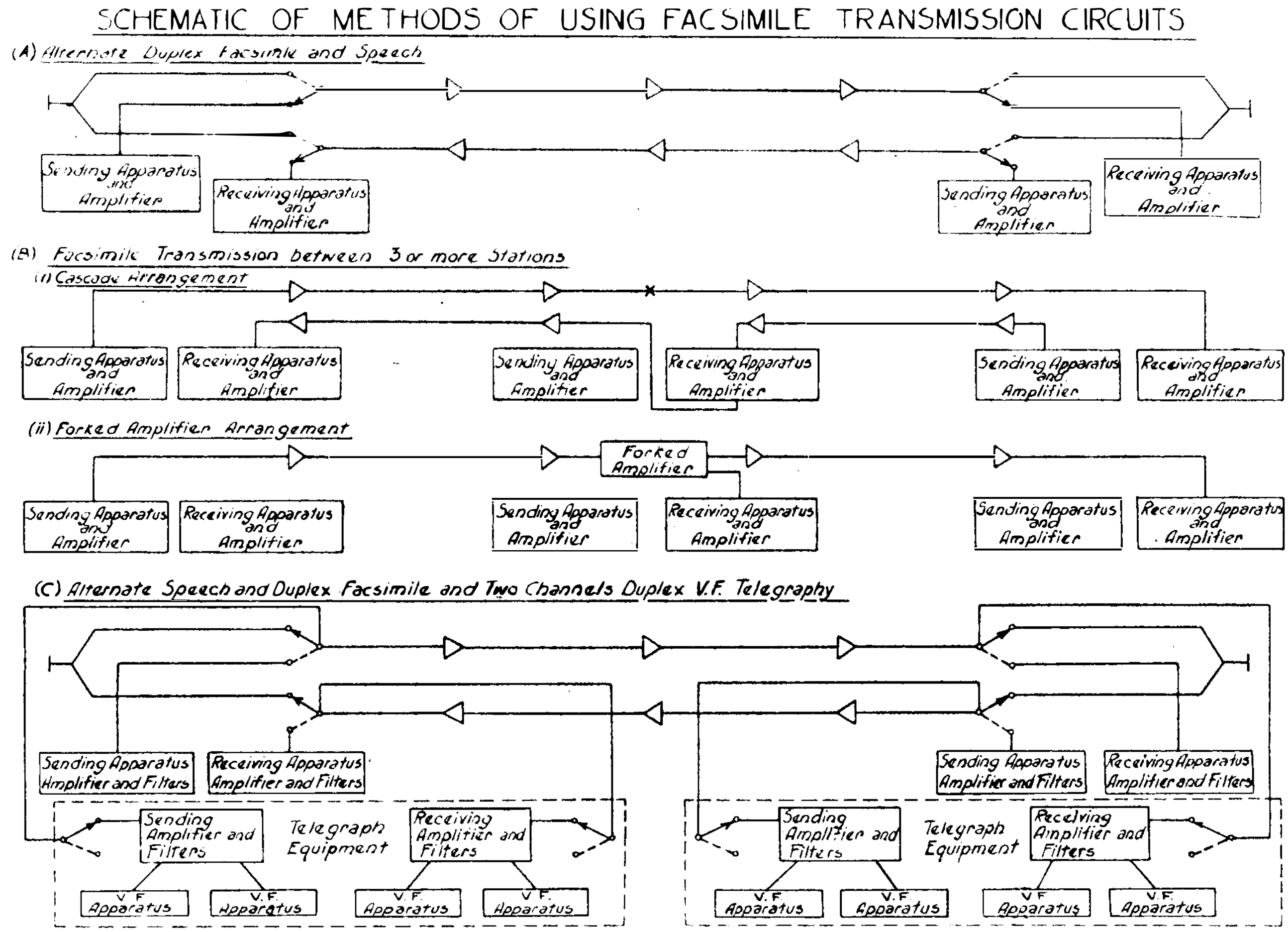


FIG. 2.

ENGINEERING RESEARCH IN THE POST OFFICE.

Capt. B. S. Cohen, M.I.E.E., F.Inst.P.

Considerable progress has been made in recent years in the Research Section of the Engineering Department both in the number and importance of the researches undertaken and in the extension of plant and buildings. The Research Section deals with all aspects of Electrical Communication and allied matters and in addition a certain number of problems on the postal side involving physical and chemical investigations, such, for example, as the correct lighting and sound proofing of various types of offices, investigating conditions under which certain materials sent by post would be likely to be a source of danger, and so forth.

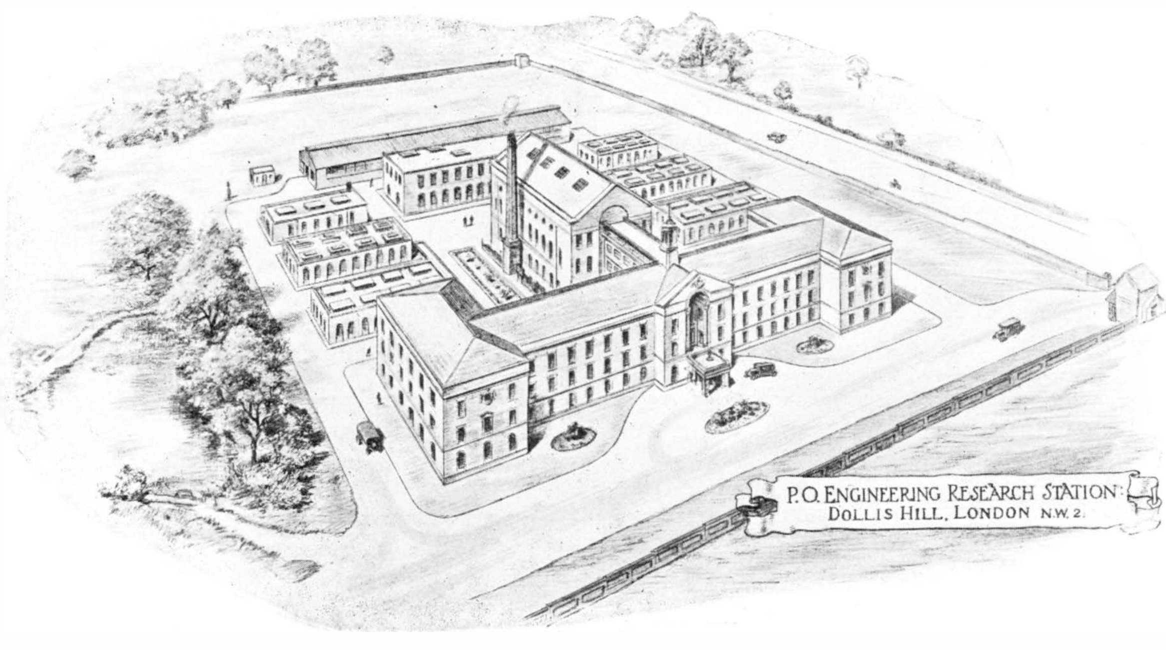


Fig. 1.

As is well known, the line of demarcation between Research and Development is, and must of necessity always be, somewhat indefinite and the Research Section deals to some extent with matters of development.

The Research Station is situated on a site of eight acres in extent at an elevation of about 250 feet at Dollis Hill, N.W.2, and in addition there is accommodation at Marshalsea Road, just over Southwark Bridge, and also rooms for Telephonic and Telegraphic purposes situated near the Trunk Exchange in Carter Lane.

When the permanent buildings at Dollis Hill are completed, the accommodation at Marshalsea Road will be given up.

Technical training now comes under the ægis of the Research Section and a special building for this purpose has been erected at Dollis Hill. The work of the Section is now divided into eight groups which are not necessarily enumerated below in their order of importance:—

(1) *Telephone Transmission Lines Group.*—In this group investigations on line problems, the design of Repeaters and carrier systems and so forth, are dealt with. The group works in close co-operation with the Lines Section of the Engineer-in-Chief's office and has an important development function in that it carries out working trials of systems on trunk lines under traffic conditions.

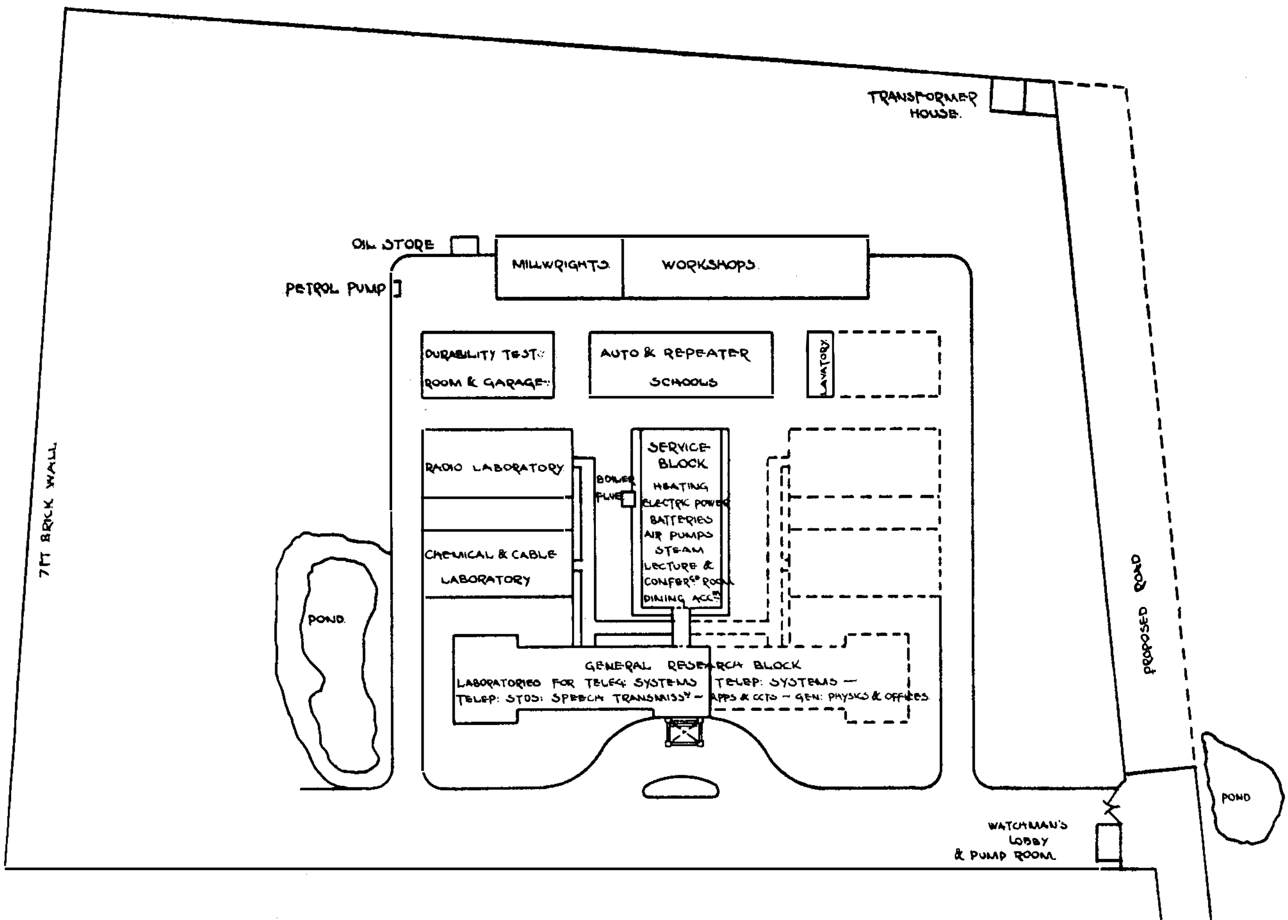
Thermionic valve investigations are also carried out by this group.

(2) *Telephone Transmission Apparatus Group.*—This group deals with all investigations involving transmission measurements of telephone instruments and components, local lines and exchange apparatus and circuits, etc., and also with researches on acoustical and electric-acoustical problems and the design and maintenance of telephone transmission standards.

(3) *Cable Research and Acceptance Testing Group.*—The acceptance tests of cables laid and balanced by Contractors and by the Department are carried out by this group, which has at its disposal a fleet of motor vans equipped with precision testing apparatus. The cable group also deals with special faults on land lines and all faults on submarine cables, and carries out studies of dielectrics, etc., with regard to their application to cable design.

(4) *Exchange Signalling and Equipment Group.*—In this group all research investigations associated with signalling equipment are undertaken. This work includes Automatic Telephone circuit problems and the design and improvement of apparatus used for signalling purposes. Durability tests on apparatus and contact material researches also come within the scope of this group.

(5) *Telegraph Group.*—This group is concerned with investigations relating to improvements in existing telegraph apparatus and systems and the critical examinations of new systems and apparatus under working conditions. The group is also concerned with the development of new systems and methods up to the



BUILDINGS SHOWN IN FULL = EXISTING & WORKS IN HAND.

FIG. 2.

point at which they may be handed over to the Telegraph Section for operation under traffic conditions.

(6) *Chemical, Physical and Metallurgical Group.*—The work of this group includes all investigations on materials for telephone and telegraph plant involving chemical and physical tests.

Investigations are carried out on corrosion problems and field tests undertaken to provide evidence of damage to Post Office plant by outside power sources. The subject of electrical interference to communication lines by power undertakings, in so far as experimental investigation is required, is also dealt with and precision electrical measurements and calibrations of testing apparatus used in the Research Station are carried out in a laboratory attached to this group. The physical investigations dealt with include those involving the use of mechanical, spectrographic, microscopical and X-ray methods.

(7) *Construction and Maintenance Group.*—The control of the Research Station's Drawing Office and Workshops for the construction of experimental apparatus required for investigations is controlled by this group, which is also responsible for the installation and maintenance of all services required for the work of the Station. The provision and upkeep of the motor vehicles required for the field tests of the Cable Group is also in the hands of the Construction Group.

(8) *Technical Training Group.*—This group is responsible for the carrying out of training courses, which at present comprise:—

Automatic Telephony	11 Classes.
Telephone Transmission	2 Classes
Proby. Asst. Engineers	1 Class.
Probationary Inspectors	1 Class.
Cable Balancing	1 Class.
Precision A.C. Testing	1 Class.
Electrolysis Testing	1 Class.
Teleprinter	1 Class.
Youths-in-Training	— Classes.
Correspondence Classes for Workmen	Winter months.

The officers in charge of these groups are for the most part of Executive Engineer rank. The Station has approximately an engineering staff of 90, an industrial staff of 100, a school staff of 50 and a clerical staff of 16.

The complete building programme is now well under way. Fig. 1 is a perspective view of the

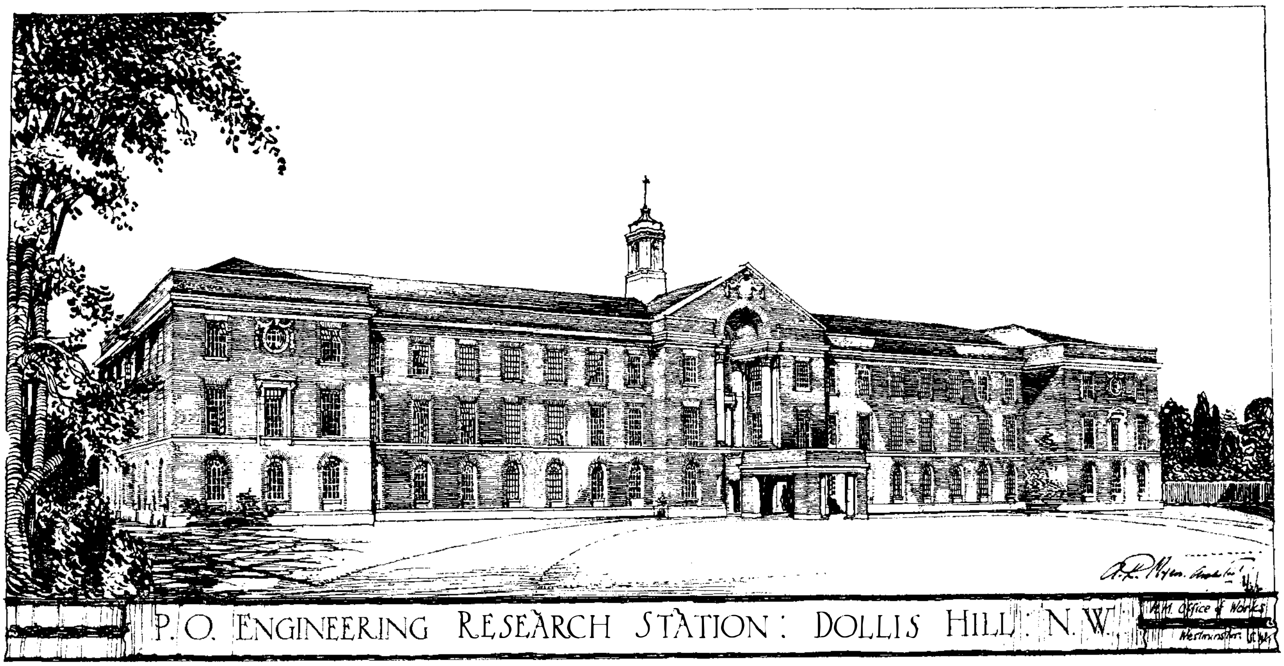


Fig. 3.

completed station whilst Fig. **2** is a plan showing the alteration of the lay-out of the various buildings. In the latter figure, buildings either completed or in course of actual construction are shown in full line. The buildings are of brick with stone facings and when completed will be well worthy of the traditions of the Department and of the work which they will house.

Fig. **3** shows the elevation of the main building in which the principal communications Research laboratories and a number of administrative offices, etc., will be accommodated. The main entrance is provided with a covered way which will enable visitors to alight and depart comfortably, and delicate apparatus to be exported and imported without damage, in inclement weather. The entrance hall will be panelled in hard wood of Empire origin and from it will lead off the Doorkeeper's and Messengers' rooms, the telephone exchange, corridors and lifts. It may be mentioned that a minor function of these buildings will be to enable the Office of Works architect to incorporate different materials in the structure with a view to determining their suitability for departmental purposes.

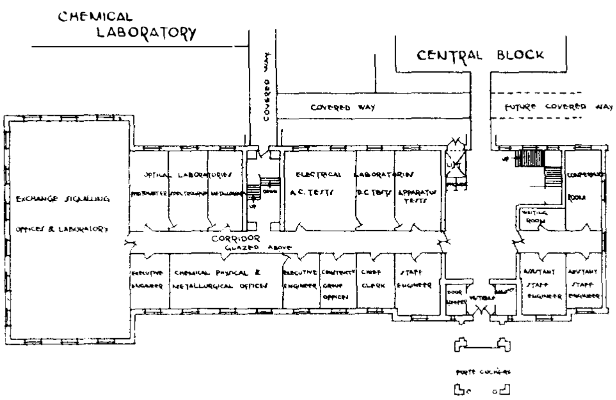


Fig. **4**.

Figs. **4**, **5** and **6** show the allocation of the three floors of the front block, with the exception of about one third of each floor which will be utilised for the Marshalsea Road laboratories and for clerical offices, etc., and the allotment for which has not yet been worked out in detail.

On the ground floor, Fig. **4**, the large laboratory of some 2,400 sq. feet on the left forms the main laboratory for the exchange signalling and equipment group. This group has, in addition, a durability tests laboratory in an outlying building and the use of the complete automatic units

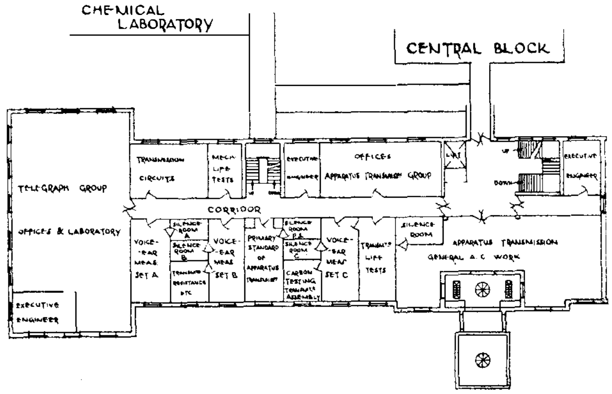


Fig. **5**.

set up in the Automatic Telephone School. There are also on this floor, three optical laboratories devoted to photometric, spectrographic and metallographic and general microscopic work respectively. The three electrical laboratories on this floor are utilized for general electrical tests, A.C., D.C. and apparatus respectively. In these laboratories will be tested all classes of electrical apparatus used generally in the Department and on the Station and for cable balancing and acceptance testing. The remainder of the accommodation is used for administrative staff offices and there is a small conference room with a telephone conference system of the type designed and developed on the Research Station. This system communicates directly with the Alder House Conference Room.

The large laboratory on the first floor, Fig. **5**,

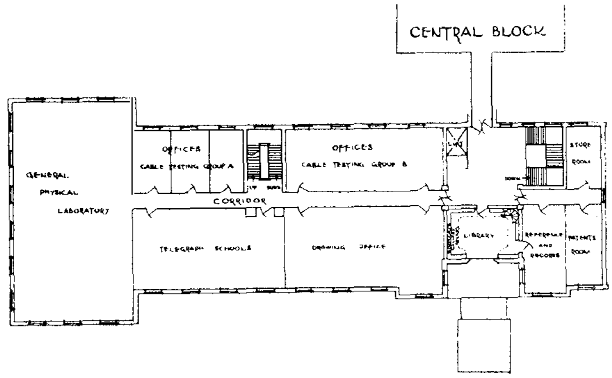


Fig. **6**.

accommodates the Telegraph Research Group. The remainder of the floor is utilized for the Telephone Transmission Apparatus Group. Certain of the laboratories here devoted to voice-ear and electro-acoustical measurement will be sound insulated and rendered non-reverberating, and in some cases will also be electrically screened by the use of expanded metal in the walls, floors and ceilings bonded and earthed.

The voice-ear measurement rooms are also ventilated by ducts connecting with the central tower of the building. The Department's primary reference system of Telephone Transmission will also be installed here.

The second floor, Fig. **6**, contains the general physical laboratory in which is included much apparatus to carry out researches on materials used in electrical communications work. The equipment includes a Moller X-ray apparatus

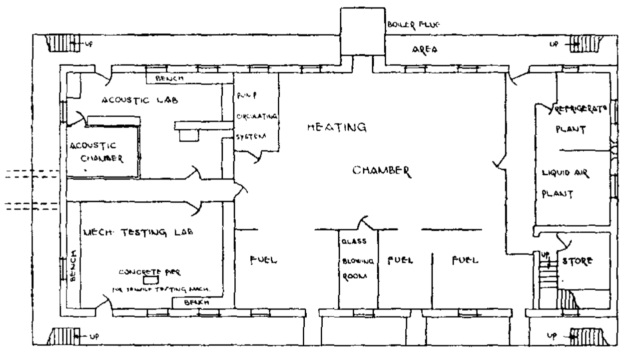


Fig. **7**.

for studying the atomic structure of powdered materials such, for example, as carbon granules and a Coolidge tube X-ray outfit for investigating solids by general radiography. On this floor are the offices for the cable testing groups, Group A. research and special faults, and Group B. routine balancing and acceptance tests. A Telegraph school devoted mainly to training in connection with teleprinters, the drawing office and the library are also situated on this floor. The last mentioned has gallery accommodation for books. The library, patents service and record rooms, where abstracts are made of communications articles not covered by the existing published abstracts, form an essential factor in a Research organisation.

The central service block is connected to the centre of the front block by means of corridors.

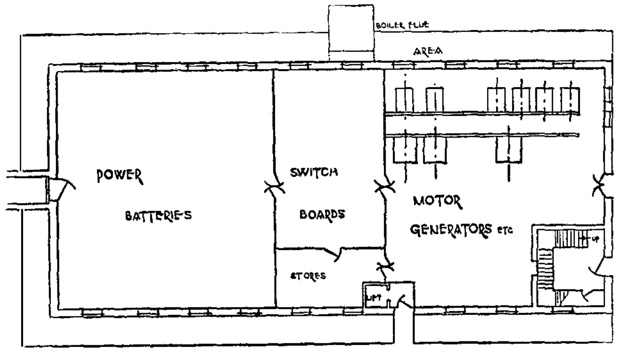


Fig. **8**.

The service block has a basement and three floors, see Figs. **7**, **8**, **9** and **10**. In the basement, Fig. **7**, is accommodated the heating plant and hot water supplies for the greater part of the station. A plant for the production of liquid air and a refrigerator are also installed here.

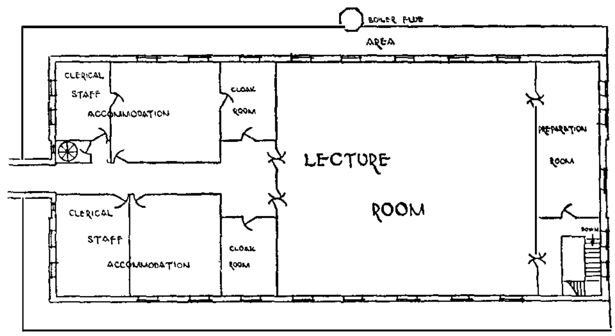


Fig. **9**.

A specially built laboratory for acoustical and electro-acoustical research in this part of the building is of particular interest. This has an inner chamber of brick lined with celotex and about two foot thicknesses of Gamgee tissue, a species of cotton wool. There is practically no

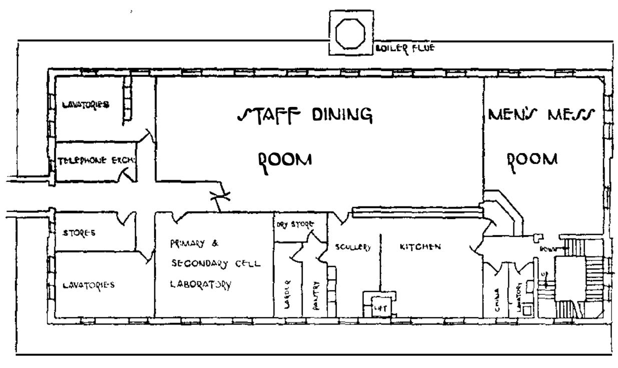


Fig. **10**.

acoustic reflection from the inner walls of this room so that measurements carried out inside are apparently the equivalent of measurements carried out in space. This room is utilised for such fundamental measurements as the acousto-electric ratios of transmitters and receivers including loud speakers. As an illustration of the effect caused by even a slight amount of internal reflection Fig. **11** shows (·) the smooth curve obtained by measuring a constant volume sound at 4000 periods per second at varying distances inside the room and (*x*) the same measurements repeated with a piece of fibre matting about five sq. ft. in area introduced into the interior. The irregular curve indicates considerable reflections which would vitiate any measurements made. An equipment of apparatus in this laboratory of special interest enables the frequency amplitude characteristics of transmitters, receivers and loud speakers to be photographically recorded over the complete audio range by the mere rotation of a handle. A general view of this apparatus is shown in Fig. **12**.

The only other laboratory on the basement floor is devoted to mechanical testing and is equipped with a tensile testing machine for metal rods of small diameter. There is a similar machine for testing telegraph strip paper. There are also Brinell hardness testers, apparatus for testing fatigue of materials and some small electric furnaces.

Fig. **13** is a general view of this laboratory.

The ground floor of the central service block, Fig. **8**, is allotted to power supplies for the whole station and comprises a motor-generator room in which is also installed telephone frequency alternators and power ringing generators. The two largest generators have each a capacity of 15 kW at 300 volts and there are 11 other sets with varying capacities and voltages.

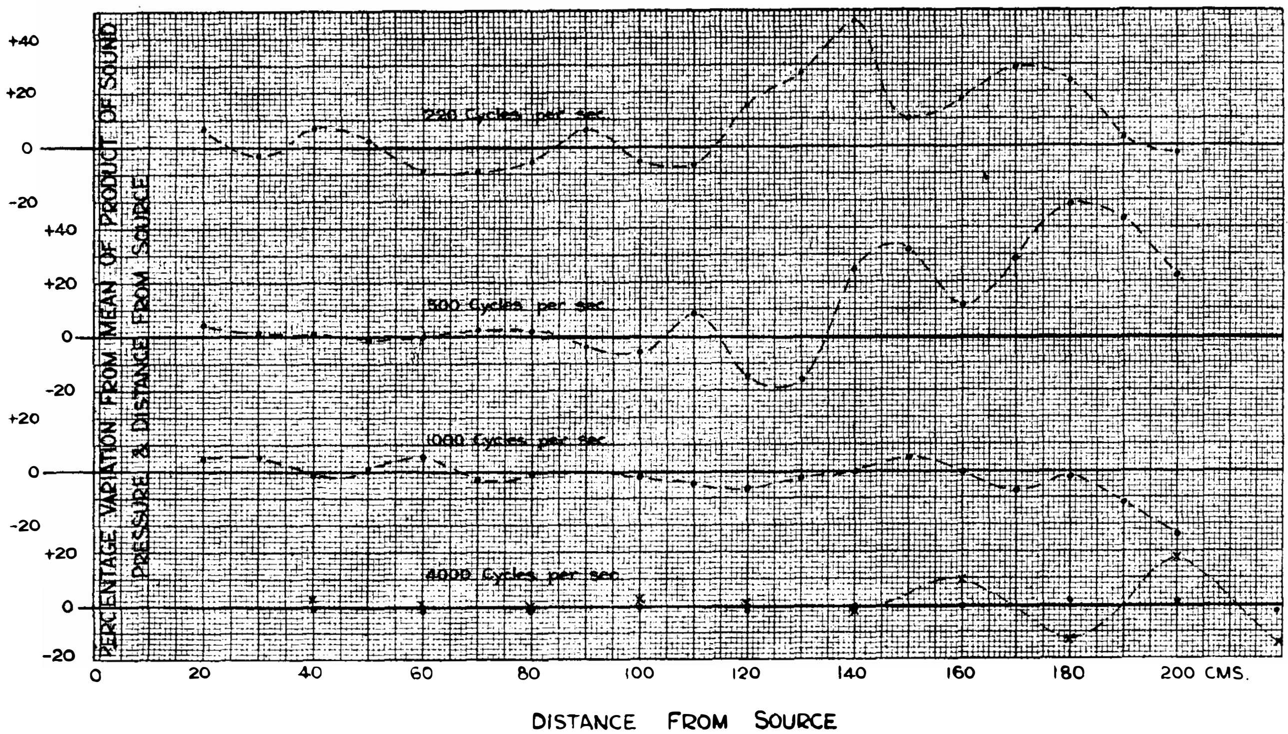


Fig. 11.—Sound Field Explorations in Acoustic Cabinet.

The central room contains the main A.C. switchboard and necessary D.C. switch gears in five bays. The main supply is 3-phase A.C. obtained from the Willesden Corporation and transformed on the station down to 415 volts.

The third room on this floor contains the storage batteries. Various makes of cell are used and there are two main batteries of 240 volt, 250 A.h., and other batteries giving voltages ranging from 12 volt to 150 volt, and capacities

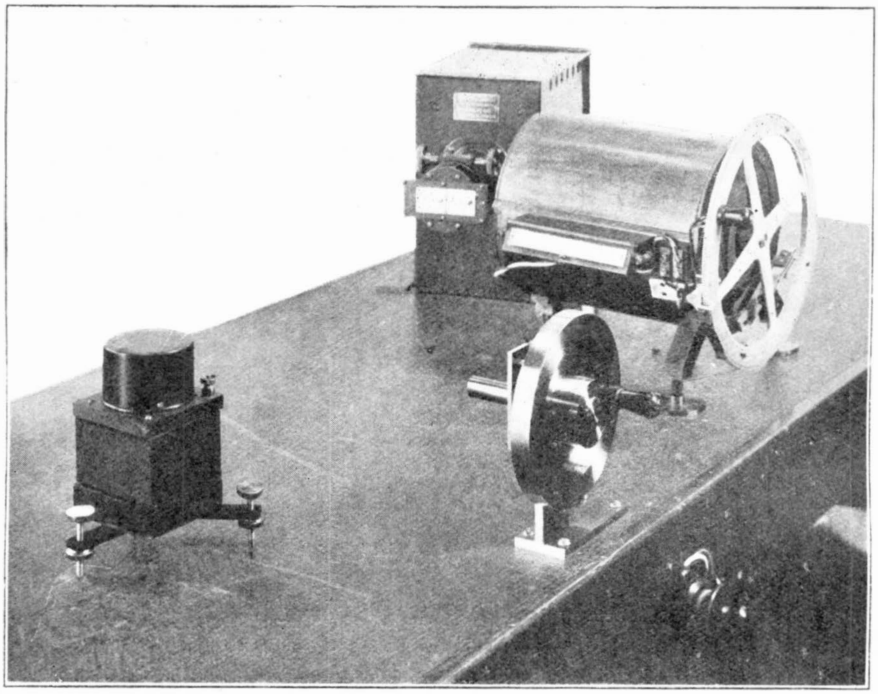


Fig. 12.

from 16 A.h. to 1000 A.h. In addition to the supplies from these batteries, which are distributed to all laboratories, a certain number of separate batteries and cuprous oxide rectifier chargers are located with the plant which they supply in order to minimise interference.

The first floor, Fig. 9, will be ultimately arranged to accommodate one small laboratory devoted to primary cell research and the remainder of the space will be wholly utilised for the Dining Club, the technical staff canteen and the associated kitchens, etc., which at the moment

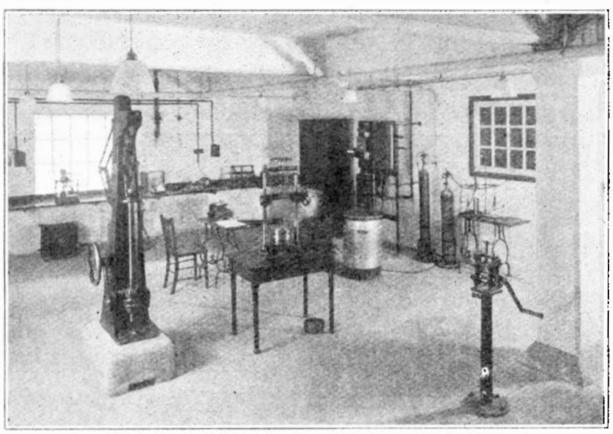


Fig. 13.

only occupy a part of this floor. This extension is partly necessitated by the influx of about 200 students and staff in the technical schools.

The second floor, Fig. 10, has a large conference room and lecture theatre, illustrated in Fig. 14. This is probably one of the finest rooms situated in any Post Office premises, and although so pleasing in appearance, is constructed with every regard to economy. The panelling of the walls and the doors, for example, are in stained Columbia pine, a cheap, soft wood which, however, gives the impression of handsome and harmonious finish. The floor is in an Indian hard wood, taking a dark red brown polish. The semi-cylindrical roof is lined with acousticos felt, linen covered and white distempered, and the presence of this felt considerably reduces the reverberation time. A moving picture projector is operated from a fireproof room on the third floor, and the upper part of the end wall of the theatre forms the screen.

The 10 oriel windows have opaque curtains for darkening, and at the same time the electrically controlled blinds covering the four roof lights can be operated from the lecture table.

Within a fortnight of the completion of this room, it was required for use in connection with

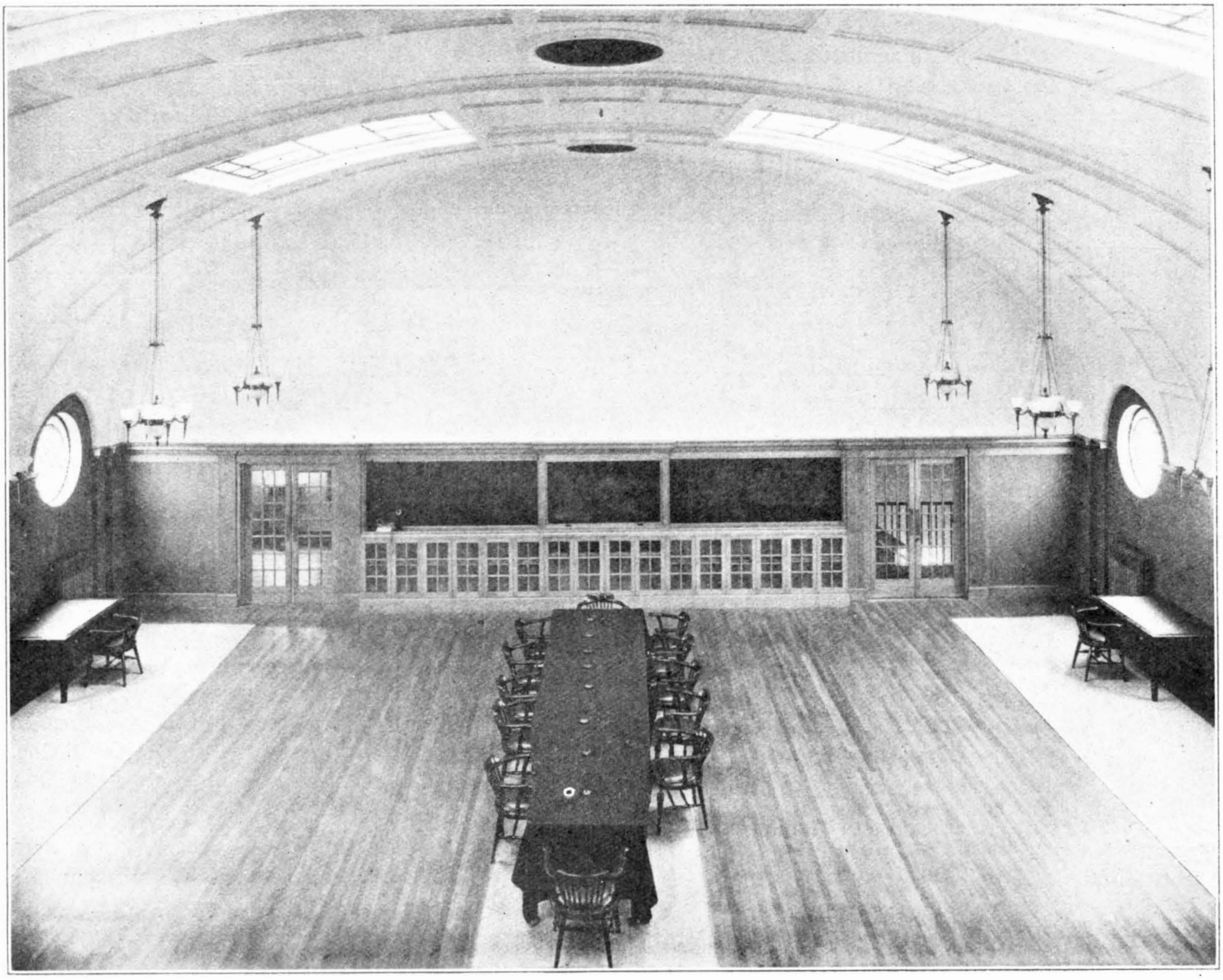


Fig. 14.

with an International Conference on power disturbance, and it has been in constant use for various committee meetings, technical classes and for the showing of educational films, of which more anon.

The remaining rooms on this floor are in use temporarily for offices and library accommodation pending the completion of the front block.

The top attic floor, Fig. 15, is devoted to photographic purposes and includes the fireproof room housing the moving picture projector. There is a well-lighted studio for taking pictures of apparatus required for issue with Research reports and a series of developing and printing rooms. The Research Section has taken a number of educational films dealing with such subjects as cable jointing, pole shifting, etc., and is at present engaged in completing a multi-reel film with talking accompaniment, entitled "The Engineering of a Telephone System." Experience is undoubtedly

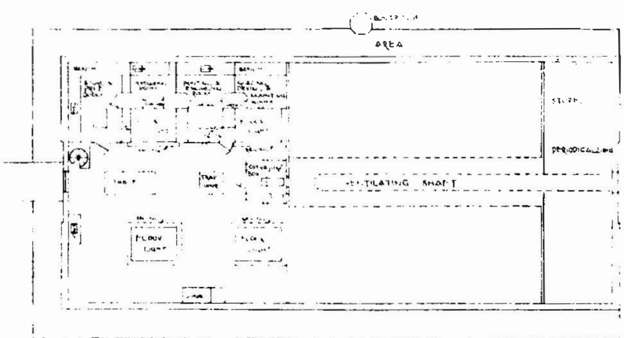


Fig. 15.

showing that much information can be imparted by the aid of the film more rapidly and economically than by any other method.

We now come to the outlying buildings which will be linked up to the main buildings by covered ways of the cloister type. The roofs of these covered ways carry the various services such as electric light and power, gas, etc.

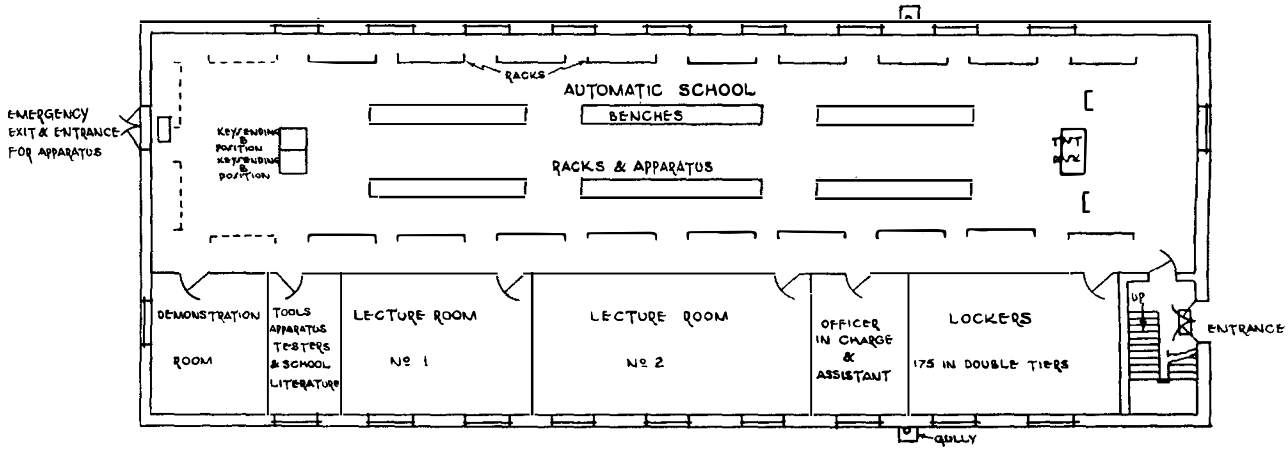


FIG. **16**.

As mentioned in the beginning of this article, the Research Section deals with Technical training and the various training courses were enumerated.

An outlying building of two stories accommodates the greater part of the training work. Fig. **16** is a plan of the ground floor of this building, which comprises a large automatic telephone exchange demonstration room fitted with units of all the systems in general use in the Department. These units can also be connected by junction lines to the exchange signalling research laboratories, thus rendering it possible for the latter to carry out researches involving the introduction of any type of standard automatic circuit. On the ground floor are also a number of small lecture and demonstration rooms.

The upper floor, Fig. **17**, includes the Telephone Repeater School demonstration room, and further lecture rooms and training staff office accommodation.

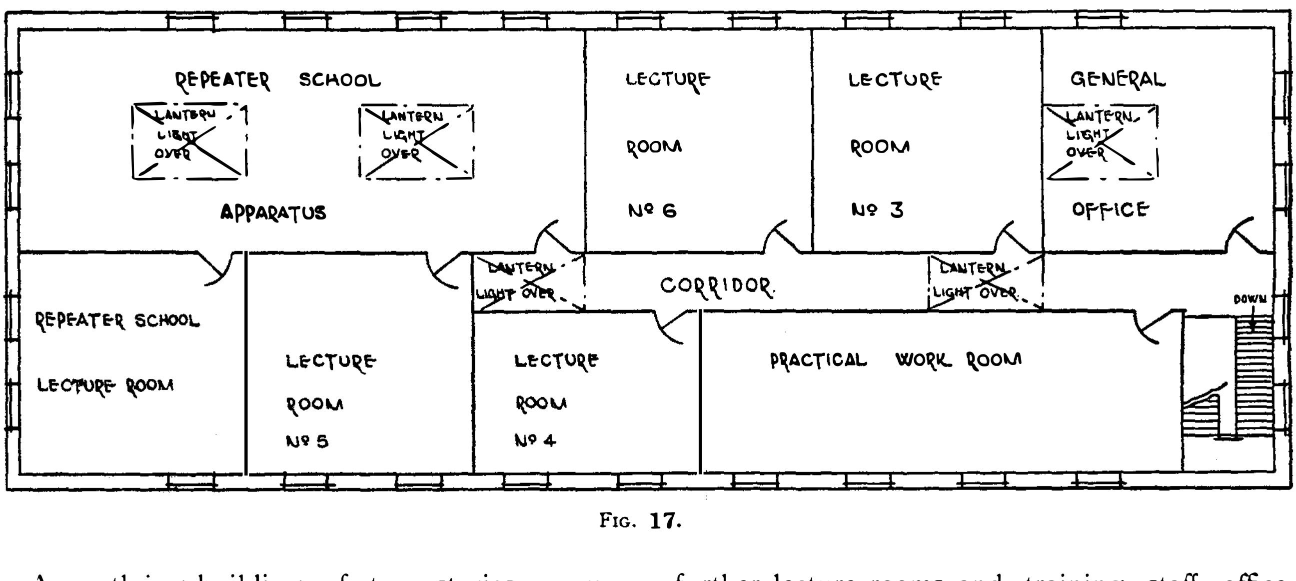


FIG. **17**.

Fig. **18** is the plan of one of the one-storey buildings which includes chemical laboratories.

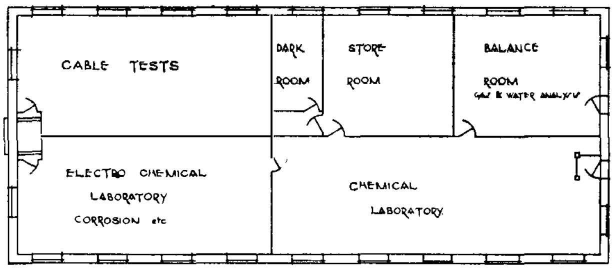


FIG. 18.

One of these is mainly devoted to corrosion and electrolysis researches, subjects which unfortunately loom largely on the communication engineer's horizon. Included here are chambers in which samples of materials or apparatus can be subjected to saline atmospheric conditions and also such salubrious airs as occur in the vicinity of certain manufacturing cities such as Widnes. An adjacent laboratory in this building will be devoted to cable research including cable dielectric and continuous loading material investigation.

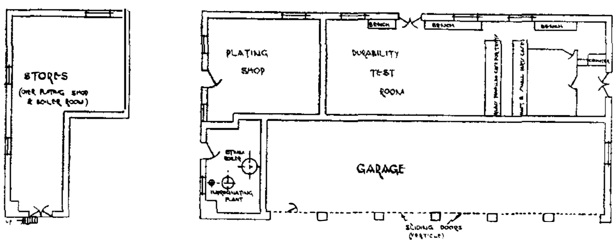


FIG. 19.

Fig. **19** is the plan of another of the outlying buildings, a considerable part of which forms a durability test room for automatic telephone apparatus, which can be operated continuously under controlled conditions. Records of interruptions and their causes are kept and at the end of a certain number of operations, usually running into the millions, the apparatus can be dismantled and the component parts subjected to detailed examination which may involve mechanical, chemical, metallographical and microscopical tests. This building also contains the garage, which accommodates the testing vans and station transport. The latter includes an omnibus which carries out a daily service between Dollis Hill and Alder House. The test vans are used in connection with cable balancing and acceptance testing, also for electrolytic surveys and any other tests required on the road. Smaller rooms in this building contain deposition plant for electro-plating with various metals and here also will be found a coil impregnating plant and a paint spraying outfit.

Fig. **20** is a plan of the workshop in which practically any form of apparatus or equipment required for research purposes can be constructed and, in addition, the plant and staff is sufficient to enable a small number of any piece of apparatus to be constructed in a reasonably short time for development purposes. As an example, the Telephone Instrument Efficiency Testing outfit, T.I.T., was designed in the Section and four sets have been turned out in the Workshop for use at testing depots, etc. A detailed description of this apparatus forms the subject of a special article on pages 31 to 36 and is quoted here with the view of indicating a typical example of the more complex and elaborate apparatus constructed on the Station for research and development purposes. Reverting to Fig. **20**, it will be observed that the workshop includes a large machine and fitters' shop and a wood working shop. These are well equipped with labour-saving tools. There is also a coil winding shop in which a small staff is kept busy with the multifarious coil winding requirements for communication research. One end of the workship buildings provides separate accommodation for the Millwrights and this portion is equipped with some heavy tools such as a pneumatic hammer and also a forge.

This article describes in a general manner the scope and lay-out of the Research Station and includes brief references to some of the plant and research apparatus. It is hoped in a further article to give some indication of the more important development and methods which have been introduced into the Service as a result of the activities of the Research Section. It may be mentioned, however, in conclusion, that an analysis of the more important researches carried out about three years ago during the preceding years indicated that they could be divided into two groups. In the first group, consisting of approximately one third, it was found fairly easy to allot a monetary value to the research, either by virtue of a definite saving in maintenance or by the introduction of a new service or channel and so forth.

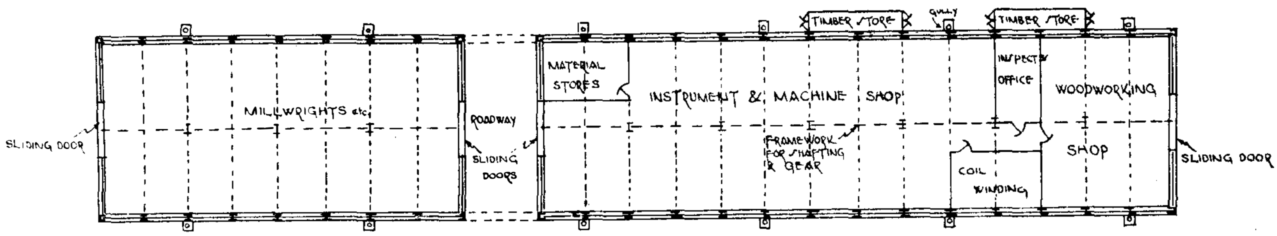


Fig. **20**.

With respect to this group of researches an estimated annual saving to the Department exceeding £150,000 was indicated and the remaining two-thirds researches, whilst more difficult to define in terms of pounds, shillings and pence, included many investigations the results of which it had been found necessary or advisable to incorporate into the Department's service, and also work which would have to be done elsewhere if not done by Research staff. As the overall annual costs of the Research Station plant and staff does not exceed £75,000 per annum it will be realised that the Research Section may be regarded as a highly successful business organisation paying a handsome profit.

A further investigation of the results of the work done last year, on the same basis as the above, showed a direct saving of £128,000 per annum, while important research and development work now in hand gives promise of very considerable reductions, both in capital expenditure and in annual maintenance charges.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 31ST DEC., 1930.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileage.				Engineering District.	Underground Wire Mileage.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
699,105	593	3,945	53,713	132	London	25,247	99,817	2,703,690	69,401
93,887	2,227	21,749	71,599	2,189	S. Eastern.	4,057	65,299	288,065	37,498
97,449	4,488	32,856	68,781	3,884	S. Western.	22,889	19,675	215,659	67,957
78,694	6,258	39,895	72,829	7,020	Eastern.	24,697	49,605	167,639	59,519
110,982	9,624	45,788	68,490	4,597	N. Mid.	33,708	72,347	288,033	96,057
97,576	4,807	31,985	83,659	3,990	S. Mid.	13,865	40,699	239,066	76,954
64,024	4,331	29,942	61,524	4,077	S. Wales.	7,244	32,654	145,798	66,132
121,515	7,920	27,231	58,244	4,548	N. Wales.	13,958	46,723	331,321	105,986
174,250	1,412	15,913	45,678	3,232	S. Lancs.	14,865	93,048	557,907	68,087
103,999	6,010	30,519	51,775	3,609	N. Eastern	15,186	53,334	287,308	68,879
70,610	3,804	24,015	41,881	2,946	N. Western.	7,947	38,315	183,955	41,979
53,531	2,443	16,059	28,324	3,189	Northern.	8,491	23,667	148,220	35,453
24,680	4,411	9,224	15,162	622	Ireland N.	136	3,163	58,090	2,405
74,931	4,744	28,234	43,812	1,368	Scotland E.	7,572	19,838	170,319	37,606
97,616	7,242	25,203	46,942	1,139	Scotland W.	11,992	30,694	249,030	33,876
1,962,849	70,314	382,558	812,413	46,542	Total	211,854	685,878	6,034,100	867,789
1,937,869	70,664	380,758	801,943	45,757	Figures as at 30 Sept., 1930.	209,635	658,766	5,900,174	832,924

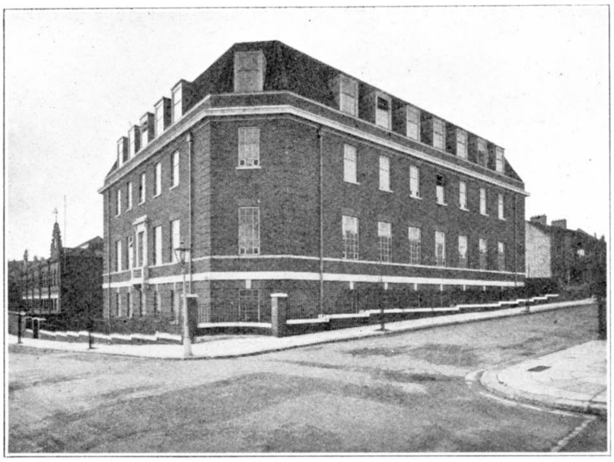
TELEPHONES

ACORN EXCHANGE.

" The Acorn which ' scatters great hopes in the seedfield of man.' "—BROWNING.

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

B. HOUGHTON BROWN,
Engineering Division, Standard Telephones and Cables, Limited.



ACORN EXCHANGE.

ACORN EXCHANGE, situated in Lexden Road, High Street, Acton, consists of a three-storey building housing an initial equipment of 4,600 lines of Step-by-Step equipment, with an ultimate capacity of 10,000 lines, and holds the distinction of being the first Exchange to be installed utilising throughout British General Post Office " Standard Open Type " (single-sided) racks as described by Mr. G. Brown in his article in this Journal, dated April, 1930. The equipment is arranged on three floors as follows :—

1st floor—Offices and Apparatus Room.
2nd floor—Power Plant, Battery Room and Apparatus Room.
3rd floor—Offices and Manual Room.

Manufacture and installation are being carried out by Messrs. Standard Telephones and Cables, Limited, Hendon, and this article is intended as a follow-up of Mr. G. Brown's article referred to above to show, with the assistance of a series of photographs, how the Engineer-in-Chief's drawings and specifications have been interpreted and put into actual practice.

At the time of writing, there are two distinct divisions of opinion concerning the method to be adopted in handling the "Open Type" racks and equipment. One is in favour of shipping fully equipped and wired racks direct from the factory, and the other is in favour of making full use of shelf unitisation, and shipping in three distinct batches consisting of (1) racks and cables, (2) shelves, and (3) apparatus. The latter method has been adopted for the installation under review, and it is hoped that, as the installation progresses, the advantages of this method will be apparent. To this end the photographs are being taken at stated intervals of the installation, and it is intended to carry this through until the completion of the Exchange.

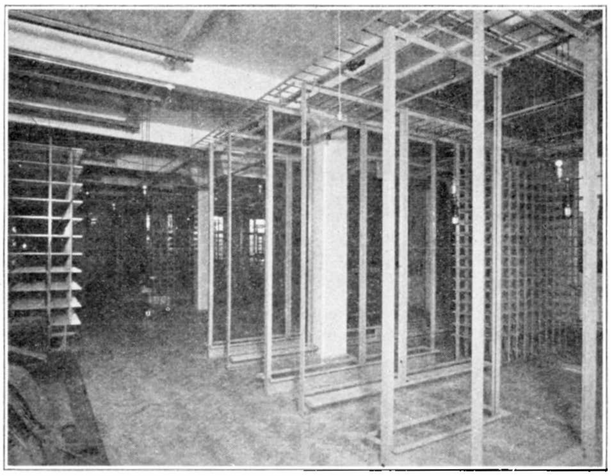


Fig. 1.

The immediate impression obtained from the photographs is the absence of the large independent framework structures with which we are so familiar in other automatic exchanges. Line and Final Units and Trunk Boards are replaced by a series of racks of such similar construction that when unequipped, unless you are sufficiently expert to be able to read the drillings on the rack uprights, it is impossible to tell what function they are destined to serve in the exchange.

The racks throughout the exchange are 10′ 6″ high and vary in width only, as detailed by Mr. G. Brown. The construction of the subscribers' uniselector rack, which, by the way, is not a new monster introduced into the telephone world, but merely a rack carrying what in the old days were known as "Rotary Line Switches," "Preselectors," or "Subscribers' Line Switches," and which have now been re-christened "Uniselectors," is identical with all other racks in the exchange.

Since, as previously stated, the photographs are intended to show the progressive installation of an automatic exchange built up on the "piece-meal" basis, we will deal with the advantages claimed for this scheme and will then show, by means of the photographs, how they have been utilised.

1. The greatest advantage in the eyes of the author is undoubtedly the fact that by shipping the framework to the exchange in advance of the apparatus

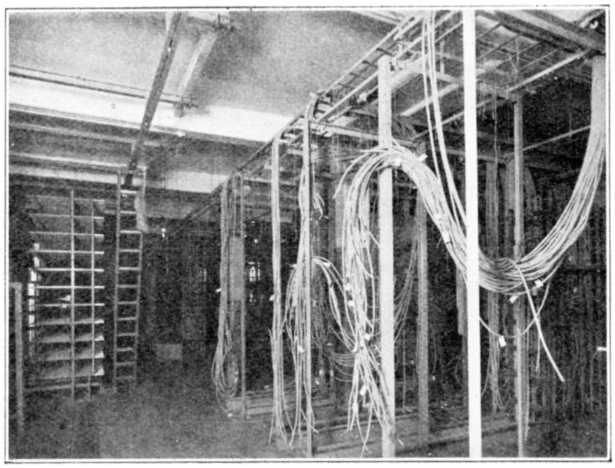


Fig. 2.

the installation and shop periods are allowed to overlap, whereas in the bulk shipment methods the installer can do practically no work until the most detailed piece of apparatus has been manufactured, thereby losing many valuable weeks.
2. Secondly, the question of handling must be considered, and here again the "piece-meal" method seems to have considerable advantages, as no expensive haulage tackle is necessary, the frameworks being shipped broken down and the heaviest item being the unit of two unequipped shelves.
3. Thirdly, all ceiling and wall supports,

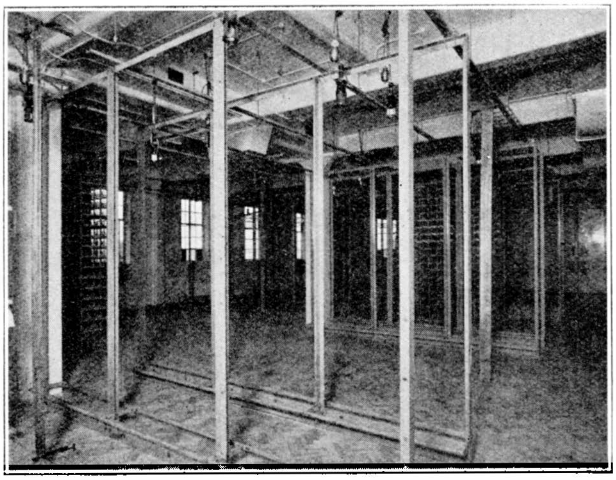


FIG. 3.

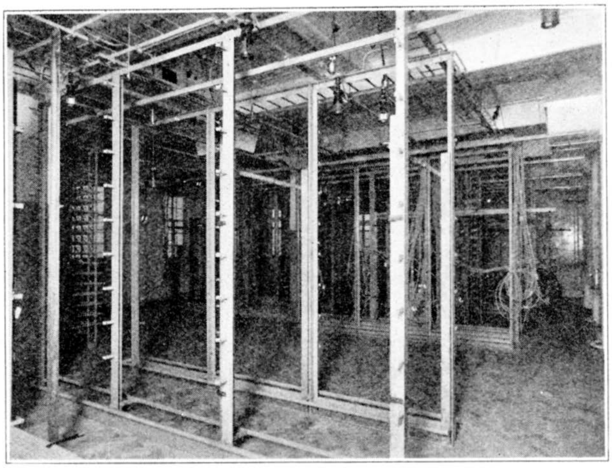


FIG. 4.

where such are necessary, can be fixed before the apparatus is in the building, thus avoiding damage due to dust and dirt and the presence of heavy scaffolding, etc.

In addition to the advantages gained by "piece-meal" shipping, there are a number of inherent advantages in the "open type" racks themselves. Briefly these are as follows:—

1. The racks being all of the same height enable a flat and even cable runway scheme to be employed and facilitate rack-to-rack bracing with the minimum disturbance to the walls and ceilings.
2. The uniformity of width of the racks greatly assists supervisory arrangements. The ideal exchange lay-out consists of long main aisles with cross aisles at regular intervals, thus giving efficient supervision with the minimum amount of apparatus and cable. This is more nearly obtained with these racks than is possible with individual double-sided structures, particularly where these require a gangway at the end as well as at the sides, and, with an ideal floor, perfect exchange supervision now comes within the realm of practical politics.
3. Advance information to enable the floor chases to be cut to receive the frames is no longer necessary, since all racks and frames, with the exception of the Main Distribution Frame, stand on the wood-block surface.

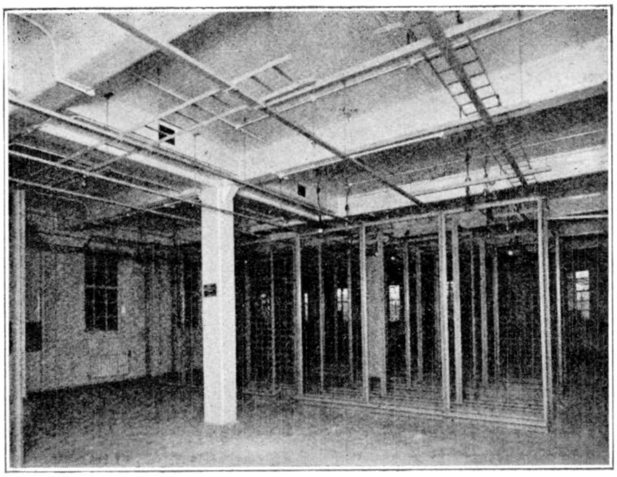


FIG. 5.

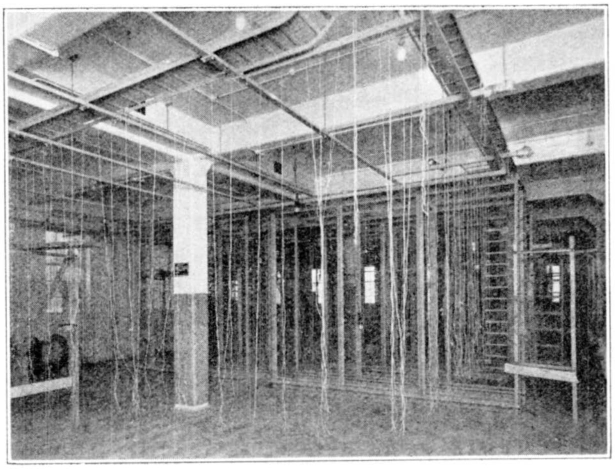


FIG. 6.

4. The use of a continuous foot upon which the racks are mounted not only distributes their weight, causing a saving in the cost of building construction, but also reduces the possibility of dust collecting in inaccessible positions to a minimum.
5. With the exception of the Trunk Distribution Frame, the dimensions of which do not line up with the remainder of the racks and which is at present being re-designed, a considerably improved floor plan lay-out is made possible.

The photographs covered by Figs. **1—8** show the first two stages of the installation. Figs. **1**, **3**, **5** and **7** were taken immediately after the rack frameworks had been assembled and bolted to the continuous angle foot. It is perhaps worthy of mention that at this stage of the work the necessity for absolutely level floor surfaces became apparent. At Acorn the floors were not perfectly level and packing strips had to be cut and fitted before the racks could be erected.

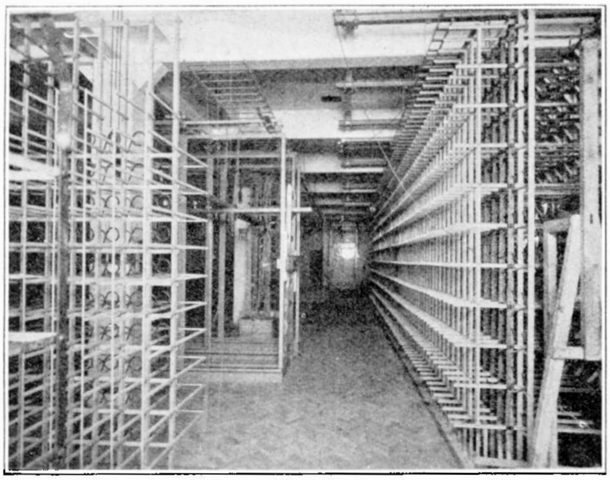


Fig. **7**.

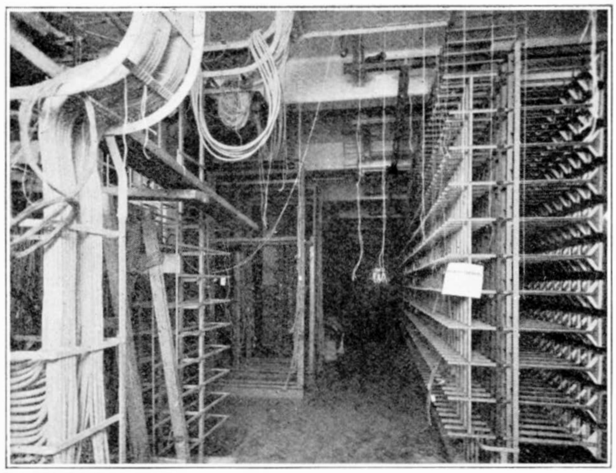


Fig. **8**.

Figs. **2**, **4**, **6** and **8** were taken at a later date, when a large percentage of the cables had been run in.

Fig. **1** shows the Main Distribution Frame and in the background the Intermediate Distribution Frame, with a four vertical uniselector Trunk Distribution Frame standing in front. The racks between the Intermediate Distribution Frame and the Trunk Distribution Frame carry the subscribers' uniselectors, and those in the foreground the " A " digit and 1st code selectors.

The method of supporting the racks by means of transverse channel sections running the full length of the room will be noted, also the flexible method employed of " 'U " bolt fixing, by which means the tops of the racks can be attached to the transverse members in any positions required.

The small number of ceiling fixtures is also apparent, and this forms an important feature since the decision has been made to complete all interior decoration prior to the commencement of an installation.

Fig. **3** should be compared with Fig. **1**, and is included to show the similarity of all racks. Reading from the front these are the C.C.I. and Coder racks, Miscellaneous Relay Set racks, 1st and 2nd Numerical Selector racks, and in the background the Final Selector Racks.

Fig. **5** indicates more clearly the arrangement of racks and gangways, and the value of the transverse channel members for supporting cable runways is also apparent.

Fig. **7** shows the Main Distribution Frame and Intermediate Distribution Frame taken from the opposite end of the room to Fig. **1**, and is included as a matter of general interest. Its value will be more apparent in later photographs.

Figs. **2**, **4**, **6** and **8** are taken from similar positions to Figs. **1**, **3**, **5** and **7** and represent the second stage of the installation; this stage constituting the process of cable running.

Fig. **9** shows a typical view of a wiring gangway after the cables have been run in and prior to their being laced to the rack cable supports, and it will not need a lot of imagination to appreciate how the work of running these cables has been simplified by the absence of shelves and apparatus.

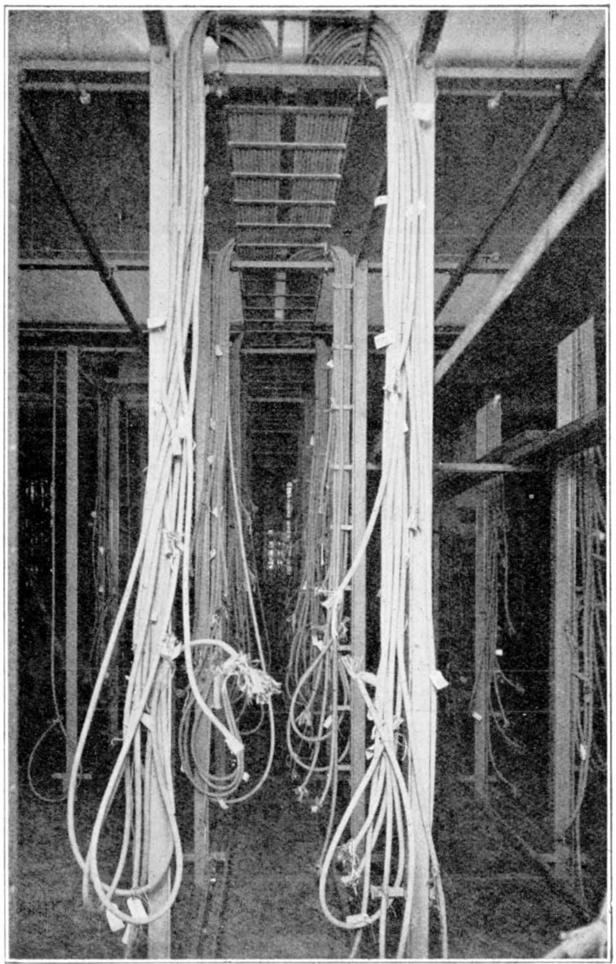


Fig. 9.

An additional use for the transverse channel members will also be noted. Here they are seen acting as travelling ladder overhead track supports.

Fig. **10** shows how the Intermediate Distribution Frame footings have been treated to eliminate the possibility of dust collecting between the horizontal foot members. The Frame is erected on a strip of ruberoid felt which is surrounded by a wooden curb. The space inside the curb is then filled in with cement, which is prevented from damaging the wooden blocks by the presence of the ruberoid.

The comparative advantages of the new system considered from all aspects, embracing cabling, power distribution, supervision and general maintenance, will be appreciated. The racks are arranged back to back with 1′ 8″ between wiring sides and 2′ 6″ between apparatus sides.

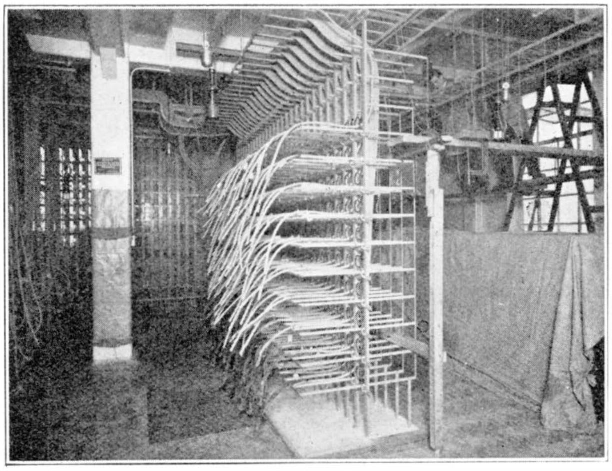


Fig. 10.

Lighting.—It will be observed that the Exchange is lit throughout by means of standard hanging lamps, necessitating the provision of inspection lamps. A scheme of flood lighting, however, is being prepared by the Engineer-in-Chief's Office for introduction into this Exchange, and will be shown up in the final series of photographs.

Conclusion.—In concluding this—the first of a series of articles dealing with the progressive installation of Acorn Exchange, thanks are due to Messrs. A. B. Eason and G. Brown, of the Engineer-in-Chief's Office, for their considerate co-operation at all stages of the development.

INTRODUCTION OF AUTOMATIC TELEPHONE SYSTEM AT NEWCASTLE-ON-TYNE.

W. A. STRADLING and H. SADLER.

ON the 31st January, 1931, the greater part of the Newcastle-on-Tyne area was converted to automatic working, and this transfer ranks as the largest individual operation of the kind yet undertaken in this country. A total of 10,600 existing subscribers' lines, together with 679 junctions were transferred at midnight from 13 Manual Exchanges of various types to the 12 new Automatic Exchanges installed by Messrs. Standard Telephones & Cables, Ltd. Particulars of the old and new Exchanges, together with those which are to be converted at a later date are given below:—

Exchange.	Type of Manual Equipment.	No. of Existing Lines.	Date of conversion.	Exchange Replacing Old Exchange.	Multiple Capacity. of Auto Equipment.	
					Initial.	Ultimate.
Central	Magneto	4400	31-1-31	Central	8800	16000
Central Relief	CB.1	2548	,,	East	1600	4700
City	CB.1		,,	West	1600	4500
Gateshead	Magneto	775	,,	Gateshead	1500	4500
Gosforth	,,	1199	,,	Gosforth	1700	4400
Gosforth Relief	,,		,,			
Felling	CBS.1	150	,,	Felling	300	900
Low Fell	Magneto	350	,,	Low Fell	1000	3400
Jarrow	CBS.1	256	,,	Jarrow	600	1100
Whickham	,,	111	,,	Whickham	200	600
Kenton	Magneto	62	,,	Kenton	100	200
Benton	,,	288	,,	Benton	700	1400
Wallsend	,,	463	,,	Wallsend	900	2800
Total transferred ...		10602	,,	Total	19000	44500
Wideopen	CBS.2.	80	Not fixed.		—	—
Lemington	CBS.1.	150	,,	-	—	—
Jesmond	CB.1	1430	,,	-	—	—
Dunston	CBS.2.	160	,,	—	—	—
Hebburn	CBS.1.	130	,,	—	—	—
Blaydon	CBS.2.	150	,,	—	—	—

As the new equipment is of the well known Strowger type used in all recent installations for the British Post Office, it is unnecessary to give any detailed particulars, but a brief description of certain general features of the scheme will no doubt be of interest. The disposition of Exchanges in the Automatic Area is shown in Fig. 1.

In preparation for the transfer all subscribers' circuits in the area were brought through the new Exchanges and tees were made on the Main Distribution Frames. Immediately after the transfer all tees were cut away and temporary jumpers were recovered from the frames, the work being completed by mid-day on Sunday, February 1st. This method of arranging for the transfer of circuits to a new Exchange has much to recommend it in cases where it can be economically adopted, as there are no external tees to be removed with the possibility of temporary interruptions after the change-over. Those who have had experience of fault control during the process of cutting away tees on external plant will appreciate the importance of this consideration.

The Central Automatic Exchange, together with the Manual switchboards for Trunk and Toll and the various auxiliary services, is accommodated at Telephone House, a photograph of which is given in Fig. 2. This building, which

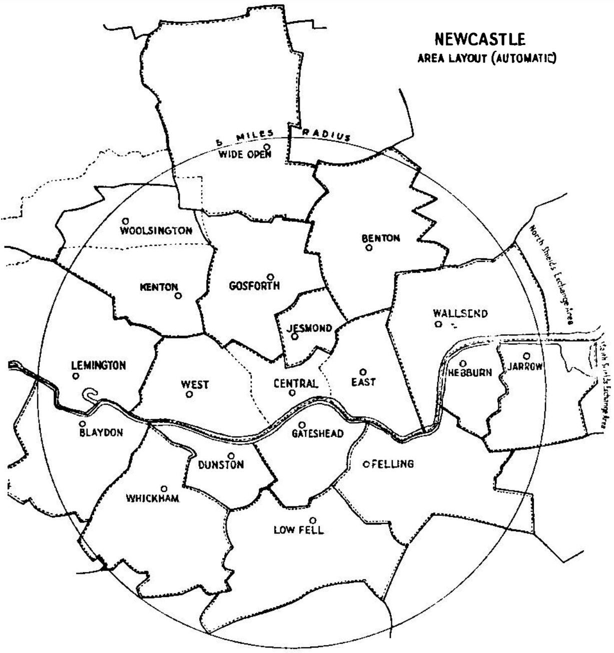


FIG. 1.—NEWCASTLE AUTO. AREA.

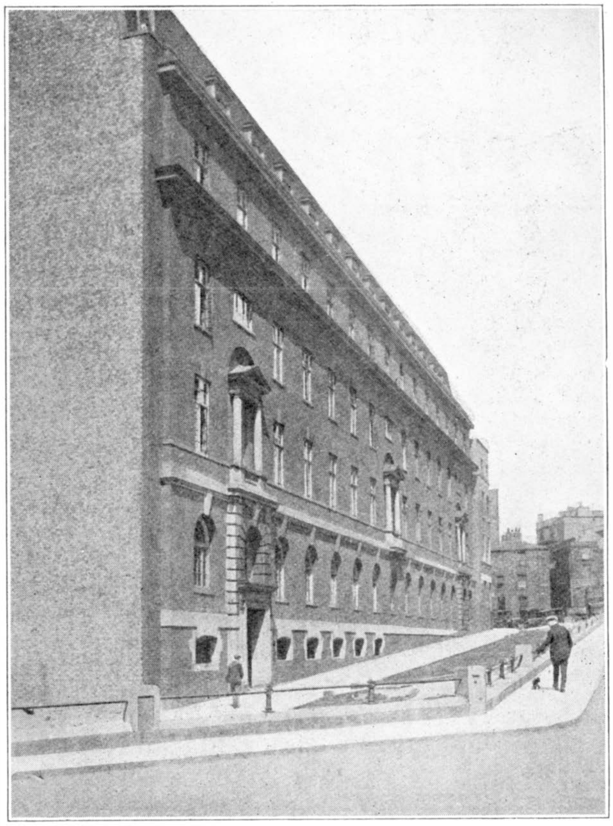


FIG. 2.—TELEPHONE HOUSE, NEWCASTLE-ON-TYNE.

presents an imposing appearance, is in Carliol Square and is erected on the site of the old Newcastle Prison. During the excavations for the

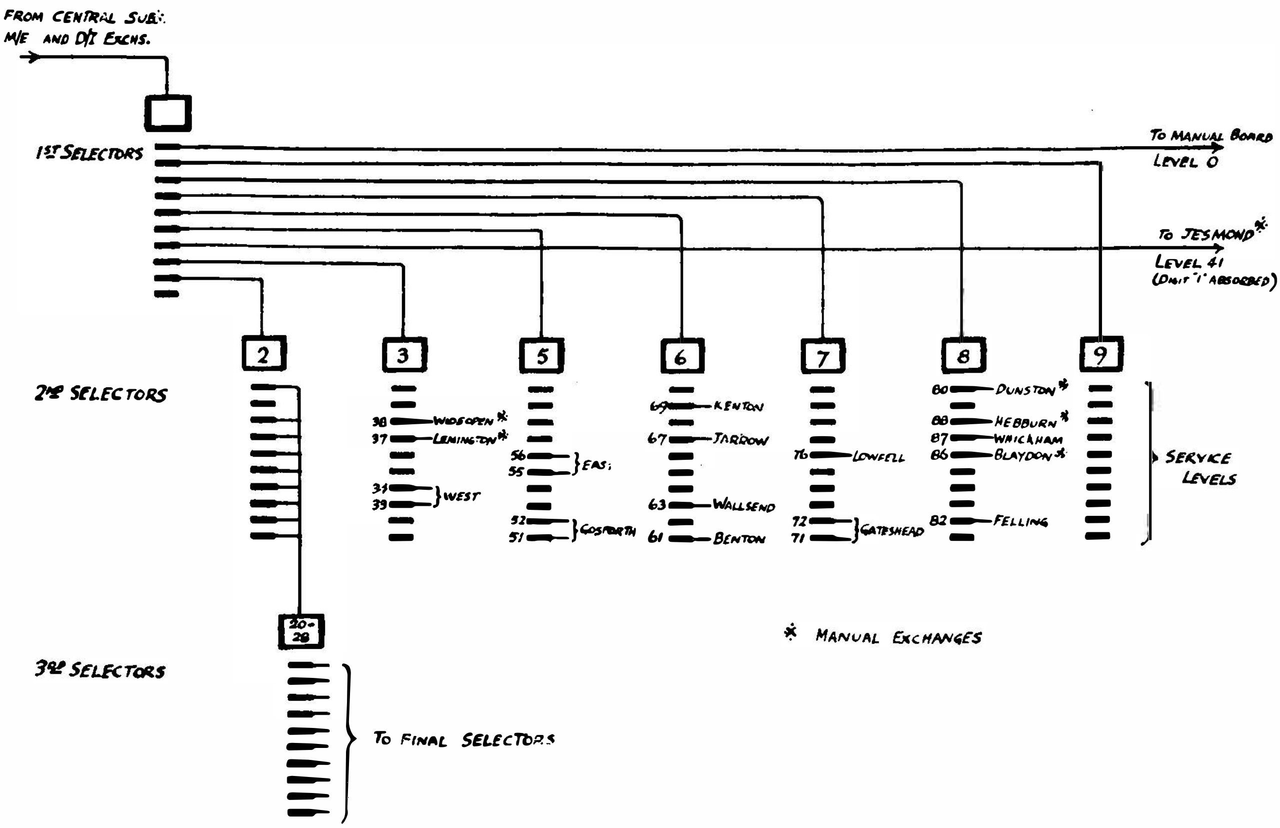


FIG. 3.—TRUNKING SCHEME.

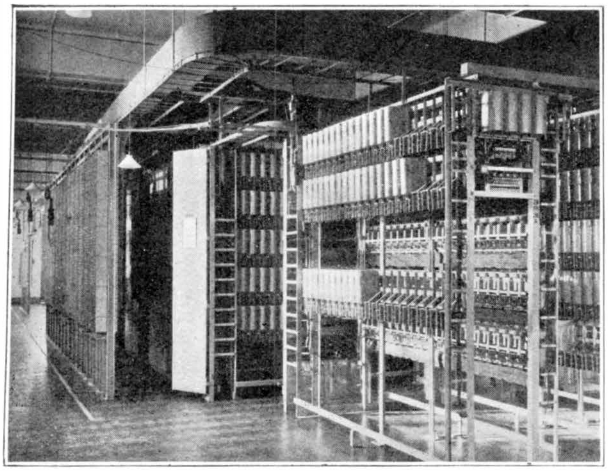


Fig. 4.—Newcastle Central. Traffic and Subs'. Meters on left. Group Selector Racks.

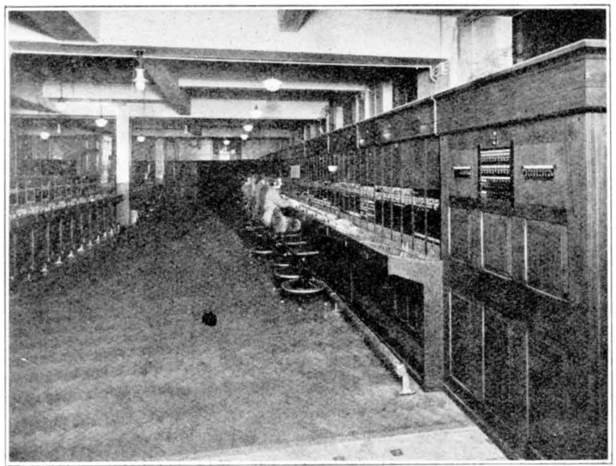


Fig. 6.—Newcastle Central. Manual Room. Enquiry Suite on the left.

foundations of the new building, the remains of a criminal were found who had been executed and buried in the prison many years ago.

The numbering scheme for Newcastle is on a uniform 5-digit basis for all Exchanges and, with the exception of Jesmond, all exchanges are served from 2nd selector levels at Central; each group of junctions thus serves 1000 subscribers. The scheme is shown in convenient form in Fig. **3**. Provision is made for direct trunking from East and West exchanges to Central subscribers, this plan effecting a considerable economy in junctions and switching plant. Direct automatic junction circuits are also provided between Gateshead and Low Fell.

The Newcastle Trunk Exchange was brought into use on November 15th, 1930, a total of 262 Trunks being transferred from the old Trunk Exchange without trouble of any kind. The Trunk suite consists of four Junction Signalling positions and 24 Generator Signalling positions, together with Trunk Record and Trunk Enquiry Tables. The Auto Manual Switchboard has a

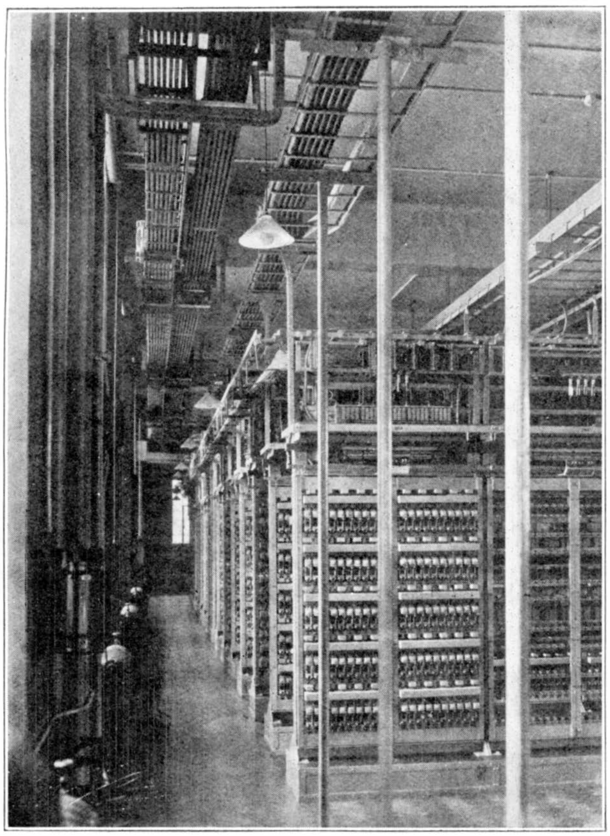


Fig. 5.—Newcastle Central. Line and Final Units.

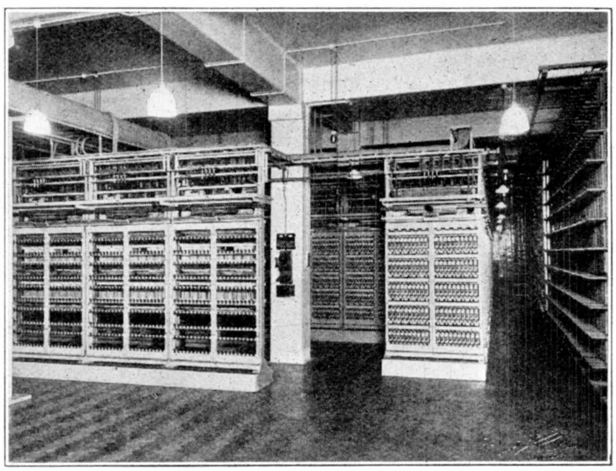


Fig. 7.—Newcastle Central. Line and Final Units. M.D.F. and Cable run.

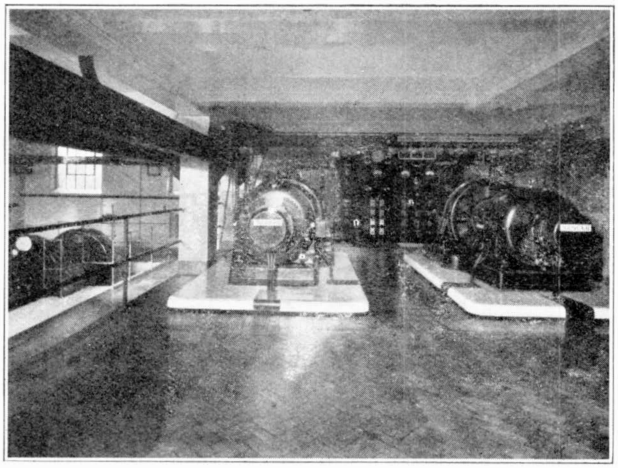


FIG. 8.—NEWCASTLE CENTRAL. CHARGING MOTOR GENERATOR AND POWER BOARD. RESERVE OIL ENGINE EXTREME LEFT.

FIG. 10.—GOSFORTH EXCHANGE.

total of 55 positions, the estimated ultimate requirements being 89 positions.

The Enquiry suite consists of 23 working positions with one unequipped. A special feature of the Enquiry suite is an archway over a break in the section to allow easy access from front to rear without a long detour. The cabling is carried over the gangway and covered with polished mahogany to match the section, an altogether pleasing effect.

The whole of the 4th (top) floor is allocated to Manual switchboard equipment, Enquiry and Trunks. The 3rd flood is occupied by Traffic Staff, Contract Officers, Dining Room and General Welfare accommodation. The 2nd floor is taken up entirely by Automatic Switching Equipment, Main Distributing Frame, Test Desks, etc. The 1st and ground floors are occupied by other Departments, *e.g.*, Board of Trade and Inspectors of Shipping.

The power plant and batteries are located in the basement; the batteries, which were installed by Messrs. The Chloride Electrical Storage Co., Ltd., are of 10,000 ampere hour capacity.

There are three 91 kilowatt generating sets of which two are motor-driven direct-coupled sets and one is an engine-driven emergency set. All three generators were built by the Electrical Construction Co. The emergency generator is driven by a 150 H.P. oil engine of the Ruston vertical type, coupled direct to the main shaft. The oil fuel consumption of this engine is .43 lbs. per brake horse power hour, and the set operates

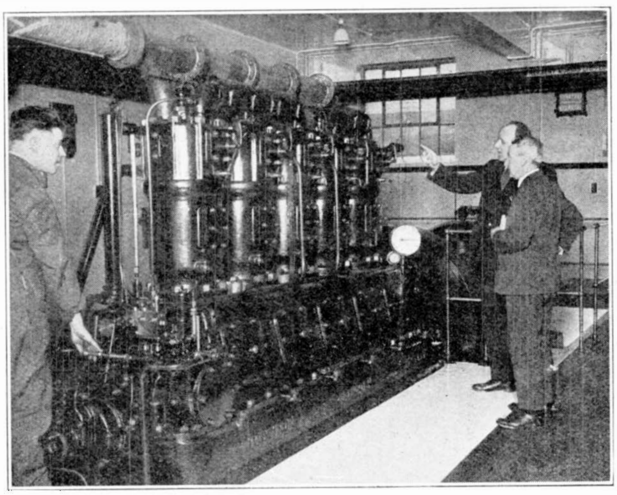


FIG. 9.—NEWCASTLE CENTRAL. RESERVE OIL ENGINE PLANT.

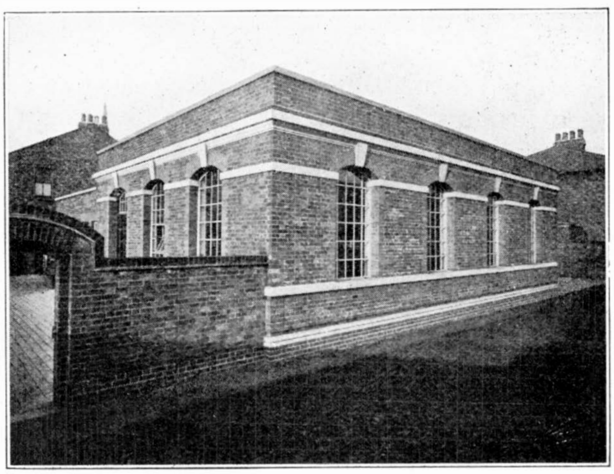


FIG. 11.—JARROW EXCHANGE.

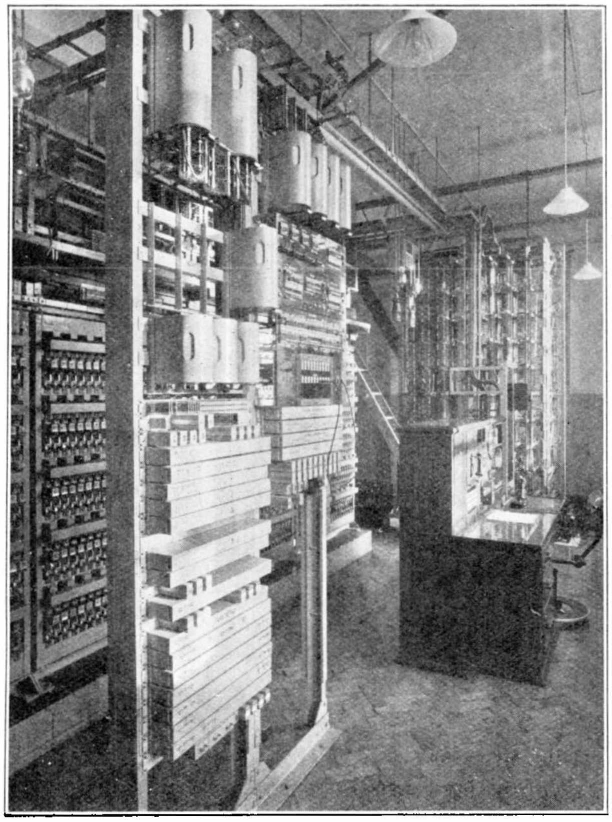


FIG. 12.—JARROW EXCHANGE. SPECIAL APPARATUS RACK, TEST DESK AND M.D.F.

at approximately 80% efficiency at full load. The compressor for this plant is run by a 4 H.P. petrol-paraffin engine capable of working up to full compression in about 20 minutes.

It may be mentioned that the weather conditions prior to and during the main transfer were of the vilest description; heavy falls of snow accompanied by gales of wind and followed by a rapid thaw had their inevitable effect on all open line work in the District. Consequently no new records could be created as regards the absence of faults, notwithstanding the most careful and efficient preparations which had been made by the local staff. In the circumstances, a total of about 250 faults, the majority of which were due to the bad weather conditions, must be regarded as highly satisfactory. Immediately the cut-over had been effected, the work of repairing the effects of the storm was undertaken

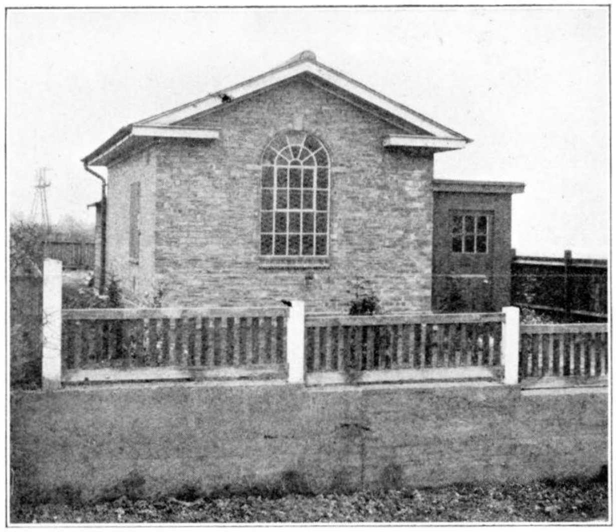


FIG. 13.—KENTON EXCHANGE.

and normal conditions were restored within a remarkably short time.

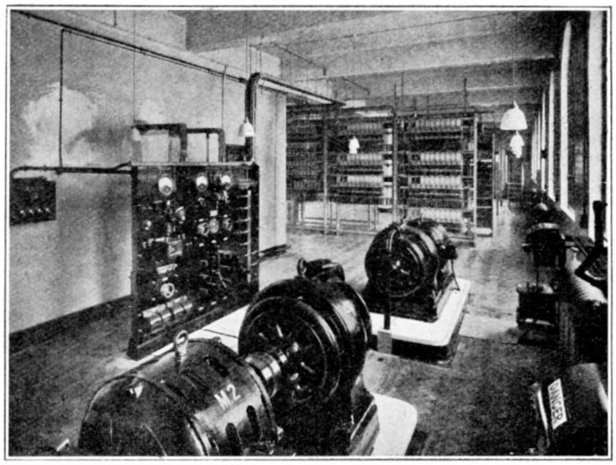


FIG. 14.—EAST EXCHANGE. CHARGING MOTOR GENERATOR, POWER BOARD AND SELECTOR RACKS.

Thanks are due to Mr. F. G. C. Baldwin, M.I.E.E., Superintending Engineer in charge of the District and other local officers, also to Messrs. The Standard Telephones & Cables, Ltd., and the Newcastle Chronicle, Ltd., for information and photographs used in this article.

For a description of the opening ceremony see page 75.

FREQUENCY CHARACTERISTICS OF STANDARD REFERENCE TYYE CONDENSER TRANSMITTERS AND MOVING COIL RECEIVERS.

W. WEST, B.A., A.M.I.E.E.

SUMMARY.—The frequency characteristics are found to depend, both in shape and level on the acoustical conditions under which the calibrations are made. If these conditions are reasonably similar to those of the Standard Reference method of calibration, the results, based on the use of the Rayleigh Disc, are very similar to those obtained by the Thermophone. When, however, actual use conditions are imitated, differences of the order of 5:1 for the transmitters and 3:1 for the receivers are found at certain considerable portions of the frequency range.

1. Some electro-acoustical instruments of the type used in the Standard Reference circuit of Telephone Transmission (at the S.F.E.R.T. laboratory at Paris) have been procured by the Research Section, and it is thought that the results of the calibrations of these instruments may be of interest to telephone engineers. Frequency-characteristic charts were supplied with each instrument and the tests to be described therefore serve a two-fold purpose. In the first place, they provide an opportunity for comparing the absolute measurements, based on a thermophone calibration, with those of the Post Office, which depend on the use of the Rayleigh disc. For this comparison it is necessary to imitate as far as possible the acoustical conditions under which the tests by the former method are carried out. Secondly, it is desirable to measure the performance of the instruments under conditions approximating to those of use.

The condenser transmitters (type No. D85880) differ somewhat from the earlier type (370W), tests on which are described in references 1 and 6. The sensitivity is greater and the depth of the diaphragm recess is less, but the frequency of mechanical resonance of the diaphragm has been reduced. The receivers (type No. D87860) operate by means of a moving coil in a permanent magnetic field, the general arrangement being similar to that of the Wente and Thuras moving-coil unit (reference 2). It will be sufficient to record the results of measurements on one instrument of each type; very similar results have been obtained on other instruments of the same type.

2. *Condenser Transmitter No. 4600.*—The methods of calibration of transmitters by means of the Rayleigh disc have been discussed elsewhere (reference 5). Two methods are used, both of which measure the sensitivity in terms of the voltage output from the transmitter per unit of applied sound pressure, but while the spherical wave method refers to the free air sound pressure, the stationary wave method refers to the actual pressure on the diaghragm. It is this latter notation which is also used in the thermophone calibration. The results of measurements of the performance of instrument No. 4600 are reproduced in Fig. **1**, wherein

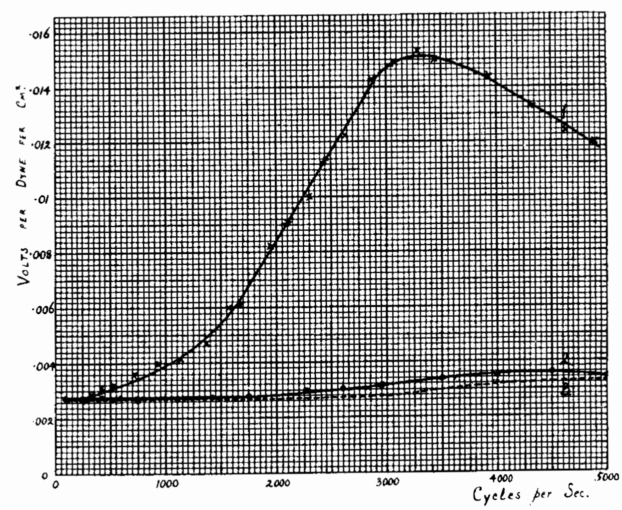


FIG. **1**.

curve 1 shows the spherical wave calibration (in terms of free air pressures), curve 2 the stationary wave calibration, and curve 3 the maker's calibration, by thermophone (both in terms of pressures on the diaphragm). In each test the transmitter was polarised with 200 volts.

3. *Receiver No. 20A.*—The calibration of a Standard Reference receiver in the Paris laboratory makes use of an "acoustic coupler" inserted between the receiver and a transmitter which has been calibrated by thermophone.

This comprises essentially a seating fitting on the face of the transmitter and extending the depth of the diaphragm recess by about 0.5 cm. The receiver fits on and the enclosed space is filled with hydrogen at atmospheric pressure. The excitation of the receiver at different frequencies creates pressures in the hydrogen which are measured by the condenser transmitter. The ear-cap of this type of receiver differs from the Post Office receiver cap; it is coned outwards, from an aperture of 2.54 cm. diameter, at a plane angle of 34° to the face of the receiver and rounded off on a diameter of about 4.76 cm. When the receiver is mounted on the coupler for calibration the space included between the aperture of the receiver cap and the diaphragm of the transmitter is about 27 c.c.

The method used by the Post Office for calibrating telephone receivers employs an artificial ear (reference 4) which is calibrated against a Rayleigh disc by the stationary wave method. Receiver No. 20A was first tested on the artificial ear; owing to the size of the aperture of the ear-cap the usual seating could not be used and a plasticine rim was provided instead. The enclosed volume in the cup of the artificial ear, measured from the aperture of the receiver cap, was about 3.5 c.c. and the calibration under this condition is shown in curve 1 of Fig. **2**. When

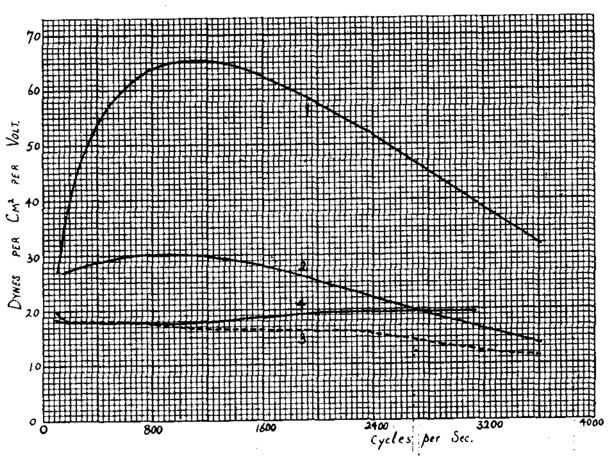


Fig. 2.

the volume was increased to about 9 c.c., curve 2 of Fig. **2** was obtained. Curve 3 shows the maker's calibration of this receiver by the method outlined above, and for curve 4 similar conditions of test were used as follows: An ebonite ring 0.5 cm. thick, having the same internal diameter as the diaphragm recess, was mounted on the condenser transmitter, and the receiver rested on this ring. An almost complete air seal was ensured by a light smear of vaseline over the lower surface and most of the upper surface of the ring—a small part was left unsmeared to permit sufficient leakage to ensure atmospheric pressure within the cavity. The volume of the cavity was thus approximately the same as that used in the Standard Reference calibration of a receiver, namely, 27 c.c., but the content was air and not hydrogen. The thermophone calibration of the transmitter was used to obtain curve 4, since this had also been used for curve 3.

The effective volume of cavity when the receiver is held to an ear was found for an ear-cap of this shape by making a similar cap to fit on to a Bell telephone receiver. The frequency of resonance of the diaphragm was observed when the receiver was held to the ear and also when it was closed with a known and adjustable volume. Observations on twelve ears showed a mean volume of 4 c.c., the extremes ranging from 2.4 to 5.4 c.c., at a frequency of about 1200 cycles per second. It appears therefore that the conditions under which curve 1 of Fig. **2** was obtained closely approximate to the actual conditions of use on the ear.

4. *Comment.*—These measurements show that considerable differences in sensitivity are to be expected according to the conditions under which the instruments are tested. Compare first curves 2 and 3 of Fig. **1**; in both of these the sound pressures measured are those at the surface of the diaphragm, and the agreement is, on the whole, very close. The Rayleigh disc calibration (curve 2) indicates, however, a somewhat lower frequency of maximum sensitivity than the Thermophone calibration (curve 3). This may possibly be due to the difference in conditions under which the tests are made; for the Rayleigh disc test the acoustical impedance at the diaphragm is non-reactive, while for the Thermophone test there is a considerable elastic reactance due to the volume of 9.1 c.c. of hydrogen in the thermophone chamber. The removal of this reactance would tend to reduce the total effective stiffness of the diaphragm and therefore to lower its frequency of mechanical resonance. The mechanical resistance due to

the air in front of the diaphragm is probably large, in both tests, as compared with the condition of free air.

When the transmitter is calibrated as an instrument for measuring free air pressures, as in curve 1 of Fig. **1**, the differences are very much greater. Two effects involved here have been discussed in detail elsewhere,* namely, the augmentation of sound pressure due to obstruction of the sound wave and due to concavity in the face of the instrument. For these transmitters the effects of mechanical resonance also appear within the frequency range, and, as stated above, it is to be expected that the frequency of mechanical resonance will be reduced by the removal of the elastic constraint of the thermophone chamber. The maximum amplitude of displacement of the diaphragm will therefore be increased—an effect which will be still more pronounced if the reduction of the mechanical resistance is also appreciable. It is the free air condition of test that most nearly represents the circumstances under which the transmitter is generally used.

The characteristics of the moving coil receiver, shown in Fig. **2**, are seen to depend fairly critically on the volume of the cavity to which it is exposed under test. If a source of sound whose strength is U, defined as the rate of volume displacement, operates on an acoustical impedance Z, the pressure developed is, by definition of the acoustical impedance, $p = Z.U$. Hence, if the strength of the source is not appreciably affected by a change in the impedance, the pressure is directly proportional to the impedance. If the impedance is that of the air in a small confined space, *i.e.*, if the wave-length is large as compared with any linear dimension of the space, this pressure will be the same over the whole of the enclosing surface. In the Appendix it is shown that this impedance can be expressed in terms of the volume Q of the space and of the absorption of sound at the enclosing surface, in terms of that due solely to an ideal tube of infinite extent (or terminated by its own impedance) whose cross sectional area is σ. Thus the impedance

$$Z = \rho c \left[\frac{\sigma - j(kQ)}{\sigma^2 + (kQ)^2} \right]$$

* *References 1, 5, 6 and 7.*

where ρ = density of air, c = velocity of sound in air $k = \frac{\omega}{c}$ and $j = \sqrt{-1}$. The modulus of the impedance is

$$(\text{Mod})\, Z = \frac{\rho c}{\sqrt{\sigma^2 + (kQ)^2}}.$$

Consideration of this expression shows that at frequencies where kQ is large as compared with σ, for any given frequency the impedance is inversely proportional to Q, but at lower frequencies the term σ reduces the effect due to a change of volume. The values of Q and σ are known for the conditions under which curves 1 and 2 of Fig. **2** were obtained; σ for the artificial ear is about 0.38 cm² and Q_1 and Q_2 were about 3.5 and 9.0 cm³ respectively. The ratio of the calculated impedances of the cavities used for curves 1 and 2 are compared with the ratio of the ordinates of these curves in the following table:—

Frequency Cycles per Sec.	Calculated Impedance ratio.	Observed Pressure ratio.
100	1.08	—
200	1.25	1.44
500	1.82	1.95
1000	2.25	2.2
2000	2.47	2.3

The volumes were not measured to a high degree of accuracy and the change of impedance as between curves 1 and 2 may be sufficient to affect the strength of the source of sound. The agreement is, however, sufficiently close to show that the observed differences are such as might be expected from purely acoustical considerations.

A comparison between curves 3 and 4 of Fig. **2** indicates that at the lower frequencies there is no appreciable difference betwen calibrations made with different, coupling devices enclosing the same volume. For these tests the resistance component is small and the term σ may be neglected at all except perhaps very low frequencies, so that the acoustical impedance reduces to $\frac{\rho c^2}{\omega Q}$ and the value of ρc^2 is substantially the same for air as for hydrogen. At frequencies higher than 1000 cycles per sec. there is divergence, due probably to the fact that with the shorter wave-lengths in air the pressure becomes less uniform throughout the chamber, which is comparatively large.

Appendix.

The Acoustical Impedance of Air in a Small Confined Space.

An expression for the acoustical impedance of air in a confined space, whose linear dimensions are small as compared with a wave-length, may be obtained from first principles so that the applicable simplifying approximations may be expressly stated. It is shown in Appendix I. of reference 3 that the acoustical impedance of a tube whose cross-sectional area is S and whose length x is terminated by a plug having reflection factor g is

$$Z = \frac{\rho c}{S}\left[\frac{1 - g^2 - j \cdot 2g \sin 2kx}{1 + g^2 - 2g \cos 2kx}\right] \quad \text{.......(1)}$$

If x is small, the interior of the tube is a small confined space and, approximately, $\sin 2kx = 2kx$ and $\cos 2kx = 1 - 2(kx)^2$. Also when g is nearly equal to unity $4g = (1 + g)^2$, approximately; the error is in fact less than 1.5% when g is as small as 0.8. In the present case this approximation is admissible since a small value of g means that a large proportion of the sound is emitted as a progressive wave, which is not consistent with the idea of sound pressure developed in a confined space. With these assumptions then equation (1) may be rewritten as

$$Z = \rho c \left[\frac{S\left(\frac{1 - g}{1 + g}\right) - jkxS}{S^2\left(\frac{1 - g}{1 + g}\right)^2 + (kxS)^2}\right] \quad \text{.......(2)}$$

As has been shown in the reference cited above, the acoustical resistance due to absorption of sound at the end of the tube is $\frac{\rho c}{S}\left(\frac{1 + g}{1 - g}\right)$. This expression may more conveniently be expressed in terms of the cross-sectional area σ of an ideal tube in which viscous effects are absent and which extends to infinity from an otherwise rigid wall. The acoustcal resistance of this termination to the tube whose area is S is $\frac{\rho c}{\sigma}$, whence $S\left(\frac{1 - g}{1 + g}\right) = \sigma$. The product $x \cdot S$ is the volume Q of the enclosed space, hence

$$Z = \rho c \left[\frac{\sigma - j(kQ)}{\sigma^2 + (kQ)^2}\right] \quad \text{........................(3)}$$

This expression is analogous to that for the electrical impedance of a capacity in parallel with a resistance. It has been calculated for a cavity of cylindrical shape; it applies, however, to any other shape provided that the pressure is uniform throughout the cavity.

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THE TELEPHONE INSTRUMENT EFFICIENCY TESTER.

A. HUDSON, B.Sc., A.C.G.I.F.C., A.M.I.E.E.

INTRODUCTION.—In an article in this Journal for October, 1929, entitled "The Mechanical Testing of Transmitters and Receivers," a description of a new method of testing subscribers' instruments in bulk is given. This method involves the use of a rhythmic type of oscillator and a special amplifier-rectifier, the characteristics of which are fully described in that article.

It is of interest to recall that the idea of utilizing a rhythmic oscillation principle as a substitute for speech in transmission measurements originated in the Post Office Research Section in 1915. (See I.P.O.E.E. Professional Paper No. 70, 1916). It is understood that the idea was adopted in America and is now in extensive use in the Bell System as a substitute for the voice.

Since the date of that article a set has been constructed for the purpose of testing the new microtelephones at the contractor's works. These instruments, owing to their peculiar characteristics, are very difficult to test by the ordinary speech methods. Factors such as side tone and the size of the observers' heads preclude the possibility of an accurate test, unless a large number of tests with several observers are made on each instrument. The "T.I.T." by providing a simple means of standardising the conditions of test enables an accurate test to be made much more quickly, a correction factor being applied to the results to allow for the difference between the two methods of test.

This set which was the first attempt to put the method into practical use has facilitated the collection of a considerable amount of data on the behaviour of a set of this kind under service conditions. The troubles inseparable from a new test in its early stages have proved of considerable value when the question of designing a set suitable for Test Section use was considered.

The experimental set is mounted on two racks, each about 16 inches high, which stand on a bench close to the actual testing bench. One rack contains the oscillator circuit, while the other has the amplifier-rectifier and control gear on it. All necessary switching is carried out by means of lever keys which are conveniently placed underneath the meter. It was found, after the installation of the set, that facilities additional to those provided were required and the keys necessary for these purposes are mounted external to the set. The oscillator feeds a loud speaker when testing transmitters and a dummy ear when testing receivers. The dummy ear which was used with the experimental set has given considerable trouble when used continuously, as it varies considerably in efficiency from day to day. This is probably due to the fact that the necessary damping is obtained from a receiver diaphragm. In the new type, which is being used in the new sets, the damping is obtained by air friction and there are no moving parts; so that this difficulty does not arise.

A maintenance scheme has been introduced and will probably be continued when the new sets are brought into use. A difficulty experienced with the staffing of the set is due to the fact that the men are only at the works for three months at one time, and it is not satisfactory for a continual succession of new men to undertake the maintenance of the set. It has been found advisable to train one man to do the necessary maintenance work, while the operator concerns himself only with the working of the set. This arrangement has other advantages, because the relieving of the operators can be effected without stopping the set while a new man is being taught. The maintenance officer attends to all records and to the weekly valve checks. The valve checks are carried out by means of a valve tester of a type which tests the valve in its working circuit, so that in the event of a fault occurring, there is a record of what the valves should do and the localisation of a fault is made comparatively simple. The valve test figures are returned to headquarters and form a useful record of the state of the set at any one time.

The chief faults which have occurred up to date have been found to be due to wear in apparatus, such as the rotary condenser, change-over keys and valves. The latter have given a considerable amount of trouble as, owing to the fact that they are on continuously for about 8 hours a day, only a valve with an exceptionally long life can be relied upon to be stable for any length of time.

Description of the new type sets.—Experience with the first set has shown that in spite of its imperfections, considerable improvements in both speed and accuracy are obtained and it has

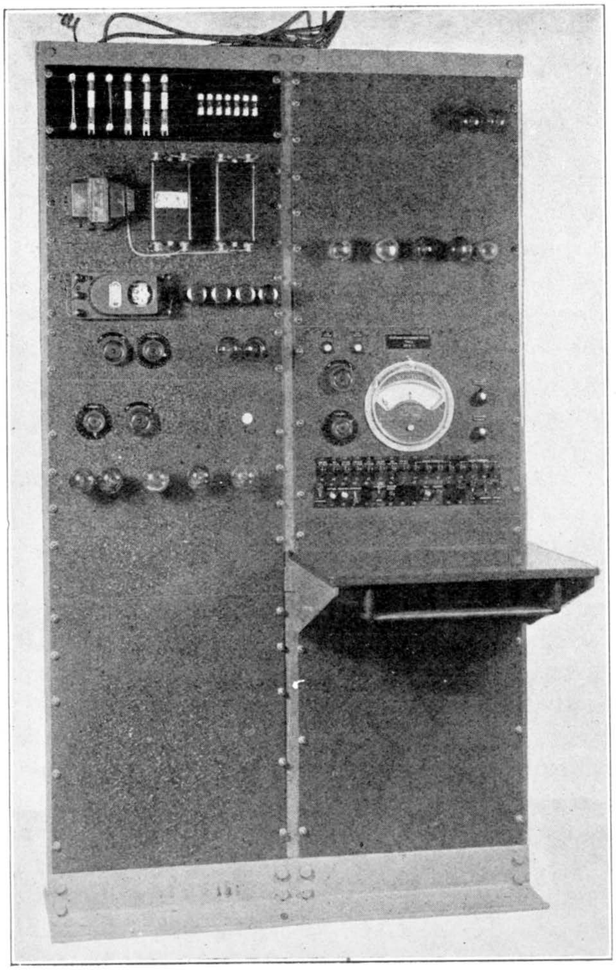


FIG. **1**.—TELEPHONE INSTRUMENT EFFICIENCY TESTER. FRONT.

been decided to equip the Test Section at Studd Street and Birmingham with sets which would embody the experience gained with the first one, with the addition of apparatus and facilities which have been shown to be desirable.

The lay-out of the new sets has been made quite different from that of the experimental set. All the apparatus has been placed on a standard double-bay apparatus rack, 6 ft. high. Photographs of the front and back views are given in Figs. **1** and **2**. It is found that this method has a big advantage over the bench type set from the points of view of floor space and maintenance. The set is completely self-contained from the operational standpoint, all the controls being concentrated on the control panel, which is immediately above the removable desk.

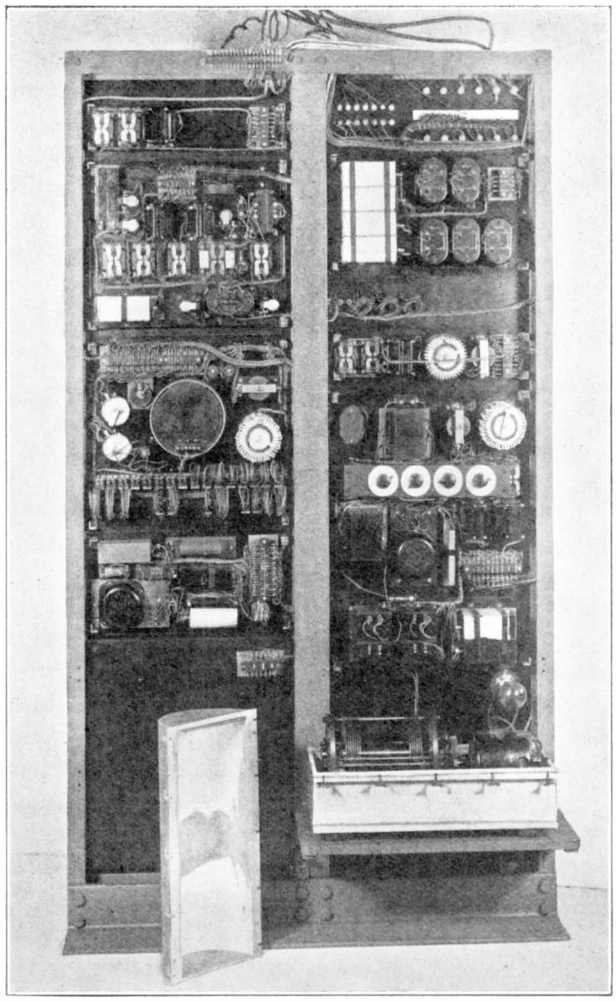


FIG. **2**.—TELEPHONE INSTRUMENT EFFICIENCY TESTER. BACK.

In Fig. **1** the left bay is taken up with the oscillator, H.T., and relay panels. The right bay contains the oscillator supplementary amplifier, amplifier-rectifier, control and instruments feeding circuits panels.

The oscillator circuit is so arranged that in the event of more than one set being required at a testing station, one oscillator can be made to serve any number up to ten sets at one time.

This is effected by fitting each operating bay with a supplementary amplifier fed from the main oscillator output. The first two sets fitted would be as shown in the photograph, while the remainder of the sets would consist of single bay racks similar to the right bay. The oscillators are arranged so that either may be used to feed all the sets at once. The advantages to be gained from this arrangement are many. Apart from the saving in cost, which may amount to as much as £1,600 in the case of a full sized installation, freedom from breakdown of the testing arrangements in the event of failure of any part of the apparatus is obtained, and this may be an important factor in a big works producing thousands of pieces of apparatus per week.

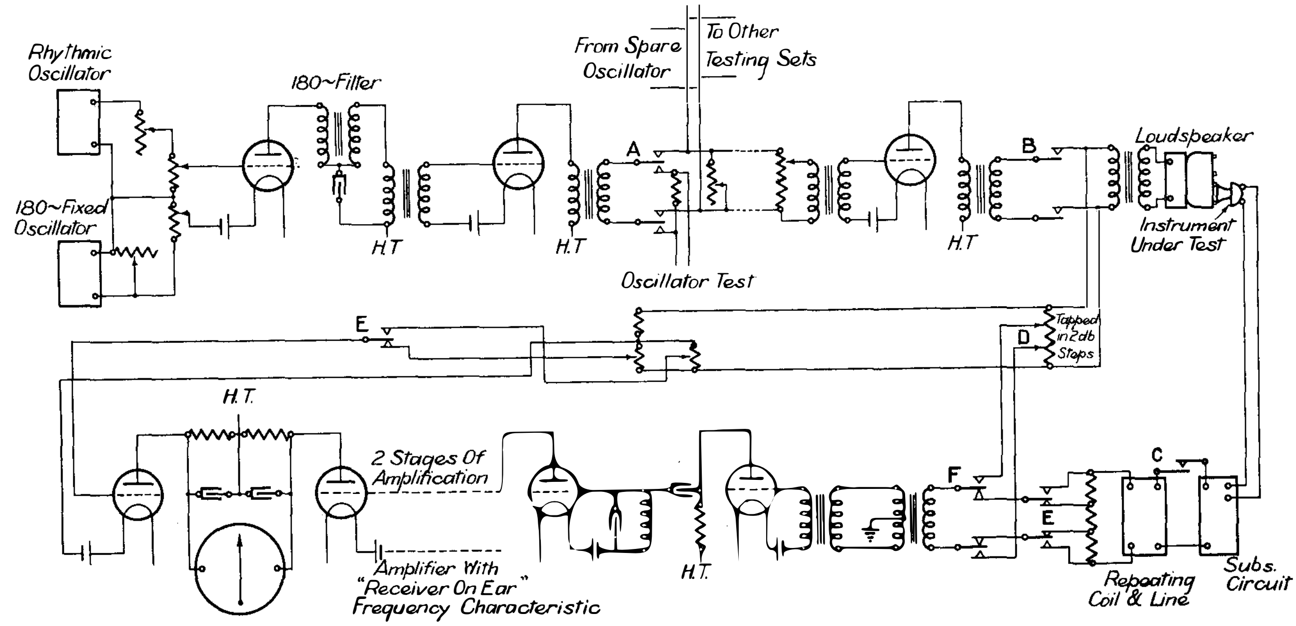
Description of Circuit Facilities.—The oscillator circuit, apart from the modifications necessary for multiple working is similar in design to the first set; advantage has been taken of the redesign to obtain a better lay-out and a cleaner wiring run. It has been found possible to control the whole of the setting of the oscillator by means of four potentiometers, which may be seen immediately behind the valveholders. Another potentiometer, not shown in the photograph, is fitted so that a correction may be obtained for the alteration in load caused by an increase in the number of testing sets. A further adjustment of the A.C. supply to the loud speaker is obtained by means of another potentiometer on the input circuit of the supplementary amplifier. This is necessary to compensate for possible losses between the oscillation and the test sets.

The relay panel contains a high resistance moving coil relay connected to the oscillator filament circuit, which, by operating one of two other relays and thence lighting one of two lamps on the control panel, gives a visual signal of the state of the filament voltage. Two other relays are fitted which give remote control of the A.C. and D.C. circuits. The H.T. panel, which is the only other panel on this bay, contains chokes and condensers mounted on the back for smoothing the H.T. supply and separating the H.T. feeds to the oscillator and amplifier-rectifier panels. The transformer and rectifiers to be seen on the front of this panel are only fitted to the set shown here. The H.T. supply for other sets will be derived from motor-generator sets with synchronous motors run from the electric light mains.

The right-hand bay contains the supplementary amplifier, amplifier-rectifier, control and instrument feeding circuits panels, taken in order from top to bottom. The supplementary amplifier panel has already been described. The amplifier-rectifier has been completely redesigned, in order to cater for the new type dummy ear. The specification as regards frequency characteristic has been kept the same (receiver on ear), but the amplification has been increased by the addition of another stage. The balanced rectifier principle, which has proved to be of considerable advantage in the working of the set, has been extended in scope so that the standard settings for receivers and transmitters may be adjusted independently of each other. See diagram in Fig. **3**.

The control panel is so arranged, in conjunction with the feeding circuits panel, that any type transmitter or receiver may be tested on its appropriate circuit; in addition, it is possible to test complete bell sets or subscribers' circuits. This is effected by means of lever type keys, which change over the transmitter, receiver, and line terminals from the standard C.B. conditions to those selected. Two circuits, in addition to the standard C.B. are fitted: standard L.B. and operators'. A blank wooden panel of considerable size is provided with a set of terminals so that any special set-up can be screwed to it and connected to the regular testing equipment. Another key disconnects the standard subscriber's circuit from its local line and brings out the local line to a separate pair of connection clips for the purpose of testing bell sets and a special type of receiver which will be referred to later.

The operational keys are arranged so that, working from left to right, each key must be operated in turn in testing apparatus such as the new microtelephone. This scheme ensures that all the tests required are performed on each instrument. Considerable difficulty has been experienced in carrying out all the switching necessary with only one key operation to each circuit change. The complications arise from the fact that interruptions at two seconds intervals are required when testing transmitters, which are unnecessary when testing receivers.



A. Change over key on oscillator.
B. A.C. interrupter relay. Operated by D.C. relay or "Standard" key.
C. D.C. „ „ Operated by Test key.
D. Standard adjustment keys.
E. Transmitter to Receiver key.
F. Test and Standard key.

Fig. 3.—Telephone Instrument Efficiency Tester. Circuit Diagram.

The testing bench is about 15 ft. long, with the loud speaker fitted in the centre. Connection of the apparatus under test is effected by means of spring clips, one set on either side of the loud speaker. Three boys are sufficient to feed instruments to the set, if a high speed of working is required, but two can work the testing bench with a consequent slowing-up of the speed.

Day to day calibration of the set is made by testing on the set a batch of specially selected and standardised transmitters or receivers in the normal fashion. The figures obtained in this way are corrected by the individual labelled allowances of the standards. The resultant figures give the figure for Department's standard according to each transmitter or receiver. The average of the batch gives a working figure which must then be corrected by the appropriate allowances in order to find the "Working throw-out figure." These calibrations have to be made at least once a day, as it is found that considerable variations may occur from time to time, though if it were found that a set remained constant for a considerable time the interval between calibrations could be increased. In the case of the experimental set, variations of the order of two db. have occurred during periods of about a week, and consequently frequent calibrations are necessary to ensure that a change is corrected before it can affect the level of acceptance.

The exact cause of these variations has not yet been discovered, as there is at present no suitable substitute for the carbon transmitter to enable a direct check to be made. Examination of the calibration figures show appreciable variations in the individual figures, so that some part at any rate of the trouble must be due to the standard apparatus.

Attempts have been made to reduce the possibility of set variation by gradually eliminating all apparatus which could possibly give rise to trouble in this connection. The set is self-checking within fairly wide limits, so that the only apparatus which, by changing its allowance, can affect the calibration of the set is the loud speaker or the dummy ear. The first is a moving coil loud speaker of well known make which is of extremely simple design and excellent

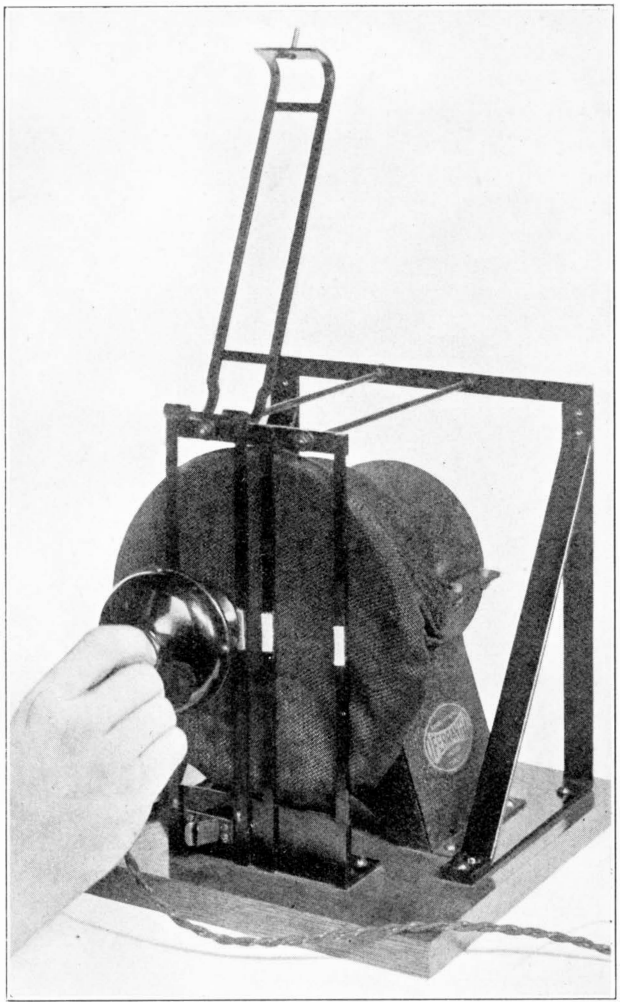


FIG. 4.—PICKING UP ENERGY FROM LOUD SPEAKER. NOTE DISTANCE GUARDS.

construction; the latter is made with no moving parts so that temperature changes and other effects will not alter its efficiency. Some trouble was experienced in the early stages due to a difficulty in applying the receiver to the device. This has now been overcome by a spring clip connection with a wide and firm seating for the receiver cap.

Use of the new sets has led to a considerable economy in time and ensures that more stable apparatus is selected as standards, because larger numbers of instruments may be tested at one time, ensuring continuity in the tests. The method actually in use is to test a batch of about 250 transmitters or receivers, either twice or three times a week, until eight or nine tests have been made on each. Those which show a variation of more than, say, 1.5 db., are discarded and the remainder are then set aside to form a stock from which standards are drawn as required to be finally calibrated, either by the speech methods, or on the T.I.T. to form T.I.T. standards.

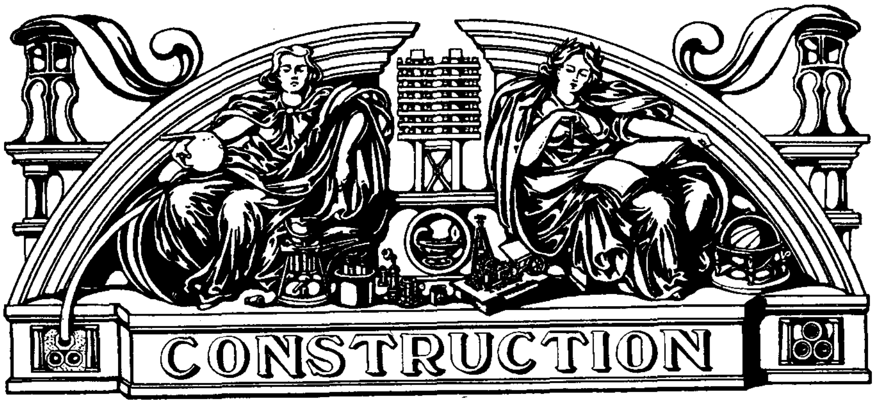
A new method of calibration is being developed which, it is hoped, will take the place of separate calibration by receiver and transmitter. The iron-cased electromagnetic receiver which is used in connection with the testing of apparatus at the subscriber's office is being improved with the object of reducing the inherent variability to a figure much below that of either normal transmitters or receivers. It will be possible to give a figure for this receiver in terms of both the Department's standards.

Future Developments.—The new type of set has been found to be quite satisfactory for the purpose for which it was designed, *i.e.*, the rapid testing of apparatus at contractors' works. The speeds obtained have been found to be higher than those hoped for. The new microtelephones have been tested at the rate of 86 an hour. Assuming that after warming up the set and calibrating it, there are six working hours a day (the minimum), about 500 instruments would be tested per day, each involving two tests. Even though two men are used at present in running the set, this is still more than twice the output per man by the old speech methods, while the figures are much more definite. Where multiple set working is found to be necessary the output per man will be much higher, because one man can maintain all the sets, so that his time would be split up amongst several sets instead of being charged to one only.

The use of this tester has been called for in the specification for Telephones Nos. 162 as the method that will be used in testing that apparatus, and it is proposed to extend it later for general use at contractors' works. A scheme for controlling the calibration of the sets has already been worked out for inclusion in the latest pattern. A db. attenuator is fitted which can be used to check the calibration of the meter, as it gives 2 db. steps over a range of 16 db. A scrutiny of the calibration figures week by week enables a running check to be kept on the working of the set, while the maintenance methods already described ensure that any fault is dealt with before it can have any effect on the supplies.

A considerable amount of research is still required in order to extend the scope of the set. Some instruments still give results which do not agree with the figures obtained on a speech test, while receiver testing is found to be uncertain when new types of apparatus are tested. Preliminary tests indicate that this discrepancy is due to the difference in temperature between the speech and T.I.T. conditions of test, although the difficulties of the tests made the results very inconclusive. A comparison of the frequency characteristics of a number of receivers shows that the efficiencies as derived from the area under the curves are much closer to the T.I.T. figures than the corresponding speech figures.

The solution of these and other problems will come with time, but no mechanical apparatus can ever completely take the place of the human voice and ear which are the ultimate referenda as to the quality of transmission.



THE ANGLO-FRENCH (1930) SUBMARINE TELEPHONE CABLE.

F. E. A. MANNING, M.C., B.Sc. (Eng.), A.M.I.E.E.

THE rapid increase in International Telephone Traffic consequent upon the technical development of long-distance communications during the past few years having completely taken up all available circuits, it was found necessary in 1930 to provide additional submarine links between England and the Continent. A description of one such link providing 24 channels has recently been published,* and this article describes another cable which will give a further 21 circuits.

The Anglo-French (1930) submarine cable was manufactured by Messrs. Siemens and Halske, of Berlin, and was laid by the cable ship " Norderney " from Le Portel to Seabrook, a distance of 32.11 nauts. The same firm also provided a land cable of similar nature for the 2.25 nauts between Le Portel and Boulogne Repeater Station. From Canterbury Repeater Station to Seabrook circuits work on the four-wire system in a 104 pair/20 lb. P.C. Quad cable, loaded with 44 mH coils at 2,000 yards spacing, and provided by Messrs. Standard Telephones and Cables, Ltd. The " Go " and " Return " circuits are separated by electrostatic screens of metallised paper. At Seabrook, four-wire/two-wire terminations with all necessary transformers and balances are installed in sheet-iron air-tight cabinets in an unattended cable hut. Two-wire working is adopted between Seabrook and Boulogne Repeater Station.

The submarine and (French) land cables are of the seven-quad, continuously loaded, A.S.P.C. type, made up in star-quad formation and allowing the use of phantom circuits. Quad crossings in the construction of the cable and large unbalances will prevent the use of double and quadruple phantom circuits, owing to high cross-talk between the double phantoms and other circuits forming their limbs.

Constructional details are as follows:—

Conductors. — Solid cylindrical annealed copper wire of 1.8 mm. (0.0709 inch) diameter and weight 22.65 kg. per km. (92.5 lb. per naut).

Loading.—One layer of iron wire of 0.15 mm. (0.0059 inch) diameter.

Dielectric.—Each loaded conductor covered with a helical winding of string and with paper, of uniform thickness not less than 0.065 mm. (0.00256 inch).

Make Up.—Four insulated conductors are stranded in star quad formation, and each quad is wrapped in paper. The cable is stranded with one quad in the centre and six in the outer layer, and the whole is surrounded by two layers of paper and one layer of Hessian tape.

* *" The Anglo-Belgian (1930) Submarine Telephone Cable," by M. E. Tufnail and J. F. Doust. P.O.E.E.J., Vol. 23, Part 4.*

Colour Scheme.—The two wires forming a pair are covered with paper of the same colour, white for the AB pair and red for the CD pair in each quad. The individual wires of each pair have no distinguishing marking. The quad wrapping papers are red, blue, white or green, the make up being as follows:—

Centre: Green.

Outer layer: Blue, white, red, white, red, white.

There is no colour indication of clockwise or counter-clockwise rotation.

Sheathing of Submarine Cable.—The cable is covered with two sheaths of an alloy of lead and tin, containing at least one per cent of tin. Between the two sheaths is a layer of bitumen compound. The mean thickness of each sheath is at least 1.8 mm. (0.0709 inch) and the minimum thickness of any transverse section is not less than 1.7 mm. (0.0669 inch). The external diameter of the outer lead sheath is (about) 32 mm. (1.26 inch).

Armouring of Submarine Cable.—The outer lead sheath is covered with layers of impregnated paper and a layer of tarred jute, of thickness at least one millimetre (0.0394 inch). Over this is placed a spiral armouring of 21 galvanised iron wires of 6 mm. (0.236 inch) diameter with a suitable lay.

The whole is served with a layer of oiled tape and two layers of three ply jute, one coating of bituminous compound being applied over each serving. The two servings of jute are laid on in reverse directions. The bituminous compound consists of 85% tar, 12.5% bitumen and 2.5% resin.

A length of about 10 nauts laid near the French coast, where the bottom of the sea is rocky, has in addition over the double lead sheath a rubber sheath of 2 mm. (0.0787 inch) thickness, to prevent ingress of water should the lead sheaths crack.

Dimensions of Submarine Cable.—

Weight: 10,800 kg. per km. (19.7 tons per naut).

Overall diameter: (about) 56 mm. (2.205 inches).

Manufacturing Lengths.—

Cable core without joints—400 metres (437 yds.).

Continuous lead sheath—800 metres (875 yds.).

Sheathing of Land Portion.—The cable is covered with a single sheath of lead-tin alloy, containing about one per cent. of tin. The mean thickness is at least 2.5 mm. (0.0985 inch) and the minimum thickness of any transverse section is not less than 2.4 m.m. (0.0945 inch).

The external diameter of the lead sheath is (about) 30 mm. (1.18 inch).

Armouring of Land Portion.—The lead sheath is covered with several layers of impregnated paper and a layer of tarred jute to form a suitable bedding for the armouring. This jute layer has a minimum thickness of at least 1.5 mm. (0.059 inch).

Over the jute bedding is a layer of galvanised iron wires of thickness not less than 1.4 mm. (0.055 inch).

A final layer of tarred jute is provided of thickness at least 1.5 mm. (0.059 inch).

Dimensions of Land Cable.—

Weight: (about) 5250 kg. per km. (9.57 tons per naut).

Overall diameter: (about) 40 mm. (1.575 inches).

The laying of the submarine cable took place on August 8th, 9th and 10th, 1930. The French shore end was landed from a barge and a coil of surplus cable about 0.119 nauts long was buried outside the cable hut. The landing operations took rather a long time, and kinking took place, which resulted in a full contact developing between the pairs in the centre quad at a distance of 0.865 nauts from the cable hut. The necessary repair was carried out by the cable ship "Norderney" and the War Department's steam vessel "Katharine" on August 17th. Some stages in the landing of the English shore end by the "Katharine" are shown in Figs. **1**, **2**, and **3**. The end in this case was cut to length.

The land cable was laid and balanced to the same electrical specification as the submarine cable, but the method of balancing differed from English procedure in that the quads and wires were jointed straight (colour to colour), balance being obtained by the insertion of condensers at certain joints. The completed land cable was

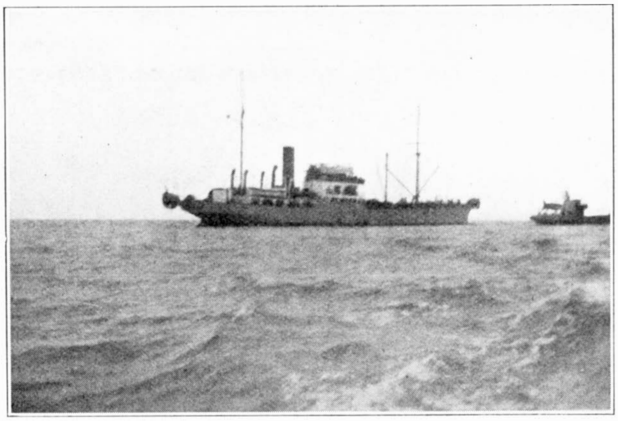


Fig. 1.—" Katharine " leaving " Norderney."

tested by the French Administration, and it is understood that it complied in every way with specification requirements.

Tests made on the submarine cable from the Seabrook end gave results almost identical with those on the completed system, which are described below. The land and submarine cables were jointed together in the cable hut at Le Portel, crosses being introduced for the reduction of cross-talk.

The completed system of length 34.36 nauts from Seabrook to Boulogne Repeater Station was tested from the Seabrook end by officers from the Research Section of the Engineer-in-Chief's Office, G.P.O., and from the Boulogne end by the French Administration, in co-operation with the contractors. The electrical characteristics obtained from these tests will now be summarised and discussed.

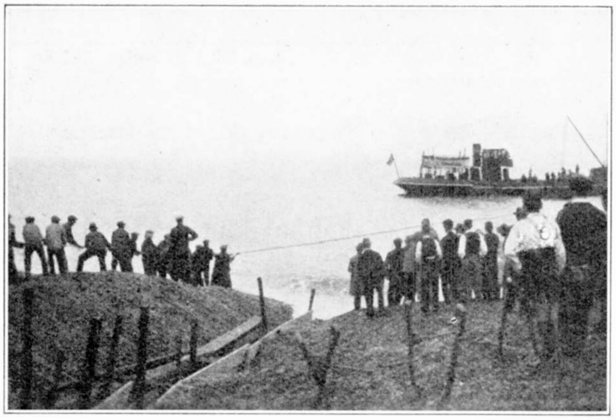


Fig. 2.—Pulling end ashore from " Katharine."

Direct Current Tests.

Conductor Resistance: average of 28 cores = 12.36 ohms per naut. The Resistance Unbalance was small, the maximum, expressed as a percentage of the loop resistance, being 0.035.

The Insulation Resistance was measured with 300 volts, between each core and the remainder earthed, after one minute electrification. The average value was 47,500 megohms per naut for the completed and terminated cable. On the submarine portion alone before terminating, an average value of 76,900 megohms per naut was obtained, which is a normal value for air space submarine cables with loose paper wrapping.*

D.C. Capacity: Average of 14 side circuits = 0.078 μF per naut.

Average of 7 phantom circuits = 0.218 μF per naut.

Fig. 3.—Landing the end.

Alternating Current Tests.

1. *Cross-talk*.—Table No. 1 gives the results of tests made with normal Post Office apparatus from Seabrook, the source of disturbance being speech or reed hummer as stated. Quads were terminated with a suitable resistance network at the distant end. The actual readings were in millionths of the disturbing current, but these have been converted to the power transference ratio between disturbing and disturbed circuits expressed in decibels, after correcting for impedance differences in line and apparatus.

* *c.f. " The Anglo-Dutch No. 3 Telephone Cable," by A. B. Morice, B.Sc. (Eng.), A.M.I.E.E. P.O.E.E.J., Vol. 19, Part 3.*

Distant end readings are also corrected for the attenuation of the disturbing circuit.

Table No. 2 gives the results of tests made with Siemens and Halske apparatus at Boulogne. In this case the cross-talk attenuation was measured at frequencies of 650, 800, 1100 and 1900 cycles per second, say b_1, b_2, b_3, and b_4, and the corresponding mean value, b, of the cross-talk attenuation is:—

$$b = -\log_e \tfrac{1}{4}\,(e^{-b_1} + e^{-b_2} + e^{-b_3} + e^{-b_4})$$

It is noted that the distant end values measured in this way are higher than the values measured with Reed Hummer and normal Post Office apparatus.

The cross-talk attenuation between any two circuits in different quads was never less than 76 decibels, and was generally very much higher.

The specified minima were:—

Side to side in the same quad	74 decibels.
Side to phantom in the same quad	61 decibels.
Between any circuits in different quads	74 decibels.

It will be seen that the specification was satisfactorily met.

The cross-talk-frequency characteristics of the circuits in quad V. are given in Fig. **4**.

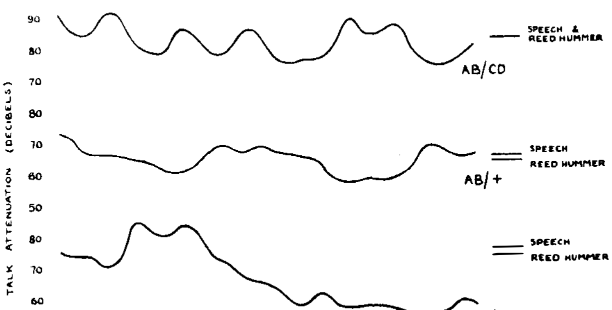


FIG. **4**.—NEAR END CROSS-TALK FREQUENCY CHARACTERISTICS OF PAIRS 9 AND 10. TESTED FROM SEABROOK.

2. *Characteristic Impedance and Uniformity of Electrical Constants.*—The characteristic impedance of each pair and each phantom circuit was measured at Seabrook over a range of frequencies from 300 to 3000 cycles per second. Curves for a side and a phantom circuit are given in Figs. **5** and **6**. The maximum deviation of the impedance from a mean smooth curve is

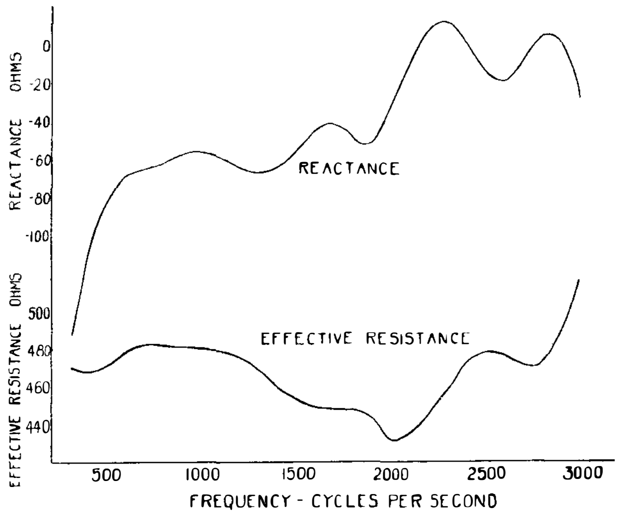


FIG. **5**.—IMPEDANCE FREQUENCY CHARACTERISTICS OF SIDE CIRCUIT OVER AUDIO RANGE.

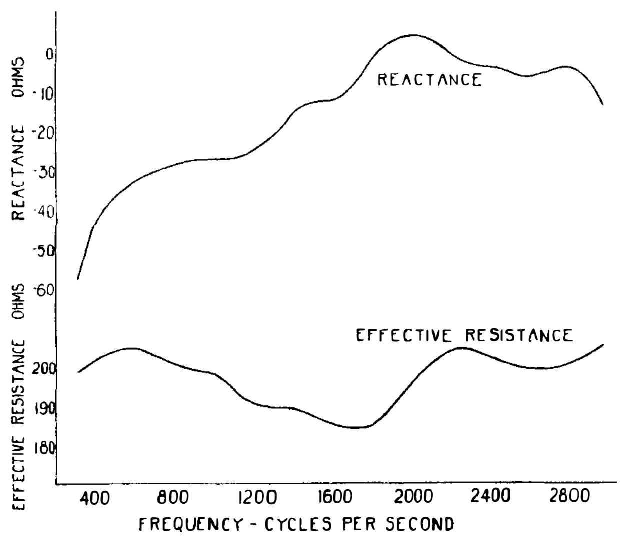


FIG. **6**.—IMPEDANCE FREQUENCY CHARACTERISTIC OF PHANTOM CIRCUIT.

on the whole higher than that obtained on similar cables in recent years, and exceeded 5% in the case of two side and three phantom circuits. It was also found that there is a considerable difference in shape between the curves of the different pairs. Impedance irregularities are caused by uneven distribution of the electrical constants along the cable, and a careful scrutiny of all the curves indicates that there is a length of some 16 nauts commencing about 9.5 nauts from Seabrook which is of different impedance from the remainder of the cable, causing the deviations noticed.

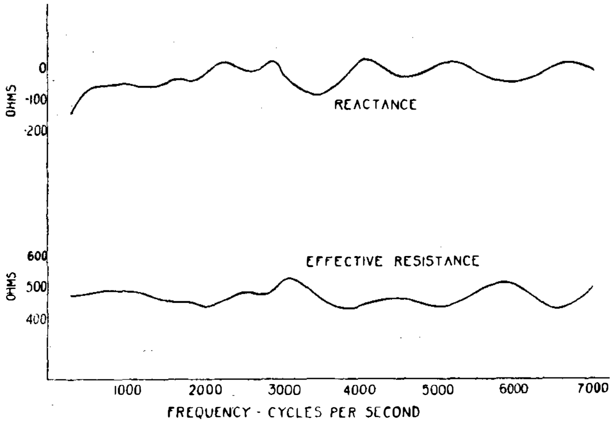


FIG. 7.—IMPEDANCE FREQUENCY CHARACTERISTICS OF SIDE CIRCUIT FROM 300 TO 7,000 CYCLES PER SECOND.

Table 3 gives the mean A.C. constants at three frequencies of all the pairs and all the phantoms in the outer layer of a short length of cable cut off the Seabrook end.

Fig. **7** shows the impedance-frequency characteristics over a range of frequencies from 300 to 7000 cycles per second for the side circuit of which the characteristics at audio frequencies are given in Fig. **5**. All side circuits were measured over the longer range, and it appears that from the point of view of impedance deviation some difficulty may be experienced in working broadcast repeaters.

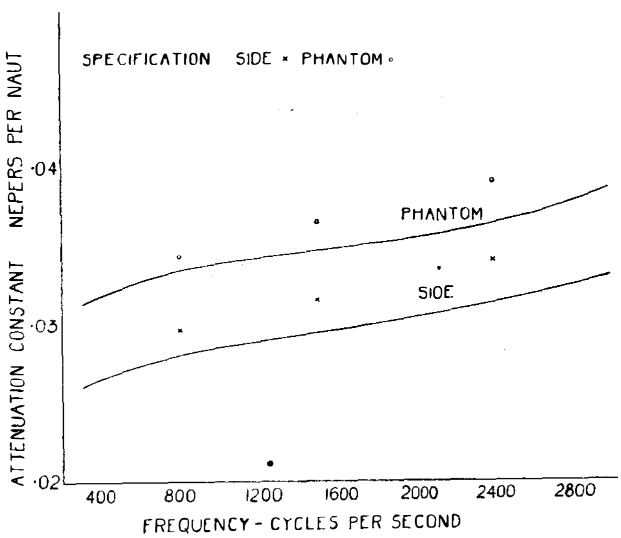


FIG. 8.—ATTENUATION FREQUENCY CHARACTERISTICS OVER AUDIO RANGE.

3. *Transmission Efficiency.*—Fig. **8** shows the attenuation-frequency variation of side and phantom circuits over a range from 300 to 3000 cycles per second, together with the specified maximum values at certain frequencies, which are not exceeded. The difference of attenuation between $f = 300$ and $f = 3000$ is 0.0069 and 0.0072 nepers per naut loop for the side and the phantom circuits respectively. Fig. **9** shows the attenuation-frequency variation of a side circuit from 300 to 7000 cycles per second.

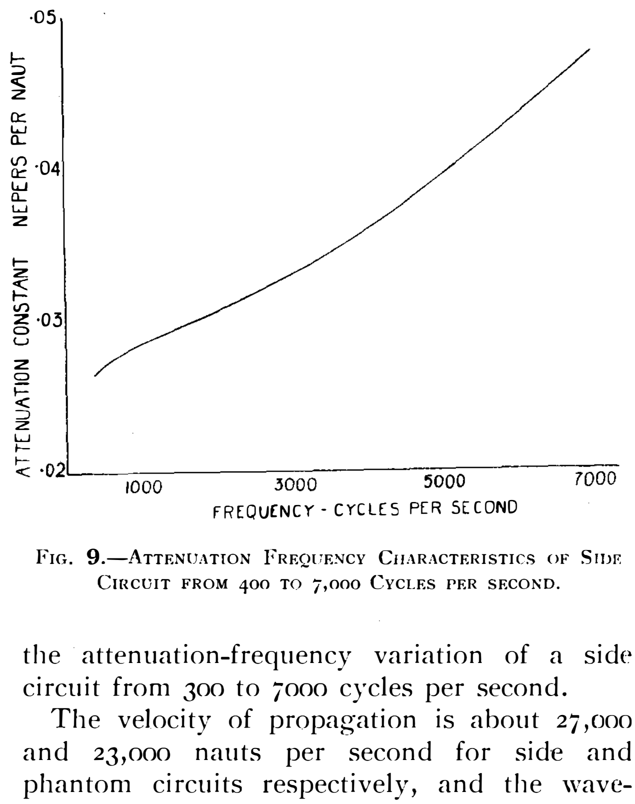


FIG. 9.—ATTENUATION FREQUENCY CHARACTERISTICS OF SIDE CIRCUIT FROM 400 TO 7,000 CYCLES PER SECOND.

The velocity of propagation is about 27,000 and 23,000 nauts per second for side and phantom circuits respectively, and the wavelength constant is proportional to frequency.

4. *Determination of Constant for Fault Localisation by A.C. methods.*—When fault localisation is being carried out by the sending end impedance method* it is necessary to use an empirical constant K obtained by tests on the

* *"A.C. Methods of Fault Localisation in Telephone Cables," by W. T. Palmer and M. E. Tufnail. P.O.E.E.J., Vol. 23, Part 1.*

completed cable. The value obtained in this case was

$$K = 13{,}650$$

This should be only slightly different from the value $\frac{1}{2\sqrt{CL}}$, but owing to irregular distribution of the electrical constants the mean value of the inductance and capacity after laying are not known. Taking the mean value of the inductance tested on factory lengths as 17 mH. per naut, and using the mean D.C. value of the capacity, *i.e.*, 0.078 μF per naut, we have

$$\frac{1}{2\sqrt{CL}} = 13{,}720$$

which is 0.51% greater than the measured value.

Some further considerations of fault localisation in this particular case are given in an appendix to this article.

The author's thanks are due to Mr. E. H. Jolley, of the Research Section, Engineer-in-Chief's Office, for supplying the photographs included in this article.

TABLE 1.

NEAR END AND DISTANT END CROSSTALK, WITHIN QUADS.

Tested at Seabrook with normal P.O. apparatus.

All values in decibels, after correction for impedance differences.

Quad.	AB/Phantom.			CD/Phantom.			AB/CD.		
	N.E.		D.E.	N.E.		D.E.	N.E.		D.E.
	Speech.	Reed Hummer.	Reed Hummer.	Speech.	Reed Hummer.	Reed Hummer.	Speech.	Reed Hummer.	Reed Hummer.
I.	69	67	66	76	71	69	90	90	81
II.	73	70	67	73	67	67	90	87	79
III.	72	70	69	68	70	66	80	80	90
IV.	69	64	73	67	64	66	85	87	78
V.	64	63	65	75	72	65	82	82	87
VI.	73	72	66	73	72	72	80	80	87
VII.	72	66	67	72	67	66	93	90	78

TABLE 2.

NEAR END AND DISTANT END CROSSTALK, WITHIN QUADS.

Tested at Boulogne with Siemens and Halske apparatus.

Mean of readings at frequencies of 650, 800, 1100 and 1900 cycles per second. All values in decibels.

Quad.	AB/Phantom.		CD/Phantom.		AB/CD.	
	N.E.	D.E.	N.E.	D.E.	N.E.	D.E.
I.	72	73	69	78	90	90
II.	73	73	69	77	90	88
III.	73	74	69	71	92	95
IV.	70	78	69	70	89	80
V.	72	69	70	76	87	100
VI.	70	70	74	78	82	94
VII.	75	75	70	75	85	88

TABLE 3.

A.C. CONSTANTS, PER NAUT. LOOP.

Mean values of circuits in outer layer, measured on 0.15 naut. length.

Circuits Tested.	Cycles per second.	Characteristic Impedance. Vector Ohms.	Attenuation Constant.	Propagation Constant.	Resistance Ohms.	Inductance Millihenries.	Capacity Microfarads.	Leakance Micromhos.
Sides	800	$477\backslash\overline{7^{\circ}42'}$	0.0264	$0.192/\underline{82^{\circ}6'}$	24.66	18.28	0.0773	1.47
	1500	$471\backslash\overline{4^{\circ}15'}$	0.0283	$0.355/\underline{85^{\circ}26'}$	25.62	17.72	0.0790	4.25
	2400	$472\backslash\overline{2^{\circ}44'}$	0.0304	$0.564/\underline{86^{\circ}55'}$	27.03	17.67	0.0791	7.41
Phantoms	800	$200\backslash\overline{7^{\circ}32'}$	0.0303	$0.225/\underline{82^{\circ}15'}$	11.85	8.64	0.2231	4.35
	1500	$198\backslash\overline{4^{\circ}3'}$	0.0311	$0.415/\underline{85^{\circ}42'}$	11.88	8.60	0.2226	9.37
	2400	$197\backslash\overline{2^{\circ}31'}$	0.0334	$0.662/\underline{87^{\circ}7'}$	12.30	8.62	0.2222	22.48

APPENDIX.

Fault localisation on the Anglo-French (1930) Cable from Canterbury Repeater Station.

Seabrook Cable Hut is unattended, and in it are situated transformers for changing from four-wire working in the Canterbury-Seabrook coil-loaded underground cable to two-wire working in the Seabrook-Boulogne continuously loaded submarine cable. Precision testing apparatus is permanently located at Canterbury Repeater Station and in order to take full advantage of this, special arrangements are necessary in the case of this cable.

1. *Direct Current Methods.*—In order that daily observation may be kept of the insulation resistance of circuits from Canterbury to Boulogne, spare unloaded wires in the Canterbury-Seabrook cable have been joined at Seabrook to the centre points of the submarine cable side of the phantom circuit transformers. This allows of an insulation measurement on a circuit composed of one wire of the Canterbury-Seabrook cable, the line windings of phantom and side circuit transformers at Seabrook, four wires in parallel in the submarine cable, and the line windings of side and phantom transformers at Boulogne. Should a cable breakdown occur, this circuit may be used for a Varley test or other direct current localisation from Canterbury by looping the centre point of the line side of a phantom transformer at Boulogne to a good wire in the Anglo-French (1926) Cable. The resultant localisation in ohms can be interpreted in terms of distance by making due allowance for the composite nature of the circuit.

2. *Alternating Current Method.*—Suppose a loaded pair in the Canterbury-Seabrook cable is put straight through at Seabrook to a pair in the submarine cable on which a fault occurs at a distance l' nauts from Seabrook.

Electrical energy supplied at Canterbury will be partly reflected at Seabrook, and a part will travel on to the fault, where further reflection will take place. The reflected energy from the fault will partly be reflected at Seabrook, and a part will return to the sending end.

Considering any one frequency f_1, the phase of a reflected wave from Seabrook on its return to the sending end will be $2a_1 l + \phi_1$,

where l is the distance in nauts from Canterbury to Seabrook

a_1 is the wave-length constant of the Canterbury-Seabrook cable at frequency f_1

ϕ_1 is the change in phase produced at the discontinuity at Seabrook.

The phase of a reflected wave from the fault on its return to the sending end will be $2a_1\, l + \psi_1 + 2a_1' l' + \psi_1' + \phi_1'$

where a_1' is the wave-length constant of the Seabrook-Boulogne cable at frequency f_1

ϕ_1' is the change in phase produced by the fault

ψ_1 is the change in phase in passing from the land to the submarine cable

ψ_1' is the change in phase in passing from the submarine to the land cable.

At a second frequency f_2 the corresponding phases are $(2\alpha_2 l+\phi_2)$ and $(2\alpha_2 l+\psi_2+2\alpha_2' l'+\psi_2'+\phi_2')$

where α_2, α_2', ϕ_2, etc., have the same significance as α_1, α_1', ϕ_1, etc., but at frequency f_2 instead of f_1.

Suppose an impedance-frequency run, using the parallel resonance bridge, is taken on a faulty circuit, and that from each resistance reading is subtracted the reading obtained on the same circuit when there is no fault, then obviously the phase change due to first reflection is practically the same at any given frequency in each case, and differences between the two curves are mainly due to first reflections at the fault, secondary reflections having little effect. Then if f_1 and f_2 are the frequencies of two successive maximum points on the difference curve, we have

$$(2\alpha_2 l+\psi_2+2\alpha_2' l'+\psi_2'+\phi_2')-(2\alpha_1 l+\psi_1+2\alpha_1' l'+\psi_1'+\phi_1')=2\pi \quad \ldots\ldots\ldots(1)$$

Whence $l' =$

$$\frac{2\pi+2l(\alpha_1-\alpha_2)+(\psi_1-\psi_2)+(\psi_1'-\psi_2')+(\phi_1'-\phi_2')}{2(\alpha_2'-\alpha_1')} \quad .(2)$$

Now in this case we may assume that $\psi_1=\psi_2$, $\psi_1'=\psi_2'$, and $\phi_1'=\phi_2'$.

$$\text{Then } l'=\frac{\pi+l(\alpha_1-\alpha_2)}{(\alpha_2'-\alpha_1')} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

But for loaded cables $\alpha \doteqdot 2\pi f\sqrt{CL}$

$$\text{Then } l' \doteqdot \frac{1}{2(f_2-f_1)\sqrt{C'L'}}-\frac{l\sqrt{CL}}{\sqrt{C'L'}} \quad \ldots\ldots(4)$$

Comparing this with the normal alternating current location formula, *i.e.*, $l=\frac{K}{f_2-f_1}$, we have

$$l' \doteqdot \frac{K'}{f_2-f_1}-\frac{K'}{K}l \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

where K′ is the fault localisation constant for the submarine cable,

and K is the fault localisation constant for the underground cable.

It is seen that the term $\frac{K'}{K}l$ in equation (5) is the length of submarine cable that would give the same phase change as l miles of underground cable. This term may be obtained directly from a knowledge of K′, K, and l, or may be determined by introducing at a known distance l' along the submarine cable a contact resistance across the selected pair.

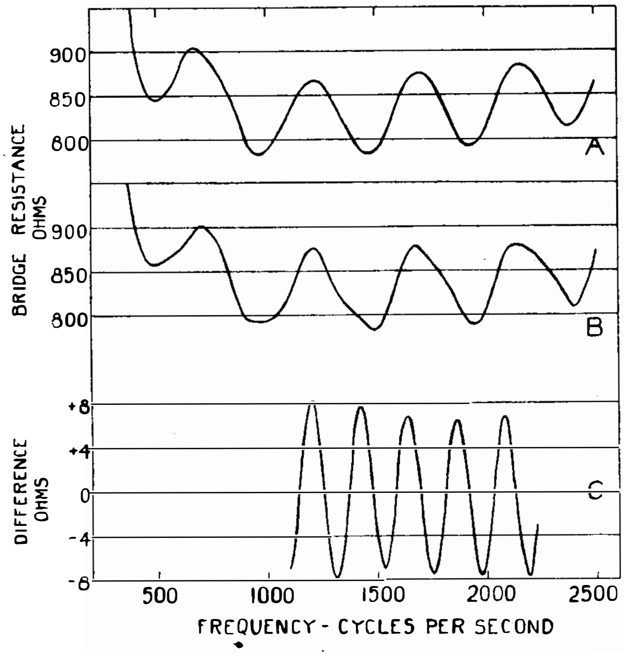


FIG. 10.—A. NORMAL IMPEDANCE (BRIDGE RES. READINGS).
B. IMPEDANCE WITH 500 OHM FAULT AT BOULOGNE.
C. DIFFERENCE CURVE B—A.

Fig. **10** shows some results of tests made in this way.* Curve A shows the bridge resistance readings obtained when testing on pair 5 of the underground cable joined straight through at Seabrook to pair 5 of the submarine cable, which was looped at Boulogne to an electrically long similar circuit. Curve B shows the bridge resistance readings obtained on the same circuit when a contact fault of 500 ohms was put across

* *Cf. Fig.* **8**, *p. 48, P.O.E.E.J., Vol. 23, Part 1. "A.C. Methods of Fault Localisation in Telephone Cables," by W. T. Palmer and M. E. Tufnail.*

pair 5 at Boulogne. Curve C shows the difference curve, over a portion of the range. Careful exploration at close frequency intervals of certain maxima gave $(f_2 - f_1)$ as 219 cycles per second. The length l' of the submarine cable is 34.36 nauts, and the localisation constant K′ is 13,650. Substituting these values in equation (5)

$$\frac{K'}{K} l = \frac{13{,}650}{219} - 34.36 = 62.32 - 34.36 = 27.96 \text{ nauts} \qquad (6)$$

Since l is known, *i.e.*, 17.257 nauts., we can obtain a value of K from equation (6).

$$K = \frac{K'l}{27.96} = \frac{13{,}650 \times 17.257}{27.96} = 8{,}425 \qquad (7)$$

The capacity per naut. of the underground cable is about 0.076 μF per naut, and the inductance per naut about 44.7 mH. Using these values we obtain

$$K = \frac{1}{2\sqrt{CL}} = 8{,}580 \qquad (8)$$

This agrees fairly well with the value obtained practically from equation (7).

If a pair in the underground cable is joined through at Seabrook to a pair in the submarine cable and this is terminated at Boulogne with its characteristic impedance in ohms—say, 480 ohms—then an impedance-frequency run can be taken to be kept as a reference. A portion of this run—say, from 1600 to 2200 cycles per second—should be measured at close frequency intervals. Then, on a fault occurring, which is located in the submarine cable by direct current tests, the same pairs must be put through at Seabrook and terminated at Boulogne with the same resistance. An impedance-frequency run can now be taken on the faulty circuit, the same close intervals being used between 1600 and 2200 cycles per second. By plotting the differences between this series of results and those previously taken for reference, a value can be obtained for the frequency interval $(f_2 - f_1)$ between successive maxima, and then the distance from Seabrook to the fault, l' nauts, is given by

$$l' = \frac{13{,}650}{f_2 - f_1} - 27.96 \qquad (9)$$

In view of rather irregular distribution of the electrical constants in the submarine cable, the constant K′ = 13,650 may not be quite accurate for faults in all positions along this cable. It is also possible that seasonal temperature variations will be found to have a slight effect on the experimental value of the term $\frac{K'}{K} l$ in equation (5). It is possible, therefore, that localisations by this method may not be within the 1% accuracy obtained in cases where the same type of cable is employed throughout between test points, but the method should prove useful in any case where the direct current methods present difficulty.

VENTILATION OF BUILDINGS: INCLUDING THE NEW SYSTEM STANDARDISED FOR USE IN AUTOMATIC TELEPHONE EXCHANGES.

J. E. McGregor, A.C.G.I., A.M.I.E.E.

In view of the recent issue of the new Technical Instruction No. XXXIX. on the Ventilation of Buildings, and the interest evinced at meetings of the I.P.O.E.E. it seems opportune to make a few comments both on the need for mechanical ventilation and on the systems adopted by the Department.

The ventilation of buildings is a subject of increasing importance, especially in large towns, where buildings are growing in size and the provision of natural ventilation is becoming very difficult. It is complicated by the fact that the free air surrounding the buildings is no longer pure, but is partly vitiated by exhaust gases from motor cars and impregnated to a greater or less extent, depending on the neighbourhood, by dust and smoke.

Windows which give adequate ventilation for smaller rooms are less effective or cause draughts in larger rooms. They often remain closed due to inclement weather or the whims of the staff employed, and even when conditions are otherwise favourable may be kept closed to exclude dust or noise. For these reasons artificial means of ventilation, which will be effective at all seasons of the year and are independent of the idiosyncrasies of the staff employed in the building, are becoming increasingly necessary.

Artificial ventilation may be carried out by means of *Suction* systems in which the air is drawn out of the buildings by fans, the ingress of air being more or less uncontrolled, or by *Plenum* or pressure systems in which the air is entirely under control, it being drawn in from the more suitable position as regards the purity of the air, filtered to remove the greater part of its dust and smoke content, and delivered as, and where, required in the building under a slight pressure. When desired, owing to manufacturing processes such as in cotton mills or for other reasons, it may be entirely reconditioned as regards its temperature and humidity.

In any scheme of ventilation it is necessary to take into account the dimensions of the room and the number of staff employed, the nature of the work carried out and whether the circulation of the air is likely to be impeded. As will be seen later, this is one of the most serious factors in the case of automatic apparatus rooms, the other being impurities in the air. Consideration has also to be given to the reconditioning of the air and the removal of dust and soot if necessary.

Until recently the percentage of carbon-dioxide, the waste product of fuel consumption and of the natural process of breathing, has been considered of vital importance, but it is now known that this percentage may be very high without injuriously affecting the human body as long as the air is in movement, other beneficial factors being moderate temperature and humidity. This is because the feeling of well-being is dependent on the temperature of the body being kept constant by the evaporation of moisture from the skin which depends on these conditions, and on the removal of the moisture and CO_2 emitted from the lungs in breathing.

The percentage of CO, the product of incomplete combustion of fuel which is poisonous, does not generally have to be considered except in the case of the ventilation of garages, but with the increasing number of motor cars in confined streets it becomes advisable to arrange for the ingress of air to be as much removed from the street level as possible. From the point of view of the prevention of the transmission of disease or illness an ample supply of fresh air and its free circulation are matters of prime importance.

Owing to the necessity for maintaining movement of the air, the ventilation of Apparatus Rooms in Automatic Exchanges becomes a very urgent matter, as, although the number of staff employed is not large in proportion to the gross volume of the rooms, the volume of free air in the room is greatly reduced and the flow of air very greatly impeded by the rows of apparatus racks, closely spaced and extending practically to the ceiling. This arrangement of racks causes a feeling of confinement and stuffiness which can only be dispelled by the introduction of a considerable volume of fresh air moving with as high a velocity as is permissible.

Complete reconditioning of the air owing to our temperate climate, need not generally be considered except as mentioned above in connection with certain manufacturing industries. The plant required is expensive and bulky, as, when employed, the incoming air has to be washed, the free moisture removed, the moisture content reduced by freezing, further moisture added if required and the temperature readjusted.

It is necessary, however, in many cases and especially in Auto Apparatus Rooms, to remove as much dust and smoke from the air as possible and this, though easy as regards material dust, is not easy as regards smoke. Air filters are of many types; they may consist of water sprays, screens of some textile material, or screens containing material such as metal turnings, expanded metal, or small pieces of tube jumbled together, the material being coated with a viscous oil on which the dust from the air is deposited as the air passes along the tortuous paths thus provided by the filter.

The Department has now had experience of a large number of the various air filters on the market and has found that a perfect filter does not exist. Practically any type of filter is effective as regards material dust, but it is a very different matter as regards smoke and the very fine soot carried by the smoke; washing the air is no better in this respect than using textile and viscous filters. Textile filters can be obtained which are comparatively very effective, but in a short time they become permanently more or less choked, involving a reduction in the amount of air passed and an excessive cost in maintenance. For small installations, however, a filter has been evolved to meet our requirements and this is embodied in what is known as the Plenum Unit which is referred to later. In this case the filtering material is of cellulose and is so cheap that it becomes economical to throw away the used, and replace it by new, material. Although this is practicable for small installations the cost of replacement becomes serious where large installations are in question and a viscous type of filter is then used, the efficiency of which is high, especially when used in the duplex form which has been standardised for use in dirty neighbourhoods.

Many types of viscous filter have been used by the Department which have been found either less efficient than the type standardised or to present greater difficulties in cleaning, in some cases permanent choking occurring as in textile filters of the more efficient types. To clean filters of the viscous type it is necessary to use a hot soda solution which does not, however, soak out all the interior dirt in a sealed type of filter cell, and the standard type has the great advantage that it is a simple matter to empty out the filtering material, clean them separately and then reassemble the filter.

Although by the use of air filters practically all the material dust and a considerable percentage of the smoke and soot can be removed, it should be borne in mind that the work of the filter can be largely negatived if dust is permitted to enter the room by other means. Dust can enter the room on the clothing and shoes of the staff, through open doors, especially if stairs and corridors are not kept quite clean, through fresh air inlets behind radiators, if they have not been shut as they should be when Plenum systems have been installed, and through the flap ventilators, which are installed to provide for the egress of the air, if they are not maintained in good condition.

Reverting to the *Suction* system of ventilation, this is usually installed where there is no need to provide air freed from dust, where there is no possibility of drawing the air supply from tainted sources, and where it is necessary to remove fumes as in kitchens and dining-rooms or dust as in bag-rooms. Usually one or more simple extractor fans are fitted in the windows on one side of the building, fresh air being admitted through the windows on the opposite wall. Where possible, if more than one fan is installed, they should be placed on different frontages, as a fan of this type may be rendered entirely ineffective by a wind. In some cases it is preferable to instal ductwork so as to draw the air out at a large number of points, in which case a cased centrifugal fan usually becomes necessary, as the open type of propellor fan cannot draw the air effectively against the resistance to air flow caused by the ductwork. For the same reason, this type of fan is next to useless if it is required to filter the air at all satisfactorily. It is also necessary that air should be admitted freely to the room through open windows or special apertures. When there are complaints as to the working of a suction ventilating system, it will frequently be found that all windows are closed so that air cannot enter freely, or that windows are open adjacent to the fan, thus short-circuiting the circulation of air across the room. Generally, when it is necessary to filter the air the Plenum system is much the most satisfactory, as there is greater freedom in choosing the point at which the fresh air can be drawn and the whole system is under control.

In the case of the earlier automatic telephone exchanges it was necessary to consider the humidity as well as the provision of air, as the material used was to a certain extent hygroscopic. This difficulty was overcome by a choice of materials, but the question of efficient ventilation remained.

In this case we were faced with the following problems: first, the provision of sufficient fresh air freed as far as possible from dust, as this is deleterious to the maintenance of the apparatus, and secondly, the proper circulation of the air so that stagnant pockets of air, possibly holding germs of disease, should not be left between the racks. Natural ventilation by the opening of the windows is out of the question, not only on account of dust troubles, but owing to the impossibility of providing efficient circulation of the air by this means. The provision of sufficient air by mechanical means presents no difficulty, except that owing to other requirements it is not always possible to obtain the best situation for the fan room, and, even when such a position has been chosen from the plans of the building, it may be found when the building itself and other buildings around it have been erected so that smoke from their chimneys is driven directly on to the air inlet by the prevailing wind.

As regards dust, what may elsewhere be a quite satisfactory filter is not necessarily satisfactory in this case, owing to the enormous settling surface presented by the apparatus. In an ordinary room the circulation of air is practically unimpeded and the very fine particles which will pass the filter will remain in the air and be carried out by it, but here we have the racks extending practically to the ceiling, the circulation of air seriously impeded, a large surface which will collect this dust and in addition the attraction of electrified surfaces for dust.

The type of viscous filter employed in the new standard system has been selected after careful consideration of the various types and makes available, as it is found the most suitable as regards efficiency, maintenance and space required. The difficulty of circulating the air has been overcome by the use of the new rotating outlets which drive the air downwards and outwards. The consequent turbulence of the air should prove beneficial both in preventing air pockets remaining between the racks and in minimising the tendency of the fine dust or soot passed by the filter to settle out of the air on to the racks.

The amount of fresh air supplied is considerably greater than that actually needed for breathing purposes by the staff, owing to the necessity of scouring out the vitiated air between the racks and also removing a certain amount of low grade heat given out by the apparatus.

In the smaller exchanges it is not feasible to provide special fan rooms and expensive plant owing to cost considerations; a system has been designed accordingly in which the fan and filter form a self-contained "Plenum Unit" and the ductwork is simple and can be erected by the Department's staff. The filter used in these units is very efficient and the dirty filtering material is simply thrown away instead of being cleaned, thus simplifying the maintenance to a minimum.

It will generally be found that the air supplied is by no means excessive in warm weather. In colder weather, however, when owing to changed conditions so much fresh air is not necessitated, the staff may find it convenient to run the fan at full output for about an hour to thoroughly clear out the air of the apparatus room and then to reduce the amount of air circulated by using the damper provided in the main duct. This method of working will incidentally reduce the slight amount of dust brought into the exchange by the air.

BACK-TO-BACK TESTING OF EXCHANGE MOTOR GENERATORS.

R. MacWhirter, B.Sc., Scotland West.

A CONSIDERATION of the familiar Hopkinson Test for D.C. Motors suggests the possibility of applying a similar test to motor-generators. The essence of the Hopkinson or other back-to-back test lies in the use of two identical machines connected to the supply mains and coupled together mechanically or electrically in such a way that one machine drives (*via* the mechanical or electrical coupling) the other machine, which generates current back to the line. Fig. 1 indicates the circulation of energy in the case of motor-generating sets.

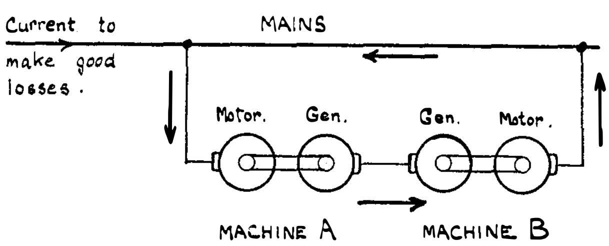


Fig. 1.

The advantages of the method are:—

(1) *Economy.*—Only the difference between the power taken by Machine A, and the power generated by B, is drawn from the supply.

(2) *Ease of control.*—The extent of loading is easily controlled by simple adjustment of field excitation. Load current is much more stable than when a liquid resistance is used.

(3) *Saving of time.*—While temperature measurements are being made on, say, Machine A, Machine B is simultaneously warming up. Thereafter only a short run is necessary with Set A inverted (*i.e.*, generating at the motor end) instead of Set B, to stabilize the temperature and complete the test on the latter set. In Telephone Exchanges the circumstances are peculiarly suitable for such a test, as two machines are usually available, together with a well equipped power-board.

Case 1—D.C. Supply.—No difficulties present themselves.

Assume two motor-generators with a reasonable range of field control, connected up as shown in Fig. 2. As a rule, a simple cross-

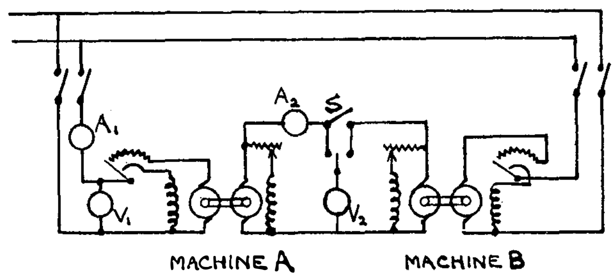


Fig. 2.

connection at the back of the board will enable the above circuit to be constructed. Fig. 3 shows a particular Ericsson board on which only a link L has to be inserted as shown. Switch S is used as a paralleling switch, and it will be seen that the ammeter and voltmeter on the board can be used as the output instruments, and the circuit-breaker retained in circuit for protection.

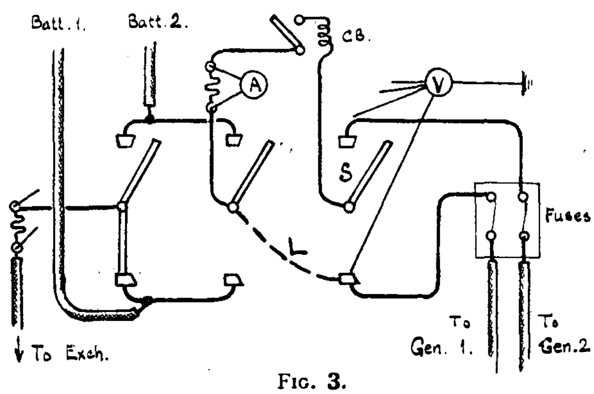


Fig. 3.

It will be seen (Fig. 2) that we have a voltmeter and ammeter connected in both the Input and Output circuits of Machine A, the machine which runs normally.

The test procedure is as follows:—

Both machines are started up with switch S opened. Field resistances are adjusted to give normal voltage (say, 46 volts) at the terminals, and switch S is closed, thus paralleling the two machines. A reading of V_1 and A_1 will now give the no-load power taken by one machine.

The excitation of Machine A is now increased. Voltages no longer balance and a current circulates round the closed circuit formed by the armatures of the two generators. This is indicated on A_2, while V_2 registers the increased voltages. Next, B's excitation is reduced until V_2 returns to its normal value. Notice that by reducing the excitation of B we have *increased* the difference between the E.M.Fs. of the machines: this manifests itself in a further rise in the reading of A_2 as we bring V_2 back to normal.

V_1 and A_1 now indicates the input corresponding to a load of A_2 amperes.

The process is repeated for a further increase in loading, and continued until Machine A is fully loaded. The usual tables of volts, amperes, watts and efficiency are then constructed. The instruments may then be re-arranged and Machine B run normally with A inverted.

Case 2—Alternating Current Supply.—It should be realised that an induction motor will function equally well as an induction generator, provided it is connected to an A.C. supply.

In normal operation, the magnetic lines of force in an induction motor travel round the shell at synchronous speed, *i.e.*, in step with the alternations of the supply voltage. The rotor rotates by virtue of the reaction between the current it carries and the rotating magnetic flux. Now the rotor currents can only be induced by rotor conductors cutting the magnetic lines of force. In other words the rotor speed must differ from the speed of rotation of the flux. Actually, the rotor revolves somewhat more slowly than the flux, the difference of speed adjusting itself to a value such that the induced rotor currents are just sufficient to overcome the torque imposed by the load.

Now suppose the rotor is driven *above* synchronous speed by artificial means; the rotor currents, and by transformer action the stator currents, will have a direction opposite to the currents considered above. In other words, the machine is running as a generator.

For those familiar with the Circle Diagram of the induction motor, the state of affairs is best represented vectorially as in Fig. 4, where—

OV : represents applied voltage.
OI_0 : represents no-load current.
$O\phi$: represents the flux.

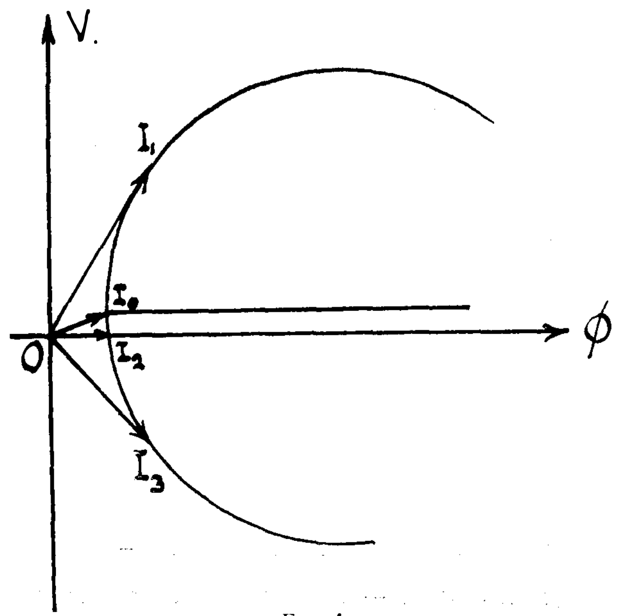


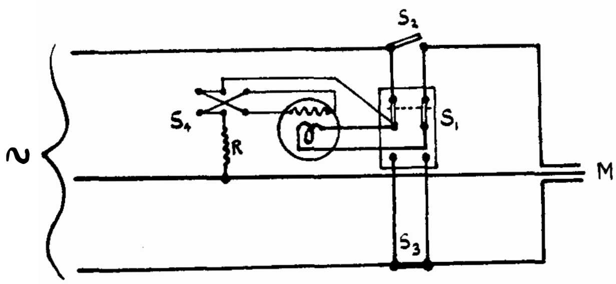
FIG. 4.

As the load is taken off and the rotor speed increases, OI_1, the load current, gradually retreats towards OI_0. If the rotor is further speeded up OI_1 will move to position OI_2 when the machine losses are just overcome, and finally to some position such as OI_3, when the machine will be generating back into the mains.

To run a back-to-back load test, then, on A.C. driven plant, the process is exactly the same as with D.C. The generators are paralleled as before, the excitation of the generating set being increased while that of the inverted set is reduced, until the machines are fully loaded.

It may sometimes be necessary to insert an extra resistance in the field circuit of the inverted set, in order to reach the higher values of load current. It is unnecessary to attempt to keep the output voltage rigidly at the specified figure, as efficiency does not vary seriously with output voltage.

A.C. Input and Power Factor.—Of the various methods of determining Input and Power Factor the " 2 watt-meter " method is the most generally convenient and accurate.



R — Series resistance in lead to voltage coil if necessary.

FIG. 5.

Fig. 5 shows a 3-phase motor with the two watt-meters connected in circuit: V are voltage coils, C current coils. In practice only one meter is used with a double-pole change-over, a reversing, and two single-pole switches. Special switches are available which enable the two latter to be dispensed with. The connections are as in Fig. 6.

For each value of the load current, two watt-meter readings are taken, one for each position of the main double-throw switch S. The associated single pole switches S_2 and S_3 must, of course, remain closed, except when the blades of the double-throw switch are thrown to either pair of contacts, when the appropriate single pole switch is opened to obtain the reading.

In general, the two readings obtained for each loading are not equal. In fact where the power factor is low, one of the readings will be negative, and it is to obtain this negative reading that the reversing switch S_4 has to be used.

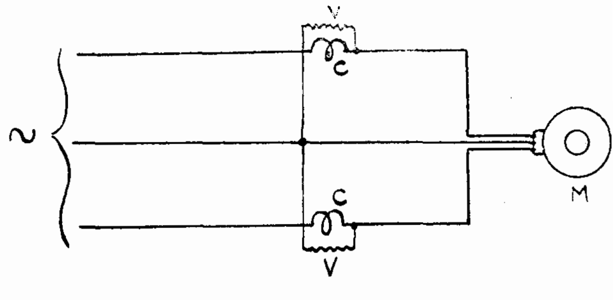


FIG. 6.

Assume we have obtained a pair of readings for some particular loading. Multiplied by the appropriate meter constant, we obtain two wattages W_1 and W_2. Then total input to the machine

$$W = W_1 + W_2$$

and calling the phase-angle between current and voltage θ, we have

$$\tan \theta = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}$$

whence by using a set of trigonometrical tables, the power factor = cos θ is obtained.

To illustrate a complete test, the following table with sample calculations has been drawn up:—

1	2	3	4	5	6	7	8	9	10	11	12	13	14
D.C.		A.C. Watts				Speed RPM	Output	Input	Effy %	$W_1 - W_2$	$\sqrt{3} \times \frac{W_1 - W_2}{W_1 + W_2}$	P.F.	Remarks
Amps.	Volts	(1)	W_1	(2)	W_2								
0	46	.26	1040	− 02	−80	1000	0	960	0	1120	2.02	.44	No-load
120	46	1.13	4520	.795	3180	972	5520	7700	71.7	1340	.302	.96	Full-load

Columns 1, 2, 3, 5 and 7 are observations.

Figures in columns 4 and 6 are obtained from those in 3 and 5 by multiplying by the watt-meter constant—in this case 4000.

Column 8 input is the product of columns 1 and 2.

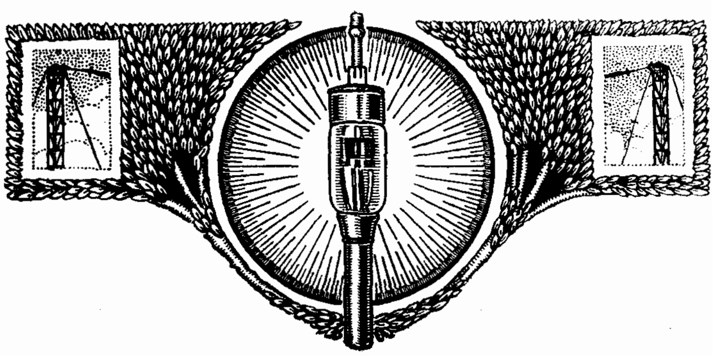
Column 9, output, is the sum of columns 4 and 6. (Note the effect of the minus sign in the no-load case). Then Efficiency (Column 10) is (Output)/(Input).

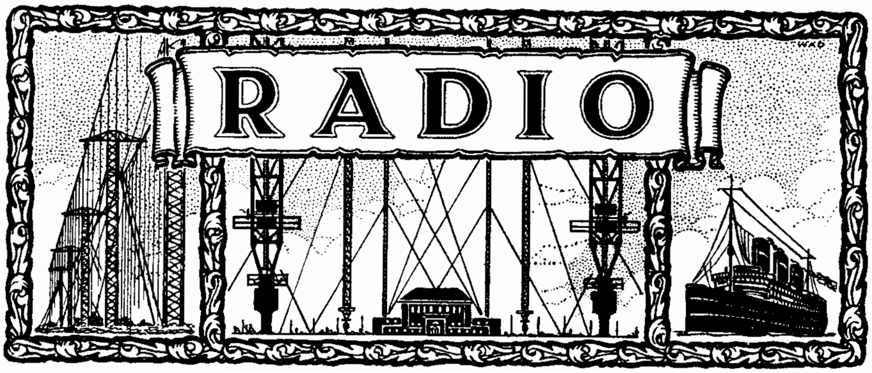
In column 11, values of $W_1 - W_2$ are listed and from this column and column 8 ($= W_1 + W_2$) we obtain column 12. These values we know to be $= \tan\theta$ so that by consulting a book of tables column 13 is readily obtained. *E.g.*, in the Full-load case, $\sqrt{3}\,\dfrac{W_1 - W_2}{W_1 + W_2} = .302$. Consulting our tables we find that 16°48′ is the angle whose tangent is .302; and turning to cosine tables we find that cos 16°48′ = .96, which value we enter as the Power Factor.

In the Hopkinson Motor-Test, where mechanical instead of electrical coupling between the machines is employed, the input W_1 to the first machine and the losses are measured, from which is calculated the output W_0 from the second machine; efficiency is then $\sqrt{\dfrac{W_0}{W_1}}$.

It might be asked whether such a test is feasible in the case of motor generators, for, if so, both measurements would be made on A.C. and with suitable switches a single watt-meter would enable all necessary measurements to be made. Such a test would, however, be less accurate than the Hopkinson. In the latter, both machines are almost equally loaded, so that an average load value against which to plot efficiency is capable of fairly accurate estimation. In the case of motor-generators, however, the losses of four machines in succession have to be made good, and the difference in loading between the first motor and last generator, (Fig. 1) is considerable. It is not, therefore, possible to assess an average load value with much accuracy.

A test was actually carried out on these lines, but results showed some 3% high when compared with those obtained by a direct efficiency test.





THE RADIO TELEPHONY TERMINAL.

W. H. SCARBOROUGH.

THE Radio Telephony Terminal is situated near the London Trunk Exchange, not only because London is a centre for the largest percentage of business interests for Overseas traffic, but also because the London Trunk Exchange offers ideal facilities for access to all long distance trunk routes throughout Great Britain and the rest of Europe with the minimum of transmission losses. At present the radio Telephony Terminal is the technical control point for seven commercial channels:—

(1) One long wave and three short wave circuits between Europe and the U.S.A., Canada, Cuba and Mexico.

(2) One short wave service to Australia, by which through connections can also be made from America to Australia.

(3) One short wave Marine Telephony service to the s.s. "Leviathan," "Majestic," "Olympic" and "Homeric" operating on the Atlantic routes.

(4) One short wave service to South America.

The method of operating the services is similar to ordinary 2-way telephone conversations, for neither the subscriber nor the trunk operator who controls the connections to the radio links have any indication that these circuits are different from ordinary line telephonic connections. Beyond the switchboard positions there is, however, an organisation of equipment and personnel vastly different from that usually associated with trunk and long distance telephone circuits.

Each radio telephony circuit is essentially a 4-wire circuit with an inter-connecting and control terminal at either end for extension to any 2-wire telephone system, with the exception that the marine telephony circuits terminate in a telephone booth on board ship.

From the radio terminal there is an independent one-way high quality transmission line for each transmitting and receiving station.

To indicate the transmission path from one subscriber to another reference is made to the long wave telephony circuit as below:—

Fig. 1.

New York to London.

New York Traffic operator.
New York terminal position.
70 miles of land line to Rocky Point Transmission Station.
3,240 miles of radio to Cupar (Fifeshire).
450 miles of land line, Cupar-London.
London terminal position.
London operator.

TRANSATLANTIC TELEPHONY - LONG WAVE CIRCUIT

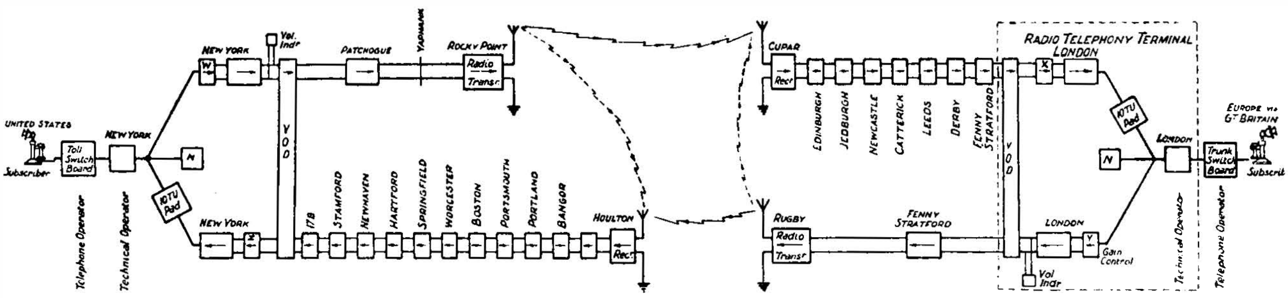


FIG. 1.

London to New York.

London operator.
London terminal position.
85 miles of land line to Rugby Transmitting Station.
2,900 miles of radio to Houlton (Maine) Receiving Station.
600 miles of land line to New York.
New York terminal position.
New York operator.

All the circuits are lined up between the 2-wire ends for a given loss of 10 dbs. in either direction, and it is, among other things, the duty of the Technical Operators to maintain, as far as possible, this standard of transmission for all types of talkers connected to the radio links. The radio transmitter must be loaded fully for each talker, as the percentage reduction in modulation at the transmitter due to a weak talker would seriously affect the grade of transmission at the distant point. The speech volume at the controlling terminal positions can be varied over a range of 30 decibels.

The terminal equipment consists essentially of a 4-wire hybrid termination, a variable control for the Transmitting and Receiving Repeaters and the Voice Operated Device. The voice operated device functions by means of the voice currents of the two telephone subscribers, in such a manner as to permit speech to pass first in one direction when one subscriber is talking and then in the opposite direction when the other subscriber talks. When no one is talking, the receiving path remains open to receive speech, whilst the transmitting path is inoperative.

The radio telephony terminal has been designed to accommodate twelve radio terminal positions arranged in pairs to occupy three sides of the room.

Fig. 2. The photograph shows the lay-out for two radio terminals excluding the voice operated devices. The racks are 10′ 6″ high and are the type normally used at Repeater Stations.

Bays 1, 2, 4 and 5 show the 4-wire termination for each channel and Bay 3 the testing equipment.

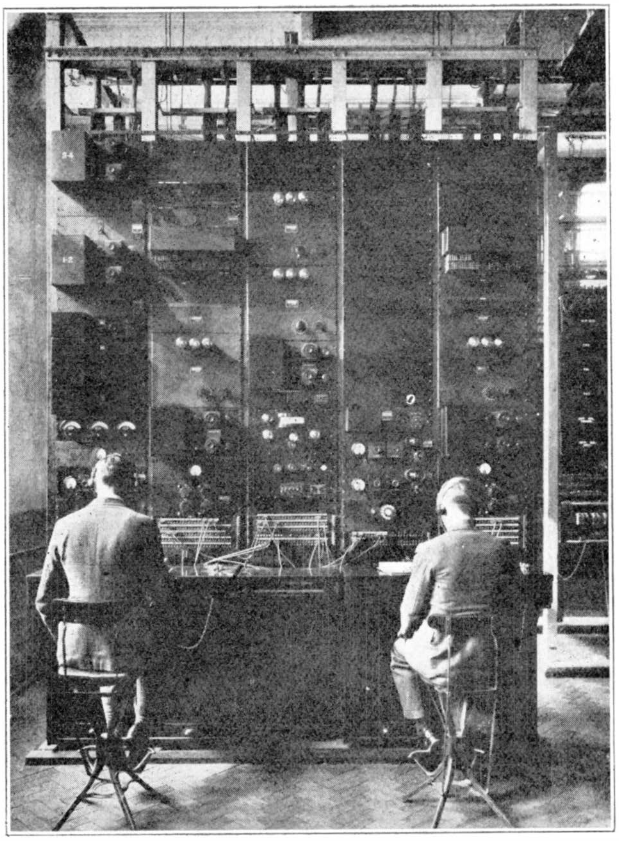


FIG. 2.—LAY-OUT OF FACE EQUIPMENT FOR TWO RADIO TERMINALS.

Immediately behind this rack, on five corresponding bays, are placed the voice operated device equipment for each channel. (See Fig. **2** (*a*)). For the purpose of describing the 4-wire termination for each channel, it is only necessary to refer to bays 1, 2 and 3.

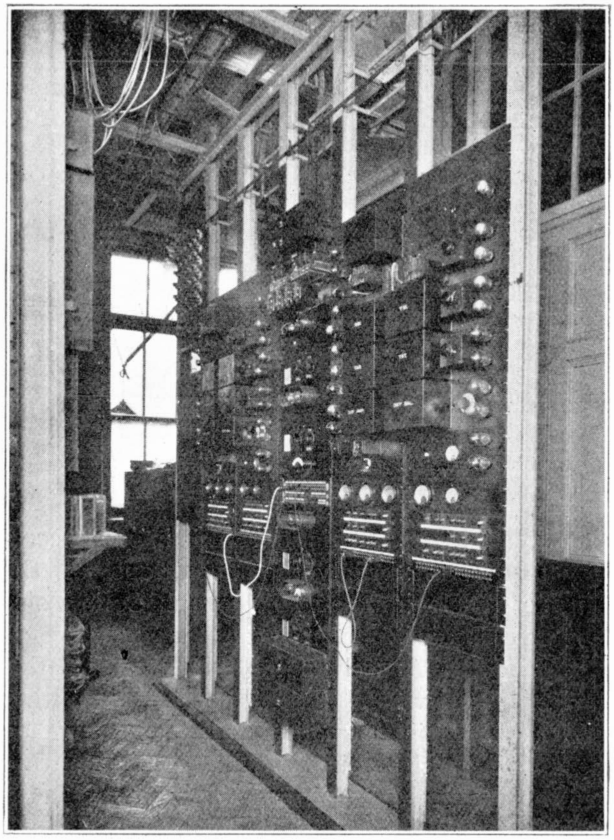


FIG. **2** (*a*).—VOICE OPERATED EQUIPMENT FOR TWO RADIO CIRCUITS.

Bay 1 contains the battery supply equipment and meter control for the various amplifiers; a dial for remote control of the receiving sensitivity of the voice operated device (dependent upon radio conditions); and a switch for varying the time hang-over of the voice operated device for given line echoes and transmission irregularities associated with the local subscribers connection.

In Bay 2 is arranged the operating equipment, consisting of the Radio jack field in which is terminated the radio circuit, gain control, volume indicator, regular transmitting and receiving amplifiers, hybrid termination (4-wire to 2-wire) monitoring control and a standard toll desk.

The standard toll desk is equipped with three sets of cords and associated keys, which permit the technical operator to talk on both front and back cords. The back cord is used for the 2-wire portion of the radio link and the front cord for connection to the trunk operator.

A telegraph key is mounted on the top of the desk for use in conjunction with an oscillator to key morse signals in lining up the circuits.

Fig. **3** shews the order of the jack field for the terminal connections, receiving and transmitting stations. The gain control for each repeater is in the form of a variable attenuator, which is in series with the terminal repeater having constant gain. It is specially constructed for variation in steps of 2.5 dbs. from zero to 30 dbs. In the case of the transmitting repeater, it may reduce the overall gain of the repeater unit by 5 dbs. for a strong talker, or increase it by 25 dbs. for a weak speaker. The control is varied in conjunction with the volume indicator connected at the output jack of the transmitting repeater to enable the technical operator to load fully the radio transmitter, and this is done by maintaining a constant speech current at this point in the system. It is therefore a means of checking the output from the terminal to the land line, which is assumed to have a constant transmission equivalent determined by the requirements of the radio transmitter. The volume indicator used for this purpose is a specially constructed thermionic valve voltmeter. It records a measure of rectified currents on a galvanometer in its plate circuit.

Reference speech volume is recorded when the galvanometer deflects between 5 and 25 divisions and approximately once to 30 divisions every 3 seconds. " Reference speech volume " is quite an arbitrary term, but for radio telephony purposes it corresponds to a speech volume which is 10 dbs. below the maximum distortionless speech output of a 4-wire repeater of the " standard " type, and is approximately the speech volume of an average male talker using a standard common battery instrument in circuit with a loop line resistance of 250 ohms. Adequate monitoring facilities are supplied to the traffic and technical operators at various points in the 4-wire links to check the operation of the terminal equipment.

Bay 3 accommodates reserve equipment and testing apparatus. In this bay is the 74006A Transmission Testing Set, which is not only

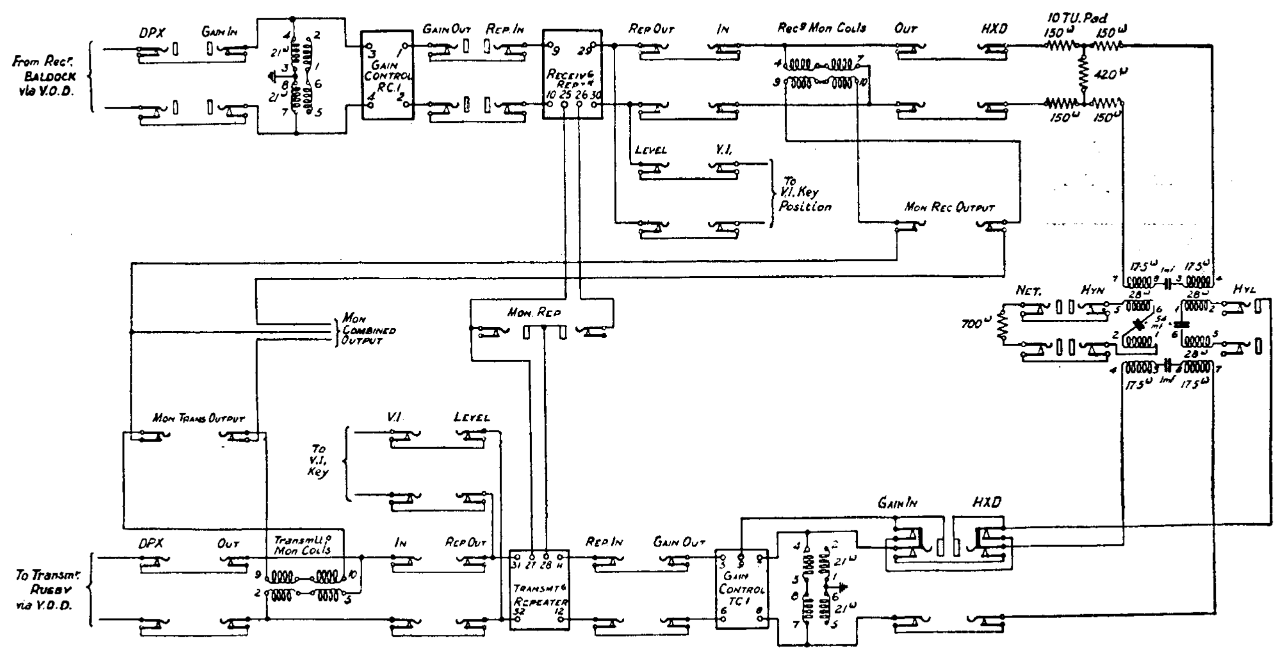


Fig. 3.—Marine Radio Telephony. Schematic of Regular Equipment.

used in conjunction with a 1500 cycle oscillator for lining up radio channels and wire lines, but is used for making half-hourly measurements of signal-to-noise ratio for recording the grade of service.

Voice Operated Devices. The reasons for the use of a voice operated device have been fully explained in an article by Messrs. C. A. Beer and G. T. Evans, which appeared in the *P.O.E.E. Journal* of April, 1927, dealing with the Long Wave Trans-Atlantic Telephony Channel. It is, however, desirable at this stage to state that a voice operated device is essential to the satisfactory operation of short wave channels, although the radio links may operate on different wavelengths: (1) To allow for independent terminal control without fear of singing conditions associated with the 4-wire link, and (2) To prevent reradiation of the received speech from either local transmitting station. If the latter were possible, eavesdroppers would only need to tune in to the local short wave station to enable them to listen to both sides of a conversation.

There are at present seven voice operated devices at the radio terminal, one of the American type, and six of the Post Office differential voice operated equipment.

As the Post Office equipment has been previously described in this journal it is only necessary to describe briefly the operations of the American Telephone and Telegraph Co.'s Voice Operated Device known as the " Vodas."

" *Vodas.*"—A schematic diagram of this device is shown in Fig. 4, the transmitting side of which is normally made inoperative by means of a short-circuit of the transmitting path at Transmitting Singing Suppressor Relay (" TSS "), and " Auxiliary TSS." Before the transmitting path is opened the receiving side must be closed in a similar way. This is done by means of amplifier-detector units, which are bridged across the transmitting and receiving line respectively.

Speech passing from the local terminal to the radio transmitter must open a path for itself instantaneously; failing this, parts of speech would be lost or mutilated. An amplifier-detector and chain of relays can be made very sensitive to perform this operation. As most lines connected to the radio link possess a certain amount of line noise it is desirable that the amplifier-detector shall not be too sensitive, or the line noise would in many instances either lock up the chain of relays or cause false operations of the device. To partially overcome this difficulty, a delay circuit has been introduced between

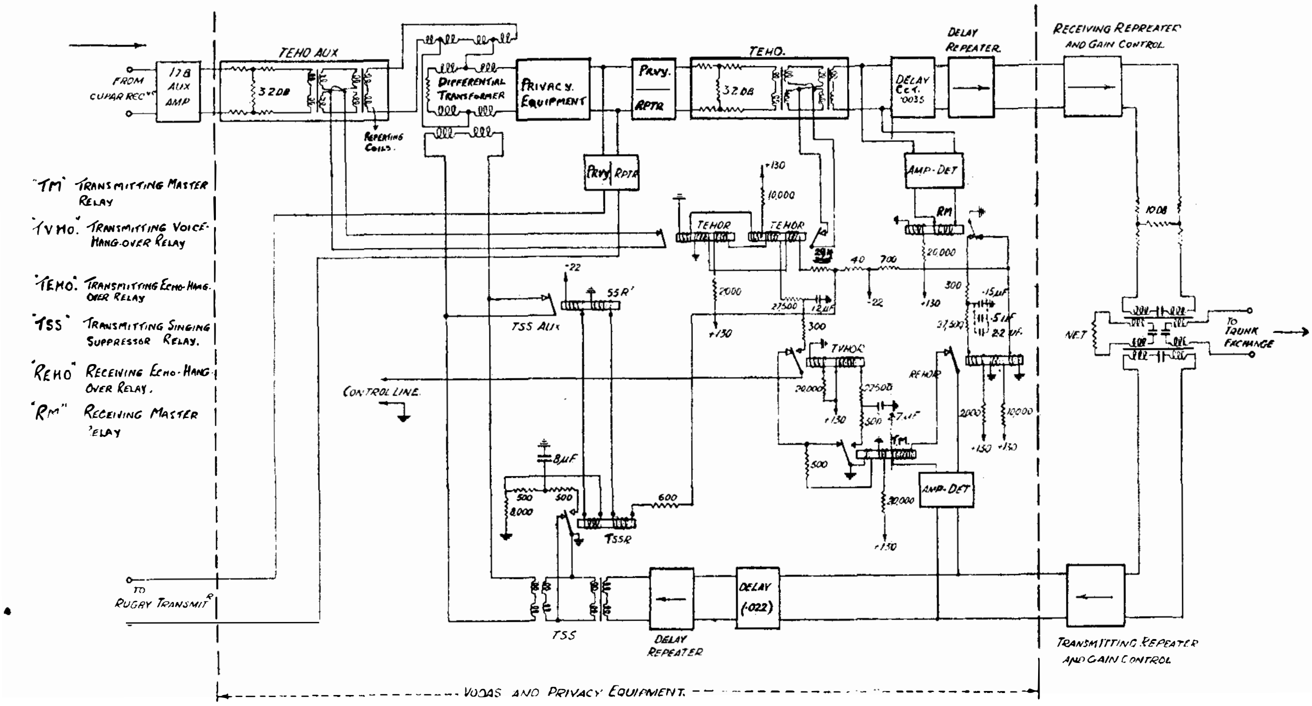


FIG. 4.—RADIO TERMINAL EQUIPMENT. SCHEMATIC OF " VODAS " WITH PRIVACY FACILITIES.

the junction where the amplifier-detector is bridged across the transmitting line and the point where the short-circuit is removed. This delay circuit of .022 second enables the sensitivity of the relay system to be reduced by approximately 10 db.

The receiving side of the device is normally open to receive speech. An amplifier detector is bridged across the line and operates a relay, the function of which is to cause the transmitting side of the device to be inoperative during the period the receiving side takes control of the speech transmission.

To ensure satisfactory operation it is essential that there should exist a ratio of signal-to-radio-noise, which will permit the amplifier detector to be operated by the incoming speech and not by radio noise. However, experience has indicated that a few false operations of the receiving side can be allowed without seriously affecting the service. The ideal arrangement is obviously a low background of radio noise which allows maximum sensitivity of the receiving amplifier-detector for all parts of speech. This sensitivity control is adjusted by the technical operator from time to time according to radio conditions.

Fig. 4 shows the essential parts of the " Vodas " together with facilities for inserting a privacy equipment when desired.

Operating Details.

The device functions as follows :—

Receiving Side.—Speech from the radio receiver enters the receiving path *via* the Auxiliary receiving repeater, Auxiliary Transmitting Echo-Hangover (T.E.H.O.) Relay, repeating coils, differential transformer, privacy equipment, delay circuit, delay repeater, gain control, terminal repeater, and thence through a 10 db. pad to the hybrid termination and 2-wire line. Speech transmission to the radio transmitter is prevented by the short-circuit applied by the Aux. T.S.S. relay.

Before entering the receiving delay circuit a portion of the speech is passed to the receiving amplifier-detector unit and operates a master relay. The operation of this relay releases a 22-volt battery, which causes the Receiving Echo-Hang-over (R.E.H.O.) relay to operate; this in turn disconnects the plate circuit of the transmitting amplifier detector, thus preventing any operation of the chain of relays associated with the transmitting side of the device.

Once the R.E.H.O. relays have operated, the release time of these relays is controlled by the charging of condensers through a resistance from the 130-volt battery supply. These condensers have been previously discharged by the earth contact of the Receiving Master relay armature. Hangover periods of .02, .04 and .11 seconds have been provided. The desired hangover, depending upon the transmission characteristics of the line connected to the circuit, is selected by means of a three-position key. All long distance lines are to a certain extent subject to impedance irregularities and experience has shown that transmitted currents pass along such lines and return to the terminal position with a definite time delay commonly termed " echo effects." For this reason it has been necessary to introduce a variable hangover to cause the transmitting side of the device to be inoperative for sufficient time to suppress such undesirable effects, which if not taken care of would cause mutilation of received speech due to false operations of the transmitting side.

Transmitting Side. — Speech entering the transmitting side, after passing through the hybrid termination, the transmitting gain control and terminal repeater, enters the transmitting amplifier-detector and operates the master Relay. The break contact of this relay removes an earth connection which allows the " T.E.H.O.," " AUX. T.E.H.O.," " T.S.S. " and " AUX. T.S.S." relays to operate, whilst its " make " contact operates the Voice hangover relay.

The T.S.S. and AUX. T.S.S. relays act as gates to open a path for the speech which has been traversing the delay circuit. The delay circuit is .022 second; as it takes .003 second for the chain of relays to operate there is therefore a clear margin of .019 second against initial clipping of the transmitted speech.

It will be observed that the armature of the Transmitting Voice Hangover (T.V.H.O.) relay must restore to its normal position before the T.S.S. and AUX. T.S.S. relays can again cause the transmitting path to be inoperative. The release of T.V.H.O. and T.E.H.O. relays is controlled by the charging of condensers of fixed value, in a similar manner to the R.E.H.O. relays associated with the receiving side of the device. After the transmitting master relay has restored to its normal position, the T.V.H.O. relay possesses a hangover of .15 second before it resumes its normal position, to prevent a closure of the transmitting path during the transit of weak syllables which may not operate the master relay.

When the armature of the T.V.H.O. returns to normal, a further delay of .04 second hangover is given to the T.E.H.O. relays to ensure that the receiving side remains closed for a sufficient time to cover the transmission delay over the land lines, *via* the local loop, London, Rugby and Cupar. This condition is essential in connection with the long wave circuit which operates on a common radio frequency for both transmitting and receiving paths.

There are two interesting features about this device which should be referred to. (1) A delay circuit is placed in the receiving path to prevent the transmission of speech across the hybrid termination during the operation of the receiving master relay before this relay makes the transmitting side inoperative. (2) To ensure rapid opening and closing of the receiving path, the armature of the T.E.H.O. relay is associated with repeating coils so arranged that when the armature is in the normal position the repeating coils have their centre terminals joined. Transmission from one coil to another is then quite normal, but when the relay armature is operated these centre contacts are disconnected and the respective coils are then in series in such a manner as to oppose one another, which prevents transmission from one coil to the other. By this means the time delay of the receiving delay circuit can be reduced, and gives the best possible balance conditions.

There are other interesting features associated with the equipment installed in the radio telephony terminal, but the main operations are covered by the foregoing description.

RADIO BEAMS.

T. Walmsley, B.Sc., M.I.C.E.

With the increasing complexity of engineering science and achievement a progressively greater degree of specialisation is demanded. In consequence, engineering must be divided into branches, and again divided and subdivided to enable the limited human comprehension to master imperfectly one small portion of the whole. Radio engineering, although perhaps the youngest branch of engineering, has advanced with such rapidity that few minds can grasp in detail all its complexities and ramifications. Still, the specialist in one branch can and should acquire a general acquaintance with the technical activities in another, and his task would be simplified if those who have devoted time to a close study of a subject would give a technical outline of their investigations. It is with this thought that the present article is penned. It is an effort to tell in terms that are not too highly technical, the activities of one branch of the Radio Section.

Principles of directive Aerials.—The principle of interference underlines the action of directive aerials. If A (Fig. **1**) is a centre of energy capable of imparting to a surrounding homogeneous medium some form of regularly timed pulsations, expanding spherical surfaces of energy will be radiated. For our present purpose, too close an enquiry into the nature of the impulses and the medium is not necessary; it is sufficient to picture wave after wave of energy passing outwards into space.

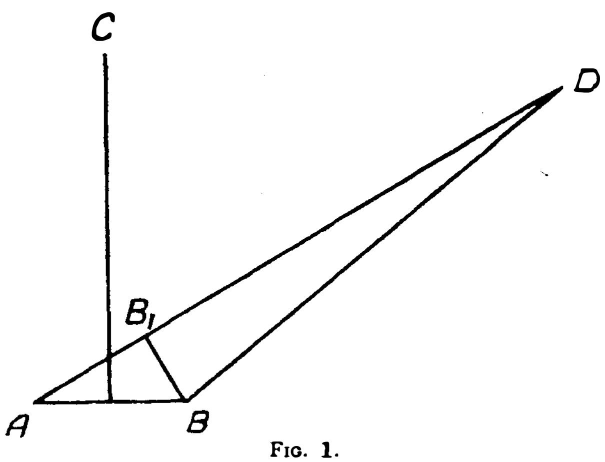


Fig. 1.

If now a second source of energy, located at B, gives rise to exactly similar pulsations as A, it is evident that the disturbance at any point in space will be affected by the energy radiated from both sources. All points, however, will not be similarly affected. For example, at the point C in the line drawn at right angles to AB, the disturbance due to both sources will be exactly the same amplitude, and if C be sufficiently far away to render the lines AC and BC sensibly perpendicular to AB, the resulting disturbance will be the simple arithmetic sum of the individual disturbances.

Another point D will experience quite a different influence to the point C. If, for example, A and B are supplied in phase with electric current having the same amplitude, and the spacing between A and B is such that the waves of energy emanating from each source arrive at D in exactly opposite phase, a cancellation effect will result.

If A and B are just half a wave-length apart, the location of D will obviously be on the lines BA and AB produced, and any other point, will experience an influence intermediate in amplitude to those at D and C.

Horizontal Polar Diagram.—It is thus possible to represent the amplitude of the disturbance—or the field strength—at any point on a circle around A and B by a closed figure, termed a polar diagram. Such a diagram is shown in Fig. **2**.

The polar diagram for the two source system AB in which wires are spaced two wave-lengths apart is shown in Fig. **3**. Lines drawn from the origin O of the diagram to the curve represent the relative amplitudes of the fields at great distances from the sources of energy.

The diagram of Fig. **3** presents such a marked difference to that of Fig. **2** that some explanation is necessary. It will be observed that at angles of 14.5° and 48.5° with the direction perpen-

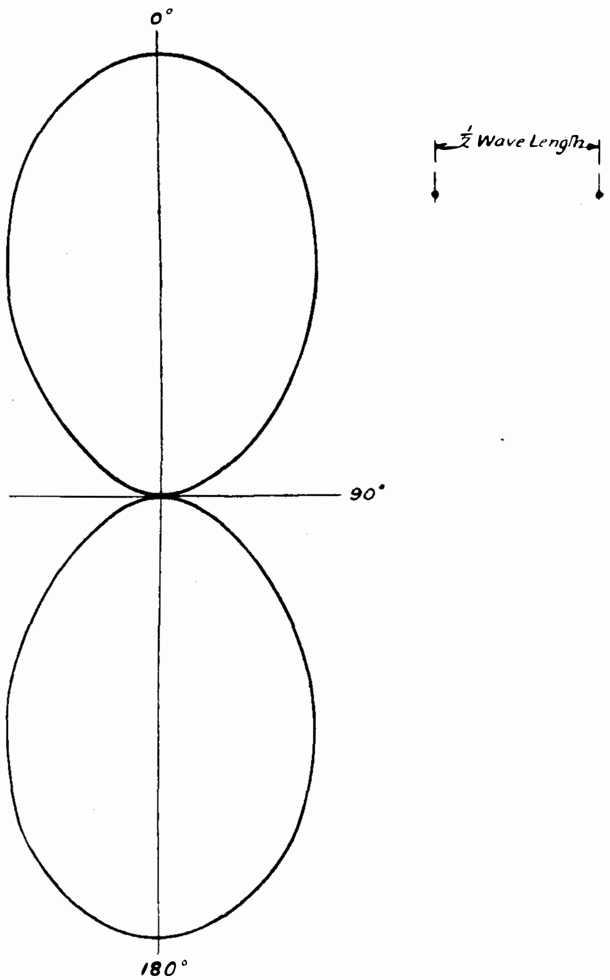


FIG. 2.—HORIZONTAL POLAR DIAGRAM DUE TO TWO VERTICAL SYNPHASED RADIATORS SPACED HALF A WAVE-LENGTH APART.

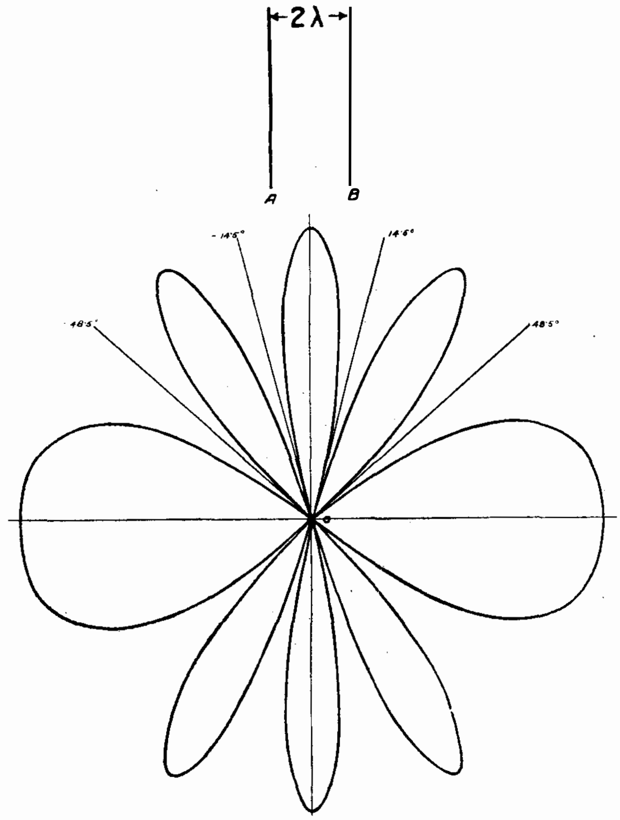


FIG. 3.—HORIZONTAL POLAR DIAGRAM DUE TO TWO SIMILAR VERTICAL SYNPHASED RADIATORS SPACED TWO WAVE-LENGTHS APART.

dicular to AB, the field strength falls to zero. The reason for this will be understood by referring to Fig. **1**.

Disturbances from A and B are propagated simultaneously.

Suppose D is a point in space a great distance away from A and B, so that the two wave fronts at D due to the radiations practically coincide. The value of the existing field at any moment will be the instantaneous sum of the individual fields. If BB_1 is drawn perpendicular to AD, B_1D and BD are approximately the same length. Thus the disturbance at D due to B will have travelled farther than the disturbance due to A by the length AB_1. Now AB_1 is equal to half a wave-length when the angle ABB_1 is 14.5°, or 48.5° and thus in directions making these angles cancellation of electric fields will be experienced.

If, instead of two radiators spaced two wave-lengths apart, four radiators spaced half a wave-length apart were used, the horizontal polar diagram would be similar to Fig. **4**. With this arrangement, there is a cancellation effect at 90°, with a maximum effect at 0° and 180°.

Heart Shaped Diagram.—It will be observed that in all the foregoing discussion, the polar diagrams due to a number of wires—or an " array "—have been derived from the polar diagram due to one radiator, namely, a circle. If instead of the circle as unit, it were possible to use a heart-shaped diagram—known also as a cardioid—such as that shown in Fig. **5**, the polar diagram due to the combination of four systems having half a wave-length space separation would give the diagram shown in Fig. **6**, which has been obtained by multiplying the values of Figs. **4** and **5** together, due regard being made to the appropriate directions.

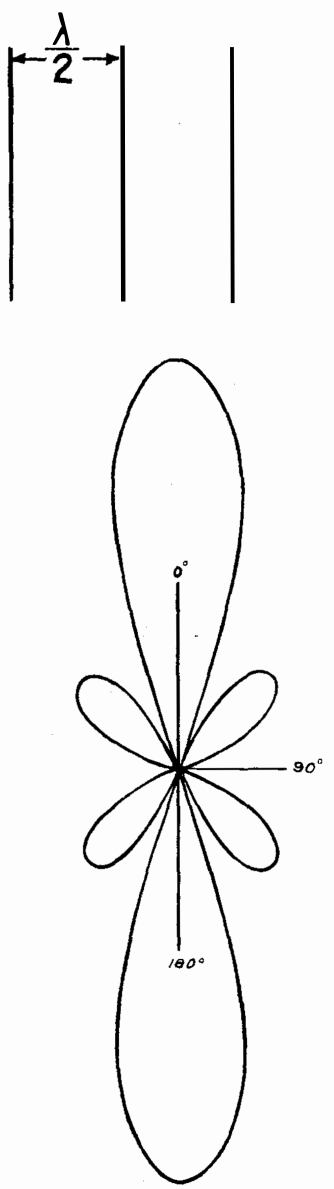


FIG. 4.—HORIZONTAL POLAR DIAGRAM DUE TO FOUR VERTICAL SYNPHASED RADIATORS SPACED HALF A WAVE-LENGTH APART.

A heart-shaped polar diagram is obtained by placing two exactly similar radiators one behind the other, at a distance of one quarter of a wave-length and feeding the radiators with current differing in phase by a quarter of a period.

Thus, in Fig. 5, if the current in radiator B lags 90° behind the current in A the fields due to the two radiators will add arithmetically in the direction AB and will cancel out in the direction BA. In other directions, the resultant field will have same value, intermediate between the two extremes.

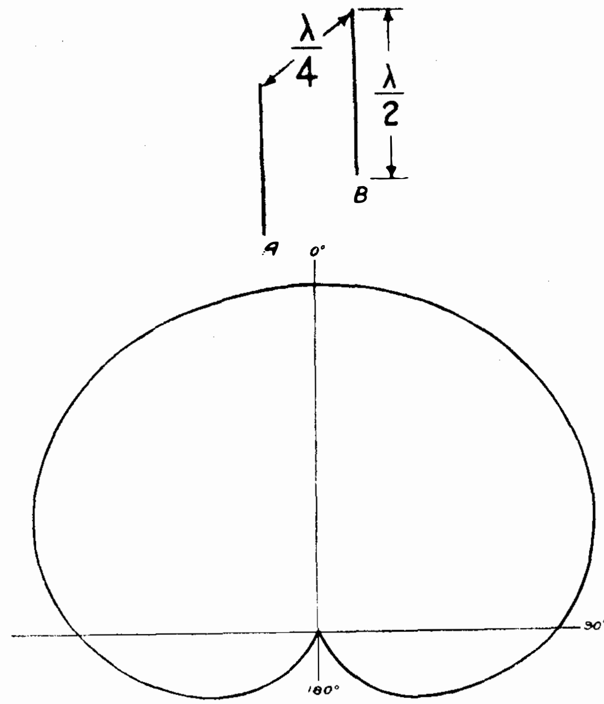


FIG. 5.—HORIZONTAL DIAGRAM DUE TO TWO SIMILAR RADIATORS SPACED A QUARTER OF A WAVE-LENGTH APART AND CURRENTS DIFFERING 90° IN PHASE.

Combining Cardioids to form a " Beam."—A " beam " aerial therefore can be built by grouping a number of cardioid producing units in a

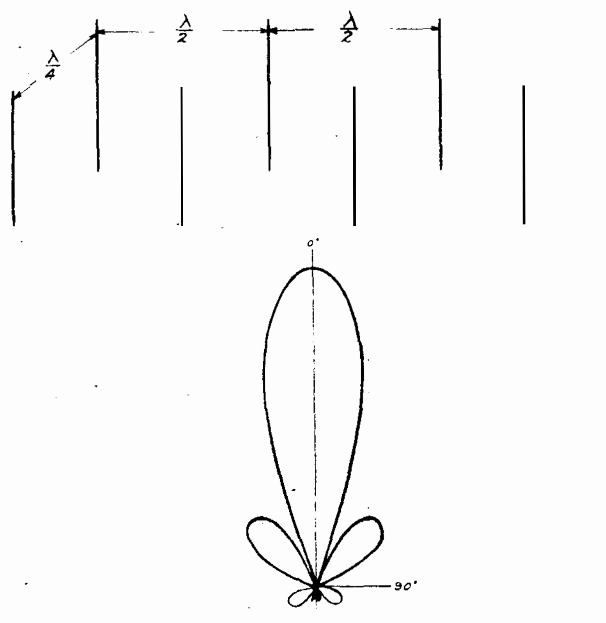


FIG. 6.—HORIZONTAL POLAR DIAGRAM DUE TO FOUR SYSTEMS SIMILAR TO FIG. 5 SPACED HALF A WAVE-LENGTH BETWEEN ADJACENT GROUPS.

line. Frequently a separation of half a wave is allowed between adjacent wires, and spans of 500 feet between extreme wires are common.

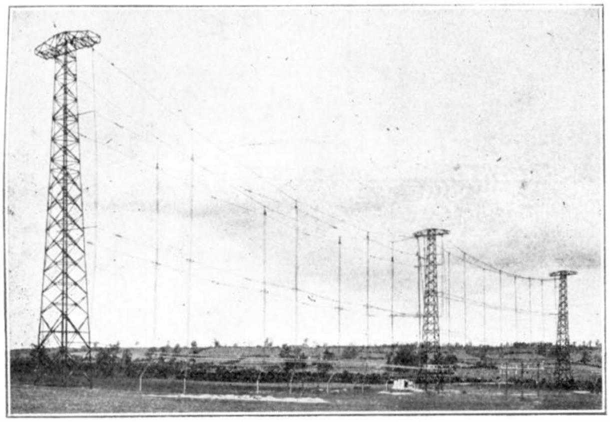


Fig. 7.—A Beam Aerial Array.

A "beam" aerial thus usually consists of two curtains of radiators, the distance between curtains being about one quarter of a wave-length. The wires of the front curtain are fed with currents all in phase, whilst the wires in the back curtain have currents in phase with each other, but 90° out of phase with the currents in the front curtain. The back curtain may be fed directly, but a more usual method is to be fed inductively. In this method, the back curtain is entirely insulated from any source of supply and reliance is placed upon the currents induced in it by the field due to the front curtain. A practical example of such a beam is shown in Fig. **7** which depicts a "beam" array supported on 180 feet self-supporting towers.

Vertical Polar Diagrams. — So far only horizontal polar diagrams have been considered, but it is obvious that the same principles just considered can be applied to polar diagrams in the vertical plane. Consider an insulated vertical wire radiator having a length equal to half a wave and its lower end at ground level. It can be shown that the field distribution due to such a radiator in a vertical plane is represented by the diagram shown in Fig. **8**. The combination of two such synphased radiators, spaced two wave-lengths apart, gives rise to the diagram shown in Fig. **9**, which is obtained from the diagrams of Figs. **3** and **8** by simple multiplication.

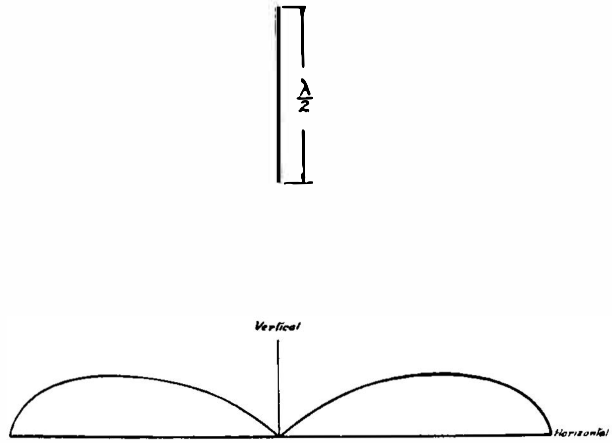


Fig. 8.—Polar Diagram in a Vertical Plane due to an Insulated Vertical Half Wave Radiator having its Lower End at Ground Level.

"Sharpening" of the vertical polar diagram can also be obtained by building radiators one on top of the other, but the cost of the necessary supporting structures quickly limits the economic usefulness of this method.

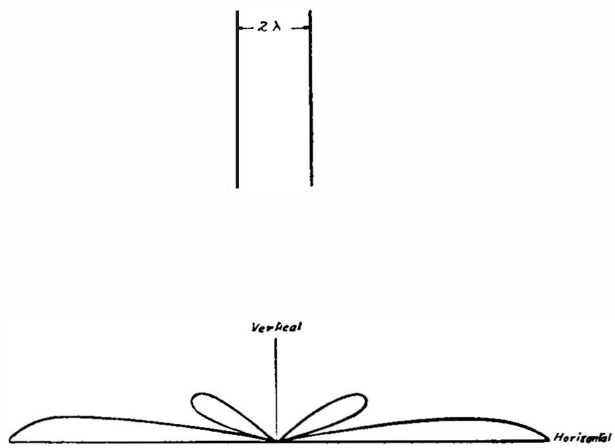


Fig. 9.—Polar Diagram in a Vertical Plane normal to the Plane containing two Synphased Vertical Radiators described in Fig. 8.

It seems hardly necessary to stress the fact that the primary object in designing "beam" arrays is to seek to direct a maximum amount of power in a desired direction and eliminate unwanted radiation in other directions, due regard being made to the economics of the question.

NOTES & COMMENTS

A SIDELIGHT ON THE EARLY HISTORY OF THE TELEPHONE.

THE name of Mr. George Bernard Shaw is known wherever the English language is read or translated, but the fact that he was at one time closely associated with the telephone business must come as news to most people. Our attention having been directed to the preface of an early novel by Mr. Shaw, "The Irrational Knot," we thought our readers would be interested in the matter. As, however, we considered it advisable first to obtain his consent to publish an extract from the preface, the following correspondence took place:—

22nd December, 1930.

George Bernard Shaw, Esq.,

....

Dear Sir,

The revelation in your preface to "The Irrational Knot" that you were a pioneer of the telephone in London is so important that I would be grateful to have your permission to publish an extract from that preface in *The Post Office Electrical Engineers' Journal.*

The passages we wish to quote are those beginning "This book is not wholly a compound of intuition and ignorance," and down to ". . . . . a question they either decided in the negative or never decided at all, for I never got anything."

Telephone engineers all over the world will be honoured to learn that they may claim you as a colleague and this Journal will undertake to defend you from any possible imputation that the British Telephone Service, in spite of the advantages of Government control, has never recovered from your association with it in 1879.

I am sending you separately a copy of the Journal, a glance at which may indicate its character to you. Remarkable as it may seem, this magazine, which circulates all over the world, is written by engineers who are paid nothing for their contributions. If you agree to allow us to publish the foregoing extract, we regret that we are not able to offer more than our usual terms.

Yours faithfully,
W. CRUICKSHANK,
Managing Editor.

30th December, 1930.

Dear Sir,

In reply to your letter of the 22nd inst., Mr. Bernard Shaw desires me to say that you are quite welcome to quote from the preface to "The Irrational Knot," but you must not represent him as presuming to pretend that he was an electrical engineer. He organized the wayleave department, but never learnt the difference between an Ohm and an Amp.

Yours faithfully,
BLANCHE PATCH,
Secretary.

W. Cruickshank, Esq.

The extract is as follows:—

Extract from the preface to " The Irrational Knot," a novel, by George Bernard Shaw.

" This book is not wholly a compound of intuition and ignorance. Take for example the profession of my hero, an Irish-American engineer. That was by no means a flight of fancy. For you must not suppose that, because I am a man of letters, I never tried to earn an honest living. I began trying to commit that sin against my nature when I was fifteen, and persevered, from youthful timidity and diffidence, until I was twenty-three. My last attempt was in 1879, when a Company was formed in London to exploit an ingenious invention by Mr. Thomas Alva Edison—a much too ingenious invention as it proved, being nothing less than a telephone of such stentorian efficiency that it bellowed your most private communications all over the house instead of whispering them with some sort of discretion. This was not what the British stockbroker wanted; so the Company was soon merged in the National Telephone Company, after making a place for itself in the history of literature, quite unintentionally, by providing me with a job. Whilst the Edison Telephone Company lasted, it crowded the basement of a high pile of offices in Queen Victoria Street with American artificers. These deluded and romantic men gave me a glimpse of the skilled proletariat of the United States. They sang obsolete sentimental songs with genuine emotion; and their language was frightful even to an Irishman. They worked with a ferocious energy which was out of all proportion to the actual result achieved. Indomitably resolved to assert their republican manhood by taking no orders from a tall-hatted Englishman, whose stiff politeness covered his conviction that they were, relatively to himself, inferior and common persons, they insisted on being slave-driven with genuine American oaths by a genuine free and equal American foreman. They utterly despised the artfully slow British workman who did as little for his wages as he possibly could; never hurried himself; and had a deep reverence for any one whose pocket could be tapped by respectful behaviour. Need I add that they were contemptuously wondered at by this same British workman as a parcel of outlandish adult boys, who sweated themselves for their employer's benefit instead of looking after their own interests? They adored Mr. Edison as the greatest man of all time in every possible department of science, art and philosophy, and execrated Mr. Graham Bell, the inventor of the rival telephone, as his Satanic adversary; but each of them had (or intended to have) on the brink of completion an improvement on the telephone, generally a new transmitter. They were free-souled creatures, excellent company, sensitive, cheerful and profane; liars, braggarts and hustlers; with the air of making slow old England hum which never left them even when, as often happened, they were wrestling with difficulties of their own making, or struggling in no-thoroughfares from which they had to be retrieved like stray sheep by Englishmen without imagination enough to go wrong.

In this environment I remained for some months. As I was interested in physics, and had read Tyndall and Helmholtz, besides having learnt something in Ireland through a fortunate friendship with a cousin of Mr. Graham Bell, who was also a chemist and physicist, I was, I believe, the only person in the entire establishment who knew the current scientific explanation of telephony; and as I struck up a friendship with our official lecturer—a Colchester man whose strong point was pre-scientific agriculture, I often discharged his duties for him in a manner which, I am persuaded, laid the foundation of Mr. Edison's London reputation; my sole reward being my boyish delight in the half-concealed incredulity of our visitors (who were convinced by the hoarsely startling utterances of the telephone that the speaker, alleged by me to be twenty miles away, was really using a speaking trumpet in the next room), and their obvious uncertainty, when the demonstration was over, as to whether they ought to tip me or not; a question they either decided in the negative or never decided at all, for I never got anything."

The following information has been sent to us from the Office of the High Commissioner of Canada:—

TRANS-CANADA TELEPHONE LINES.

Alberta Section to be Completed.

The Alberta Department of Railways and Telephones is to spend £90,000 during the current year on the completion of the section in that province of the trans-Canada telephone line. The amount named will cover the construction of 160 miles of line from Strathmore easterly to the Saskatchewan boundary.

Work carried on in 1930 in connection with the all-Canada route cost about £90,000. In some cases lines already in use were brought up to the higher standard of efficiency set for the coast-to-coast line.

The trans-Canada telephone line is expected to be in operation by the end of 1931, and when completed will obviate the necessity of routing calls through the United States at certain points. Eight of the telephone companies or governmental telephone systems are co-operating to provide the through circuit which will make conversation possible between Halifax and Vancouver by an all-Canadian route. The systems in question are those of the Maritime Telephone and Telegraph Company, the New Brunswick Telephone Company, the Bell Telephone Company of Canada, the Manitoba Government Telephone System, the Saskatchewan Government Telephone System, the Alberta Government Telephone System and the British Columbia Telephone Company.

It was announced recently in Vancouver that the British Columbia Telephone Company had started the construction of that section of the trans-Canada line passing through the Pacific Province. The British Columbia link will cost £250,000, involving the installation of 655 miles of telephone line, of which 125 miles have already been built. The British Columbia link is to connect with the line being built by the Alberta Government telephone system through the Crow's Nest Pass, the line passing by way of Macleod, Calgary, Medicine Hat and onwards to the Saskatchewan boundary. In eastern Canada much work has been done during the past few years in preparation for the trans-Canada service, and in Montreal recently representatives of the eight operating systems met at a special maintenance school conducted by the Bell Telephone Company of Canada to study problems connected with the operation of this new 4,000-mile line.

TELEPHONE DEVELOPMENT IN CANADA.

Continued expansion of the Bell Telephone System.

The Bell Telephone Company of Canada, Ltd., the largest of the telephone systems operating in the Dominion, intends to spend £4,000,000 on development during 1931. The Company, which operates exclusively in the provinces of Ontario and Quebec, has during the past five years invested no less than £24,000,000.

The major portion of the 1931 appropriation will be spent on the improvement of existing telephone facilities, although there will be plans for certain necessary extensions. Central office equipment will cost upwards of £1,000,000; long distance (outside plant) about £550,000; exchange lines nearly £1,000,000; land and buildings £200,000; and subscribers' station equipment over £1,000,000. The Company will continue to carry out the conversion of its urban systems from manual to automatic services. In Montreal, Toronto, Hamilton, Quebec and Windsor—five of the leading cities served by the Company—there has been a continuous installation of dial switching apparatus.

Major extension projects contemplated for 1931 include the rebuilding of one of the main lines between Montreal and Toronto costing about £130,000. "Carrier" equipment is to be added to the long distance line from Oshawa to Winnipeg in order to provide additional talking channels to points in western Canada.

The Secretary of the I.P.O.E.E. has sent us two interesting documents of an earlier telegraph age—one, General Order, No. 121, of the U.K. Electric Telegraph Coy., Ltd., issued from the Secretary's Office, 537, Gresham House, Old Broad Street, on 16th July, 1866; and the other, Folio No. 40, 1872 (an early edition of the P.O. Circular) in which appears a list of promotions and appointments in the Engineering Department. The General Order gives instructions upon the adjustment of the Siemens Relay, the

Morse Inker and Keys, and explains the treatment to be applied in dealing with Split and Failing Currents, Occasional Failing of Current in an Instrument and Permanent Local Currents in Relay Instruments. The Folio mentions Mr. R. S. Culley as Engineer-in-Chief, one Assistant Engineer-in-Chief, one Electrician and Submarine Superintendent, two Chief Clerks (Mr. J. Hookey is one), three Clerks 1st Class and 11 Clerks (General Body), among whom we observe the names of Messrs. J. B. Chapman, J. Willmot and A. F. Varley. There were six Divisional Engineers, one being Mr. W. H. Preece, and two Superintending Engineers for London. Seven Superintendents First Class are given and 23 Second Class, including Messrs. J. Gavey in the Southern Division and A. W. Heaviside, Northern. Mr. A. Bell is Superintendent of Factories and Mr. J. Shaw Superintendent of Bolton Factory. Among the Special Staff is a Controller of Special Arrangements and Supervisor of Schools; Mr. M. Cooper is an Assistant Superintendent on this staff. The Folio concludes with the following items:—

Dismissals.

Telegraphist. . . . . for making use of disgusting language on the wires.

Telegraphist. . . . . for insubordination.

In the *Electrical Review* of the 30th January the death is recorded of Col. H. Laws Webb, which occurred on the 19th of the month. The Colonel, then well-known in the telephone world as Mr. Laws Webb, was a redoubtable protagonist of private enterprise in telephony before the transfer, and contributed numerous articles to the press both on the technical and service sides. He negotiated a concession for telephones with the Turkish Government and had been a director of the Constantinople Telephone Co. since its formation. He joined the R.A.F. during the war and was employed on communications, attaining the rank of Lieut.-Colonel.

The many friends of Mr. J. R. Andrews, formerly Executive Engineer, Newcastle-on-Tyne, and Chairman of the Freemen of that City, will be pleased to hear that he has been appointed a Justice of the Peace.

Mr. Jupp, of the Test Section, has sent us the following cutting from "Standard Topics." He adds, "If the method were ever required here, the most difficult operation would be to catch the rat!

RATS!

If we were not confident that we can rely upon the absolute veracity of our correspondent, we might be inclined to doubt this story, which has been forwarded to us from Italy by C. S. Briggs, General Manufacturing Department.

Not a "Standard" Process.

"The other day I chanced to hear of a highly original and amusing method of pulling a drawing-in wire into a telephone duct. In fact, I thought it too good to lapse into obscurity, and I am here giving it the publicity that I think it deserves.

It appears that an empty duct in Turin had defied all efforts to pull into it the usual drawing-in wire preparatory to pulling in the cable. All approved methods had been tried and tried again, but yet the necessary connection could not be made. At last one of the gang came forward with a very original scheme. He, it appears, had caught a water rat, and his idea was to tie a string to the rat and then persuade it to run down the duct, thereby taking the string to the far end. Amidst much laughter it was decided to give this method a chance. The rat was produced, the string was attached to the thoroughly frightened animal who, encouraged by a blow-lamp flame, ran as fast as his legs could carry him to the other end of the duct, dragging the end of the string with him. As a reward for this invaluable service the rat was given his freedom, which I think no rat had ever more richly deserved."

The following errors, we regret to state, appeared in Vol. 23, Part 4, Jan., 1931:—

p. 306. Fig. 12. Attenuation Frequency Characteristics of Super-phantoms. Completed Cable.

Fig. 13. Impedance Frequency Characteristics of Super-phantoms. Completed Cable.

p. 307. Table 2. R (ohms loop) Side circuit, 21.8. Phantom Circuit, 10.68.

HEADQUARTER'S NOTES.

EXCHANGE EQUIPMENT.

The following works have been completed :—

Exchange.	Type.	No. of Lines
Livingstone	New Auto.	3000
Macaulay	,,	4500
Pollards	,,	4000
Gladstone	,,	4900
Rhos	,,	900
Ashton-on-Ribble	,,	550
Leyland	,,	420
Oxford	Auto Extn.	340
Brierley Hill	,,	Access Equipment
Nottingham	,,	190
Western Park	,,	300
Walsall	,,	Modifications
Arkwright	,,	Routiner Equipment
Sherwood	,,	Routiner Equipment
Rochdale	,,	Modifications
Ilford	,,	Excess Fee Metering
Western (London)	,,	Modifications
Mitcham	,,	Excess Fee Metering
Beckenham	,,	Excess Fee Metering
Mansfield	,,	Observation Equipment
Worthing	New Manual	3460
Morecambe	,,	1080
Chester	Manual Extn.	520
Bristol Motors	P.A.B.X.	20
Taunton Corporation	,,	20
Shell Mex (Belfast)	,,	20

Orders have been placed for the following works :—

Exchange.	Type.	No. of Lines
Pendleton	New Auto.	1620
Selly Oak	,,	1230
Abbeyhill	,,	540
Bayswater	,,	4600
Manchester Optg. School ...	,,	Positions
Colindale	,,	1940
Ashton-under-Lyne	,,	1700
Gately	,,	1400
Mayfair	,,	8550
Regent	,,	6700
Langham	,,	3300
Grosvenor	,,	2700
Tulse Hill	,,	6400
Ashfield	,,	400
Sunderland	,,	3900
Boldon	,,	500
Bishopwearmouth	,,	400
Woodgate	,,	400
Main (Oldham)	,,	3430
Headingly	Auto Extns.	400
Armley	,,	240
Clerkenwell	,,	Key sending
National	,,	Key sending
Darlington	,,	700
Edinburgh Central	,,	1740
Amherst	,,	100
Sherwood	,,	Routiner Equipment
High Wycombe	New Manual	2000
Orpington	,,	1700
Chislehurst	,,	1300
Seven Kings	,,	3000
Brentwood	,,	1800
Hastings	Manual Extn.	Observation Equipment
Northampton	,,	Observation Equipment
Bournemouth	,,	Observation Equipment
Yorkshire Penny Post	P.A.B.X.	30
Maggs & Cory	,,	30
Wolverhampton Corpn. ...	,,	20
London Tfm. Service	,,	620
King & Hutchings	,,	30

OXFORD UNIVERSITY.

SUMMER COURSE FOR ENGINEERING TEACHERS AT MERTON COLLEGE.

A NEW step in the education of Post Office Engineers was taken in the summer of last year when, by arrangement with the Board of Education, a number of officers of the Engineering Department devoted a portion of their annual leave to attending a course of training at Merton College.

The course was intended for teachers engaged in teaching Engineering Subjects, the primary aim being to consider the most suitable means of presenting to students certain of the subjects taught in the National Certificate course and the City and Guilds of London Institute grouped course in Telephony and Telegraphy, also to review recent advances in Engineering and Electrical Science and practice.

The Officers attending the course were selected from those engaged in teaching at Technical Colleges and Polytechnics in England and Wales. Twelve members of the Post Office staff attended, in company with about 50 others, most of whom were teachers by profession.

The Course consisted of lectures, demonstrations and discussions. The first lecture each day was devoted to either Telegraphy or Telephony and was given by a recognised authority in the particular aspect of the art dealt with. The second lecture was of a more general nature, but had reference to subjects bearing directly on Telephony and other forms of electrical communication, such as the presentation of the elements of Electricity and Magnetism, Units and Dimensions, also the Thermionic Valve and its applications in the practice of measurement and other related topics.

The lecturers included Dr. Chapman, H.M.I., Prof. C. L. Fortescue, M.A., Mr. E. W. B. Gill, M.A., Mr. A. C. Jolly, Prof. E. Mallett, D.Sc., Prof. E. W. Marchant, D.Sc., Mr. E. B. Moullin, M.A., and Mr. G. F. O'dell, B.Sc.

Discussions followed these lectures. A considerable portion of the time spent in the "Telephony" discussions was devoted to the present City and Guilds syllabus,—the general opinion of those attending these discussions being that the syllabus required some modification, but concrete proposals for such modifications were not advanced. The writers, however, consider it very desirable that each year's syllabus should contain a preamble setting out the standard of knowledge which it is hoped the students will have attained at the end of the year. It transpired during these discussions that the advantages of the grouped course scheme are not sufficiently well understood by teachers or explained to the students at the time of enrolment, with the result that students often receive only partial instruction instead of the comprehensive training intended.

For the purpose of these discussions the members of the Course were divided into small groups and the discussions took place in the Tutors' rooms, where the expressions of opinions were stimulated by the congenial atmosphere that prevailed.

The final lectures of the day were given after dinner by eminent educationalists. The following list indicates the diversity of the subjects dealt with:—

"The Development of Thought"—Mr. A. S. Barnes, the Chairman of the Course.

"Recent Research on the Design of Airships"—Prof. Southwell, University of Oxford.

"Science and Engineering"—Prof. F. C. Lea, D.Sc., Sheffield University.

"The Science Museum"—Sir Henry Lyon, Director of the Science Museum, South Kensington.

"Plasticity and Flow of Metals"—Prof. B. P. Haigh, Royal Naval College, Greenwich.

"Teaching of Engineering History"—Mr. L. Pendred, President, Inst. Mech. Engineers.

"The Practical Training of Students"—Sir Henry Fowler, Chief Engineer, L.M.S. Railway.

"Electrical and Mechanical Resonance"—Prof. C. L. Fortescue, Imperial College of Science and Technology.

Each of the lectures was followed by a keen and stimulating discussion.

A library of about 400 volumes of recent books dealing with Science, Engineering and Education was available in the College for the use of the members.

Another feature was a lecture by Mr. Moullin on "Laboratory Work"; this was followed by a visit to the Electrical Engineering Laboratories of the University, which were in the process of being equipped.

All members of the Course resided in the rooms of the College normally occupied by the undergraduates, and this provided opportunities for social intercourse and discussions which frequently continued into the small hours.

Mr. E. H. Shaughnessy, O.B.E., M.I.E.E., and Col. Lee, B.Sc., M.I.E.E., visited the College during the course and took part in various discussions, both formal and informal, and we feel sure that they appreciated to the full the opportunities mentioned in the previous paragraph.

All meals were taken in the Dining Hall of the College. This Hall is the finest in Oxford, the walls and doorway having been built in the time of Walter De Merton, the Founder. Merton College has the honour of being the oldest in Oxford, and in it the real idea of a College is first found. Its statutes date back in the earliest to 1264 and are the models of other foundations both in Oxford and Cambridge. The College buildings may not claim to be the most beautiful, but are undoubtedly the most interesting in the University. The oldest portions are quite a century older than any other existing College building in Oxford and still preserve in many parts their original form.

Facilities for cricket, tennis, golf and swimming were provided, but the inclement weather prevented advantage being taken of these, with the result that our recreation consisted of visits to Colleges and other places of interest. The members of the Course familiar with Automatic Telephony conducted, by kind permission of Capt. Harris, the Sectional Engineer, the remaining members of the Course over Oxford Automatic Exchange.

The Chaplain of the College was good enough to conduct a special service in the College Chapel, which was attended by the staff and members.

The success of the Course as a whole owed much to the genial personality of the Chairman, Mr. A. S. Barnes, and the untiring work of the organising Secretary, Mr. Hartas Jackson, H.M.I. The Electrical Communications section was in the hands of Dr. Chapman, H.M.I., and to his enthusiastic and unselfish efforts the undoubted success of this part of the Course was due.

In conclusion, the writers would like to express their heartfelt appreciation of the lectures, discussions and intimate association with Tutors and Professors which they enjoyed during their residence in college. The experience, the expositions and the instruction received cannot but be of lasting benefit to all those who attended.

H. G. S. Peck.
C. W. Brown.

DISTRICT NOTES.

LONDON DISTRICT.

Growth of Telephone System.—The nett increases in the number of exchange lines and stations during the quarter ended 31st December, 1930, were 6,603 and 10,793 respectively.

New Trunk Cable—London to Brighton.—Preparations are being made for the provision of a new cable to Brighton which will be of unusual type. It will contain 74 pairs of wires in star quad formation and the weight of the conductors will be 10 lbs. per mile. The overall diameter will be 0.8 inch. The cable will be drawn into ducts through the London District, but from Coulsdon onwards the cable will be suspended on existing poles.

In normal circumstances a trunk cable containing so many conductors requires a separate duct and there is not always a spare duct available. In this case there is no spare duct over a large portion of the route, but owing to the small diameter of this special cable it is possible to find space in partly occupied ducts and thus the time required to provide additional ducts will be eliminated. On account of its light weight, the cable will be attached to existing poles on the open route. The total time required to provide the cable will therefore be shortened by several months, as compared with the type of trunk cable which has hitherto been provided. Repeaters will be provided at Crawley, *i.e.*, about midway to Brighton. The cable will be utilised to provide 37 four-wire circuits.

Extension of Tandem Exchange.—The growth of traffic and the increase in the number of exchanges has necessitated a further extension of the main Tandem Exchange.

The equipment is being installed by the A.T.M. Co. to the Engineer-in-Chief's specification, and consists of additions to the cabling from I.D.F. to Test Jack Frame with increased accommodation thereon, C.C.I. and " Auto to Auto " repeaters, First Tandem Selectors and boards, and Third Code and Tandem Selectors and boards. Code Selectors are available to traffic from manual, and Tandem Selectors to traffic from auto exchanges only.

The London District is responsible for the regrading required to bring the new equipment into use, and considerable work will be involved.

The following brief summary shows the increase in capacity of the exchange produced by the extension :—

	Before Extension.	*After Extension.*
Maximum Number of junctions I/C from Manual Exchanges	2680	2880
Maximum Number of junctions I/C from Auto. Exchanges	2400	2880
Maximum Number of junctions O/G from Tandem	6400	9400
Total Number of Selectors (10 contact)	10838	13543
Total Number of Selectors (20 contact)	400	1600

New Automatic Exchanges.—Gulliver exchange was opened on January 1st, 1931, with 1,300 subscribers transferred from Hampstead. This exchange has an initial capacity of 4,400 lines and an ultimate capacity of 10,000 lines.

Pollards exchange was opened on February 4th with the transfer of 1,736 subscribers from the Pollards manual exchange, which was a C.B. 20 exchange installed as a temporary measure some years ago in the same building. The initial capacity of the auto exchange is 4,000 lines and the ultimate capacity 10,000 lines.

Both the above automatic exchanges were installed by Messrs. Siemens Bros. & Co.

Until Saturday, November 17th, the Hendon and Colindale automatic satellite exchanges were based on Maida Vale as a parent. On the above date they were transferred without hitch to a parent exchange at Gladstone. Over 900 lines were involved in this transfer, including all manual board circuits between the parent and satellites, Keysender " B " junctions and miscellaneous circuits. When the Gladstone Exchange was opened it dealt with the satellite traffic only, but on January 17th this was added to by the transfer of 2,300 lines from Willesden and Hampstead Exchanges. The Gladstone Exchange was equipped by Messrs. Ericsson and has an initial equipment of 5,100 lines. The ultimate capacity is 10,000 lines.

Work is proceeding on the equipment of the following new automatic exchanges :—

Prospect (Barnes).	Acorn (Acton).
Hampstead.	Southall.
Leytonstone.	Perivale.

The manual work for Southall and Perivale will be concentrated at Acorn and it is expected that appreciable economy will thereby be effected.

Progress is being made with the provision of a sub-tandem exchange in the Reliance building. This will be followed by other sub-tandem exchanges as the need arises. The object of these exchanges is to relieve the main Tandem exchange of the short distance indirect traffic.

Closing of Manual Exchanges.—The Kelvin manual exchange has been entirely freed by the transfer of the remaining lines to the Western Auto exchange and the manual equipment is being recovered for use elsewhere.

The Frobisher manual exchange is also being recovered in consequence of the transfer of the lines to the Frobisher automatic exchange, which is hypothetical on the Flaxman Exchange. This will result in the evacuation of the building in the Cromwell Road which was originally known as the Western Exchange and was one of the oldest C.B. exchanges in London.

Automatic Registration of Excess Fees.—Apparatus has been installed at the Mitcham and Ilford Exchanges for the automatic registration of fees in excess of the unit fee.

New Manual Exchanges.—The installation of new manual exchanges at Ewell and Downland (Coulsdon) has commenced and also the new operators' training school at the Terminus Exchange building (King's Cross).

New Buildings.—New buildings for automatic exchanges are being erected at Plashet (Plaistow), Byron (S. Harrow), Hither Green, Bayswater, Merton, Tulse Hill, Mayfair, Colindale, Bowes Park, Bethnal Green, Kensington and others are about to be commenced. New buildings for manual exchanges are being erected at Sanderstead, Seven Kings, Chislehurst, Pinner, Epsom and Purley.

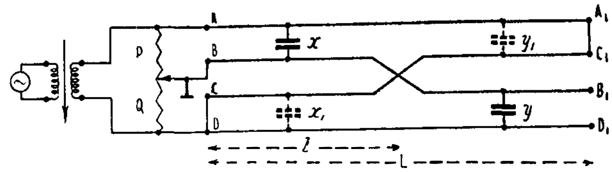
Fire Alarm System.—A Gamewell Fire Alarm System is being installed by the Standard Cables and Telephone Company for the L.C.C. in the Southwark Area. Whitefriars Fire Brigade Station is being equipped as a Superintendent's Station, and Southwark Fire Brigade Station as an Out Station. From the latter there will be two loop circuits comprising 28 call points. The two stations will be connected by Junction circuits, and the operation of a call point will transmit the code of the particular call point to both Stations. The signals will be received audibly on gongs and permanently on a tape which will also be dated and timed. As is generally known, in the Gamewell System a permanent current of 100 mA. is maintained on the call point circuits, the signals from the points being produced by mechanism which interrupts the permanent current a definite number of times corresponding to the number chosen as the code of the point. The circuits are therefore under constant test and the arrangements at the controlling station are such that faults on the system are at once revealed. It is possible for the system to continue working with a disconnection in the line circuit, and a single earth fault will not put it out of action. It is also claimed to be proof against accidental false alarms. The working of the present installation will be watched with interest, as upon its success or otherwise will probably depend the decision of the L.C.C. to adopt a similar system throughout London.

SOUTH MIDLAND DISTRICT.

Locating the Crosses in Split Cable Pairs,

by E. P. Brown (South Midland District).

The following method has been found useful in locating the point at which certain irregular crosses, in split pairs, have been made during jointing operations in twin and multiple twin cables.



The split pairs are connected up and joined to the slide wire as shown in the diagram. For the purpose of rendering the capacities x^1 and y^1 ineffective during the test, the connection between C and D at the near end also A_1 and C_1 at the distant end, are made.

By adjusting the slider a point will be found where silence in the telephone will be obtained, or, as is most usual with this test, minimum sound will be heard in the telephone at some point on the slider.

For a balance

$$\frac{Q}{P} = \frac{\dfrac{l}{\omega Y}}{\dfrac{l}{\omega X}} = \frac{y}{x} \text{ and } \frac{Q}{P + Q} = \frac{x}{x + y} \quad \ldots\ldots(1)$$

Where ω = 2π frequency.
x = Capacity in farads between A and B.
y = Capacity in farads between B_1 and D_1.
P = Arm of slide wire.
Q = ,, ,, ,, ,,

Assuming the mutual capacity of the pairs to be equal and uniformly distributed throughout the length L, then $x + y \equiv L$.

Substituting in (1)

$$l = L \cdot \frac{Q}{P + Q}$$

Where L = length in yards of section under test
l = distance in yards to cross.

On lengths up to two miles or so, where the test is most useful, *e.g.*, a section containing a number of joints, good results have been obtained.

On very short lengths, the test becomes less sensitive owing to the loop resistance of the section under test being connected across the slide wire.

A slide wire consisting of a piece of 36 S.W.G. resistance wire stretched on a graduated board 36″ long has been used with success, the source of supply for testing current being a buzzer and repeating coil, but of course, a non-reactive slide wire used with a balanced and screened transformer is preferable.

Retirement of Mr. C. G. Roach, A.M.I.E.E.

The retirement of Mr. C. G. Roach last autumn terminated the official career of one of the most genial and stalwart representatives of the band of engineers who have been intimately associated with the work and progress of the Department from their youth onwards.

Mr. C. G. Roach, A.M.I.E.E.

Mr. Roach entered the service as a Boy Learner at Newton Abbot in November, 1883, and was subsequently at Totnes. In 1886 he was appointed telegraphist at Gloucester and was later transferred to C.T.O.

Mr. Roach joined the Engineering Department as a Sub-Engineer in 1897 and, after experience at Holloway Factory, went to South Wales, where, at Pontypridd and Swansea, he was a pioneer in the active development of rural telephone service and opened up many new exchanges in the Rhondda and Swansea Valleys. On promotion to 1st Class Engineer in 1908, Mr. Roach's energies were transferred to Bolton and subsequently, in 1909, he became Sectional Engineer, Plymouth, taking that Section over from the Royal Engineers.

In addition to the local telephone development in the Plymouth area Mr. Roach was engaged in the completion of the Western Underground Cable to Penzance and was prominent in taking over the Marconi Ship and Shore Wireless Station. Following the acquisition of the Marconi installations, the first Departmental Wireless Station was erected at Bolt Head and later replaced by the more powerful Station at Lands End. A paper descriptive of the latter Station was read by Mr. Roach before the Western Section of the Institution of Electrical Engineers in March, 1914.

During the war period, enemy submarines were very active around the Cornish and Scilly coasts and Mr. Roach had many anxious and difficult times maintaining communication with a depleted staff.

On promotion to Assistant Superintending Engineer in the South Midland District in 1925, Mr. Roach took an active part in the work, consequent upon the very rapid growth of the service, and maintained the keenest interest in the latest engineering developments.

During his stay at Plymouth, Mr. Roach became a bowls enthusiast and his prowess as a bowler with many successes to his credit is widely known. In 1922 he was runner-up in the E.B.A. singles final and in 1923, he played for England in all three International games. In the same year he won the Civil Service National Championship Singles and, with his (then) Superintending Engineer as partner, the Pairs also. The games were played on the green of the South London Bowling Club and in winning four finals on one day Mr. Roach set up a record which he will find it difficult to beat. Mr. Roach is a regular competitor at several of the Bowling Tournaments and has won the Pairs at Bournemouth, besides being runner-up on several occasions with different partners. During his stay in Devon he played regularly in County games and the Berkshire County Bowling Authorities now make frequent use of his services.

Among his other activities Mr. Roach is an ardent Freemason and a Past Master of the Craft.

It is pleasing to record that Mr. Roach retired in full health and youthful vigour. As a token of the esteem and good wishes of his friends and colleagues Mr. Roach was asked to accept an all-mains wireless set. The opportunity was chosen to present it to him at the first I.P.O.E.E. (South Midland Branch) meeting of the session when a large attendance of the members was assembled to hear the Chairman's lecture—" Maxwell—Heaviside—Einstein." Mr. J. E. Taylor, Superintending Engineer, made the presentation in felicitous terms before commencing his lecture.

H.C.G.

NORTH EASTERN DISTRICT.

Underground Work in Grass Margins.

An interesting experiment was made in the North Eastern District recently, at Coneysthorpe, in the County of Broad Acres, where there are still wide grass margins which escaped enclosure in the days when many tracts of such land were filched from the public.

The country at this point is very exposed, and the decision to establish a rural automatic exchange, with the prospect of securing ultimately some 20 subscribers at a village about 1¼ miles from the exchange site, raised the question of overhead versus underground plant. Consideration of this question resulted in a decision to provide an underground line in an unorthodox manner.

Of the 2,129 yards it was found that 1,706 yards was " easy " grass margin, and when a local farmer was approached and his terms sought for the hire of his Fordson tractor plough, he offered to cut the trench for £2 !

Figs. **1** and **2** show the tractor at work, under the supervision of the farmer !

A double cut trench of 18″ average depth was made by the plough, *i.e.*, each section was traversed twice. The remaining length of the trench, carriageway entrances and road crossings was cut by manual labour.

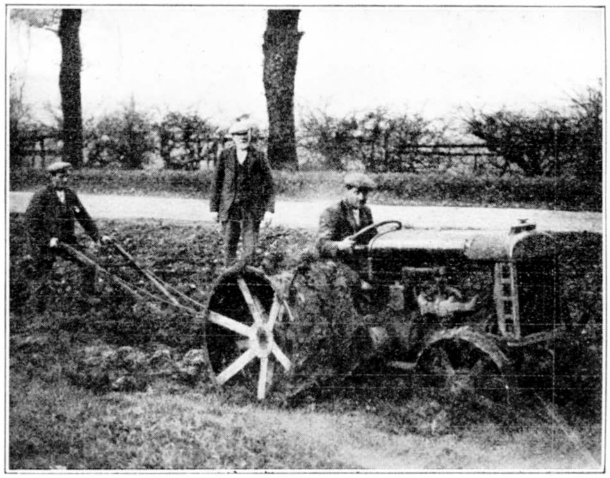


Fig. 1.—Cutting the Trench.

It was considered that the local conditions were such that ordinary lead-covered cable, whether laid direct in the ground or placed in wood troughing, would be liable to corrosion; and it was felt also that the life of " protected," *i.e.*, taped, cable would probably be unduly short. The Engineer-in-Chief arranged therefore for the supply of an experimental type of protected cable, the " protection " taking the form of an external coating of " Pernax," the thickness of which is .075″, thus increasing the diameter from the standard (for 25 pr/10) of 0.60″ to 0.75″.

Fig. 2.—Another view.

Fig. 3.—Laying the Cable.

The method of laying the cable in the trench was as follows:—

The cable drum was mounted on one of the Department's freighters, which moved slowly along the road parallel to the track as the cable was paid out. Fig. **3** indicates the method followed.

It was the intention to fill in the trench by means of the tractor plough, but exceptionally wet weather prevented the adoption of that method. Fig. **4** is interesting, as it shows the "Pernax" cable in position and also the character of the grass margin which inspired the experiment, the success of which leaves no room for doubt as to whether it could safely be repeated.

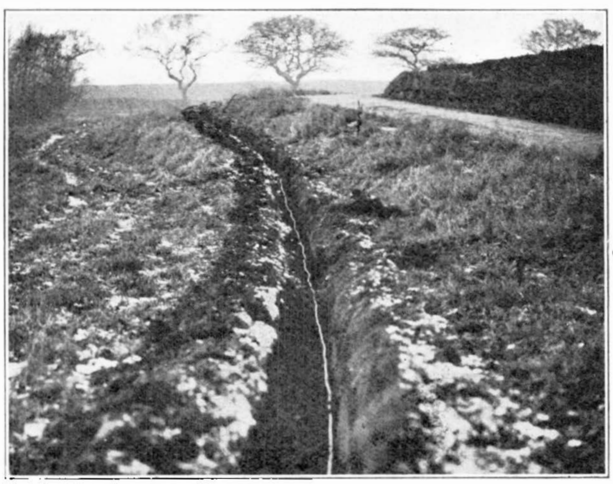


Fig. 4.—The Cable in position.

SCOTLAND WEST DISTRICT.

Work is at present in progress at several points between Ayr and Stranraer and between Stranraer, Port Kail and Knock Bay, in connection with the laying of the underground ducts which are to take the new Ayr-Stranraer, Port Kail, Knock Bay underground cable. This cable will form a link in the new trans-Atlantic telephone service and will also provide improved telephone service between Scotland and Ireland.

The pulling in and jointing of the cable between Glasgow and Ayr is also proceeding. The new cable will contain specially loaded pairs to suit B.B.C. requirements.

A site for a new Repeater Station, conveniently situated with respect to the landing point of the submarine cable which will reach this country from the Atlantic *via* the North of Ireland, has been secured and building plans have been prepared.

The Scotland West District has taken full advantage of the introduction of the new Rural Automatic Exchange equipment; as many as 42 Exchanges of this type have now been opened in this District, with an additional 14 authorised or in progress.

This automatic equipment has proved itself highly satisfactory in meeting the needs of many out-of-the-way places in the Western Highlands of Scotland, as witness the illustration in the last number of the Journal depicting the substantial stone-built structure at Ballachulish at the entrance of the wild and historic Pass of Glencoe. Among other places in the West of Scotland and the Western Highlands of Scotland which have been similarly served might be mentioned Kinlochleven, Spean Bridge, Appin, Onich, Corpach, Strachur, Carradale, and Pirnmill, Machrie and Lochranza in Arran.

Improved telephone trunk service for the Western Highlands is being catered for by the erection of a direct Glasgow-Fort William trunk (Trunk communication to Fort William prior to the provision of this circuit was *via* Oban and Inverness) which was handed over for traffic at the end of January, and trunk communication will shortly reach the outpost of this District on the Mainland when the new Exchange at Mallaig is opened with a trunk circuit Mallaig to Fort William.

In Glasgow itself, two new C.B. No. 1 Manual

Exchanges have been opened. These will afford relief to the existing exchanges of Langside, Giffnock and Western.

At Ayr and Prestwick installation work in connection with new automatic exchanges is in progress. At the former, the equipment will consist of a manual board of 11 positions (ultimate 17 positions) and automatic equipment for 1835 subscribers' lines (ultimate 3860). At Prestwick, which will be a satellite exchange to Ayr, the equipment is for 560 subscribers' lines with an ultimate of 1260.

In both these places the new automatic equipment will replace old magneto exchanges.

OFFICIAL VISIT OF CIVIC PARTY TO NEWCASTLE CENTRAL AUTO EXCHANGE.
Photo by Journal and North Star, Newcastle.

NORTHERN DISTRICT.

OFFICIAL VISIT OF CIVIC PARTY AND REPRESENTATIVES OF CHAMBER OF COMMERCE AND PUBLIC UTILITY UNDERTAKINGS TO NEWCASTLE CENTRAL AUTOMATIC EXCHANGE.

The preservation of good relationships between the Post Office and the general public in the Tyneside area could not fail to receive a substantial impetus by the official visit of the Lord Mayor of Newcastle and party to the new Central Automatic Exchange, Newcastle, on the afternoon of Thursday, the 5th February, 1931. The Postmaster-Surveyor, Superintending Engineer, Northern District, and District Manager, with their respective staffs, co-operated to give to a most important assembly of gentlemen drawn from the area an indelible impression of the spirit of service of the Department as evidenced in the transfer to automatic working of the Newcastle Telephone System.

The guests comprised the Lord Mayor of Newcastle-on-Tyne (Alderman David Adams), and Lady Mayoress, the Sheriff (Dr. Leech), members of the City Council, the Mayors of Gateshead, Wallsend, and Jarrow, the Chairman of adjacent Councils, the Chairman of the Postal Sub-Committee of the Chamber of Commerce (Mr. Charles Irwin), Lord Kirkley, Sir Arthur Lambert, Mr. Herbert Shaw (Secretary of the

Chamber of Commerce), Mr. E. S. Byng (Managing Director of Standard Telephones & Cables, Ltd.), and many other prominent gentlemen.

The party assembled in the Dining Room of Telephone House and was accorded a welcome by the Postmaster-Surveyor (Mr. F. Ferguson) who remarked that the transfer which had taken place at midnight on the 31st January, under adverse circumstances in point of weather, had proved to be wholly successful, and had provided a service which was working very smoothly. The District Manager (Mr. J. D. W. Stewart) said that the installation just opened had put the Newcastle Area in the forefront, as regards telephone advancement, not only of this country but of the world. He would, however, like to mark the passing of the old system by an expression of his appreciation of the work of the women of the Department who had operated the manual system for a long period in circumstances which called for qualities of patience and tolerance. The Superintending Engineer (Mr. F. G. C. Baldwin) welcomed the guests on behalf of the Engineering Department and referred to the development of telephone switching devices culminating in the system installed in Newcastle, which represented the product of the best brains available practically throughout the world. He remarked that the Newcastle transfer had raised the percentage of telephone exchange lines worked on an automatic basis in this District from 17.7 to 50, and compared the latter figure to the national figure, which, in November last, stood at 37. He gave a brief description of the improvements effected by automatic apparatus and referred to the fact that the actual transfer of the Central Exchange and its eleven satellites had been completed in eight minutes. He paid a tribute to the work of the Standard Telephones & Cables, Ltd., and drew pride from the fact that the complicated network of underground cabling plant had been designed and installed by the staff of the Northern Engineering District.

The party then divided itself into twelve groups under the direction of an equal number of members of the P.O. Engineering staff as guides and, commencing from several points, the groups simultaneously and without confusion made a tour of the Exchange. Each point from the Power Room to the Auto Manual Switch Room, where Traffic Officers took charge, was explained to the visitors, and from the interest displayed and the questions asked it was evident that they were considerably intrigued by the intricate apparatus, and appreciative of the importance of the function of each part of the installation.

The party again assembled in the Dining Room to have tea, in the course of which Mr. L. Simon, Director of Telegraphs and Telephones, speaking from the Secretary's Office, London, gave a message, amplified by two loud speakers, to the Lord Mayor. Mr. Simon said "It gives me much pleasure to have this opportunity of sending a word of greeting and good wishes to the municipal heads and prominent citizens of Newcastle and the neighbouring towns. Yours is among the earliest of our big industrial areas to change from the manual to the automatic telephone system, which represents the latest stage of technical development in the field of telephony. I may be permitted to express the hope that the new system will commend itself to the subscribers, present and future, and that the telephone will continue to play a part of ever-increasing usefulness in the manifold business and social life of your great community."

The Lord Mayor, in reply, paid a tribute to the efficiency of the Post Office Engineers and expressed his satisfaction at the installation of the automatic system in the "Metropolis of the North." He asked the Director to convey a message from Tyneside to his (the Lord Mayor's) friend, the Postmaster-General, in which the hope was expressed that a reduction of telephone rates would result from the introduction of more efficient and economical apparatus. Mr. Simon replied that he was pleased to hear the expression of appreciation, but could not be expected at that moment to give any opinion regarding the suggested reduction of telephone rates. He would, however, convey the message to the Postmaster-General.

The Lord Mayor then addressed the visitors and expressed appreciation of the efforts of the Department in the dispersal of the operators rendered surplus by the change-over. He congratulated all concerned in the installation and expressed his pleasure at the opportunity afforded that afternoon of viewing the working of the new system.

The Sheriff, following, described the exchange as " a veritable wonder house," and expressed his thanks at being allowed to accompany the Lord Mayor on the visit.

The Chairman of the Postal Sub-Committee of the Chamber of Commerce (Mr. Charles Irwin) alluding to the fact that the Exchange building had been erected on the site of the old Newcastle Gaol, said that the presence of the Sheriff on such an occasion in contrast to the occasions on which Sheriffs had formerly visited the site evidenced the progress of the age. He referred to the facilities provided to Tyneside business men by the Telephone system in being able rapidly to communicate with the merchants of the world, and spoke of the cordiality of the relations between the Chamber of Commerce and the Post Office officials of the District. A proposal by Mr. Irwin of a vote of thanks to the local Post Office Authorities for their hospitality was carried with acclamation.

Mr. Ferguson concluded the proceedings by expressing the thanks of the local officials for the attendance of the visitors.

The Inauguration of the Automatic Telephone System, Newcastle-on-Tyne, January 31st, 1931.

By an Eye-witness.

The last day of January, 1931, was destined to be a memorable one in the history of telephony in the extreme north of England, for it marked the passing of the old manual system which had faithfully served for so long and its replacement by automatic switching methods in Newcastle-upon-Tyne and a large portion of the surrounding territory known as Tyneside. The day dawned bright and clear and gave promise of favourable conditions for the conversion to automatic working of the subscribers' lines comprised in the huge Newcastle and district telephone system which was due to take place at midnight. Later in the morning some concern developed in the minds of the older members of the Post Office Engineering staff who were due to take part in the transfer operation, when snow of that peculiar consistency which always gives cause for apprehension to the telephone engineer, accompanied by boisterous wind, commenced to envelope the town and countryside. By evening a white snow mantle overlay a bog of slush, except in the towns where traffic had obliterated the disguise.

Towards midnight, the storm at its height, a group of participants in the night's telephonic undertaking approached the scene of the principal operations, splashing, slipping, struggling through the churned quagmire, now ankle deep, and the outlook was, at least for one, enlivened by sudden but fortunately painless " full contact " with the semi-fluid mass. " Short-circuit " of the mess, however, was quite impossible, and when the wet and chilly result of the " full earth " was removed from his person, the struggle was resumed.

Observed upon this cold and wintry night with wind-blown flakes of snow, quickly turning to rain, still falling, Telephone House, situated upon the site of the demolished Newcastle Gaol, presented a striking appearance; towering above its now deserted neighbours standing gaunt and grim, with every window of its upper floors ablaze with light, the striking contrast conveyed an impression of some pending event of more than ordinary significance.

Once within the shelter of the portals of the telephone building the striving elements without were very near forgot. The warm and quiet calm which reigned within recalled the atmosphere of some great cathedral standing midst the turmoil of a vast and busy city. The ringing of a distant telephone bell quickly dispelled the impression, however, and revived recollection of the important and delicate task which was pending, and of the fact that this Telephone House in less than an hour was suddenly to become the hub of the communications of the telephone using community of industrial Tyneside. One visualised the underground lead and copper tentacles stretching beneath slushy streets to eleven scattered satellites with lighted windows shining in the blackness, all waiting silently, unostentatiously, for the signal suddenly to summon them to assume their allotted functions.

Within the brilliantly lit apparatus room, to the uninitiated mind, the scene was one of mysterious activity; amongst racks and frames filled with seemingly inanimate devices moved silent apparitions, some white-footed and khaki-clad, vigilant and active, giving final attention to needful apparatus preparatory to its approaching endowment with life.

Without, the city slept beneath its pall of snow, indifferent to, unconscious and, indeed, unmindful of the devotion of some two hundred souls to the requirements of the telephone community.

As the fateful hour of midnight approached numerous figures with cat-like tread and serious mien moved silently to their allotted posts; main frame, protectors, test desk, fuse panel, power board, racks and switches, all were quickly manned. The controlling officer in sombre garb and with solemn step assumed the position from which he would influence the whole of the complex operations. Anxious expectation gave birth to silence, and silence grew; tense became the atmosphere as of some pending consequential ceremonial; quiet reigned supreme; no sound was heard save an occasional word utteried beneath the breath. A recalcitrant switch buzzed somewhere in the recesses of the racks, then paused and stopped, as though shamed by the stillness; but the clock ticked steadily on. The momentous signal that the thirteen old switchboards were clear of traffic, deathknell of the old exchanges, was awaited in almost breathless silence. Still the clock ticked on. Eleven fifty three! Eleven fifty four! Eleven fifty five! Go! At last the controlling officer bestirred. Disconnect! Disconnect Gateshead, disconnect Gosforth Benton, Wallsend. Disconnect Kenton, Low Fell, Jarrow, Felling, Whickham, Central, City. Disconnect! At last the word was given and the signal flashed accordingly to the waiting operatives at a dozen distant points. Silence again ensued, with anxious figures standing by like statues but with thoughts alike of disruptive operations now in progress at those distant places in the snow and winter darkness. Still the clock ticked tranquilly on in indescribable silence, silence almost audible. Into his transmitter now and again with receiver at his ear the controlling officer murmured, whilst with pencil he recorded one by one the executions now in progress. The hand of the clock moved steadily, slowly, persistently on towards the dawn of another day. Tick, tack, click, clack, and the city still slept on. The midnight hour arrived at length. The strokes of midnight boomed from many a steeple far and wide. Midnight chimed from many a turret outside;—but the city still slept on and those within heard not the quivering tones. Presently the controller shifted uneasily in his seat. "Low Fell! Low Fell!" he wailed. "What be the matter Low Fell?" Ah! Low Fell is clear, all clear, all clear at last. The murderous deed is done.

One minute past the midnight hour—six short minutes and the whole of the city's telephones were dead. Not a voice at that moment traversed the copper network of the telephone system of Tyneside. Thirteen old exchanges lay bereft of the lines they had nurtured so well and so long, never again to exercise their former functions. "Not a sound was heard, not a funeral note," but a pang of regret shot momentarily through the hearts of those responsible for the act. Their former cares were slain—slain by their own hand, never more to need the careful attention they had so generously lavished upon them. But banish the thought; with a wave of the arm and a word flashed again over a dozen circuits simultaneously, the signal was given to turn the now severed lines upon the new equipment waiting ready and seemingly expectant to receive them, and in two short minutes it was done. Out of their months of labour, out of their days of travail, out of their hours of test the twelve new exchanges sprang suddenly into life. Wires and circuits, cables and coils, relays and switches, group selectors and finals all were electrified, quickened and summoned to activity. Lamps blinked and winked and glowed; switches buzzed and chattered; a bell tinkled; the birth of the new automatic system was accomplished.

The controller sighed wearily, laid down his receiver, arose from his seat and gravely glanced at the clock. But the city still slept on!

OUTLINE NOTES ON TELEPHONE TRANSMISSION THEORY.

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

(SECTIONS 5, 6 AND 7).

SECTION 5.

In addition to the imaginary "infinite" line case, considered in Section 3, three other important practical cases must be considered, viz., the "open" and "short" circuited conditions respectively, for any length of line and the more general case of a line terminated with a given impedance (Z_r).

I. Case of Open Circuit at Distant End of Line.

(See Fig. 7).

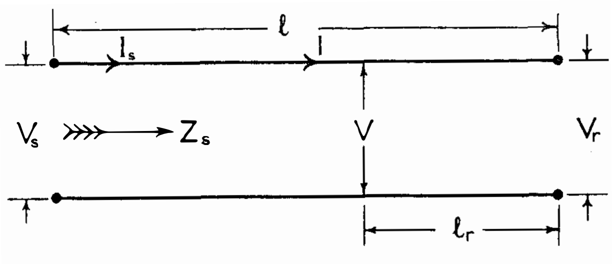


Fig. 7. Open Circuited Line.

(*a*) *Expression for the Impedance (Z_s) Offered at the Sending End.*

The received current will be zero in the open condition and hence by equation (12) of Section 2:—

$$0 = I_s \cosh \gamma l - \frac{V_s}{Z_0} \sinh \gamma l$$

(where l is the distance to the open circuit).

This gives $Z_0 = \frac{V_s}{I_s} \tanh \gamma l$

or $Z_0 = Z_s \tanh \gamma l$

$\therefore Z_s = Z_0 \coth \gamma l$ ....(1)

(*b*) *Expressions for Voltage (V) and Current (I) at any Point Distant (l_r) from the Receiving End of Open Line of Length (l).*

From equation (13) of Section 2:—

$$V = V_r \cosh \gamma l_r + I_r Z_0 \sinh \gamma l_r$$

But with the open line $I_r = 0$

$\therefore V = V_r \cosh \gamma l_r$ ....(2)

Now $V_r = V_s \cosh \gamma l - I_s Z_0 \sinh \gamma l$ by equation (11), Section 2, and since $V_s = I_s Z_0 \coth \gamma l$ by equation (1) above, then

$$V_r = V_s \left(\cosh \gamma l - \frac{\sinh^2 \gamma l}{\cosh \gamma l} \right)$$

$\therefore V_r = \frac{V_s}{\cosh \gamma l}$ ....(3)

Hence from equations (2) and (3):—

$V = V_s \frac{\cosh \gamma l_r}{\cosh \gamma l}$ ....(4)

For the current, equation (14) of Section 2 gives:—

$$I = I_r \cosh \gamma l_r + \frac{V_r}{Z_0} \sinh \gamma l_r$$

Since $I_r = 0$

$\therefore I = \frac{V_r}{Z_0} \sinh \gamma l_r$ ....(5)

Now $V_r = \frac{V_s}{\cosh \gamma l}$ by equation (3) above and hence:—

$I = \frac{V_s}{Z_0} \frac{\sinh \gamma l_r}{\cosh \gamma l}$ ....(6)

II. Case of Short Circuit at Distant End of Line.

(See Fig. 8).

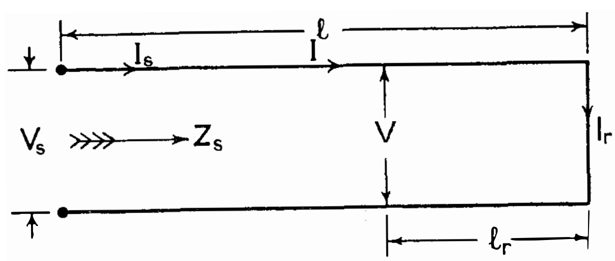


Fig. 8. Short-circuited Line.

(*a*) *Expression for the Impedance* (Z_s) *Offered at the Sending End.*

The received voltage will be zero in the short-circuited condition and hence by equation (13) of Section 2:—

$0 = V_s \cosh \gamma l - I_s Z_0 \sinh \gamma l$ (where l is the distance to the short circuit).

This gives $Z_0 = \frac{V_s}{I_s} \coth \gamma l$

or $Z_0 = Z_s \coth \gamma l$

$$\therefore Z_s = Z_0 \tanh \gamma l \quad \text{..........(7)}$$

(*b*) *Expressions for Voltage* (V) *and Current* (I) *at any Point Distant* (l_r) *from the Receiving End of a Short-circuited Line of Length* (l).

From equation (14) of Section 2:—

$$I = I_r \cosh \gamma l_r + \frac{V_r}{Z_0} \sinh \gamma l_r$$

But with a short-circuited line $V_r = 0$.

$$\therefore I = I_r \cosh \gamma l_r \quad \text{..........(8)}$$

Now $I_r = I_s \cosh \gamma l - \frac{V_s}{Z_0} \sinh \gamma l$ and since by equation (7):—

$$V_s = \frac{I_s Z_0}{\coth \gamma l}$$

$$\therefore I_r = \frac{V_s}{Z_0}\left(\frac{\cosh^2 \gamma l}{\sinh \gamma l} - \sinh \gamma l\right)$$

$$\therefore I_r = \frac{V_s}{Z_0 \sinh \gamma l} \quad \text{..........(9)}$$

From equations (8) and (9)

$$\therefore I = \frac{V_s \cosh \gamma l_r}{Z_0 \sinh \gamma l} \quad \text{..........(10)}$$

For the voltage, equation (13) of Section 2 gives:—

$$V = V_r \cosh \gamma l_r + I_r Z_0 \sinh \gamma l_r$$

Since $V_r = 0$

$$\therefore V = I_r Z_0 \sinh \gamma l_r \quad \text{..........(11)}$$

Now $I_r = \frac{V_s}{Z_0 \sinh \gamma l}$ by equation (9) above.

$$\therefore V = V_s \frac{\sinh \gamma l_r}{\sinh \gamma l} \quad \text{..........(12)}$$

III. General Case of a Finite Line, Length (l) Closed by any Terminal Impedance $Z_r e^{j\phi_r}$. (See Fig. 9.)

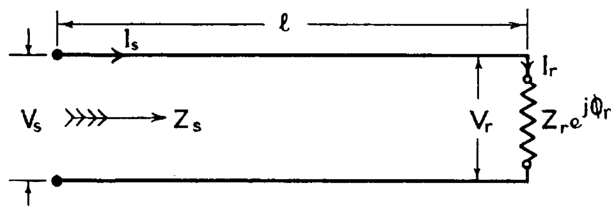


Fig. 9. Line Terminated by Impedance $Z_r e^{j\phi_r}$

V_r = p.d. across Z_r.

I_r = current through Z_r.

$$\therefore \frac{V_r}{I_r} = Z_r$$

From equations (11) and (12) of Section 2:—

$$V_r = V_s \cosh \gamma l - I_s Z_0 \sinh \gamma l$$

$$I_r = I_s \cosh \gamma l - \frac{V_s}{Z_0} \sinh \gamma l$$

Dividing, $\frac{V_r}{I_r} = Z_r$ becomes:—

$$Z_r = \frac{V_s \cosh \gamma l - I_s Z_0 \sinh \gamma l}{I_s \cosh \gamma l - \frac{V_s}{Z_0} \sinh \gamma l}$$

$$\therefore I_s Z_r \cosh \gamma l - V_s \cdot \frac{Z_r}{Z_0} \cdot \sinh \gamma l = V_s \cosh \gamma l - I_s Z_0 \sinh \gamma l$$

Collecting terms:

$$\therefore I_s (Z_r \cosh \gamma l + Z_0 \sinh \gamma l) = V_s \left(\cosh \gamma l + \frac{Z_r}{Z_0} \sinh \gamma l\right)$$

$$\therefore \frac{V_s}{I_s} = \frac{Z_r Z_0 \cosh \gamma l + Z_0^2 \sinh \gamma l}{Z_0 \cosh \gamma l + Z_r \sinh \gamma l} = Z_s$$

$$\text{or} \quad Z_s = Z_0 \left\{\frac{Z_r \cosh \gamma l + Z_0 \sinh \gamma l}{Z_0 \cosh \gamma l + Z_r \sinh \gamma l}\right\} \quad \text{.....(13)}$$

Note 1.—If Z_r has the value Z_0 then equation (13) becomes:

$$Z_s = Z_0 \quad \text{..........(14)}$$

which is an important equation, as it shows that *if a uniform line of any finite length be*

terminated by an impedance equal to its characteristic impedance (Z_0) then the **sending end impedance is Z_0,** *and the line therefore behaves as an infinite line (Cp. equation 1, Section 3): i.e., the* impressed wave is propagated smoothly, without reflection at the distant end.

Note 2.—If the receiving impedance is short-circuited so that $Z_r = 0$, then equation (13) becomes :—

$$Z_s = Z_0 \tanh \gamma l \qquad (15)$$

which is the expression derived in equation (7) for the short-circuited line.

Note 3.—If the receiving impedance is disconnected, so that $Z_r = \infty$, and equation (13) is written in the form :—

$$Z_s = \frac{Z_0 \cosh \gamma l + \frac{Z_0^2}{Z_r} \sinh \gamma l}{\frac{Z_0}{Z_r} \cosh \gamma l + \sinh \gamma l}$$

then putting $Z_r = \infty$ in this equation :—

$$Z_s = Z_0 \coth \gamma l \qquad (16)$$

which is the expression derived in equation (1) for the open-circuited line.

Note 4.—If the open-circuit or " free " impedance of a given circuit be written Z_f and the short-circuited or " closed " impedance written Z_c then by equations (1) and (7) :—

$$\sqrt{Z_c Z_f} = Z_0 \qquad (17)$$

and $$\sqrt{\frac{Z_c}{Z_f}} = \tanh \gamma l \qquad (18)$$

Equations (17) and (18) have a very important practical application, because the values Z_c and Z_f of a circuit are readily measured by a simple A.C. bridge (See later notes for examples) and thus *from these two measurements both the circuit parameters Z_0 and γ are easily calculated at any desired frequency.* The former of these, Z_0, is useful in determining the best terminating impedance required, whilst the latter, $\gamma = \beta + j\alpha$, will give the attenuation of current and phase-angle change produced at the frequency of test. (Cf. later Section on Line Attenuation Measurements).

SECTION 6.

I. Wave Distortion in Cables.

From equation (18), Section 2, it is clear that as the frequency increases so does the attenuation constant β, so that for the higher harmonics of a given impressed wave-form the attenuation is greater, on a given length of cable, than for the fundamental. Also, from equation (19), Section 2, the wave-length constant is different for each harmonic of the complex wave, *i.e.*, the velocities of propagation of the harmonics are different. Thus while in an actual pair of conductors about 30 miles long the vowel sound of " O " gives an oscillographic record approximately that shown in Fig. **10** (*a*) at the *beginning* of the line, at the *end* of the line the record is more like that shown in Fig. **10** (*b*). This shape is

Fig. 10a. Sent Signal.

Fig. 10b. Received Signal.

smoother—with much less third and higher harmonics, having slightly different phase relationships—and generally diminished in amplitude. So all sounds become smoothed or " distorted " and do not re-appear as they are sent (because of the distinctive higher harmonics which are lost) unless the distortion is stopped or minimized. If all frequencies could be transmitted with equal attenuation and their velocities made the same, the problem of " amplitude distortion " (caused by unequal attenuation of harmonics) and " phase distortion " (caused by unequal wave-lengths of harmonics) would be solved. In practice the problem can be partly solved in the case of the transmitting line by adding inductance to the natural inductance of the cable circuits. The reason for this is discussed briefly as follows:—

Distortionless Condition.—Heaviside wrote equations (18) and (19) of Section 2, in the form—

$$2\beta^2 = \sqrt{(GR + \omega^2 LC)^2 + \omega^2 (LG - CR)^2} + (GR - \omega^2 LC)$$

and $$2\alpha^2 = \sqrt{(GR + \omega^2 LC)^2 + \omega^2 (LG - CR)^2} - (GR - \omega^2 LC)$$

respectively.

From these expressions it is clear that:—

if $\frac{R}{L} = \frac{G}{C}$ ....(1)

then $\beta = \sqrt{RG}$ ....(2)

and $\alpha = \omega\sqrt{LC}$ ....(3)

so that that the attenuation (β) is *independent of frequency* and the propagated wave velocity, (v) of all frequencies is *independent of frequency* (since $v = \frac{\omega}{\alpha}$ and $\alpha = \omega\sqrt{LC}$ by equation (3)) and is equal to $\frac{1}{\sqrt{LC}}$. Therefore no distortion of any harmonic of a complex wave takes place and the wave maintains its shape in such a line—which is known as a "*distortionless*" *line*.

Again, from consideration of equation (1):—

$Z_0 = \sqrt{\frac{R}{G}}$ or $\sqrt{\frac{L}{C}}$ ....(4)

which shows that Z_0 is also independent of frequency and hence all waves encounter the same impedance when transmitted over a line whose electrical constants bear the relation CR = LG.

Further, it is easy to prove that $\beta = \sqrt{RG}$ (equation (1) above) is the *minimum value* of β. See Example 2 at end of Section.

Now in actual circuits the *natural* inductance of the conductor is so small that $\frac{R}{L}$ is much greater than $\frac{G}{C}$, *e.g.*, 1 mile of Standard Cable having

R = 88 ohms per mile loop
L = 0.001 henry per mile loop
G = 1×10^{-6} mho. per mile loop
C = 0.05×10^{-6} farad per mile loop

gives the ratios:—

$$\left.\begin{array}{l} \frac{R}{L} = 88{,}000 \\ \frac{G}{C} = 20 \end{array}\right\}$$

which represents the order of inequality for ordinary air-space paper-core cables.

Again, 1 mile of aerial line having

R = 2.2 ohms per mile
L = 0.00332 henry per mile
G = 1×10^{-6} mho. per mile
C = 0.01×10^{-6} farad per mile

gives the ratios:—

$$\left.\begin{array}{l} \frac{R}{L} = 660 \\ \frac{G}{C} = 100 \end{array}\right\}$$

which represents an inequality, but much less than that existing in paper-core cables.

As it is desirable to make $\frac{R}{L}$ = or $\rightarrow \frac{G}{C}$ Heaviside originally suggested (in 1887) that increased inductance would be beneficial for a loop circuit used for speech transmission. Another method of making $\frac{R}{L} \rightarrow \frac{G}{C}$ is to increase the leakance factor (G) and this has been tried, but the greater attenuation which results is undesirable in long circuits.

Heaviside's suggestion, however, of increasing, in some manner, the inductance has the advantage of *decreasing* the attenuation when the added inductance is correctly introduced. (See Section 7). The following simple example will illustrate this advantage of increased inductance apart from the question of the practical methods adopted for artificially increasing L:—

Example 1.—Consider a cable having the electrical constants per mile loop, R = 88 ohms, L = 1 millihenry, C = 0.05 μF. Then neglecting G and taking ω = 5000 radians per second (corresponding to mean speech frequency) the attenuation (β) per mile loop is calculated from :

$$2\beta^2 = \omega C\{\sqrt{R^2 + \omega^2 L^2} - \omega L\}$$

—which is equation (18) of Section 2 with G put equal to zero. This gives

$\beta \fallingdotseq 0.100$ neper per mile loop ....(1)

[For definition of neper see later Section on Transmission Units.]

If now L is artificially increased to 100 millihenries per mile loop *in such a way as to be considered uniformly distributed* throughout the cable length then from :—

$$2\beta^2 = \omega C\{\sqrt{R^2 + \omega^2 L^2} - \omega L\}$$

$\beta = 0.033$ neper per mile loop ....(2)

$\fallingdotseq$ one-third the value given in (1).

In other words the transmission efficiency, as measured by volume of received sound at one definite frequency, is much greater in the case of L = 100 mH., than in the ordinary cable with L = 1 mH. Further, the value of $\frac{R}{L}$ is decreased, by the extra inductance, from 88,000 to 880—a figure much nearer the value for $\frac{G}{C}$, which is of the order of 20 for ordinary paper-core cables.

Example 2.—To prove that $\sqrt{RG}$ is the *minimum* value of β. By differentiating, with regard to L, the expression :—

$$2\beta^2 = \sqrt{(R^2 + \omega^2 L^2)(G^2 + \omega^2 C^2)} + GR - \omega^2 LC \text{......(1)}$$

the result is :—

$$4\beta \cdot \frac{d\beta}{dL} = \frac{\omega^2 L\sqrt{G^2 + \omega^2 C^2}}{\sqrt{R^2 + \omega^2 L^2}} - \omega^2 C$$

For β to be a minimum put $\frac{d\beta}{dL} = 0$ and this gives the condition :—

$$LG = CR$$

By substituting this condition in (1) the minimum value of β is found to be—

$$\beta = \sqrt{RG}.$$

Example 3.—What loading will be necessary to produce distortionless transmission in a line having the following loop-mile constants :— R = 6.3 ohms, L = 0.06 henry, G = 0.15 micromho, C = 0.054 microfarad? Find the attenuation constant before and after loading. (*C. & G., 1930*). [f = 800 p.p.s.]

Example 4.—Show that the current at a distance x miles from the sending end of a telephone line, of length l miles, which is open-circuited at the receiving end, is given by—

$$I = \frac{V_s}{Z_0} \frac{\sinh \gamma(l - x)}{\cosh \gamma l}$$

where V_s is the voltage at the sending end, γ the propagation constant, and Z_0 the characteristic impedance.

If $V_s = 10$ volts, $\gamma = 0.15 + j\,0.786$, $Z_0 = 725\ \underline{/10^\circ}$, $l = 15$ miles, find the current at distances (x) of 5 and 10 miles from the sending end. (*B.Sc. Final, 1929*).

[See equation (6) of Section 5.]

SECTION 7.

Loaded Cables.

The inductance added to a cable primarily to produce distortionless transmission, by forcing all components of the complex speech wave to attenuate more nearly at the same rate and travel more nearly with the same velocity, is generally introduced in practice by one of the two following methods :—

(I.) By means of inductance coils inserted in series at regular intervals along the line. Such inductance coils limit the wave-length which can be transmitted (*i.e.*, there is a certain maximum frequency above which transmission becomes very inefficient and eventually impossible) in exactly the same way as *lumped loads* upon a stretched, uniform, vibrating string limit the wave-length which it will transmit. (See References at end of Section). It is this analogy which has caused the series inductance coils to be regarded as electrically lumped loads and they are generally called "*loading*" *coils*.

(II.) By the provision of one or more layers of iron (or iron alloy) wire wound upon each conductor of the loop and known as *continuous-loading, uniform-loading* or *Krarup-loading*.

I. Coil-loaded Lines.—Professor Pupin (1890) first arranged to have inductance coils specially prepared and placed at equal intervals along the line. Thus the method is variously known as the Pupin-system, Series-method, Coil-loading method, or Lumped-loading method. In this system the *correct spacing* of the loading coils to produce the equivalent effect of a uniform loading, is a matter for a rigid mathematical investigation which at this stage is not required. [See later Section of Notes on Equivalent Networks and Campbell's Formula for the propagation constant of a coil-loaded line.] It is sufficiently instructive here to consider the mechanical analogy of a stretched string loaded by small weights at equal intervals along its length and which can be proved to vibrate practically as though *uniformly loaded* if there be *not less than π loads per the wave-length which it is desired to transmit.* From analogy there must be at least π series inductance coils per wave-length, λ, of an electrical wave if a circuit is to behave as a uniformly loaded circuit. Thus *π coils per wave-length* is a limiting condition and the circuit will not transmit higher frequencies efficiently. Now to obtain sufficiently clear speech for practical purposes it is sufficient if the harmonics up to a frequency (f_m) of the order of $f_m = 2000$ p.p.s. only are transmitted, *i.e.*, in a coil-loaded cable there must be *at least* π coils per wave-length at a frequency of $f_m = 2000$ p.p.s. *If this upper frequency of the transmitted band of frequencies were the only consideration* the following rule (once used in the Post Office as a coil-spacing rule) is of interest:

Let λ = wave-length at f p.p.s.

d = spacing of coils in miles

$\therefore \ \lambda = \pi d$ (Cf. pp. III. of Section 3).

$$\text{But } \lambda = \frac{2\pi}{a} = \frac{1}{f_m\sqrt{CL}}$$

$$\therefore \pi d \doteq \frac{1}{f_m\sqrt{CL}}$$

Hence if $f_m = 2000$ and L_1 = inductance of each loading coil, then since $L_1 = \frac{L}{d}$

$$\therefore \ CL_1 d \fallingdotseq 25$$

If f is to be > 2000 then the constant 25 in this equation must be decreased.

It will be seen later that consideration of phase distortion, echo effects, cross-talk requirements, permissible repeater gains, etc., have modified the above simple relationship in practice and it can merely be expressed as $CL_1 d < 25$.

Actual Spacing values used for *U.G. circuits* are from $1\frac{1}{8}$ miles to $2\frac{1}{2}$ miles approximately, [In the case of special circuits such as music or carrier circuits 1,000 yards spacing and light loading is employed.] for *submarine cables* from 1 to 2 nautical miles, and *aerial lines* (if loaded at all) from 8 to 12 miles. (See (4) below). The aerial lines do not require such heavy loading because of their higher natural inductance and lower capacity. (Cf. example in Section 6).

The actual loading coils are formed of rings of iron (or magnetic alloy) wound in sections with insulated wire so that one half the winding is in each limb of the circuit (with the magnetic effects additive) and the *balance* of electrical constants (R, L, G and C) is thus disturbed as little as possible. (Fig. **11** refers). The following is a summary of the general requirements for these coils:—

(1) *Low conductor resistance*—of the order of 5 to 15 ohms.

(2) *High insulation resistance*—of the order of 10^4 to 10^5 megohms between windings with 100 volts D.C.

(3) *Low capacity between windings*—of the order of 3×10^{-3} microfarad.

(4) *Magnetic stability* with time and current, *i.e.*, the value of L must not change.

As a rule the coils are designed so that $\frac{R}{L}$ of a coil is as small as possible—from 25 to 50. So that taking $\frac{R}{L} = 50$ and R = 6.5 to 12.5 ohms the corresponding values of L are L = 130 to 250 milli-henries. For smaller values of L with a ratio of $\frac{R}{L} = 70$ and R = 1.12 ohms the value of L is 16 milli-henries.

(5) Non-interference between coils of neighbouring circuits—generally obtained by efficient closed magnetic circuits and by screening.

(6) Economy of space.

(7) Reasonable cost.

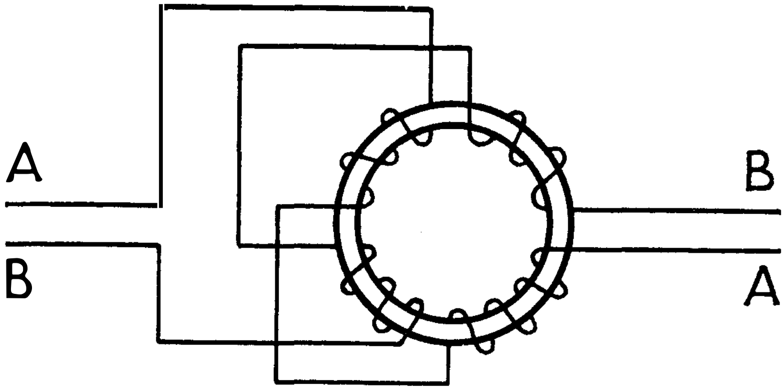


FIG. 11.—SIDE CIRCUIT LOADING COIL.

Phantom Circuits and Phantom Loading.—The conductors, in Fig. **12**, of a four-wire unit in a star-quad cable or multiple-twin cable can be arranged during manufacture so that there is little or no mutual inductance between the pairs of the circuit and thus no interference (cross-talk) due to this factor. It is more difficult, however, to arrange the balance of the

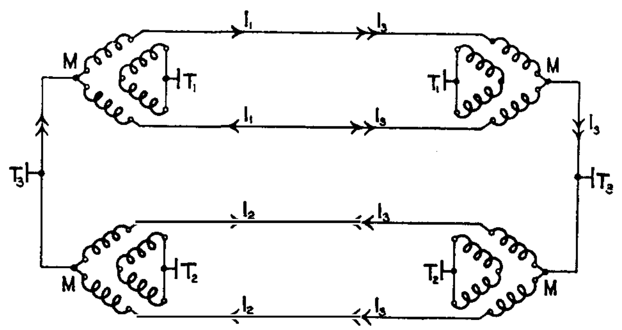


Fig. 12.

various capacities between wires, so that no interference results, and this balance has to be obtained as far as possible during installation of the cable lengths. (See later Section of notes).

A third circuit can be obtained as in Fig. **12**, using the two wires of No. 1 circuit in parallel as one limb and both wires of No. 2 circuit as the other limb. (Difficulty is in this case experienced in arranging the wire *and* earth capacities, so that little or no cross-talk takes place from the side circuits to the third circuit and this feature is dealt with in later notes). This third circuit is called the "*phantom*" circuit and its constituent pairs are called the "*side*" circuits. The tapping points, M, must of course be in the electrical and magnetic centre of the side circuit transformer windings so that currents from No. 3 circuit split in opposite but equal amounts and do not disturb telephones T_1 and T_2 by "overhearing" at these terminations.

The phantom circuit is loaded as indicated in Fig. **13**, and where the phantom coil has in effect both wires of each side circuit wound on

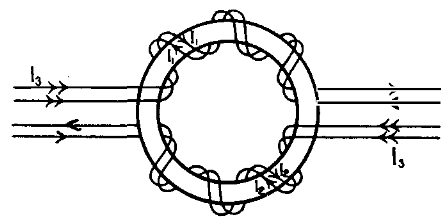


Fig. 13.—Principle of Phantom Coil Winding.

the magnetic core in such a way that only I_3 produces any magnetic flux, but I_1 and I_2 have their respective magnetic effects neutralized.

(Section 7 to be continued.)

Further References:—

Prof. Pupin—Trans. Am. I.E.E., March 22nd, 1899, and 19th May, 1900.

Prof. Routh—"Advanced Rigid Dynamics," p. 260.

Lord Rayleigh—"Theory of Sound," Vol. 1, p. 233.

Dr. G. A. Campbell—Phil. Mag., 1903, Vol. 5, p. 313.

Dr. F. Luschen and K. Küpfmüller—Journal I.P.O.E.E., Vol. 20, Part 3, p. 207.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

LONDON CENTRE NOTES.

The third meeting of the Session, presided over by Mr. Gomersall, was held on Tuesday, December 9th, 1930, when Mr. A. O. Gibbon, M.I.E.E., read a paper entitled " The Electrical Control of Time Services in the British Post Office."

There was a good attendance and the discussion was opened by the Astronomer Royal, Sir Frank Dyson. Amongst others who took part in the discussion were Mr. H. R. Kempe, a former Chief Electrician of the Post Office, Col. Edgecombe, past-President of the Institution of Electrical Engineers, Mr. F. Hope-Jones and Col. Angwin.

The paper and discussion brought out the varied applications of automatic timing devices in the Post Office.

The fourth meeting, presided over by Mr. Gomersall, was held on Tuesday, January 13th, 1931, when Mr. F. R. Perris, A.C.G.I., B.Sc. (Hons.), D.I.C., A.M.I.E.E., read a paper entitled " Secondary Cells."

There was a good discussion, ranging from academic theories to practical difficulties. Mr. Perris ably replied to the many points raised.

The fifth meeting, presided over by Mr. Gomersall, was held on Tuesday, February 10th, 1931, when Mr. W. R. Tyson, B.Sc. (Eng.), A.M.I.E.E., read a paper entitled " The Equipping of Automatic Exchanges."

The paper provoked an interesting and lively discussion, several manufacturers being keenly interested.

Informal Meetings.

The third informal meeting, presided over by Mr. Gomersall, was held at Denman Street on Tuesday, January 27th, when Mr. H. W. Fulcher, A.M.I.E.E., read a paper entitled " Ventilation of Telephone Exchanges." The paper was illustrated by lantern slides and a collection of testing instruments, air filters, etc., was available for inspection. The paper aroused an interesting and instructive discussion which brought out the fact that much time and thought has been given to ventilation. Mr. Fulcher ably replied to the many points raised and afterwards explained and demonstrated the uses of the various exhibits.

The fourth informal meeting, presided over by Mr. P. T. Wood, was held at Denman Street, on Tuesday, February 24th, 1931, when Mr. E. H. Slattery read a paper entitled " Public Wayleaves: a few Observations."

The paper dealt exhaustively with the question and a good discussion, to which Mr. Slattery replied, contributed to the knowledge of many of the members.

In each case there was a stimulating discussion, which further emphasized the very great value of these informal discussions to the staff and to the Department. The large attendance shows how greatly these discussions are appreciated, but there is still room for those who wish to gain knowledge of matters with which they are dealing or may have to deal at some future time.

T.H.

NORTH WESTERN CENTRE.

A meeting of the Centre was held on the 15th December, 1930, when a paper entitled " Unit Costs; Their use in the control of Expenditure and as an aid to the supervision of Works " was read by Mr. S. Upton, M.I.E.E., before a good attendance. At the outset, Mr. Upton drew special attention to the title of the paper and emphasised that he proposed to discuss U.M.C. and U.C.C. as a machine for use in the control of expenditure and an aid to supervision, *i.e.*, starting from the completed monthly statistics. Beyond a brief description of the work involved in compiling the statistics therefor, the paper dealt with their practical use by Sectional Engineers and their staff and included actual examples of good and bad methods.

During the general discussion which followed, graceful reference was made by Mr. Finlayson (opening the discussion) and other speakers to Mr. Upton's approaching retirement and to the part he had taken in the I.P.O.E.E. meetings by contributing papers and helping in the discussions. The Chairman (Mr. J. M. Shackleton, M.I.E.E.) echoing these sentiments said that Mr. Upton had only to say the word and they would gladly arrange for a special meeting so that they might have the pleasure of listening to yet another paper from him. One thing he would miss very much indeed was Mr. Upton's contributions to discussions—he had regarded him as a sort of reserve and standby—he could always be relied upon to step into the breach and revive a flagging discussion.

Other papers read during the Session were—one from Mr. A. Diggle on the "Rochdale Automatic Exchange—Some interesting features," and one on "Rural Automatic Exchanges" from Mr. T. F. Levens.

An exhibition of official films given in November last with an interesting running commentary by Mr. W. H. Albry (Engineer-in-Chief's Office) was much appreciated by a large audience, which included the District Manager (Mr. J. K. Murray) and many of his staff and a number of the Department's workmen. The exhibition was repeated at Bolton, an outlying centre in the District.

SOUTH LANCASHIRE CENTRE.

The third meeting of the Institution was held on December 15th, when the following departmental cinematograph films were exhibited:—

"Jointing Cables."
"Pole Hole Excavation."
"Pole Shifting."

Mr. Albry, of the Engineer-in-Chief's Office, provided an instructive running commentary during the display. The films evoked great interest as was shown by the questions subsequently raised, to which Mr. Albry ably replied.

At the fourth meeting held on January 12th, four short papers were read.

"Secondary Cells," Mr. W. H. Cross.
"Rural Auto Exchanges," Mr. R. C. Davies.
"Teleprinters," Mr. H. J. Moores.
"The Decibel," Mr. C. E. Morgan.

Although the time available was scarcely sufficient for all the points of interest to be dealt with, good discussions followed. The paper on the application of automatic switching methods to the provision of satisfactory service in rural areas was particularly interesting.

The fifth meeting held on January 27th was the occasion of a joint meeting with the North Western Centre of the Institution of Electrical Engineers and the Manchester Association of Engineers.

The subject of the meeting was a lecture by Mr. S. G. Brown, F.R.S., on "Loud Speakers, Gramophone Pickups and Recording Apparatus." Mr. Brown was unable to be present and the lecture was delivered by Major C. A. Russell Stower. One of the main points of the lecture was the author's opinion that the horn type of loud speaker gives the most satisfactory results, and that it is only a matter of time before this type once again comes into general use. Another view put forward was that the moving coil type of pickup, of which an experimental model was described, is well worth developing.

The lecture was illustrated by lantern slides, and various types of loud speaker and pickup were used to demonstrate the salient points. A carbon microphone pickup was shown to be capable of giving an output sufficient to operate a loud speaker without the use of an amplifier. A demonstration of home recording for the gramophone supplied another element of novelty. Major Russell Stower spoke his concluding remarks into the microphone and the record thus obtained was reproduced before the audience. The meeting terminated with a hearty vote of thanks to Mr. Brown and Major Russell Stower.

Representative gatherings of the staff have been held on two occasions to congratulate two members of the staff, who have earned promotions involving their removal to other parts of the country. The first of these gatherings was held on the 1st January, when Mr. E. R. Davies, Higher Clerical Officer, was presented with a radio set and loud speaker by the staff to mark the occasion of his promotion to the rank of Staff Officer at Cardiff.

On the 2nd February Mr. C. E. Morgan, Assistant Engineer, and late Secretary of the Local Centre of the I.P.O.E.E., who has been promoted to Executive Engineer at York, was the recipient of a pedestal lamp, as a token of the esteem in which he was held by his colleagues.

It is with feelings of deepst regret that we have to record the passing of Mr. W. R. Booth, Inspector, whose death occurred on the 14th January after an illness lasting several months. The funeral ceremony was attended by members of all grades. He leaves behind impressions of the greatest sincerity and earnestness and of the kindest consideration shown to all with whom he came into contact.

SCOTLAND WEST CENTRE.

The second meeting of the Session was held in the Royal Technical College, Glasgow, on 3rd November. The lecturer was Mr. H. G. S. Peck, B.Sc. (Hons.), M.I.E.E., and the subject "The Director System." There was a good attendance of members and visitors from the Commercial Staffs.

The lecturer approached the subject by first describing a Strowger selector or two-motion switch, indicated the various ways in which selection may be made, and concluded with the trunking chart of the Farme Street Building, which will accommodate four of London's 10,000 line exchanges with directors and other apparatus which will be used in common by them. The limitations of the non-director system when used in multi-office areas, and the application of the director system to the simultaneous operation of automatic and manual exchanges in an area were fully dealt with. A considerable part of the lecture was devoted to an exposition of the adaptability of the director systems to meet the trunking requirements of an area having regard to the number and holding time of calls, the geographical position of the exchanges, the cable routes connecting them, to the increased traffic efficiency of large groups of circuits and the use of Tandem exchanges. The lecturer was at particular pains to explain, with the aid of the blackboard, the method by which the three digits dialled as the initial letters of the exchange name are translated by the director into any required "Code" of from one to three trains of impulses. The lecture was fully illustrated by means of lantern slides.

A well-sustained discussion, or rather series of questions, taken part in by members and visitors, indicated that interest in the lecture had been maintained throughout.

NORTH WALES CENTRE.

The third meeting of the Session was held on 1st December, 1930, when the Chairman, Mr. R. A. Weaver, presided over an audience of almost 200, including 50 workmen and 25 visitors from the higher schools of Shrewsbury, and saw an exhibition of technical films illustrating Bar and Spoon and Auger excavation, L.C. cable jointing, pole lifting and shifting, and the working of an automatic telephone exchange. Mr. Albry (Engineer-in-Chief's Office) was present and lectured on the films as they were exhibited, and the volleys of questions which he had to meet at the end of each reel was sufficient evidence of the keen interest with which the display was followed.

The fourth meeting was held on 15th January, 1931, when Captain N. F. Cave-Brown-Cave, B.Sc., M.I.E.E., read a paper entitled "Some Non-metallic Materials and their Characteristics." The lecture covered Oils, Paints, Varnishes, Cellulose Lacquers and Enamels, Insulating and covering materials, Overhead Line Insulators, Ducts, Cement, Concrete and Timber, and a fine collection of samples of fibres, chemicals, paint and enamel work, etc., etc., was on view. A formidable list of questions was then addressed to the lecturer and in reply to the desire expressed by many speakers that the subject should be completely covered by a further paper on "Metallic Materials used in the Department" Captain Cave-Browne-Cave eventually gave a promise that this would be done next Session.

At the fifth meeting held on 11th February, 1931, Mr. G. H. Carrier read a paper entitled "Some Notes on Electrons," of which the following were the main headings:—

Conductivity of gases.
Electric Radiation and Leakage.
Ionisation of Gases.
Cathode Rays.
Transference of Electricity through solids.
Atomic Structure.
Zeeman effect.
Photo Electric Effect.
Electronic emission by Heat.

The paper was well illustrated by slides and a number of demonstrations were given very effectively. The delivery of the paper and the demonstrations occupied so much time that little was left for discussion, but appreciation of the lecture and the very great trouble which had been gone to in covering so wide a subject, was expressed by the Chairman and several other speakers.

SCOTLAND WEST CENTRE.

At our December meeting the following Departmental films were shown:—

(1) Jointing L.C. Cable—Wire Twisting.

(2) Pole Excavation
- (*a*) Bar and Spoon.
- (*b*) Iwan Auger.

(3) Pole shifting, Pole lifting jacks.
- (*a*) Lifting pole out of ground and placing in new pole hole.
- (*b*) Pole Lifting Jacks and Trench method.

Mr. W. H. Albry, of the Engineer-in-Chief's Office, explained the operations shown on the screen as the exhibition progressed and on completion of each spool there was an interval for discussion, which was fully taken advantage of by the members and by the large turn-out of workmen present.

The February meeting was of an informal character and the subjects under discussion were

High Maintenance Costs.
Internal, Underground and Overhead.

The leaders in the discussion were Messrs. Jeary, Bagley and MacIntyre, and the general discussion was well maintained.

A further series of Departmental films was shown at the March meeting—

(1) Assembling and adjusting a Dial, Auto. No. 10.

(2) Wiring and forming a Switchboard Jack.

(3) Hello Europe.

The Chairman directed attention to several points of particular interest shown on the films and the exhibition was generally appreciated.

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BOOK REVIEWS.

"Telephone Theory and Practice: Theory and Elements." By Kempster B. Miller. London: McGraw-Hill Publishing Co. Pp. xiv. + 486. 25s. net.

One of the first text-books on the subject of Telephony was "American Telephone Practice," first published in 1900. It was greeted with lively enthusiasm by telephone engineers and older readers of this Journal will doubtless remember its debut. Since 1904, when the second edition was published, the author, Mr. Kempster B. Miller, has been unable to find the time to bring his book up to date. When the opportunity *did* present itself, Mr. Miller found that his early work needed totally re-writing and he decided to leave it as a historical record of the telephone practice of the preceding generation and to provide a new work dealing with present-day practice.

So complex has the subject become that Mr. Miller has found it necessary to divide his subject into three sections, to each of which a separate volume is devoted; the volume which is the subject of this review is the first in the series and is to be followed by two further volumes, "The Telephone Exchange" and "Lines and Transmission," which are in course of preparation.

In the first volume, the author sets out to gather together all the scientific data and facts which form the foundation of present-day telephone practice. In the first part, he gives a brief survey of the development of speech and language and shows how Man has endeavoured to obtain a range of communication beyond the limits of his voice. The last chapter of this part is devoted to a discussion of the various components which go to make up a telephone system.

The first three chapters in Part II. are devoted to a study of sound in its relation to the human voice and ear. Telephone engineers have come to realise the necessity of a knowledge of the precise manner in which the ear, in conjunction with the brain, interprets the sound waves reaching it, and these chapters owe much of their lucidity to the researches of Dr. Harvey Fletcher and his colleagues in the Bell Telephone Laboratories. The upper and lower limits of audibility and the threshold of hearing and feeling are discussed at considerable length and some attempt is made to account for them in the light of Fletcher's modification to Gray's "maximum amplitude theory." The author quotes several interesting experiments which show that the mechanism of the ear supplies, subjectively, components which, although present in the original sound waves, are not present in the sound waves reaching the ear from the diaphragm of a telephone receiver. The author quotes from Fletcher: "Experimental tests show the rather unexpected result that the elimination of all the harmonic frequencies above 2,000 cycles affects the musical quality of a bass, baritone or a contralto voice to a greater extent than the quality of a high soprano voice." A discussion on the masking effect of tones and the binaural property of the ear, employed in sound ranging, concludes the chapter.

Various kinds of sound are discussed in the following chapter and a description of the organs of speech and the effect of the resonant chambers formed by the mouth and throat is given.

Chapter 8 is devoted to the theory of alternating currents, with special reference to voice currents. A brief description of the principle of line loading, and of low pass, high pass and band pass filters is given.

The next chapter contains a description of the theory of the vacuum tube and describes the principles of amplification, rectification, oscillation, modulation and demodulation.

The last chapter of Part II. provides a survey of the various magnetic materials which are used in the construction of telephone apparatus and considerable space is given to a description of the permalloys and perminvars, two groups of alloys which have been recently discovered.

Part III. contains descriptions of the various elements of apparatus, such as wires for equipment use, coils and electro-magnets, resistors, condensers, flexible cords, and the various contact metals available and the methods in which joints are made.

Mr. Miller is to be congratulated on the very lucid descriptions he has given and the clarity of the illustrations. In gathering together all the scientific data which are fundamental to a study of telephony, he has rendered a service not only to students of the subject but to the engineer. The book is practically non-mathematical and is extremely interesting to read.

W.S.P.

Binders for A.T.M. Coy's Engineering Bulletins.

We have received from the Automatic Telephone Manufacturing Co., Ltd., bound sets of Engineering Bulletins descriptive of A.T.M. Strowger Automatic equipment and engineering practice. The bulletins are assembled in handsome binding covers in which additional bulletins can be inserted and kept for handy reference.

J.McK.

" The Practical Electricians' Pocket Book, 1931."

The thirty-third edition of this pocket electrical encyclopædia has just been published. Two new chapters have been added to the book. Both of them, " Commutator Troubles and Their Cure " and " Electro-Plating " have been compiled by contributors well known to readers of past editions—C. Sylvester, A.M.I.E.E., and S. Wernick, B.Sc. (London), Hons. Chem. No less than six sections have been so thoroughly revised that they may be said to be new. The Central Station data in which comprehensive supply details for every town of importance in the United Kingdom are given, has been most thoroughly overhauled and the information contained therein is the latest available.

There are sixty-seven chapters containing a thousand-and-one facts, but each fact can be ascertained at a glance by means of a comprehensive detailed subject index arranged in alphabetical form, which alone occupies some twenty pages.

Containing some 600 pages in all, the Practical Electricians' Pocket Book is wonderful value for 2/10, at which price it can be obtained from the publishers, post free.

" Let's Help." Sir Charles Bright, F.R.S.E., M.Inst.C.E., the well-known expert on submarine cables and author of " Submarine Telegraphs," " The Story of the Atlantic Cable," etc., has written a collection of papers on " Good Causes " and combined them in a volume under the above title. Sir Charles includes some 46 examples of organisations whose objects are the sweetening of public life and the creation of a spirit of individual enterprise and mutual help and encouragement among those whose lives have not been cast in pleasant places.

The book is dedicated to the Prince of Wales and we can recommend it to all whose desire is to wipe out the reproach of our being a C3 nation. The publishers are George Routledge and Sons, and the price 4/6 net.

" The Flow and Measurement of Air and Gases." By A. B. Eason, M.A. Second edition revised. (London: Charles Griffin & Co., Ltd.). Pp. 254. 20/- net.

It is always a matter of interest to encounter a text-book written by a colleague, and Mr. Eason's work and experience with pneumatic tube systems in the Post Office is an assurance that anything he contributes to this subject would be valuable and authoritative.

The subject matter of this work is one in which an increasing amount of literature has been published in recent years and it is interesting to note that in preparing the present revised edition the author has consulted upwards of sixty text-books and over five hundred articles and reports.

The source of information are referenced very fully so that readers can readily consult the original articles when necessary.

As might be expected the results obtained by different workers under varying conditions are sometimes difficult to correlate, but the author has gone to considerable trouble in his efforts to do this and, wherever possible, has given the results of his own experience and measurements for comparison.

While it has not been found necessary to modify the portions of the book dealing with pneumatic tubes, since the essential principles remain the same, the author has taken the opportunity of providing fresh information regarding fresh developments such as automatic working.

Greater advances have been made in knowledge of the flow of gases through orifices and in the development of methods of measurement, and of recent years electrical methods have been successfully applied to this purpose. For example, electrical engineers have found it convenient to measure the losses in electrical machines by the temperature rise in the gases used for cooling the machines and for this purpose an accurate knowledge of the quantities of gases involved is essential. This method of determining losses has also been used in measuring the efficiency of high frequency apparatus where more direct methods cannot be applied. For such purposes electrical methods of determining the flow of large quantities of gases at low pressure seem to be particularly suited and it is therefore pleasing to note that such methods of measurement receive adquate treatment in this work.

It can be confidently predicted that this revised edition of Mr. Eason's book will find a large sphere of usefulness, not only to engineers engaged on pneumatic tube and compressed air problems, but to all other workers concerned with the flow of gases.

" Modern Radio Communication." By J. H. Reyner. Third Edition. (London: Sir Isaac Pitman & Sons, Ltd.). Pp. 260. Price 5/- net.

This book is intended to cover the syllabus of the City and Guilds examinations, the subject matter suitable for the Grade I. examination being in normal type, while matter required for the final examination is printed in smaller type or otherwise identified.

In this third edition opportunity has been taken to revise the sub'ect matter in places and the present issue contains about 40 pages more than the previous edition.

The purpose of the book is reasonably fulfilled as regards the requirements for the Grade I. examination, but for the final examination the subject matter is scarcely sufficient, and in attempting to cover the whole scope of radio communication within the limits of this modest volume the author has set himself an almost impossible task.

One of the more serious omissions is the absence of any reference to the supersonic heterodyne method of reception, which is of great importance for commercial working, especially in the case of radio telephony because of its possibilities in selectivity.

In dealing with the subject of connection of radio telephone circuits to land lines a description is given of the Santa-Catalina installation which is over ten years old and now dismantled. Modern practice has led to many improvements which have been described from time to time in the technical press.

In dealing with call devices no reference is made to the marine automatic call devices now used on hundreds of vessels for registering distress calls. The author moreover suggests that all such devices are unreliable, costly and unlikely to be used, whereas in actual fact the use of such devices is rapidly increasing owing to the economies they permit in staff.

Chapter IX., dealing with the principles of radio communication, could be usefully revised in the light of modern practice and the use of short waves. The statement that the economic limit of aerial power on 600 metres wave-length is 6 K.W. is probably true as regards spark transmitters where the aerial is energized only for about 1% of the time. The statement is not true for undamped wave transmiters and a sriking example of this is the London National Broadcasting station with 68 K.W. aerial power working on the still lower wave-length of 261 metres.

In spite of these obvious deficiencies the book is an excellent little text-book for classes and private students, and attention is called to its defects in the hope that the author will take an early opportunity of rendering it still more useful.

A.J.G.

" Switchgear Practice." By Henry E. Poole, B.Sc. (London), A.M.I.E.E., A.C.G.I. Messrs. Chapman & Hall. Price 15/-.

This book as its name implies carries the reader over a wide range of switchgear in general use for power distribution. After describing and discussing the merits of various protection systems for localising faults which may arise on power distribution networks the author includes a chapter on construction data in which in addition to the regulations laid down by B.E.S.A. he quotes those of V.D.E., the German Institution of Electrical Engineers, which go further than the former and include minimum clearances for the interior of oil switches and take into consideration the rupturing capacity as well as the rated volts in the design of the apparatus. The detailed construction of air and oil break switches is then considered with numerous illustrations, giving particulars of operating parts and also complete switches for use in connection with different voltages and loads. The various types of switchboards are then treated, including the panel type, open frame work, mild steel truck, and other removable units. Brickwork and concrete cells for switchgear is also dealt with. A chapter is also included describing switchgear for use in mines with examples of Continental as well as British practice. The book is well arranged and illustrated with a large number of examples of actual apparatus in use with a minimum of references to scientific theory. Since the advent of the British Grid System the necessity of providing switchgear with sufficient rupturing capacity to deal with the large amount of power involved when a serious fault occurs is of increasing importance and the book should appeal to all those interested in the design and operation of industrial and other types of switchgear.

H.B.C.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

Promotions.

Name.	From	To	Date.
Anson, B. O.	Assistant Staff Engineer, E.-in-C.O.	Staff Engineer, E.-in-C.O.	1-6-30
Woollard, F.	Executive Engineer, E.-in-C.O.	Assistant Staff Engineer, E.-in-C.O.	1-6-31
Maddock, G. M.	Executive Engineer, E.-in-C.O.	Assistant Staff Engineer, E.-in-C.O.	1-4-31
Hanford, S.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	4-1-31
Cave-Browne-Cave, Capt. N. F.	Executive Engineer, Testing Branch, Birmingham.	Assistant Suptg. Engineer, Eastern District.	1-4-31
Brocklesby, C.	Executive Engineer, S. Lancs. District	Assistant Suptg. Engineer N.E. District.	To be fixed later.
Morgan, C. E.	Assistant Engineer, S. Lancs. District.	Executive Engineer, N. East District.	25-12-30
Adams, W. J.	Chief Inspector, Testing Branch.	Assistant Engineer, Testing Branch.	13-2-31
Cooper, G. H. S.	Inspector, London District.	Chief Inspector, E.-in-C.O.	24-12-30
Whitehead, W. C.	Inspector, London District.	Chief Inspector, London District.	30-12-30
Longmore, F. W.	Inspector, E.-in-C.O.	Chief Inspector, E.-in-C.O.	24-12-30
Warne, G. C.	Inspector, London District.	Chief Inspector, London District.	28-9-30
Sard, P. J.	Inspector, London District.	Chief Inspector, London District.	1-1-31
Proctor, F. H.	Skilled Workmen, Cl. I., E.-in-C.O.	Inspector, E.-in-C.O.	4-10-30
Price, J. W.	Skilled Workmen, Cl. I., E.-in-C.O.	Inspector, E.-in-C.O.	22-6-29
Smith, E. R.	Skilled Workmen, Cl. I., E.-in-C.O.	Inspector, E.-in-C.O.	10-1-30
Oldacre, A. G.	Skilled Workmen, Cl. I., E.-in-C.O.	Inspector, E.-in-C.O.	25-5-30
Thomas, G. E. T.	Skilled Workmen, Cl. II., E.-in-C.O.	Inspector, E.-in-C.O.	1-8-30
Pyrah, F.	Skilled Workmen, Cl. II., E.-in-C.O.	Inspector, E.-in-C.O.	8-11-30
Miller, R. W.	Unestablished Skilled Workmen, E.-in-C.O.	Inspector, E.-in-C.O.	23-11-29
Belfit, F. W.	Skilled Workman, Cl. I., Scot. West District.	Inspector, Scot. West District.	25-10-30
Wade, W.	Skilled Workman, Cl. I., S. Wales District.	Inspector, S. Wales District.	27-8-30
Gill, W. E.	Skilled Workman, Cl. II., N. Mid-	Inspector, N. Mid. District.	To be fixed later.
Riddle, H.	Skilled Workmen, Cl. I., S. West District.	Inspectors, S. West District.	28-4-29
Wiltshire, R. E.	Skilled Workmen, Cl. I., S. West District.	Inspectors, S. West District.	8-2-31
Nixon, J. L.	Skilled Workman, Cl. I., N. Mid. District.	Inspector, N. Mid. District.	To be fixed later.
Winter, J. L.	Skilled Workman, Cl. I., N. Ire. District.	Inspector, N. Ire. District.	16-8-30

Retirements.

Name.	Rank.	District.	Date.
Platt, W.	Executive Engineer.	N. East.	22-12-30
Henrici, R. C.	Assistant Engineer.	S. Wales.	26-12-30
Davies, E. I. S.	Chief Inspector.	,,	4-12-30
Barclay, W.	Inspector.	Scot. West.	31-12-30
Connacher, A. H.	,,	,,	31-12-30
Young, J. A.	,,	London.	18-12-30
Guile, T. H.	,,	S. East.	31-12-31
Chadd, C. A.	,,	London.	31-12-31
Stewart, W. W.	,,	N. Mid.	31-12-31
Ellison, F.	,,	S. Lancs.	31-12-31
Aked, J.	Chief Inspector.	S. Mid.	26-1-31
Eager, H. C.	2nd Class Engineer.	Testing Branch.	10-1-31
Carr, E. R.	Inspector.	London.	3-2-31
Woods, A.	,,	N. East.	31-1-31
Jones, T. V.	Assistant Engineer.	London.	31-1-31
Pollock, C. E.	,,	N.	31-1-31
Bassett, S. W.	Executive Engineer.	E.	3-3-31
Leigh, J. H.	,,	S. Lancs.	5-3-31
Wilkinson, E.	Inspector.	N.E.	28-2-31

APPOINTMENTS.

Name.	From	To	Date.
Gill, C. J.			
Markby, E. J.			
Horner, F. H.			
Holloway, A.			
Edwards, W. K.			
Devey, G. B.			
Blight, A.			
Westcott, A. G. B.			
Gormley, L. V.			
Moore, G.			
Latimer, E. D.			
Rimes, R. E.			
Howell, L. T.	Probationary Inspectors.	Inspectors.	1-12-30
Coates, G. H.			
Crook, H. G.			
Lee, W. H.			
Hawking, W.			
Kirkham, W. D.			
Stevens, P. F.			
Blair, D. C.			
Hunt, A. H. F.			
Brown, H. R.			
Gosling, F.			
Vann, C. J.			
Millen, G. J.			
Boocock, R. O.			
Anderson, E. W.			
Perryman, C. F.			
Robinson, A. K.			
Couch, P. R.	Limited Competition.	Probationary Assistant Engineers.	1-1-31
Helman, S. L.			
McMillan, D.			
Knapman, D. E.			
Hunt, R. H.			
Knox, A. H. C.			
Tobin, W. J. E.			7-1-31
Rousell, S. M. E.			7-1-31
Lewis, N. W. J.			
Dickson, E.			
Leigh, H.	Open Competition.	Probationary Assistant Engineers.	
Cook, A.			1-1-31
Lucas, F. N.			
Calveley, C. E.			
Pitcairn, A. C			

DEATHS.

Name.	Rank.	District.	Date.
Alexander, R.	Assistant Superintending Engineer	N. East.	27-12-30
Chapman, E. J.	Inspector.	London.	5-1-31
Akehurst, R. G.	,,	,,	11-1-31
Smith, W. E.	Chief Inspector.	,,	12-1-31
Booth, W. J.	Inspector.	S. Lancs.	14-1-31
Sperrey, H.	,,	London.	28-1-31
Holder, W. S.	,,	S. West.	27-1-31
Aked, G. F.	,,	N. Mid.	24-2-31

REVERSION.

Name.	From	To	Date.
Lambert, S.	Chief Inspector, N. Wales District.	Inspector, N. Wales District.	21-12-30

TRANSFERS.

Name.	Rank.	From	To	Date.
Hay, P. G.	Assistant Engineer.	London.	S. East.	4-1-31
Baines, J.	,,	E.-in-C.O.	N. East.	15-2-31

CLERICAL ESTABLISHMENT.

PROMOTIONS.

Name.	Rank.	District.	Promoted.	District.	Date
Gerke, J. J.	Clerical Officer.	L.E.D.	Higher Clerical Officer.	L.E.D.	23-7-30
Gardiner, H.	,,	L.E.D.	,,	L.E.D.	16-12-30
Denton, J. C.	Higher Clerical Officer.	N. East.	Staff Officer.	Eastern	1-1-31
Davies, E. R.	,,	S. Wales.	,,	S. Lancs.	4-1-31
Bullock, C.	Clerical Officer.	N. Mid.	Higher Clerical Officer.	N. Mid.	23-7-30
Franklin, G. W.	,,	Eastern	,,	Eastern	1-1-31
Brown, H.	,,	S. Lancs.	,,	S. Mid.	11-1-31
Tyler, J. T.	,,	N. Mid.	,,	N. Mid.	9-8-30
Preston, ●.	,,	S. Lancs.	,,	N.	1-1-31
Colman, W. A	,,	N. Mid.	,,	S. Eastern	1-1-31
Wilson, E.	,,	Eastern	,,	S. Mid.	1-1-31

RETIREMENTS.

Name.	Rank.	District.	Date.
P●well, G. T.	Staff Officer.	S. Wales.	3-1-31
Rankin, W. H.	Higher Clerical Officer.	N. Mid.	13-2-31
Matthews, T. E.	,,	S. Lancs.	21-2-31
Crawford, G. W. J.	Staff Officer.	Scot. West.	31-3-31
Smith, H. S.	Higher Clerical Officer.	London.	31-1-31

COMMUNICATIONS.

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

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