THE FORTIETH MILESTONE

Elliott & Fry

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Western Electric Company Limited

THE FORTIETH MILESTONE

Being a record of forty years' achievement of the WESTERN ELECTRIC COMPANY, LIMITED in the advancement of International Communication

Reprint from "Men of the Day"
1923

FOREWORD

E make no apology for putting on record the achievements of the Western Electric Company Limited, which we believe to be unique in the development and improvement of world communications.

The Company employ several thousand people in their various factories and offices and in addition maintain a very large organisation for construction work.

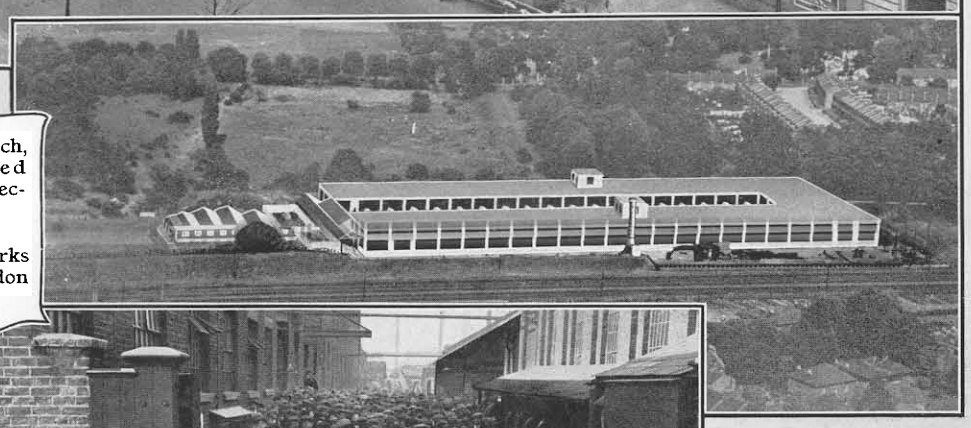
This Constructional Staff is carrying out Cable and Loading Coil installation work in the greater part of Europe, as well as for the British Post Office in this country ; and a staff of almost equal magnitude is engaged on the internal erection of Telephone Exchanges and Repeater Equipments.

The ramifications of this constructional organisation are world wide and representatives are found in all parts of our great Empire as well as in the far away countries of China, South America, etc.

A gratifying feature of the Company's service is the large number of employees who wear a distinctive button denoting 15 years' service and over, in some cases the period exceeding 35 years.

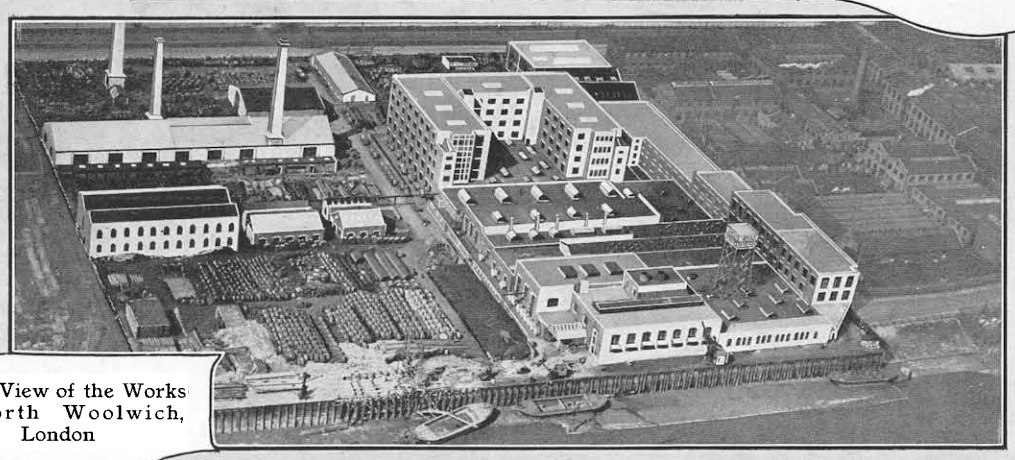
The Company claims no altruistic motive, its methods and status are those of a business that must be self-supporting, yet nevertheless, the function that the Western Electric Company Limited has to fulfil is a permanent and necessary one in the civilisation of our times.

Connaught House, Aldwych, London, the Registered Offices of the Western Electric Company, Limited



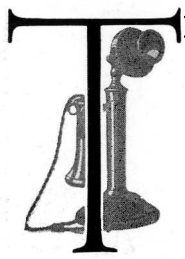
Aerial View of the Works at New Southgate, London

Employees leaving the North Woolwich Works



Aerial View of the Works at North Woolwich, London

INTRODUCTORY



HE earliest events in the sequence of discoveries which led to the ultimate invention of the telephone are perhaps the more intriguing because there enters into the picture the element of the sheer unknown, with no basis upon which to commence. We, in these days of higher scientific development, are inclined to minimise the value of the earlier discoveries, as they appear to our greater intellect so simple; perhaps even obvious. Yet, again, it must be remembered that the short space of forty-five years separates us from the date of Alexander Graham Bell's discovery, and to-day, surveying the past, how great has been the progress made.

To-day we talk over cables between points nearly four thousand miles apart. We talk across the sea; we talk between aeroplane and aeroplane in the air; in fact the telephone is universal, every civilised country in the world using it for general purposes of speech communication.

The history of communication is the history of human progress. From the very earliest record of history up to this day, can be found evidence of untiring effort to devise a means of communication; yet all these efforts were in the direction of a secondary rather than a primary means, a substitute for direct intercourse which distance made impossible.

When our countrymen in days gone by set out on their adventures to find new lands, to explore, to study, that their added knowledge might benefit mankind, they severed themselves from all communication with their brothers; all ties and affections were broken, and not until Alexander Graham Bell's invention was this gulf perfectly bridged, this barrier to human progress wholely spanned.

The mere nature of man, the fundamental character with which he was created, made this achievement inevitable. Just as we conquered the ocean, just as we discovered each step in the advancement of means of human transport, so it was that we should eventually overcome this further barrier to our intellectual advancement. By common communication only, can the knowledge of one influence the life of another.

Each new invention throughout the years while forming a link in the chain of advancement, lacked the power to permit discussion, to permit immediate discourse, the exchange of views. Not even the telegraph permitted these essentials to perfect distant communication. A word spoken means but little without human expression conveying the personality behind it, and this power of words, this correct interpretation of their utterance, was not made possible until the discovery of the telephone.

The telephone, of all means of communication, conveys the words and the personality with them. Throughout the ages there has raged a perpetual struggle to convey personality, and at no time more than the present has the need of it been greater. Personality is the pith of life, its power shapes the individual, moulds the nation, dominates the universe; indeed, it is the greatest factor in every phase of life. It is not the spoken words but the person expressing them that makes the impression, and if the impression is to be made over a distance, then the telephone —the crowning triumph of communication—alone makes this possible.

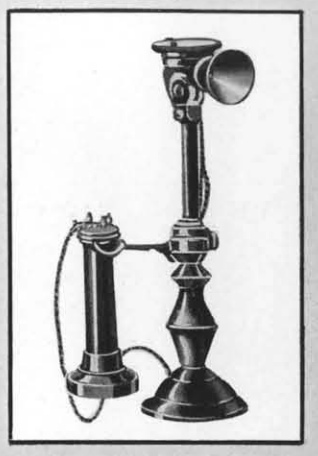
The honour of the discoveries which led to the introduction of the telephone, goes to those who spent their lives in the cause of the furtherance of science for the benefit of mankind, and the Western Electric Company, Limited, share with but few others, the honour of the great development of telephony since that day in March of the year 1876 when our famous countryman, Alexander Graham Bell, of Edinburgh, made the discovery which was to change the whole system of world communications and advance the cause of science to the benefit of all mankind.

THE PIONEERS

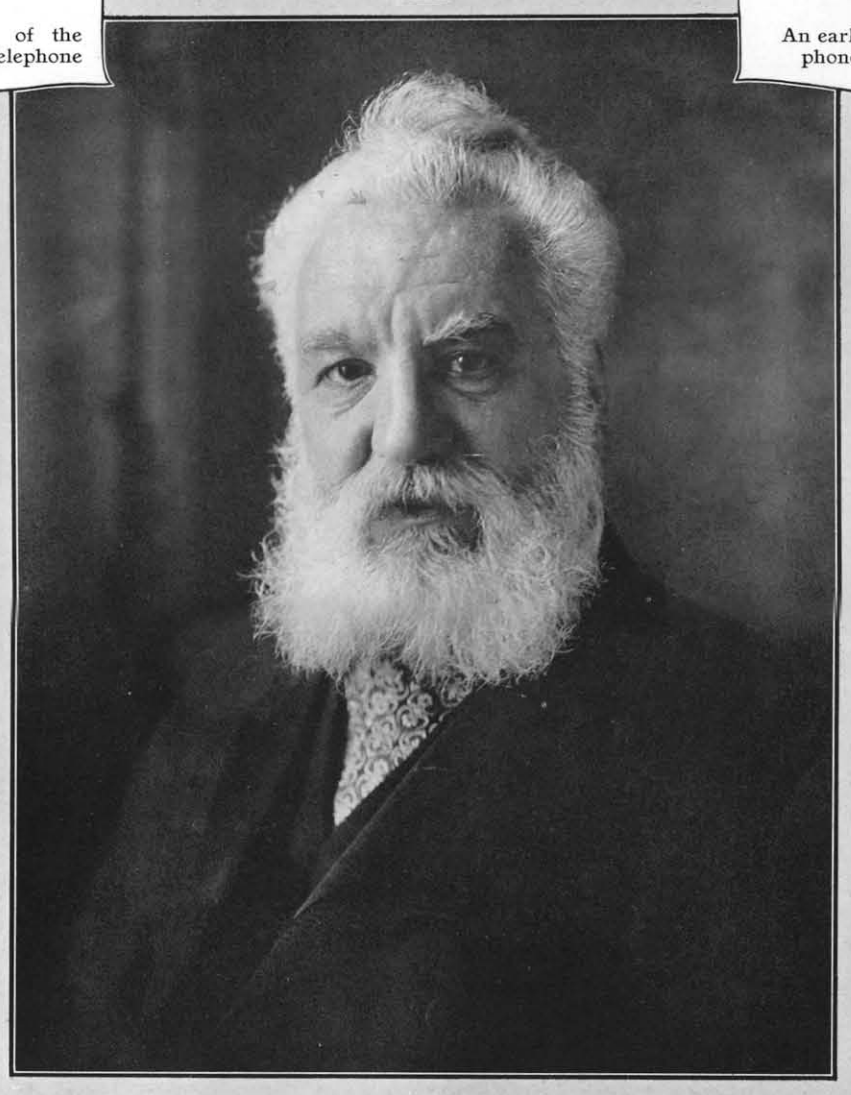
With the name Alexander Graham Bell, pioneer, visionary and inventor, who revolutionised the art of world communication, we commence our history. To him and to his associates we owe the telephone and its magnificent developments. These men had visions as they worked at their invention and were not appalled by the immensity of the new world of engineering problems which they had entered. They were not deterred by the hostile criticism of conservative sceptics or by the inevitable disappointments which attended their pioneer work. With the prophetic insight of genius they foresaw the vast links of communication which should in the years to come connect town to town and continent to continent.

1898
The forerunner of the modern Desk Telephone

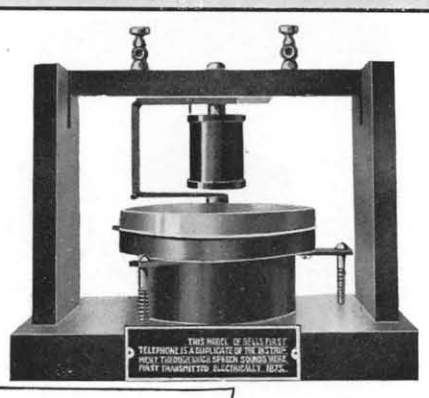
1902
A type which was popular for many years



1886
An early type of Telephone Instrument



The late Dr. Alexander Graham Bell



1875
Duplicate of Alexander Graham Bell's first telephone

1923
The Desk Telephone universally used to-day

From the ranks of these men developed the Bell Telephone Association, formed in 1877. In 1882 the Western Electric Company obtained the sole manufacturing rights of the American Bell Telephone Company, this firm afterwards becoming the American Telephone and Telegraph Company. The Western Electric Company then realised the importance of spreading the telephone throughout Europe, especially Great Britain, and in 1883 they established an English branch in Moorgate Street, London, from which developed the Western Electric Company, Limited.

Forty years have elapsed since this modest house was established, with its tiny staff of three men. Its development has been astounding. In place of this one building there are now huge offices in London, factories at Woolwich, Bexley Heath and New Southgate, branch offices in Leeds, Cardiff, Glasgow, Manchester and Birmingham; in Newcastle, Southampton, Dublin and Belfast; in Cairo, Simla, Johannesburg and Singapore.

This colossal expansion has run parallel to the expansion of the world's electrical communication, and can, in fact, be identified with it. Nearly all important improvements in the art of electrical communication have been introduced into England by the Western Electric Company. This is a far reaching statement, borne out by history, for the telephone apparatus and equipment which is so familiar at the present day is based mainly upon the work which the Company has done. However, the telephone and its kindred apparatus is not the only field wherein the Company has effected great developments. Machine telegraphy, dry core cables, wireless and carrier transmission, all these branches of electrical communication bear the imprint of the Company's work.

Unfortunately, it is impossible to give here a detailed record of its manifold activities—volumes could be written on this subject, each volume a miracle of scientific research, untiring energy and unconquerable patience. These qualities have moulded and built up the huge fabric of world electrical communication throughout the past forty years, and the men of the Western Electric Company may, perhaps, be pardoned if, when considering the big part that they have played therein, the record fills them with pride. However, we must be content to outline a few striking examples of their achievements. The story must be short. We must leave to the imagination of the reader the wealth of picturesque detail which should enliven the bare facts, and must epitomise in the brief pages at our disposal, the monumental record of the work of forty years.

THE MANUAL TELEPHONE EXCHANGE

The most widely used form of telephone exchange is the Manual type wherein a central battery system supplies the whole of the signalling and speaking current required.

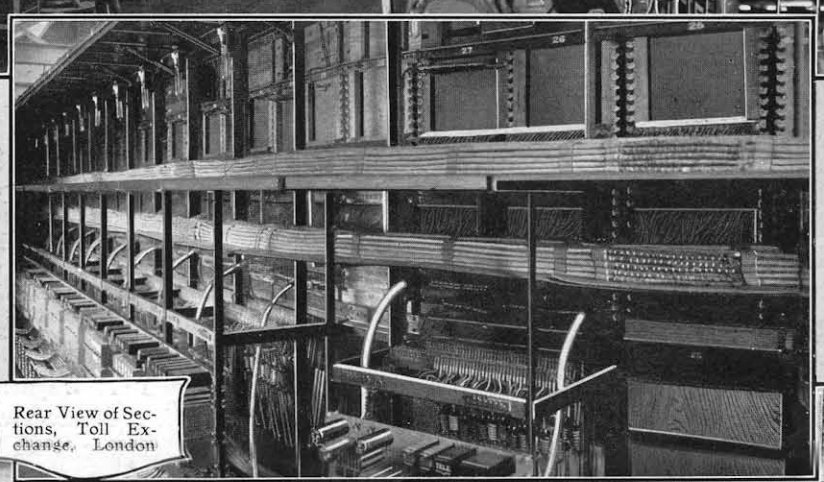
As an example of the best features of Modern Manual Exchange construction the installation at Liverpool Central commands attention. This exchange, one of the biggest in the country, has an ultimate capacity of 10,000 lines. From neighbouring exchanges and from local subscribers these lines enter the cable vault of the building in lead covered paper insulated cables, and are terminated at the main distribution frame. Here protective devices are installed to guard exchange apparatus against injury from lightning or stray currents. An intermediate distribution frame, situated between the main frame and the switchboard, facilitates the quick distribution of lines throughout the exchange.

Each operator receives the calls of 80 to 120 subscribers and by means of a multiple can connect any two of the 10,000 subscribers together. In order to connect up with other exchanges 650 outgoing junctions and 840 incoming junctions have been installed.

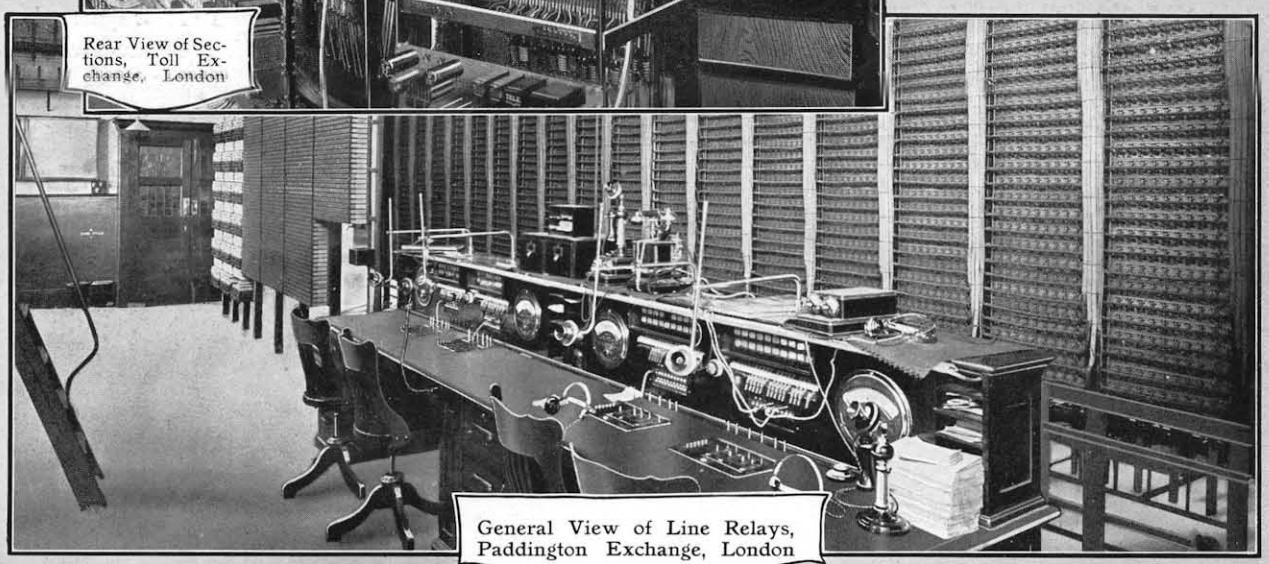
The operations involved in connecting up subscribers are simple, and a brief outline may be of interest. When the subscriber lifts his telephone a lamp lights up in front of the receiving operator who asks for the number required. If this number is on her exchange she connects up the two subscribers through the multiple. If the call is for a subscriber on another exchange, the operator transfers the call to the required exchange by means of an outgoing junction, and the distant operator makes the required connections. Lamps on the connecting cord of the operator originally receiving the call enable her to supervise the connection.

A very important feature to note is that each operator is provided with a means of automatically registering the number of calls made by each subscriber.

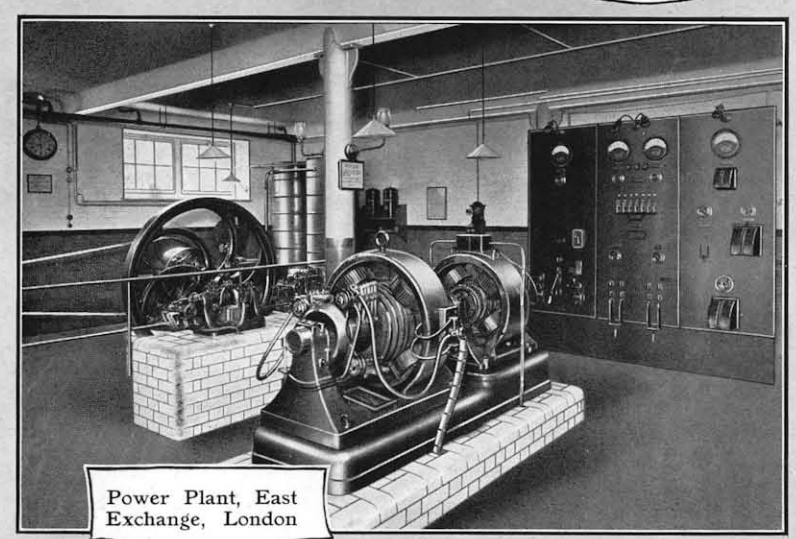
View of Operating room, Gerrard Exchange, London



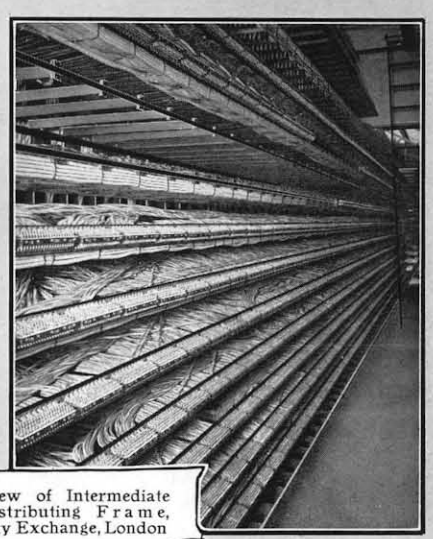
Rear View of Sections, Toll Exchange, London



General View of Line Relays, Paddington Exchange, London



Power Plant, East Exchange, London

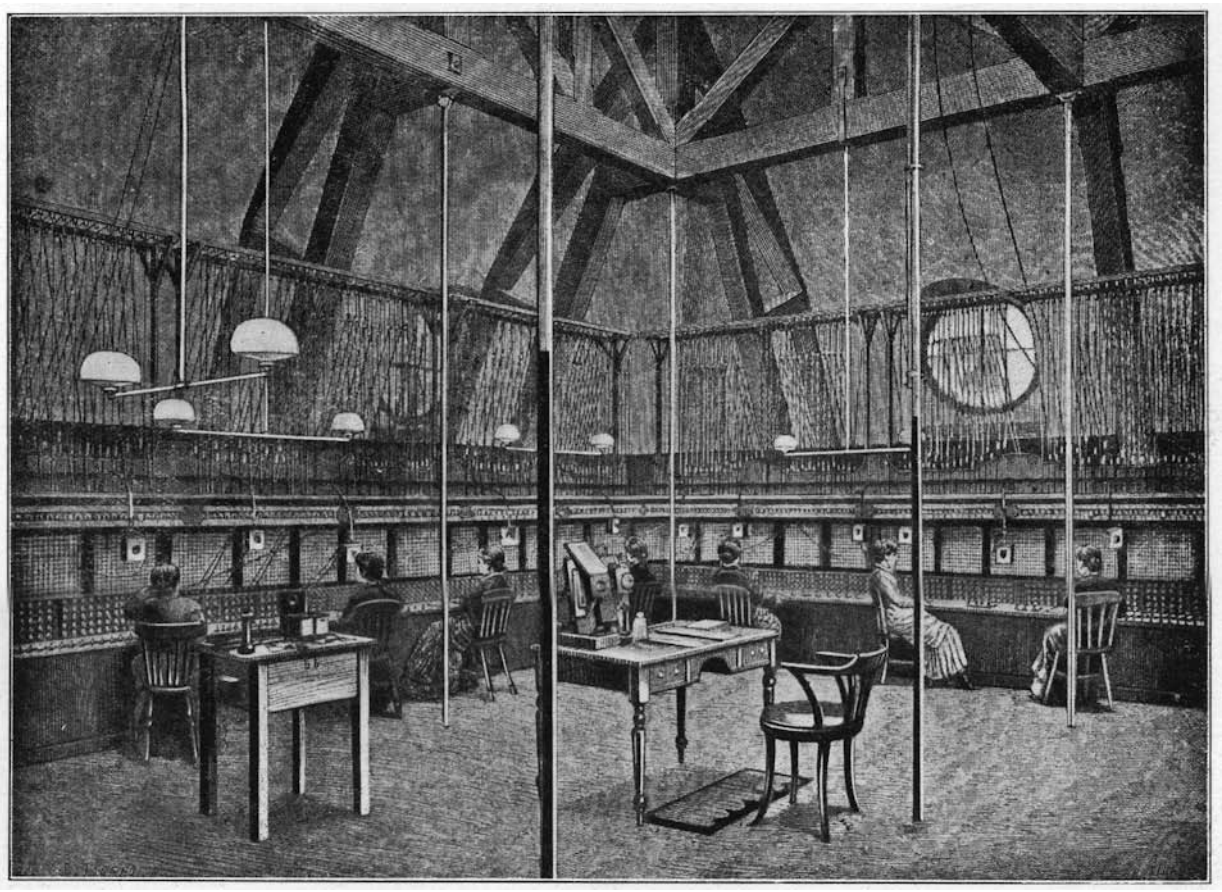


View of Intermediate Distributing Frame, City Exchange, London

In order to maintain an uninterrupted service, a duplicate power supply and duplicate machines for ringing subscribers have been installed. This duplication ensures the maintenance of a constant voltage on the supply battery.

Efficient service is the primary consideration, and to preserve this, testing desks are installed, enabling all faults inside or outside the exchange to be speedily located. A special inside and outside staff carries out repairs immediately a breakdown is reported. Again emphasising the importance of efficient working, special desks are provided for monitors and supervisors who assist the operator when knotty problems arise, and deal patiently and assiduously with complaints and enquiries from the multitude of people they serve.

The Company have installed in Great Britain alone no fewer than 128 Manual exchanges, totalling 362,369 lines with an ultimate capacity of 726,060 lines.

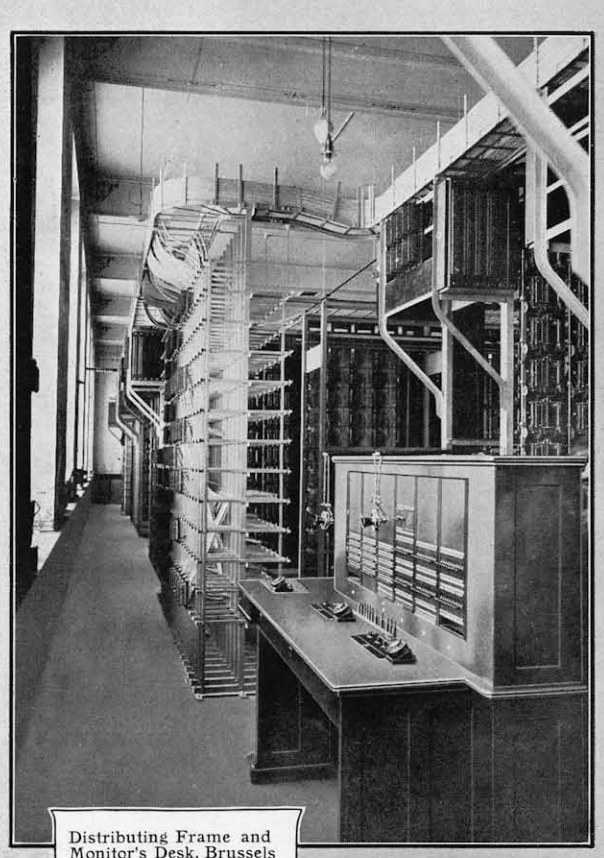


Multiple Switchboard, Liverpool. From the *Electrical Review* (London), October 18, 1884.

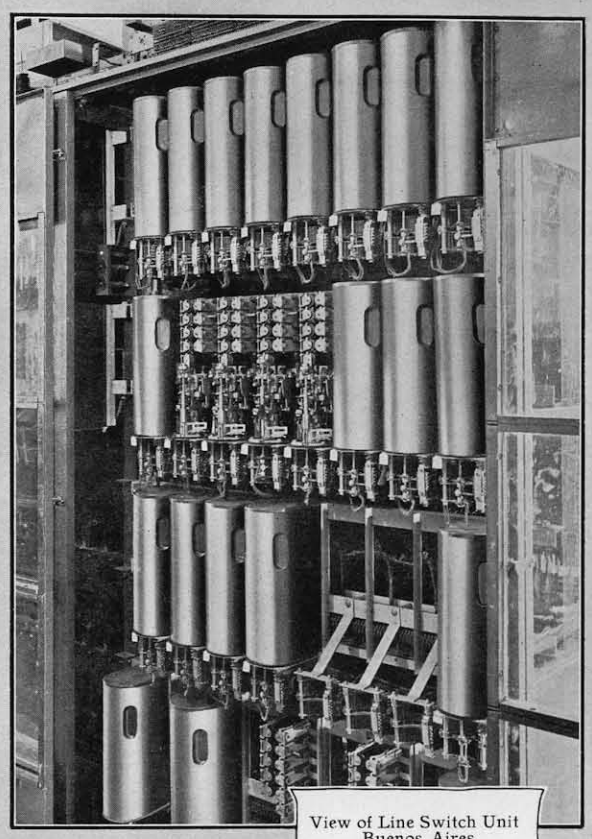
LONDON TOLL EXCHANGE

With the opening of the London Toll Exchange, a new era dawned in England in the history of telephone exchange construction. It is the first English exchange capable of dealing with non local telephone calls on a no-delay basis. The function of the London Toll Exchange is to relieve the long distance exchange, London Trunk, of the traffic between London and provincial exchanges within a radius of 25 miles. Perhaps the most important consideration from the point of view of the subscriber—the public—is that the London Toll Exchange has completely revolutionised the handling of this traffic in England, speeding it up to an unprecedented rapidity. When it is realised that (we quote official statistics) 95 per cent. of the calls made are completed without delay, users of the telephone will recognise the immense value of this innovation.

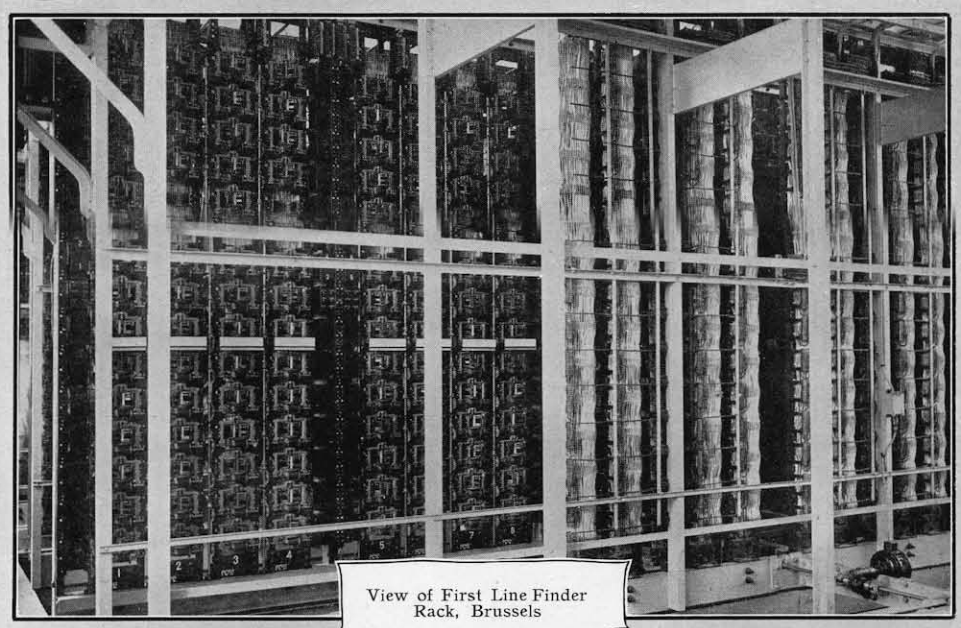
The instantaneous trunk connections are obtained by means of a complete multiple of outgoing toll lines and junctions outgoing to the London local exchanges. This multiple is available to every operator, so that if circuits are free, a connection between a London local subscriber and a provincial subscriber within the area can be completed instantaneously. Calls which cannot be completed on demand are booked, and the connection established as soon as the lines are free, the London subscriber being ultimately called and connected over the outgoing junctions from the Toll Exchange



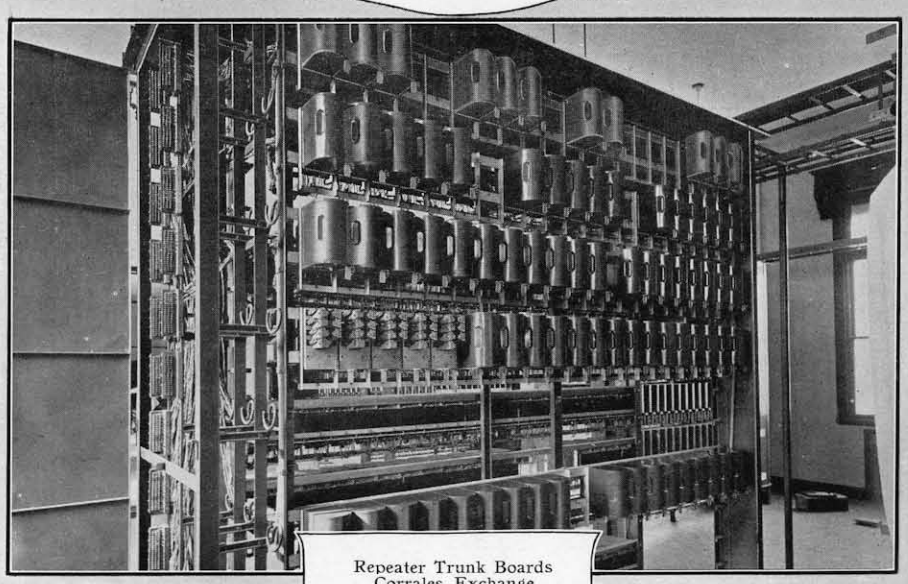
Distributing Frame and
Monitor's Desk, Brussels



View of Line Switch Unit
Buenos Aires



View of First Line Finder
Rack, Brussels



Repeater Trunk Boards
Corrales Exchange
Buenos Aires

A marked feature of this exchange is the installation of special test connectors which are cabled direct from the main frame to the test desk. There are three groups of positions. The first deals with calls incoming from London Trunk exchange ; the second with calls incoming from London local exchanges ; and the third with calls incoming from the provincial exchanges within the London Toll area.

Special facilities for supervising calls and for dealing with complaints and enquiries have been installed, and the rest of the equipment is similar to that of the standard local exchange.

AUTOMATIC TELEPHONE SYSTEMS

The more one knows of the complications associated with the inter-connecting of telephone lines through modern exchanges, the more incredible it seems that an assembly of mechanical devices can carry out the operations without human aid. The simple case of one line requiring automatic connection with another line terminating on the same board would, perhaps, not present undue difficulties, but considering large areas we know that the majority of calls will be for subscribers having lines terminating on a board in a distant part of the city. The mechanical apparatus therefore, in this case, must first select a disengaged junction line to the required board where a second set of apparatus must select the required line. This in itself becomes a problem of some magnitude, but adding the various auxiliary operations such as the testing of lines, the rejection of engaged lines, the supply and cut off of ringing current to the required line, registration, and sometimes, the collection or return of fees from call boxes ; it will be realised that the mechanism must have almost human sagacity.

As might be expected, the Western Electric Company, Ltd., with its associated companies, being the premier telephone manufacturing organisation in the world, has devoted considerable attention to the development of automatic telephone equipment, and a review of its achievements together with a few notes on the various systems the Company manufacture, will doubtless be of interest.

ROTARY AUTOMATIC TELEPHONE EXCHANGE

The Rotary Automatic Telephone System is power driven : a small electric motor being sufficient to keep a large exchange in operation : this permits switches of a more robust construction to be employed than would otherwise be the case, and owing to the mechanical nature the system is frequently referred to as a Machine Switching System.

Excellent examples of this type of apparatus are the installations at Christiania, Copenhagen, The Hague, Brussels, Zurich, all designed for telephone networks, with ultimate capacities of several hundred thousand Subscribers.

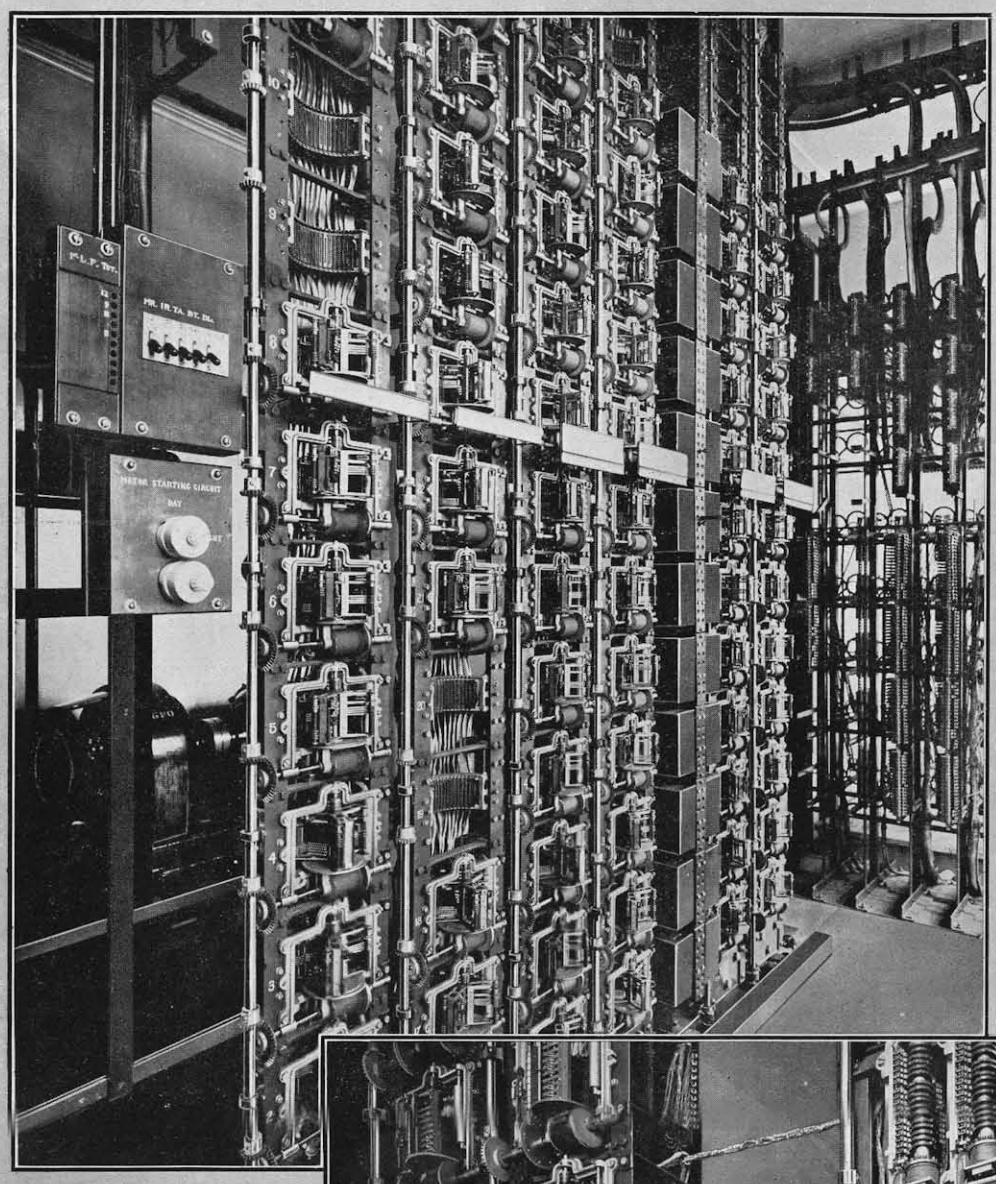
The exchanges in the Christiania area consist of the main exchange having two units each of nine thousand lines, three other exchanges having eight thousand, six thousand and four thousand lines respectively ; and four satellite exchanges, two of one thousand lines each and two of one hundred lines each.

The system provides for full automatic working, operators being required only in connection with the toll switching service. Even this manual operation is reduced to a minimum, the switching being actually semi-automatic. The operators employed are located at the main exchanges to answer the demands of toll operators. On receiving a request from a toll operator for a wanted number in any one of the exchanges, the toll switching operator depresses the corresponding number keys on her key set, and the connection is automatically completed.

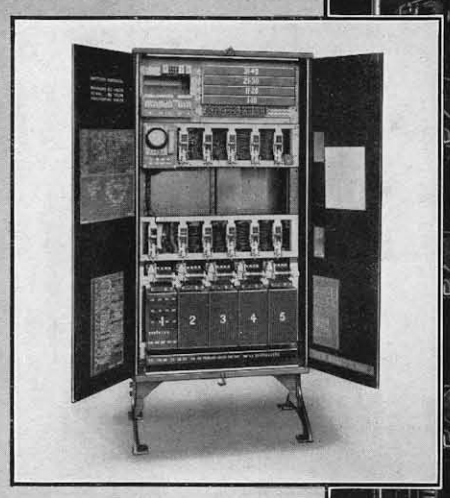
As a result of continued improvement in equipment design the exchanges now being installed are constructed in unit form. These units are completely assembled, wired, and tested in the factory. This effects a great saving of time in completing the installation, and as all of the apparatus in a particular circuit is mounted together, reduces the task of maintenance to absolute simplicity.

The Rotary System employs ingenious apparatus known as a register. These registers function as mechanical " brains " ; receiving, storing and delivering impulses ; apart from converting the series from a decimal to a more suitable non-decimal basis. The outstanding feature of the device is that no calls can possibly be lost.

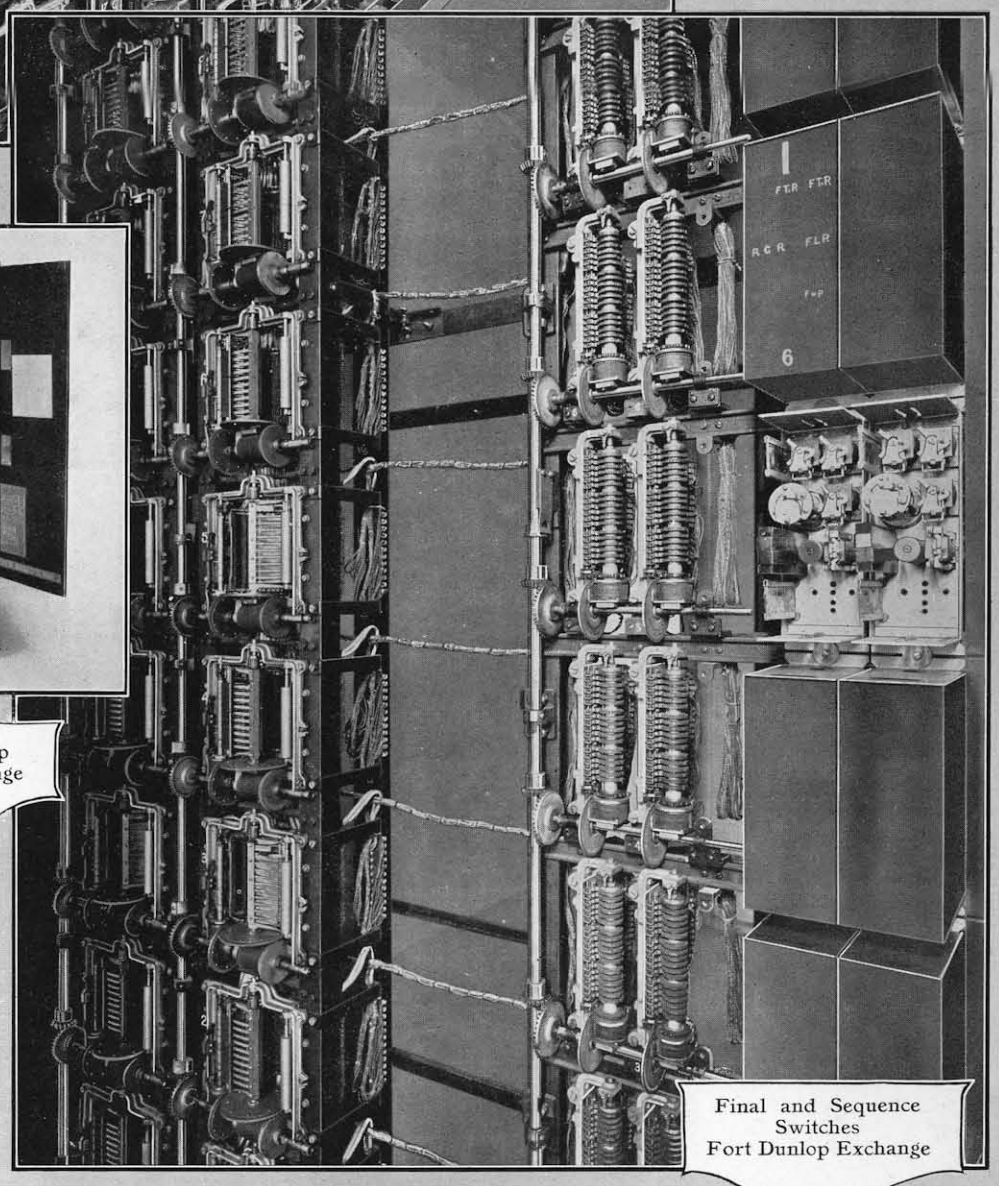
The recording is impartial, mechanical and 100 per cent. efficient.



Line Finder Bays
Fort Dunlop Exchange



The Step-by-Step
Automatic Exchange



Final and Sequence
Switches
Fort Dunlop Exchange

THE STROWGER AUTOMATIC TELEPHONE EXCHANGE

In 1920, an agreement was made whereby the Western Electric Company should act as foreign sales agents of the Strowger Automatic System, as manufactured by the Automatic Telephone Company of Liverpool. Recently, the Western Electric Company has taken up the construction of Strowger automatic equipment, and is now engaged in manufacturing the apparatus at its New Southgate Works.

Briefly, this automatic system operates in the following manner :—

Subscribers' lines pass through the usual main distribution frame, and are cabled to individual rotary switches which connect their lines to selectors, and through to disengaged trunk circuits. The switches have a brush portion, consisting of four wipers, which sweep round a bank of contacts covering twenty-five circuits.

The special feature of the system is that each line finds its own path through the exchange by means of these line switches, no intervening line finders being required. The subsequent switches on the whole circuit operate directly under the control of the dialling impulse. The calls are not stored up through any mechanism but proceed as fast as the subscriber operates his dial. When the called line is engaged, or when all the intermediate paths through the exchange are occupied, the " engaged " tone is sounded back to the caller.

It is interesting to note that the Western Electric Company is now occupied in the production of certain switching apparatus which will probably revolutionise the Strowger system, making it eminently suitable for the most complex networks such as exist in London and the larger provincial towns.

The Strowger system has been successfully installed by the Western Electric Company in many parts of the world. A notable example is the Buenos Aires equipment, cut over early in 1923, where four automatic exchanges, serving 7,500 lines, are now successfully operating over a large area. The ultimate size of the network will be 30 exchanges controlling 30,000 lines.

Nine existing " central battery " exchanges are fitted with call indicator equipment working direct from the automatic exchanges. For calls from manual to automatic, twenty-six key sending positions are fitted in the automatic exchanges. Calls from small magneto exchanges in the area are handled by " dialling-in " positions at the automatic exchanges.

At Basra in Mesopotamia three automatic switchboards have been installed, and in spite of the severe climatic conditions of the country, the standard equipment is giving excellent service.

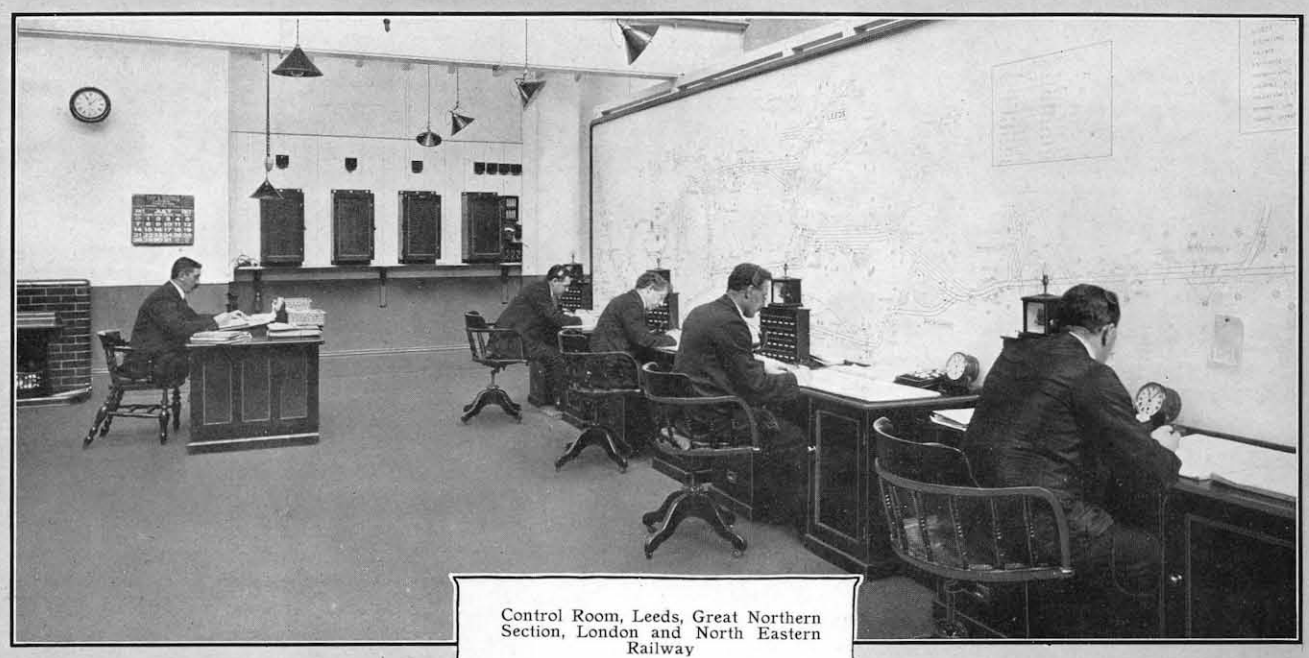
A 5,000 line equipment at Dairen, in Manchuria, was cut over in March, in 1923, and is also giving very satisfactory results, while many equipments have been installed during the last few years throughout the world.

PRIVATE BRANCH AUTOMATIC TELEPHONE EXCHANGES

Large business houses and institutions have been quick to realize that prompt service, absolute secrecy and an uninterrupted 24 hour service may be secured by the introduction of a private Automatic Exchange. Where inter-working is desired with the public telephone service it is essential that a suitable system be installed and as illustrating a type of small Rotary pattern Branch Exchange manufactured and installed by the Western Electric Company it is proposed to briefly describe an equipment now operating at the works of the Dunlop Rubber Company, at Fort Dunlop.

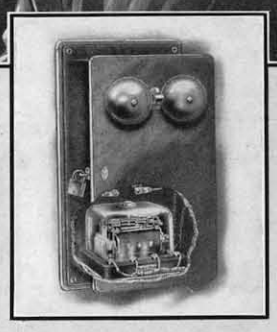
The board at present is equipped for 300 lines, but it has an ultimate capacity for 800 lines. All local calls, *i.e.*, automatic station to automatic station, are completed without the intervention of any operator, the subscribers controlling the automatic switches by the manipulation of a dial. To handle calls to and from other exchanges, a manual switchboard is provided, consisting of three single-position sections. All lines on the automatic system are multipled over these sections, so that incoming calls may be handled in the regular manual method without engaging any of the automatic apparatus.

The manual switchboard is furnished with sixty answering equipments to which are connected indiscriminately, lines from the automatic exchange, lines from other private branch exchanges belonging to Messrs. Dunlop, and lines from the Birmingham public exchange. The arrangement of connecting these lines permits of the equalization of incoming traffic over the three positions.



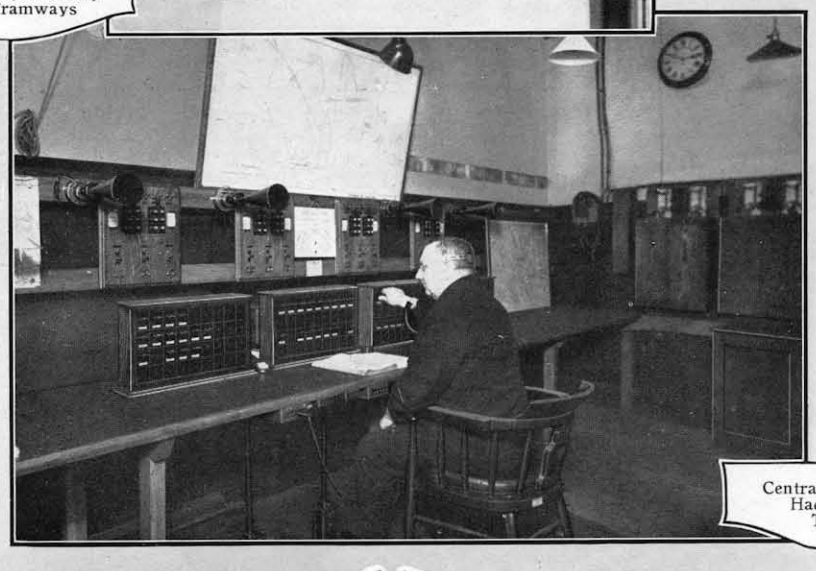
Control Room, Leeds, Great Northern Section, London and North Eastern Railway

Control Room, Stratford, Great Eastern Section, London and North Eastern Railway



The Selector Set used at Way Stations and Signal Cabins

Way Station, Finsbury L.C.C. Tramways



Central Control Room, Hackney, L.C.C. Tramways

There are also sixty bothway junctions, to which some of the answering equipments are cross-connected for bothway working between the Automatic Private Branch Exchange and other exchanges. To secure the services of the manual operator, automatic subscribers dial the figure " 0." Whether the source of the call be an automatic or a manual exchange, the cord circuits on the manual positions will operate according to the General Post Office standard method.

To complete an incoming call to an automatic subscriber, the operator tests the line in the multiple in the usual manner, and if this line is busy, plugs into the relevant jack and offers the call to the required subscriber without breaking down the local connection. If the person wanted agrees to take the incoming call, the operator actuates a key in her cord circuit, thus setting free the automatic switches over which the local connection was established, and retaining the required station in connection with the outside line.

Several equipments similar to the above have been installed both for public telephone authorities and for private users : among the latter might be mentioned an installation as ordered by the Anglo Persian Oil Company for the National Oil Refinery Company's Works at Skewen, South Wales, and just recently, a 200 line equipment for the Glasgow Corporation Tramway Department.

SMALL AUTOMATIC PRIVATE BRANCH EXCHANGES

During the last few years, the Western Electric Company has developed a particularly simple type of automatic exchange with a view to meeting the increasing demand for small installations having a capacity up to about 140 lines.

With the introduction of this simple " Step-by-Step System," as it is sometimes called, the Company has completed the range of automatic telephone equipments, from small private branch exchanges of ten lines to vast networks of 10,000,000 lines, and is in the fortunate position of being able to supply an equipment working on the particular system most suitable for the local conditions.

These small private branch exchanges are made in units of thirty-five lines, and two of these units can be specially coupled together to provide for an ultimate capacity of seventy lines. The maximum capacity of this system is 140 lines, and with each additional unit a group switch is supplied for inter-connecting. The switches used are of the " Step-by-Step " pattern, as distinct from the Western Electric Company's well-known power driven Rotary System.

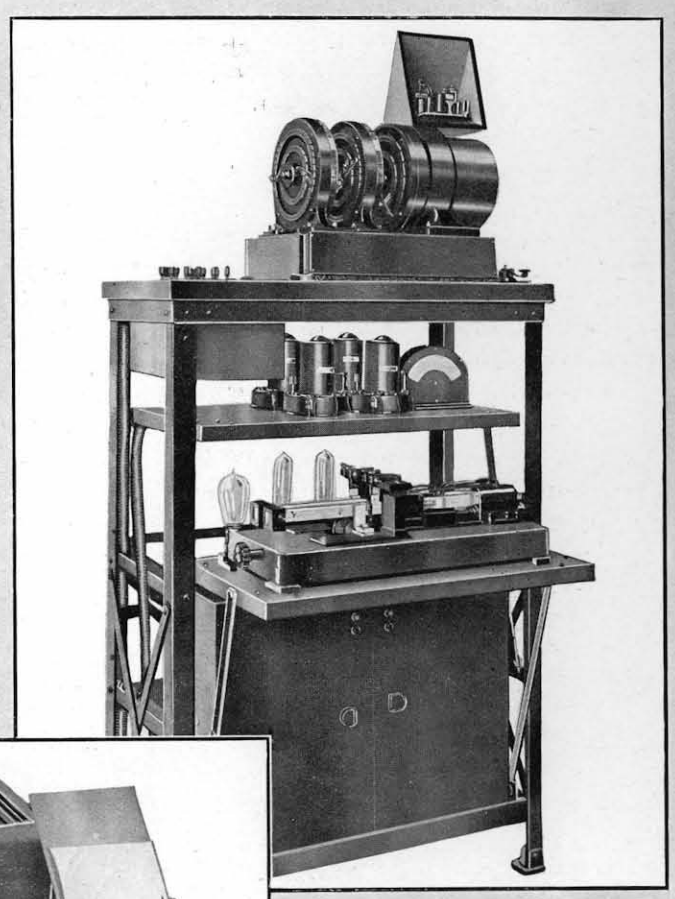
The apparatus employed is of a very simple nature, consisting of the line and cut-off relays for each line, the line finders which hunt for the calling line, the selectors which select the wanted line, and the sequence switches and associated relays which help to complete the connection. The board has an operating voltage from 32 to 40 volts, and owing to this wide variation, no automatic regulator is required. As would be expected, on so simple a system the whole of the energy necessary is supplied from a central battery.

Many of these private branch exchanges have been manufactured and installed in various parts of the world. Typical installations in this country can be found at the London Joint City and Midland Bank, Bradford, The Rochdale Union, Rochdale, Messrs. Sutton's Plant at Reading, and at the Earl of Fitzwilliam Collieries, Elsecar, Yorkshire, etc., etc.

THE TRAFFIC CONTROL SYSTEM

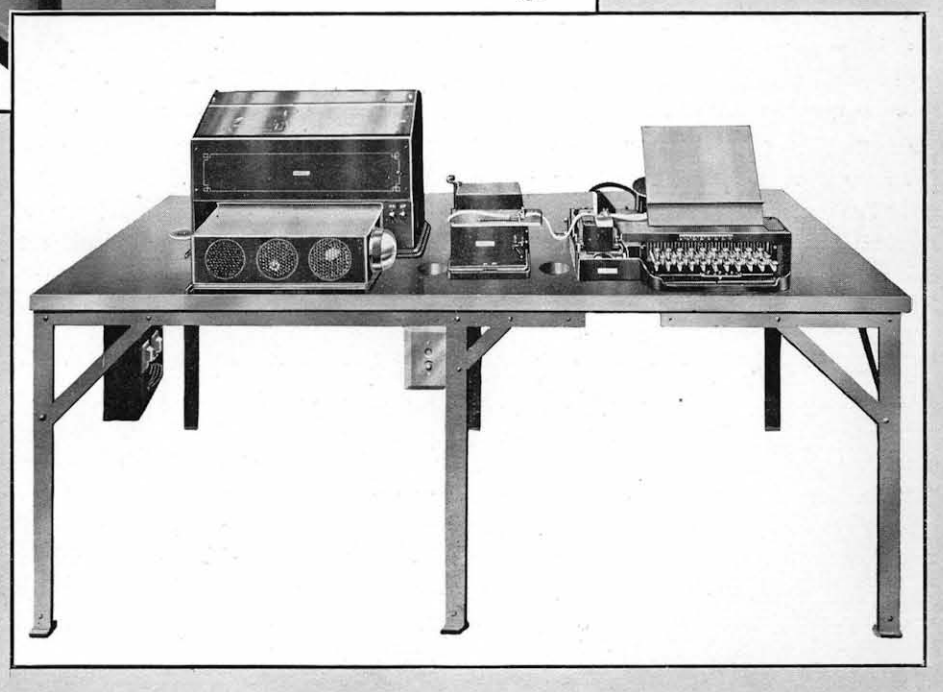
In the control of traffic, particularly on railways, where apart from the regular signalling arrangements there is much to be done in the marshalling of goods and in the collection of reports from clearing yards, the telephone has proved an invaluable acquisition. Foreseeing the possibilities, the Western Electric Company developed a special adaptation of the regular telephone known as the Western Electric Traffic Control System and which is now to be found in use on many of the large railways in Great Britain, the British Colonies and in general throughout the world.

The outstanding feature of the system is a " Selector " device which enables the Controller to select and ring exclusively any one station out of as many as seventy-eight stations, all of which may be connected to one pair of wires running throughout the system. In addition, this apparatus is so designed that, if necessary, the Controller can give instructions simultaneously to all the stations under his control.



Multiplex Distributor Set, showing Distributor Faces and Tuning Fork for synchronising

Start-stop Set for Printing Telegraph, showing complete Operator's Key-board, Transmitter, Perforator and Page-printer



Multiplex Operating Set, showing Key-board on the right and Page-printer on the left

The advantages of the system are enormous, for when the conditions at every point on the line are known, the railways are able to handle very much heavier traffic loads. It can be arranged for the Controller to have in front of him a moving model of the section under his control, and every traffic movement which takes place can be so rapidly reported to him that the whole picture of the section is always before his eyes.

The control boards are sometimes fitted with movable pegs carrying cards, and the cards bearing complete information such as type and hauling power of engine, number of wagons and weight of train, enable the Controller to secure the maximum efficiency of each unit on his section. A calculation made by a railway official shows that the saving in engine power, wagons and wages on one section in a fortnight paid for the apparatus twice over and also for its maintenance.

While the English railways were the first to take interest in this system, the Indian railways were not very far behind. The London and North Eastern Railway Company have installed the system throughout the North Eastern Section, the Great Central Section, and the Great Northern Section, while the Great Western Railway Company have installations throughout the Rhymney Section and the Taff Vale Section. In 1911 Indian railway officials investigated the system, and the actual volume of traffic control business in India now far exceeds that carried out in England. Ten of the largest railways in India are using the Company's traffic control system, and the track mileage under this control exceeds 7,000 miles. In addition, the railways of Africa, the Federated Malay States, and Ceylon have taken up the Western Electric Traffic Control System.

A few years ago the possibility of adopting this system on tramways and light railways was considered, and the results have been very successful. A comparatively small body, the West Ham Corporation Tramways, first adopted it. There were only eight way stations, placed at various busy points on the tramway system, and a Controller was installed to give advice on traffic matters and to keep a complete log of all routine matters and unusual events. The system was found to work very satisfactorily and the results more than justified the expenditure.

Recently the London County Council installed the system on the North side of the Thames, where about 200 boxes have been fitted at the various busy traffic centres.

In addition to the control of railway and tramway traffic the system has been applied to other cases where interworking is required between a number of points and where for economic reasons only one pair of line wires is practicable.

THE MULTIPLEX PRINTING TELEGRAPH SYSTEM

Modern telegraphy, like most other branches of industry, has been revolutionised by mechanisms and machines. The first commercial telegraph system employed five line wires to transmit one message, and the speed of service probably did not exceed 15 messages an hour. To-day it is common practice over one line wire to operate eight channels, and the total carrying capacity may be anything from 500 to 600 messages an hour.

The Western Electric Company's Multiplex Printing Telegraph System has been designed to secure the maximum line economy and the maximum operator output, without undue pressure. An equipment was first installed in this country in 1914, on an underground cable circuit between London and Manchester, and is still operating satisfactorily. It provides eight channels (four in each direction) and the speed of operation is forty words per minute per channel, or a total of 320 words per minute over the line. Records show that in one hour it has actually handled 570 telegrams, and in one working day of 16 hours, a total of 6,060, and this on only one wire.

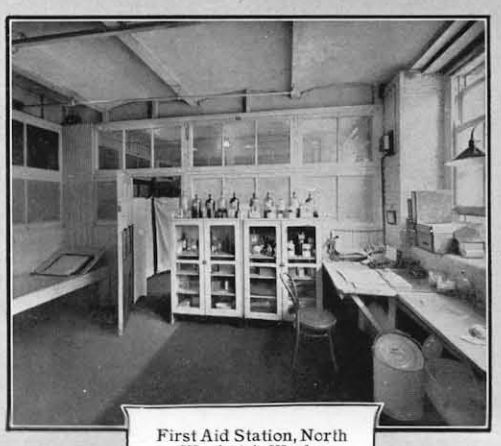
Transmission by this system is entirely automatic, only typing skill being required by the operators. It employs the five-unit code which is the most economical from a line transmission standpoint.

Two-way operation is accomplished by means of the well known duplex balance, and the four channels in each direction are secured by means of distributors. These are really rotating commutators which connect the line successively to four transmitters at one end and four printers at the other. The distributor faces carry a number of phosphor-bronze rings divided into four sectors of five segments each. An automatic transmitter is connected to each sector of the sending face, and a machine printer to each sector of the receiving face.

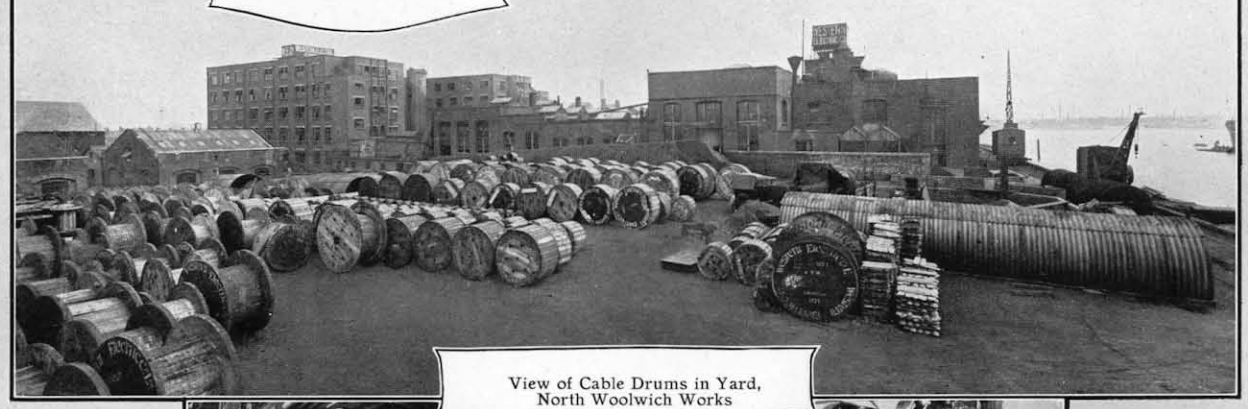
The shaft of the distributor is driven by a Phonic wheel motor, and carries a number of copper brushes, which, in wiping over the distributor segments, distribute

Telephone Apparatus Assembly Shop, North Woolwich Works

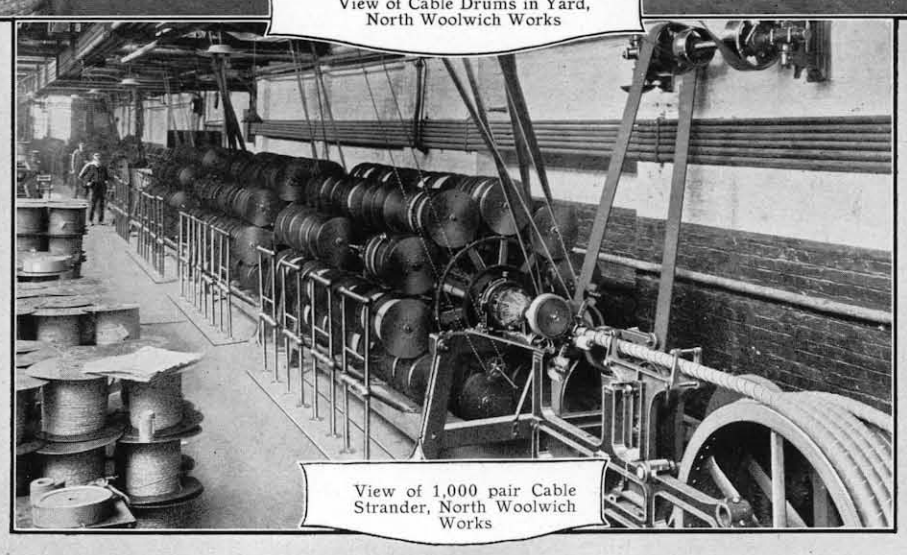
Switchboard Erecting Shop, Bexley Heath Works



First Aid Station, North Woolwich Works



View of Cable Drums in Yard, North Woolwich Works



View of 1,000 pair Cable Strander, North Woolwich Works

the line successively to the four operating equipments. The brushes on the sending face co-operate with the transmitters to send out to line, at each revolution, a combination of positive and negative impulses, their sequence being determined by the perforations in a paper tape passed into each transmitter. The brushes on the receiving face collect the impulses received from the distant station, and distribute them to relays associated with the printers. These machines print the telegrams direct in column form on a roll of paper which is torn off as each telegram is completed.

For a quadruple or four channel installation, four operating tables are required, each of these accommodating one sending and one receiving operator.

To meet the requirements of lines carrying a light traffic a more simple equipment has been developed, known as the Start-Stop, a one channel system. Telegrams may be transmitted either directly from the keyboard, or by means of a perforated tape and automatic transmitter. The efficiency of the Start-Stop does not depend upon the skill of telegraph operators. Any typist can operate the apparatus and render a greater output than is possible with any other system. A complete installation of this equipment is working between Cape Town and Johannesburg.

The system is specially suited to the needs of mercantile establishments, where inter-communication between factory and offices, or distribution of information to a number of departments is necessary. In fact when the possible applications of the multiplex printing telegraph system with its manifold advantages are appreciated, it will be recognised that whatever the type of business considered, the system will prove to be a valuable asset to efficient organisation.

SIMULTANEOUS TELEPHONY & TELEGRAPHY

One of the most interesting developments which has been effected in the communication art during the past few years is the Western Electric Company's "Composite System."

Compositing provides a commercially practicable means of operating the telegraph and the telephone simultaneously over the same line wires, and offers a very economical method of fully employing lines and increasing their usefulness.

It should be understood that the system is not limited to any particular telegraph system, the only restriction being that the frequency of telegraph signalling must not exceed thirty cycles per second.

By simplexing, it is possible to transmit three telephone messages over two pairs of line wires, and by compositing these, and equipping them with Multiplex Printing Telegraph apparatus, six telegraph channels in each direction also can be provided. Four line wires can thus be made to carry simultaneously three telephone messages and no less than twelve telegraph messages.

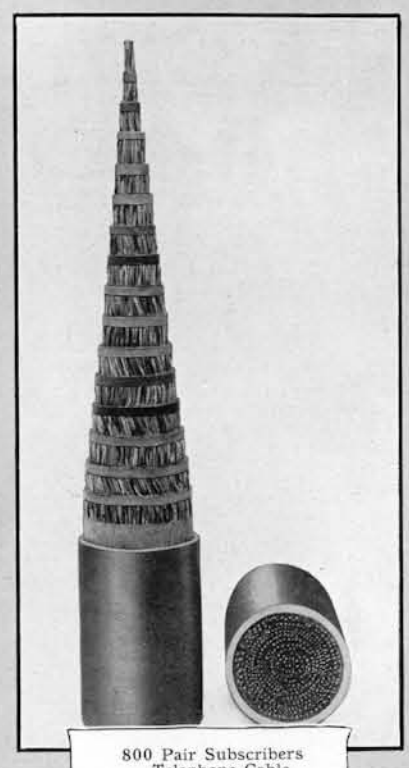
Impressed by the possibilities of the system, several English railway companies investigated it and finally adopted the Composite apparatus—1922. In America, on the route between New York and San Francisco, a line consisting of four open wire conductors was enabled to carry no less than twenty-seven circuits. These were successfully operated between Chicago and Omaha, a distance of four hundred and fifty miles. The total of twenty-seven was made up of :—

Two Physical Telephone Circuits.
One Phantom Telephone Circuit.
Four Earthed Telegraph Circuits (which can be worked either one-way or two-way).
Twenty two-way Carrier Telegraph Circuits.

A Composite set consists of a network of inductance coils and condensers, or as they are termed, filters, by virtue of which a circuit is divided into two branches, one for high frequency currents (telephone), and one for low frequency currents (telegraph). In the telephone branch, condensers in series with the lines act as a high impedance to telegraph currents, and any feeble impulses which do pass these condensers are drained off to earth through inductance coils and condensers bridged across the lines. In the telegraph branch, inductance coils in series with the lines offer a high impedance to telephone currents, and with their associated condensers they also act as a filter, passing through telegraph frequencies up to 80 cycles only.

The Composite set has many advantages. Inexpensive and easy to instal, having purely electrical features and no moving parts to get out of order, the set demands no supervision for its continuous efficient working.

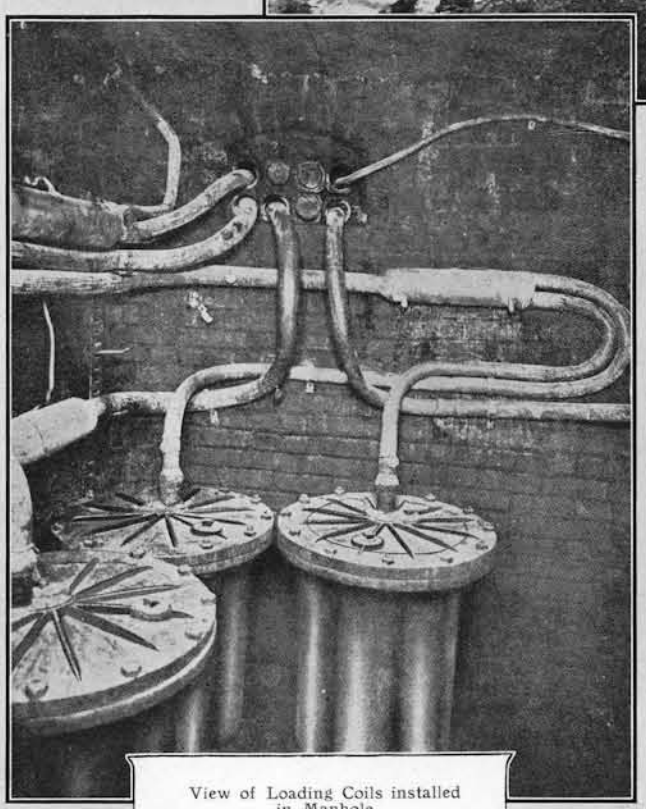
Loading Coil Shop,
North Woolwich Works



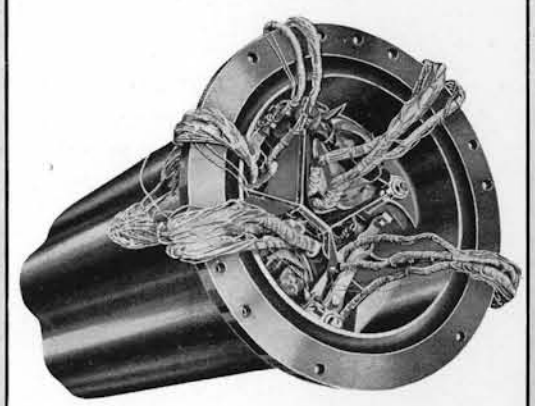
800 Pair Subscribers
Telephone Cable

Fanned End of Telephone
Cable, London-Birmingham
Trunk Line

Paying in Cable London-
Birmingham Trunk Line
near St. Albans



View of Loading Coils installed
in Manhole



Internal View of Loading
Coil Pot

TELEPHONE CABLE AND LOADING COIL DEVELOPMENT

In the development of the underground telephone cable, the Western Electric Company may claim to have effected a revolution. This revolution was brought about by the invention of a new type of dielectric, embodied in the dry core cable of 1890. Prior to this date, the only available dielectrics had been solid materials of high capacity. The length of transmission line was in consequence very short, the size of the cable was limited, and its cost high. The new type of cable was composed of copper wire, insulated with dry air and a loose lapping of paper, the whole core being enclosed in a lead sheath. This cable is now used universally for telephone communication.

Improvements in the manufacture and design of dry core cable followed rapidly, and the size of the conducting wires was decreased and the size of the cables increased. The maximum sizes of cable now made by the Western Electric Company are as follows :—

Weight of Wire per mile	*Number of Pairs in cable*
20 lb.	400
10 lb.	800
$6\frac{1}{2}$ lb.	1,200
$4\frac{1}{4}$ lb.	1,500

The 400 pair 20 lb. (.9 m.m.) conductor cable is a comparatively recent development, the Company having, in 1921, manufactured and installed cable of this size for the British post office at Kingston-on-Thames.

The $4\frac{1}{4}$ lb. (.4 m.m.) conductor cable is a special development for future use ; the Company having designed this unique cable with an eye to the growing demand for cables containing the largest possible number of circuits.

During 1914-1915 and 1919-1922 (exclusive of the war period) the Company carried out a large amount of cable work for the British post office in the Midlands and South of England, involving the laying of ducts, the construction of manholes, and the manufacture and installation of subscribers' cable of all sizes. In the period since 1919 the Western Electric Company has laid over 500 miles of duct and installed 680 miles of cable for local line purposes alone. The circuit mileage in these cables totals some 44,000 circuit miles.

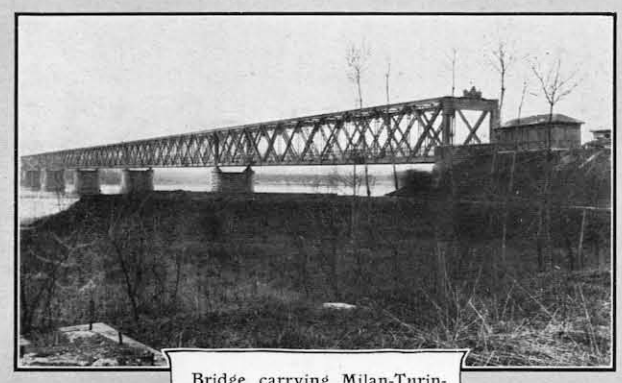
Although useful for short lengths of line, the dry core cable was limited by capacity effects from being used for long distance communication. In 1899 Professor Pupin discovered a means of annulling the harmful effects of capacity, by the use of inductance coils, and the Western Electric Company adopted and developed this invention.

Marked improvements followed, and the system of inserting " loading coils " along a line not only increased speech efficiency, but increased the efficiency of the " phantom " or superimposed circuit. These improvements were embodied in the first long distance telephone cable installed in Europe, the London-Birmingham cable. The cable and loading coils were manufactured and installed by the Company, the line was opened in July, 1915, and the results obtained proved conclusively the efficacy of loading.

As the cable possessed several novel features and was the first of its kind in Europe some particulars may be of interest. The cable was designed upon the "Multiple Twin " principle. The paper insulated conductors were twisted into pairs, and two pairs were then twisted so as to form four wire units or " quads." The quads were stranded up to form the entire cable which finally comprised :—

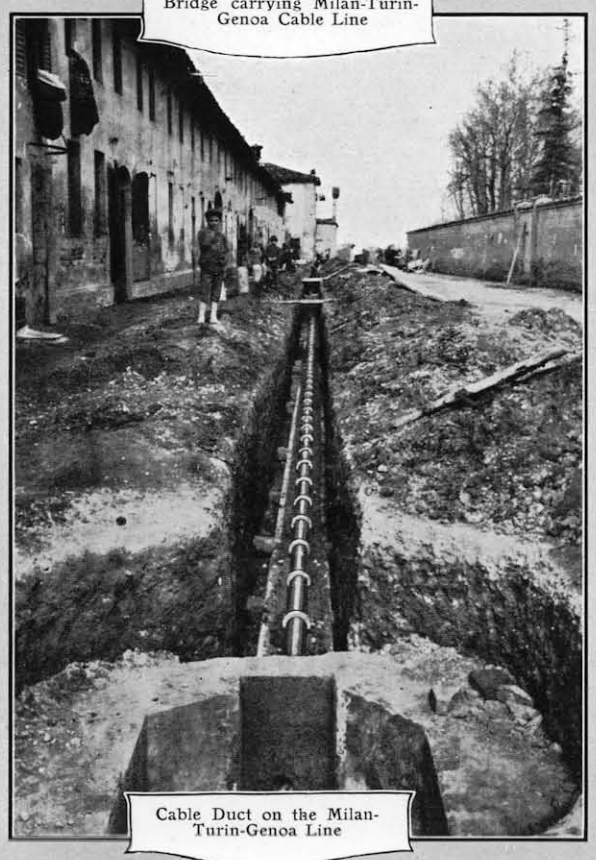
4	wires	300 lb.	...	.137″ (3.48 mm.) diameter
28	,,	200 lb.	...	.112″ (2.84 mm.) ,,
24	,,	150 lb.	...	.097″ (2.46 mm.) ,,
48	,,	100 lb.	...	.079″ (2 mm.) ,,
Total ...	104 wires = 52 pairs or 26 quads.			

The cable was laid in self-aligning stoneware ducts, the loading coils being accommodated in reinforced concrete manholes at intervals of $2\frac{1}{2}$ miles. In order to reduce the possibility of over-hearing to a minimum, all the circuits were carefully balanced electrically at each jointing point in accordance with the methods owned and controlled by the Western Electric Company. The final tests on the cable showed remarkable results, and at the time of its completion the London-Birmingham cable had no equal in Europe in magnitude or efficiency.

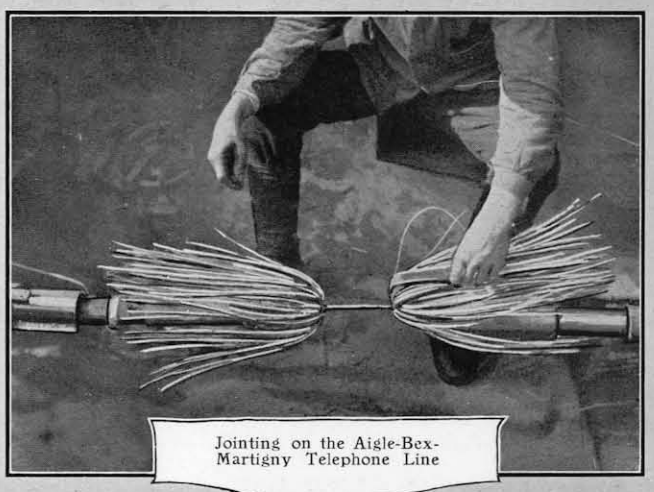


Bridge carrying Milan-Turin-Genoa Cable Line

Jointing an 11,000 volt Cable for the Sheffield Corporation

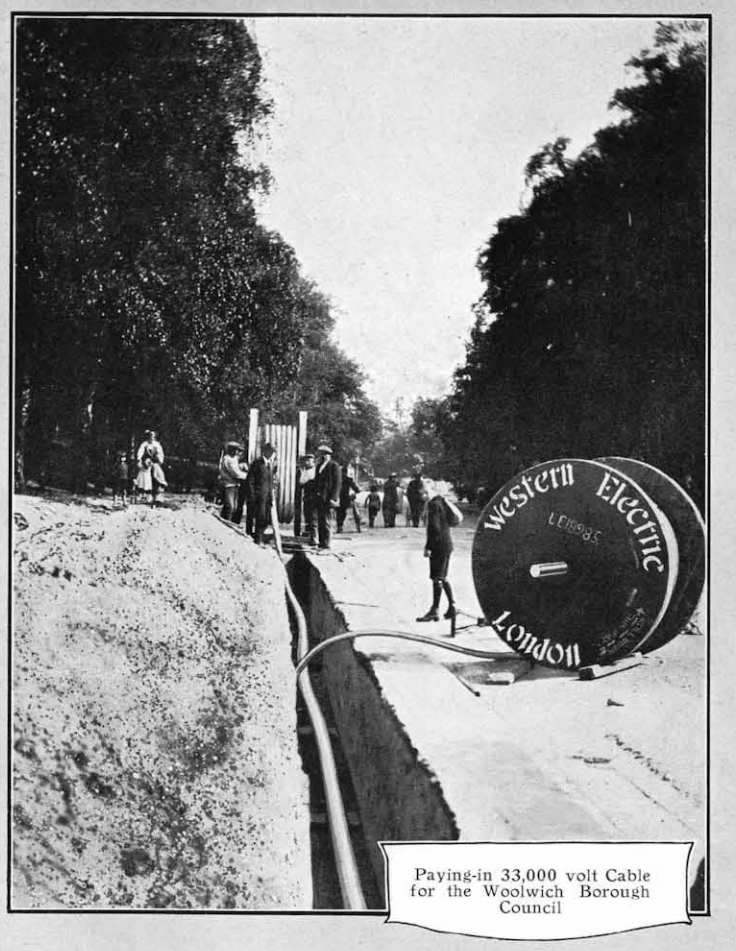


Cable Duct on the Milan-Turin-Genoa Line

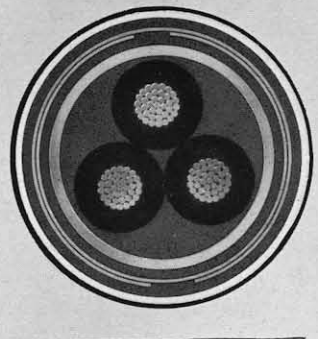


Jointing on the Aigle-Bex-Martigny Telephone Line

Cable Trench at entrance to Simplon Tunnel



Paying-in 33,000 volt Cable for the Woolwich Borough Council



A Section of the 33,000 volt Woolwich Cable

In addition to the London-Birmingham cable, the Western Electric Company manufactured and installed the following cables, designed for long distance telephone traffic :—

Bolton-Preston ...	20 miles	27 quad	70 lb.
Bolton-Blackburn ...	13 miles	27 quad	70 lb.
Leeds-Bradford ...	9.5 miles	62 quad	40 lb.
Leeds-Dewsbury ...	9.0 miles	62 quad	40 lb.
Dewsbury-Huddersfield	7.75 miles	48 quad	70 lb.
Oldham-Halifax ...	20 miles	26 quad	100 lb.

However, it is only recently that underground cable telephone communication has been made possible from one end of the country to the other. The repeater—described elsewhere in this publication—has accomplished this result, and huge economies have resulted, the weight of conductors being reduced to one-quarter of their normal size and the number of pairs being correspondingly increased.

Since the war, the Western Electric Company has manufactured and installed many long distance cables. Amongst these achievements are the following :—

London-Old Stratford ...	53 miles	80 quad.	40 lb.
London-Slough	24 miles	154 quad.	20 lb.
Slough-Reading	18 miles	154 quad.	20 lb.
Marlborough-Bristol ...	42 miles	154 quad.	20 lb.
Derby-Birmingham	40 miles	61 quad. plus 45 quad. 40 lb.	20 lb.
Derby-Sheffield-Leeds ...	60 miles	61 quad. plus 45 quad. 40 lb.	20 lb.
Leeds-Catterick	48 miles	61 quad. plus 45 quad. 40 lb.	20 lb.
Manchester-Preston	32 miles	48 quad.	70 lt.

These cables form part of certain systems of long distance communication with repeater stations, where the repeaters are situated about 50 miles apart, with intermediate loading points at every 2,000 yards.

As we write, far-reaching developments are taking place in the design and manufacture of dry core cables and in methods of installation, and we are approaching, step by step, the perfection of long distance telephone communication.

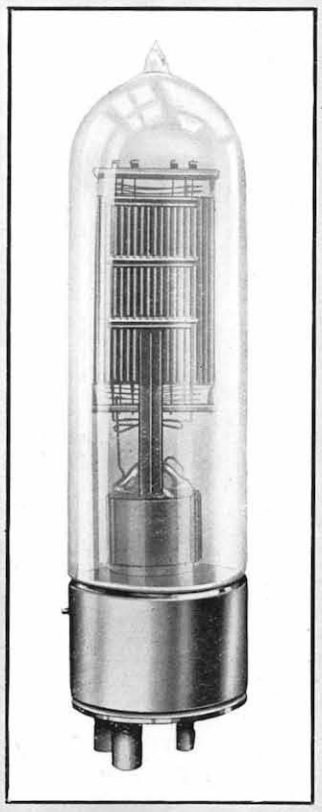
POWER CABLE DEVELOPMENT

Modern cables as used in the transmission of electric power are generally constructed with an insulation consisting of impregnated paper suitably protected, and in the development of these cables the Western Electric Company, Ltd., has played no unimportant part.

Some twenty-six years ago the Company took over the factory and goodwill of the Fowler Waring Company at North Woolwich, but a disastrous fire occurring within the first two years of their possession almost destroyed the former Company's works and incidentally compelled the Western Electric Company to rebuild. This was accomplished with the Company's characteristic thoroughness, and from that time onwards the Company has been actively engaged in designing, manufacturing and laying power cables on a large scale for the Government and municipal power schemes in this country and also extensively abroad.

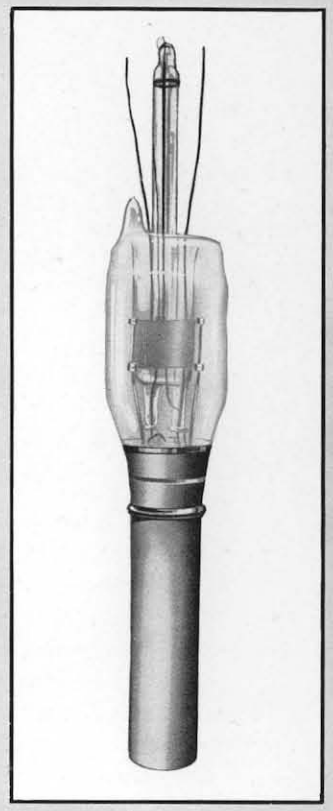
The quality of the impregnating compound used in the manufacture of paper insulated power cables is a very important factor and we may note in passing that recently the Western Electric Company, Ltd., has been carrying out experiments with new types of compound, combining high dielectric strength and low dielectric loss with a state of " semi-liquid flow " at all normal working temperatures. This last mentioned property is essential from a mechanical standpoint in order to allow one spiral layer of paper to slide over another, and thus prevent splitting of the insulation. The latest compound produced has given excellent results in this direction, besides being a more efficient dielectric.

This development is of considerable value, as with the increasing demand for higher voltage cables, the problems involved in dielectric stress and loss have become more and more acute. Manufacturers have had to carry out considerable experimental work dealing with " super voltage " cables, and it is interesting to record that the Western Electric Company is now engaged in making large extensions to its power cable experimental plant.

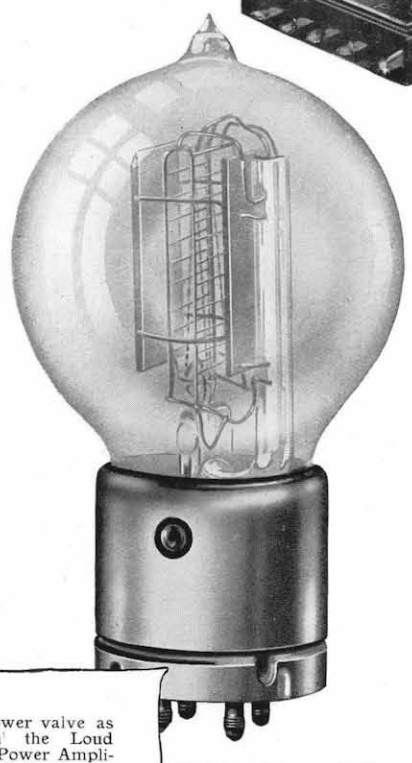


250 Watt Power Valve used for Wireless Transmission and Broadcasting. Also used in the Public Address System

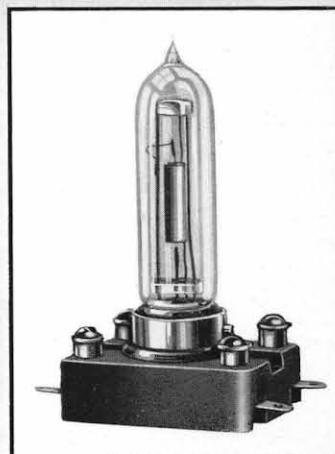
Low Voltage Cathode Ray Oscillograph for the study of minute currents at enormous frequencies



10 Kilowatt Power Valve, water cooled anode, used in Trans-oceanic Wireless Transmissions



Small Power valve as used in the Loud Speaker Power Amplifier



The Wecovalve (or Pea-nut Valve) which operates from a single Dry Cell

The demand for cheaper power has produced the "super-generating station," equipped to yield enormous power, and to deliver it at much higher voltages than have been previously used. In connection with these high pressure distribution schemes, the Western Electric Company has laboratories and shops equipped to turn out paper-impregnated and lead covered cable for working pressures up to 60,000 volts. A recent example of this type of cable is the .25 square inch, 3 core, 33,000 volt cable, manufactured and installed by the Company for the Borough of Woolwich. This cable is steel tape armoured and is laid direct in the ground.

The cable was tested in the factory to a pressure of 75,000 volts between cores, and 45,000 volts between cores and earth for 15 minutes. After laying and jointing, it successfully withstood 60,000 volts between cores, and 50,000 volts between cores and earth for fifteen minutes. Two short test-pieces of this cable were connected by a trial joint, and withstood a pressure of 165,000 volts without breakdown.

Much of the success which has attended the cable developments of the Western Electric Company is due to its wide experience in the laying of underground systems. A special installation section deals with the work of route surveying, excavating and installing. The problems that arise in this work are diverse, and demand technical skill, and the ability to deal with sudden emergencies, and unusual situations.

To illustrate some of the peculiar features of outdoor construction one might refer to the 11,000 volt, .2 square inch, 3 core cable, manufactured and installed by the Company for the Beckton-Woolwich, 3-mile transmission line. This cable was run in duplicate, and passed under the new King George V Docks and through the subway under the Thames at Woolwich.

The cable was laid direct in a six foot duct which, during laying, was continually filling with river water. In these exposed positions a special double armouring of galvanised iron wire and tarred jute protected the sheath from corrosion and mechanical damage. Continuous pumping was necessary to clear the duct during the installation, but in spite of the difficulties encountered, the whole cable line was installed without mishap or delay.

The demand for economic electric power is increasing, and is being chiefly expressed in super voltage transmission schemes. In this direction the Western Electric Company is concentrating its power cable resources, confident of the success that must inevitably result from applied scientific research, combined with the most modern power cable plant and manufacturing methods.

THE THERMIONIC VALVE

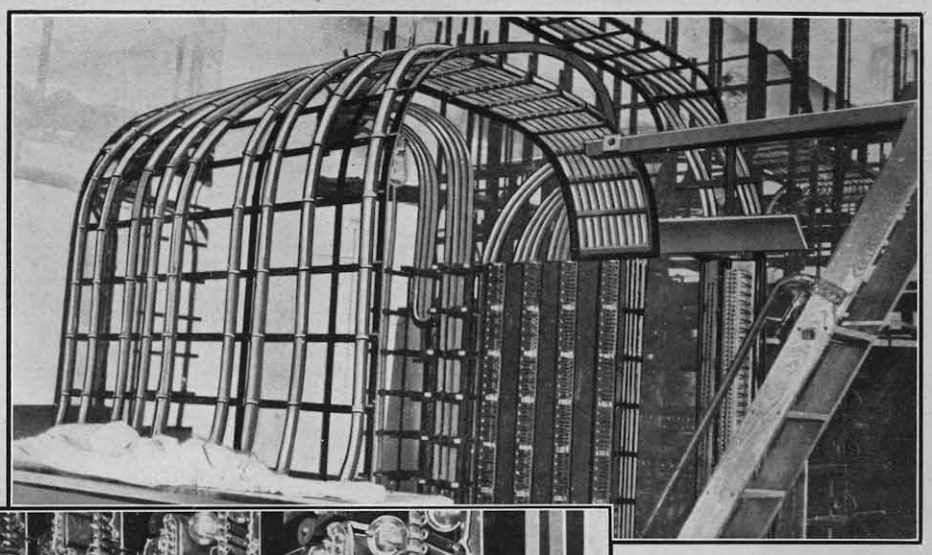
One of the most remarkable scientific inventions of modern engineering is the vacuum tube, known more familiarly as the valve. This device has revolutionised the field of wired and wireless telephony and telegraphy. The valve has become literally a household word. Its action is well known, and in its application to telephony it may have a triple function, modulation, oscillation, or amplification.

To the development of the vacuum tube the Western Electric Company has devoted considerable research, and some of the special features of its products command our attention.

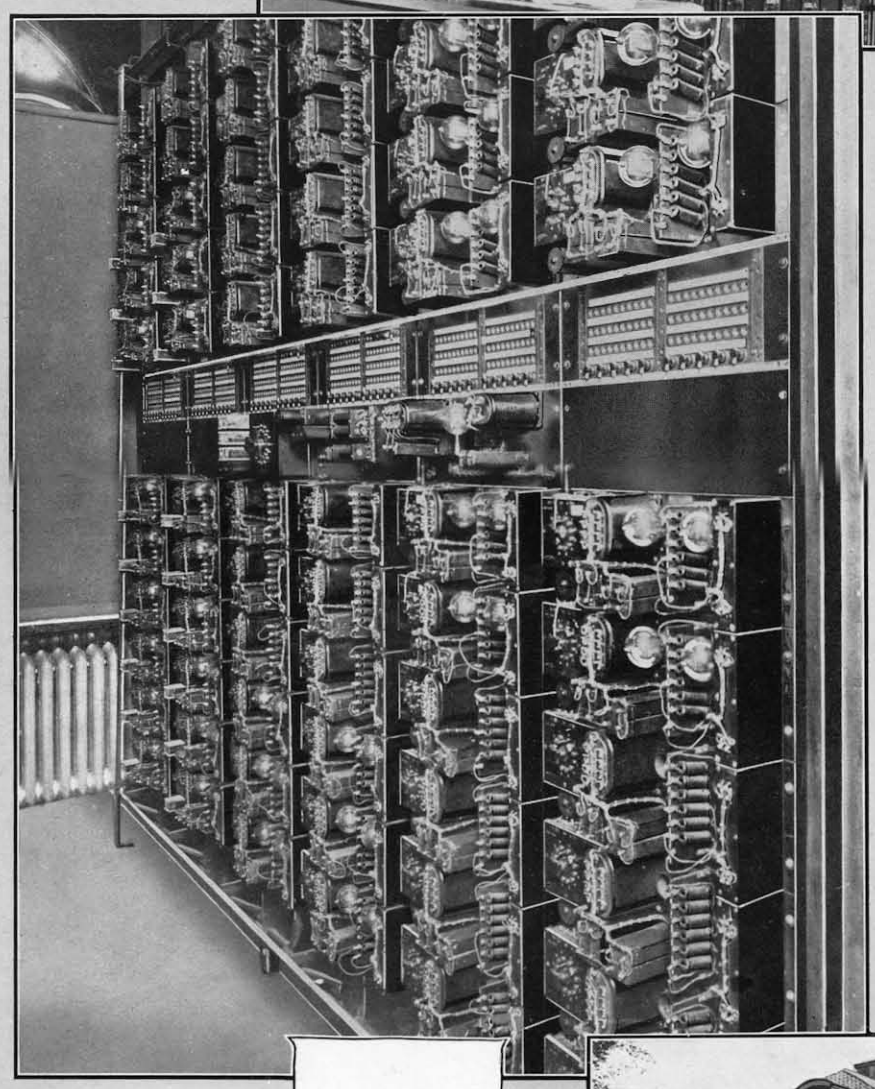
The Company investigated and developed the discovery that a filament having a thin coating of oxide would give greatly increased emission of electrons at a much reduced temperature. The logical results of this invention were that less power was needed to heat the filament, and since the heat produced was diminished, the life of the vacuum tube was lengthened.

For commercial maintenance at wireless or repeater stations absolute uniformity is essential. This is a distinguishing feature of Western Electric Vacuum Tubes, obtained by employing a very robust construction which enables the normal manufacturing limits to be reduced. It is actually possible to change one Western Electric Vacuum Tube for another without making any alteration in the voltage supplied to the tube terminals, and there is no difference between the operating characteristics of any two tubes.

Perhaps the most remarkable vacuum tube designed by the Western Electric Company is the baby tube known as the "Wecovalve," or Peanut type. This tube is only two inches high, and operates on a filament supply of one dry cell. At the same time the uniformity of its operating characteristics is identical with the high standard of its bigger brothers. As an indication of the capabilities of these tubes, seven of them, used in a standard wireless receiving set with a frame aerial, will receive high power American stations in England.



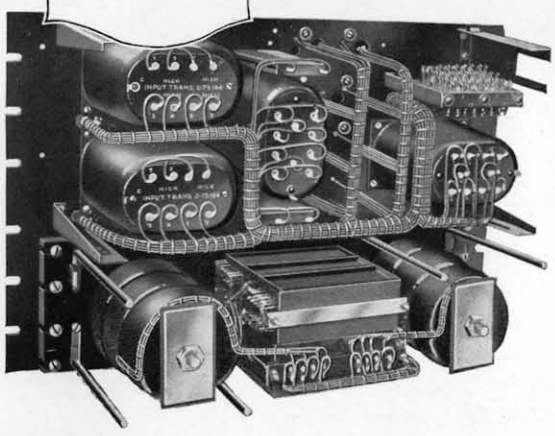
General View of Cabling inside Telephone Repeater Station



A typical through-line Telephone Repeater Installation

The Repeater Building at Orebro, Sweden

Cord Circuit Telephone Repeater Panel



The most recent product of the Western Electric Company's research is the high power vacuum tube. To estimate accurately the value of this tube it is necessary to realize that the standard type is of no use for high power work. The power dissipated in a tube is manifested as heat which is lost by radiation, the glass walls of the tube gradually becoming overheated. The limit of power lost is reached at about one or two kilowatts.

With the development of the high power vacuum tube, many new problems arose, were confronted, and were solved. To obtain a high dissipation of energy on the plate a water cooling system was adopted, and to facilitate this the plate was made in the form of a copper cylinder as part of the outside casing of the tube. In order to attach the cylinder to the glass portion of the tube a copper-glass seal was necessary. This was brought to perfection, so that the stresses set up during heating to 350° C. or cooling to the temperature of liquid air, did not rupture either the glass, or the junction between the glass and the seal. The filament leads were made of heavy copper rods and were sealed into the glass portion by means of the special seal. The helical grid and its supports were made of molybdenum, and the filament of tungsten. Cooling was effected by means of a water jacket surrounding the copper anode, the water being continuously circulated, and in view of the very high plate voltages employed, rubber pipes were used to insulate the plates from ground.

The importance of these high power tubes cannot be over-estimated. They have made trans-Atlantic telephony possible, and even now, the rapid developments in hand are opening out huge vistas in the fields of long distance telephony, wireless and carrier working.

REPEATERS AND REPEATER STATIONS

For years past attempts have been made to find a means of amplifying the speech currents at various points in a telephone line and to retransmit magnified currents in a manner which would eliminate the depreciation ordinarily associated with the long transmission lines which are now coming into use in steadily increasing numbers.

In the year 1894 Oliver Heaviside published the fundamental formula for "loading" cables, that is, the addition of inductance to a line in such a manner as to increase the maximum length over which telephonic speech could be maintained. Professor Pupin brought this method into a commercial possibility, but still there was no amplification of the voice currents, only a reduction in the loss or attenuation.

The earliest commercial form of "Repeater"—as such amplifying apparatus is now generally termed—was a mechanical device and had certain inherent defects, but to-day, repeaters, as designed and manufactured by the Western Electric Company, Ltd., and which are based on the thermionic emission of hot filaments, are so nearly perfect in operation that their very existence is quite unknown to the general public.

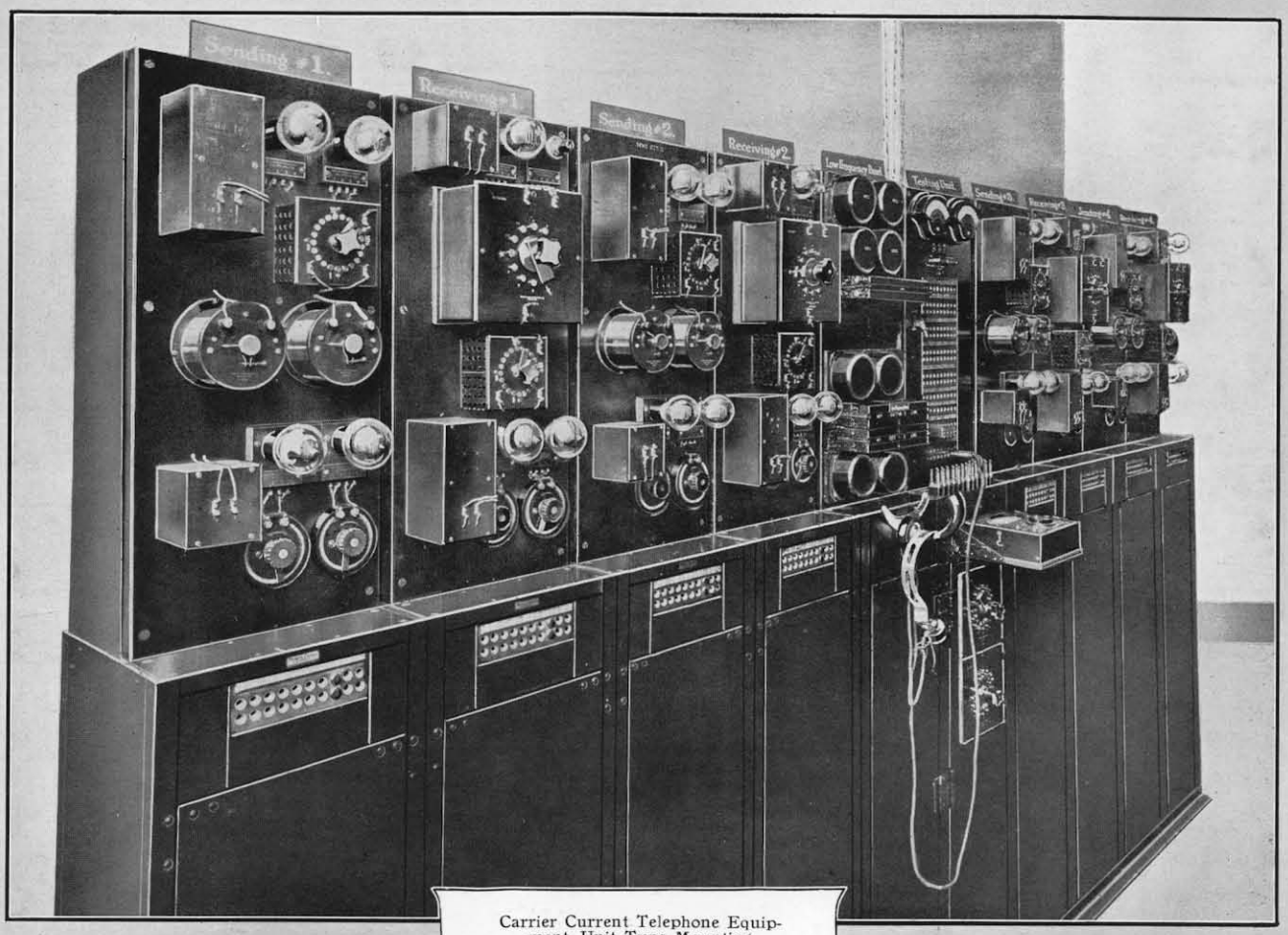
In England, Repeater Stations are either in operation or in course of erection at Fenny-Stratford, Derby, Leeds, Ipswich, Catterick, etc.; whilst many stations have been erected by the Western Electric Company, Ltd., in Holland, Italy, Sweden, France and Switzerland.

There are two general types of telephone repeaters in use, the "Cord Circuit," and the "Through-Line" repeater. The "Cord Circuit" repeater connects toll lines to form a long line when there is not sufficient traffic to justify a direct continuous circuit, and is equipped with standard supervisory signalling and monitoring facilities. In the toll-line multiple in front of the operator, each line with which the "Cord Circuit" repeater is to be used requires two adjacent jacks, one of which is connected to the line itself, and the other to a balancing network designed for that line.

The repeater cords are equipped with double plugs, which make connection with both jacks, so that when the repeater set is used with a given line an appropriate balancing network is also connected. The amplification from the repeater set is regulated by a potentiometer under an operator's direct control. The battery circuit is closed only when the repeater set is in actual use, and consequently energy is consumed only while the set is actually employed.

The "Through-Line" repeaters differ from the "Cord Circuit" type, being permanently associated with a particular line and at all times in operation. For signalling purposes, relays are connected across the lines at the repeater stations.

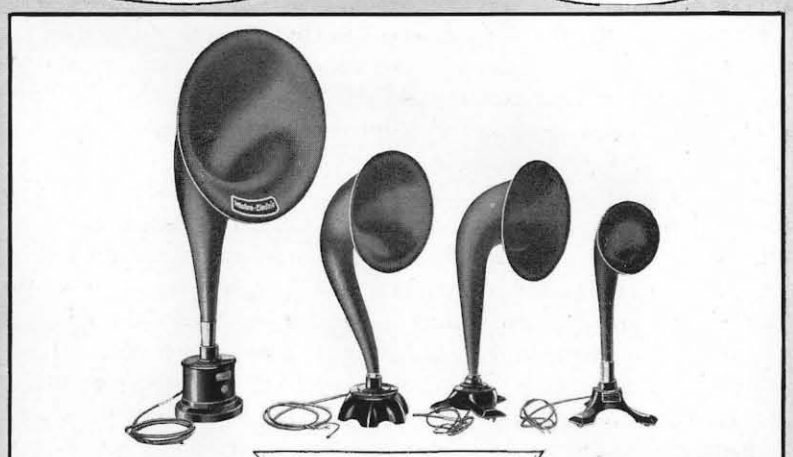
There are two types of "Through-Line" repeaters. In the first a separate repeater element amplifies the speech in each direction, and each line is balanced by an artificial line or network; and the second is similar, but has only one repeater element



Carrier Current Telephone Equipment, Unit Type Mounting

The Wireless Loud Speaking Equipment

Wireless Head Receivers



A line of Wireless Loud Speakers

for transmitting in either direction; the two lines balancing each other, instead of utilising a balancing network.

Owing to the fact that with ordinary repeaters "echo" effects are occasionally produced over long loaded cable circuits, a 4-wire repeater has been developed, amplifying each circuit in one direction only. This avoids the "echo" and, as no balancing is necessary, excepting at the ends of the circuits, a higher degree of amplification is possible. Hence, the 4-wire repeater effects considerable economies over long distance circuits, as the size of copper wire used can be reduced or the number of repeater stations decreased.

Space will not permit a more detailed description, but the subject cannot be left without first reviewing the possibilities opened up by the introduction of repeaters in the lines of modern communication.

By the use of telephone repeaters the public is now receiving high grade telephone transmission over very long distances such as could only be otherwise accomplished by the use of heavy copper line wires and other apparatus, the cost of which would be prohibitive. Repeaters can also be applied effectively to reduce the cost and annual charge on new lines of medium length by virtue of the small wires permissible and, from the standpoint of expenses and profits, this is of even greater importance than effecting a saving on a few circuits of extreme length.

CARRIER CURRENTS

"Carrier" current telephony and telegraphy is the technical term used to describe the superposing of additional circuits on a pair of line wires, through the medium of high frequency currents. Interference between the various circuits is prevented by differentiating between the frequencies of the several carriers, and as the transmission efficiency decreases rapidly as the frequency increases, the frequency must be kept to its lowest practicable value.

In a multiplex system, therefore, to obtain a maximum number of separate circuits or channels, each circuit must confine itself to a narrow range of wave-lengths, differing as little as possible, consistent with efficient operation, from the other ranges used. To secure these conditions a tuned circuit having a single inductance and a condenser is employed, this circuit transmitting energy of one specific frequency alone, and reflecting energy of all other frequencies. However, this entails an appreciable loss, and a series of electrical networks has been devised to reduce this loss to a minimum. This invention—the filter—and the vacuum tube, its sister invention, have revolutionised carrier current transmission.

The Western Electric Company has three general types of carrier systems in use, the three channel carrier telephone, the four channel carrier telephone and the 10 channel carrier telegraph. All systems are designed to fit in the plant and operating arrangements now standard in the most up-to-date telephone systems, the circuits obtained being often more efficient than those already existing. The only attention necessary, when the systems are in operation, is that the toll test-board man should see that the filament currents and other adjustments are correct.

The systems are designed to be used on long open wire lines, and as the standard equipment is elaborate and, consequently, fairly expensive, its application to short lines is not an economical proposition. It has not yet been found practicable to apply the system to cable circuits.

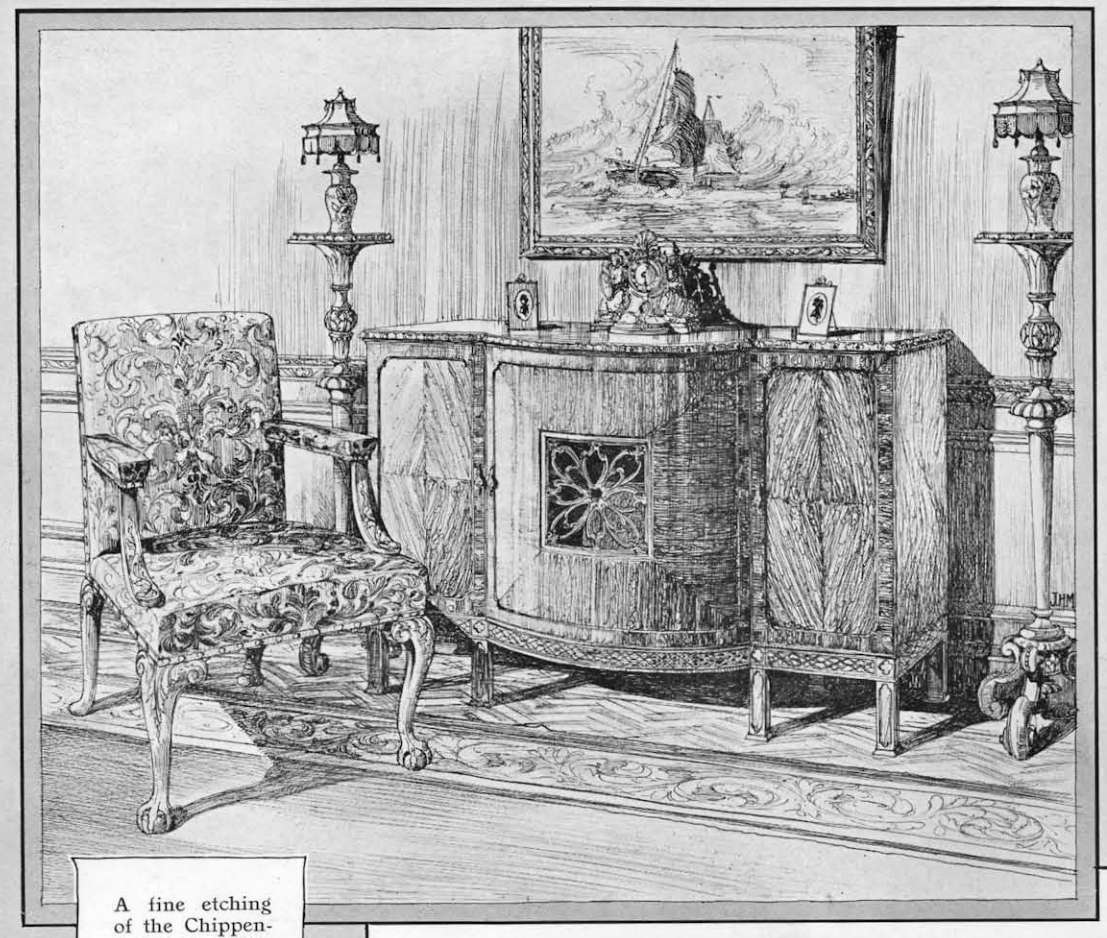
The systems comprise two carrier terminal sets, one at each end; and in most cases one or more intermediate carrier current repeaters. In addition, there are at all terminal and repeater points filter arrangements, called carrier composite sets, which separate electrically the ordinary circuit from the carrier circuits.

The outgoing carrier toll circuits are led to the carrier terminal instead of directly to the open wire lines. Signals, whether telephonic or telegraphic, are there made to modulate the carrier current in a modulator tube. At the receiving station, the signals are detected in a demodulator tube, amplified, and led to the toll switchboard in exactly the same manner as the ordinary low frequency signals.

The four channel carrier telephone system has been designed for long distance working. The equipment includes one spare receiving unit and one spare transmitting unit, and a repeater test unit is provided to facilitate maintenance.

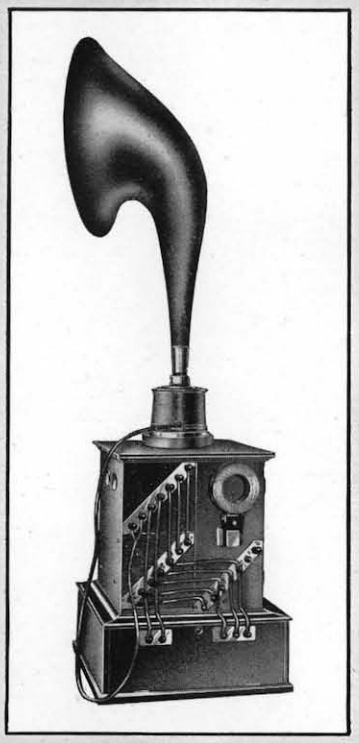
The carrier repeater is arranged to amplify the energies of all the carrier channels. The energy of the regular voice frequency circuit is bridged around the carrier repeater, either straight through or through a voice frequency repeater.

The three channel carrier telephone system differs in some respects from the four channel system, and is better adapted for smaller distances, between 300 and 400 miles. The "terminal" comprises three channel units (each consisting of the trans-



A fine etching of the Chippendale Cabinet Set. There are no external connections whatever

View of Cabinet Set, open, showing the compact arrangement of the apparatus



Rear view of "Weconomy" Receiving Set, showing the neat method of wiring

A complete "Weconomy" Receiving Set with Loud Speaker

mitting and receiving circuits for the one channel), a test unit and a power panel. The repeater used in conjunction with this system is the same as that used for the four channel system.

Carrier telegraph circuits are much superior to the ordinary low frequency telegraph circuits, especially on very long lines. This is due to the fact that the time lags introduced by mechanical telegraph repeaters are eliminated by the use of thermionic repeaters. It is interesting to note that these circuits have been successfully operated with high speed printing telegraphs.

Whereas, the system described above allows for a maximum of either four carrier telephone circuits, three carrier telephone circuits, or 10 duplex telegraph circuits, it is possible to utilise for carrier telegraphy, part of the spectrum of wave lengths now used for one or more carrier telephone channels. It is, for instance, possible, using in part the three channel carrier telephone and the 10 channel carrier telegraph system, to obtain two carrier telephone circuits and eight carrier telegraph duplex circuits.

The success of the system may be gauged from the following figures which give the total carrier channel mileage at present in commercial use in the United States.

System	*Length of Route Miles*	*Total length of Carrier Channels Miles*	*Percentage increase in Route through multiplexing by Carrier*
Carrier Telephone	4,776	16,576	347%
,, Telegraph	10,919	78,870	620%

APPARATUS AND SETS FOR WIRELESS RECEPTION

In the early months of the year 1922, more than six months before the now familiar broadcasting licences were issued, the Western Electric Company foreseeing a possible demand on the part of the public for simple wireless receiving sets, commissioned a section of highly trained experts to investigate the situation. So convinced were these experts that broadcasting could be satisfactorily accomplished and that it would ultimately add to the amenities of social life that application was made to the authorities for permission to erect and operate a wireless broadcasting station. The Western Electric Company, Ltd., although not alone in making an application, was certainly one of the very few companies which realized the immense possibilities and responsibilities attending such an undertaking.

The outcome of this was the formation of the British Broadcasting Company ; but that is another story. It suffices here to emphasise that the Company can justly claim to be among the pioneers of broadcasting in the British Isles.

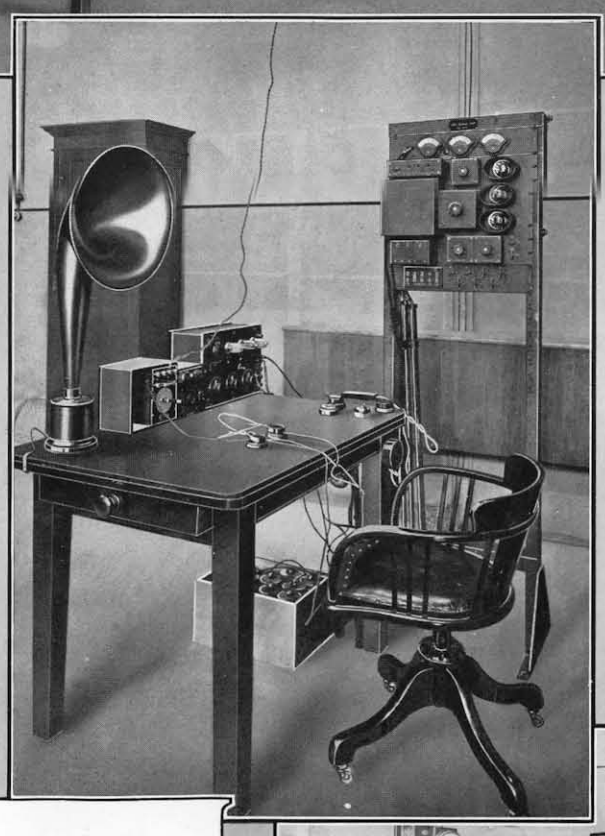
With commendable promptitude wireless head receivers and simple inexpensive crystal sets were produced ; over seven thousand being on the market before the official broadcasting licences were available. The excellent qualities of both the head receivers and the crystal sets were quickly appreciated by the trade and the influx of orders became so great that a scheduling system had to be adopted whereby a certain quantity of goods were despatched to the customers in strict accordance with the size and date of the order.

Then followed the production of valve sets of a variety too great to mention here. These also were eagerly sought, but perhaps the most conspicuous feature of the early days of the wireless broadcast movement in England was the striking success attending the introduction of the Western Electric Loud Speaker.

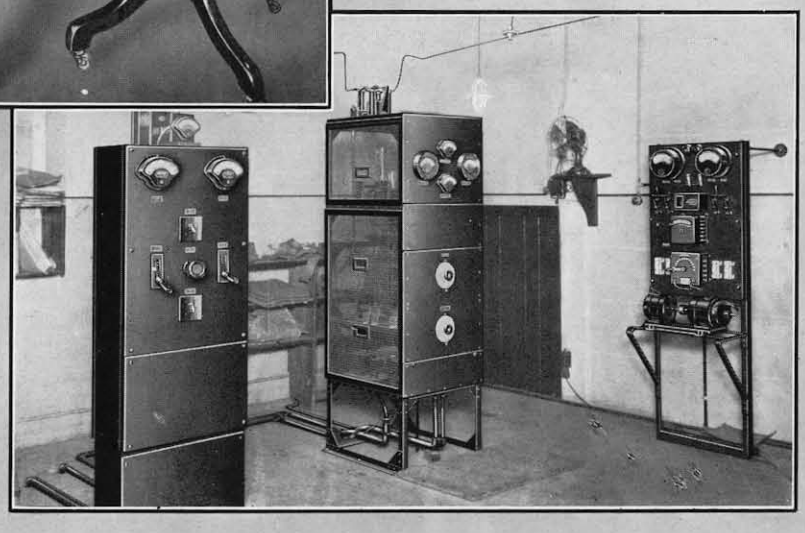
This is now produced in several forms, but the large Loud Speaker which operates on the balanced armature principle and has a non-metallic diaphragm was the original and is still the most generally favoured. A special power amplifier is supplied with the Loud Speaker, the two being known as the Loud Speaking Equipment. This power amplifier has played no unimportant part in securing the popularity of the equipment, and it is largely due to the close attention when designing the amplifier, to ensure freedom from distortion, that such excellent results are obtainable from the loud speaking equipment.

As might be expected, the possession of a satisfactory loud speaker paved the way for the production of complete wireless receiving sets constructed in cabinet form, and the Company is now producing superb wireless sets in any of the standard period designs. These cabinets are almost perfect pieces of craftmanship and may

Internal view of the Studio, Birmingham Broadcasting Station



Control Room of typical Broadcasting Station, showing special Input Panel



The Transmitting Equipment of a British Broadcasting Station

be classed not merely as wireless sets, but as artistic furniture which will enhance the appearance of the most luxuriously appointed reception room.

Referring back to ordinary valve receiving apparatus and amplifiers, it is interesting to note that the Western Electric Co., Ltd., from the commencement adopted and standardised a design which lent itself particularly to the building of complete sets by instalments or as it is sometimes called, on a " unit " system. Each unit, be it a detector set or an amplifier, is, with the exception of the batteries, self-contained and of such a size that it will range along with another unit or units when required. In this way one can start with a simple detector set and build up until a complete loud speaking assembly is obtained.

Another noteworthy feature incorporated in the design of the W.E. sets from the commencement of the wireless broadcast industry is that of enclosing the apparatus within the sets, leaving only the terminals and adjusting mechanism exposed. This renders the apparatus acceptable as permanent furniture in a home, whereas the sets as often constructed by the wireless enthusiast and others would probably not be tolerated once the novelty had expired.

In a science such as wireless telephony, development is extremely rapid, and even as this is written the introduction of the " Wecovalve "—a new W.E. low temperature valve which will operate from a single dry cell—bids fair to revolutionise the industry. Still, the standardised designs adopted by the Company are being retained ; the new valves and other modifications, as demanded by the recent discoveries, being added immediately the engineers advise the searching life and general durability tests are satisfactorily completed. Thus we shall see upon the market—perhaps before this publication appears—a complete range of new designs in wireless receiving sets using the " Wecovalve," or low temperature valve operating from dry cells which will be known as " Weconomy " Wireless Sets, the latter consuming less than one tenth of the electrical energy taken by the general type of valve hitherto commonly used on wireless receiving sets.

WIRELESS TRANSMITTING EQUIPMENT

On November 15th, 1922, the Birmingham Broadcasting station, equipped with the Western Electric radio transmitting set, was officially declared open. A description of the equipment used may be of interest.

The microphone of this set is identical with that employed in the Public Address System apparatus. The equipment for speech input consists of a three stage amplifier, with a reactance capacity coupling between the stages. The system of transmission is known as the " constant current " system, and has two 250 watt valves acting in parallel as oscillators, and another two acting as modulators. In addition, a 50 watt valve is employed to amplify further the output of the speech amplifiers, before it reaches the grids of the modulators. The continuous oscillations set up are transferred to the antenna circuit by indirect coupling, the antenna current being about 12 ampères. In order to filter out commutator noises, the high voltage plate supply of 1,600 volts is fed through a network of inductances and condensers. The antenna employed is strung at a height of 80 feet from the ground and is 110 feet long, consisting of four wires, spaced at intervals of six feet. The range of the apparatus is officially rated at 100 miles, but reports received testify to a greater transmission efficiency, messages having been received as far away as the Azores off the coast of Central Africa, and Ontario in the middle west of Canada.

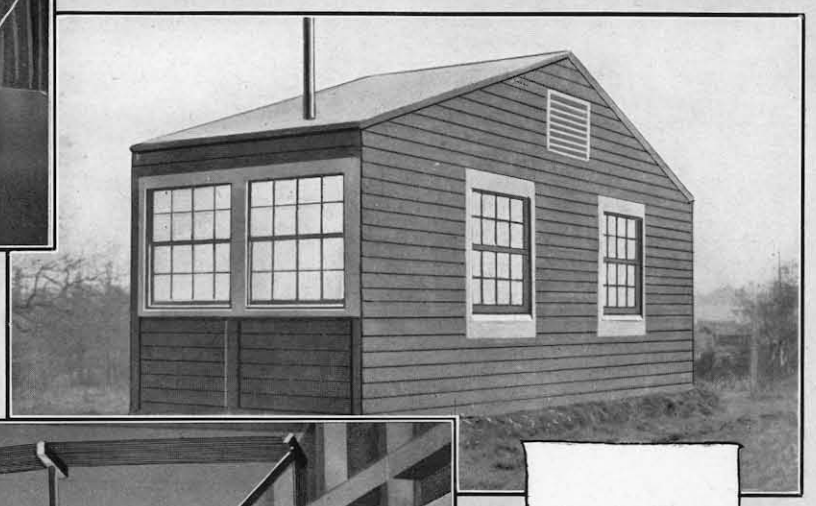
The Company have transmitting sets for all needs, the power in the aerial being 500 watts, 100 watts, 50 watts or 10 watts. They also specialize in equipments suitable for ship to shore transmission.

TRANSATLANTIC WIRELESS TELEPHONY

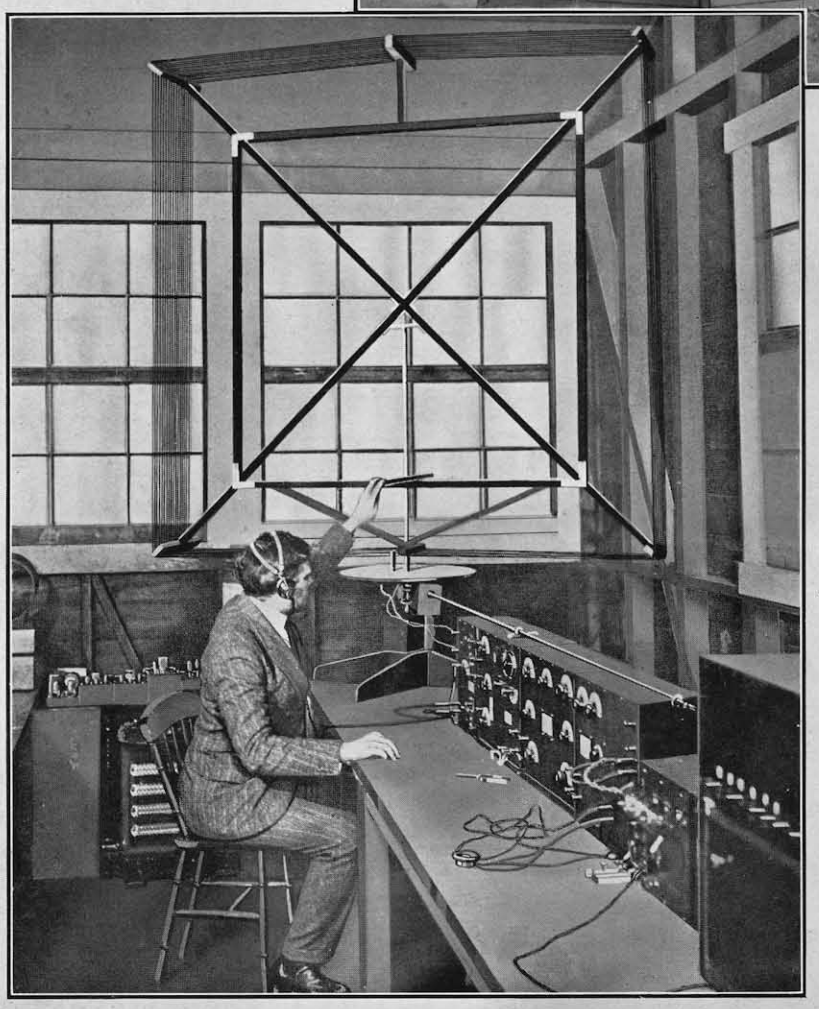
On the night of 14th-15th January, 1923, at the Company's works at New Southgate, a distinguished company of representative engineers, together with members of the daily and technical Press, listened for two hours to Mr. H. B. Thayer, President of the American Telephone and Telegraph Company, and others talking from 195, Broadway, New York.

For some weeks previous to the demonstration, the scientific staff of the American Telephone and Telegraph Company, in co-operation with the Radio Corporation of America, had been conducting experiments with special radio telephone apparatus and methods. During these experiments the engineers used the

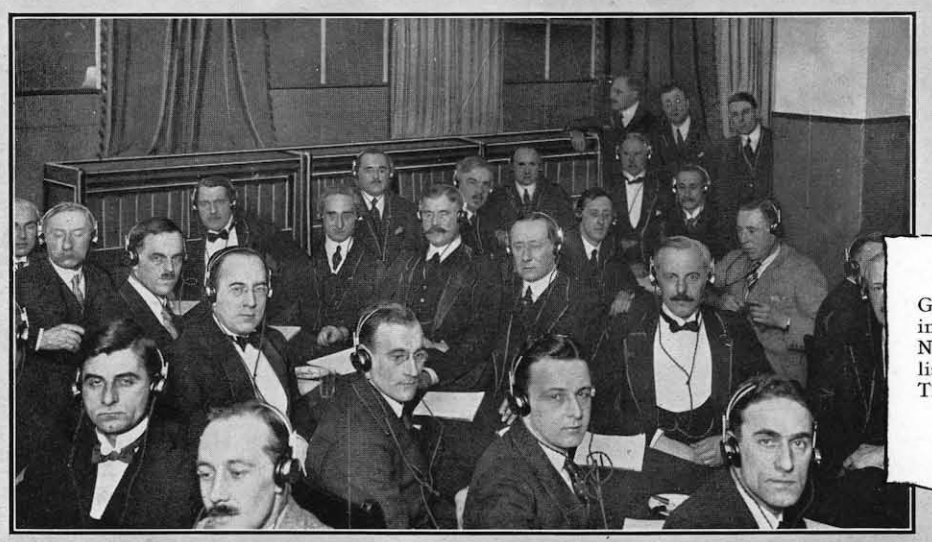
Mr. H. B. Thayer speaking from New York to the New Southgate Works



Exterior View of Hut housing the Receiving Equipment at New Southgate



Internal view of Hut showing Receiving Set with six-foot Frame Aerial



Guests assembled in the Library, New Southgate, listening to Mr. Thayer's message

station of the Radio Corporation of America at Rocky Point, Long Island, to send signals and words to Western Electric engineers at New Southgate, England, in order to observe results obtained under all possible conditions. On this eventful Sunday evening complete messages were scheduled for transmission, and President Thayer telephoned from his office to England, via Rocky Point Radio Station, as follows :—

" This is Mr. Thayer, of the American Telephone and Telegraph Company, speaking from 195, Broadway, New York City, through the Rocky Point station of the Radio Corporation of America.

" The radio apparatus and system used in this test is made possible by co-operation between the American Telephone and Telegraph Company and the Radio Corporation of America, and is the result of research and experimental work in the laboratories of the American Telephone and Telegraph Company, and in the laboratories of the Radio Corporation of America and its associated companies.

" In 1915 the American Telephone and Telegraph Company transmitted a message across the Atlantic by radio telephony from Arlington, Virginia, to the Eiffel Tower in Paris, where it was heard and understood by our own engineers and by others. During 1915 we also sent a telephone message from Arlington part way across the Pacific Ocean to the Hawaiian Islands, where it was heard and understood by our own engineers and by officers of the United States Navy. Since then great improvements have been made in the art, not only of radio, but of telephony and of radio telephony. In the experiments which we are now conducting we are making use of these improvements.

" Beyond a small group listening for this message in England, I do not know whose ears this message may reach. To all who hear it, I wish health and prosperity. Will you who are now hearing it inform me that you have heard it, and tell me how clearly it comes to you."

Mr. Thayer began speaking at nine p.m. New York time, corresponding to two a.m. Greenwich time, and at 9.11 information was received from England by cable announcing the complete success of the experiment.

General Carty, Vice-President, sent a message at 9.7 p.m. and at 9.14 a cablegram arrived reading : " Purves recognised Carty's voice." (This refers to Major T. F. Purves, Engineer-in-Chief of the General Post Office.) Further messages from Mr. Gifford, Vice-President, and others were all heard distinctly by the audience at New Southgate.

During the progress of the test, the British Press representatives cabled Mr. Thayer as follows : " Representatives of British Press congratulate American Telephone and Telegraph Company and Radio Corporation on their epoch making experiment, the success of which has exceeded their expectations, and in which they see the dawning of a new era in long distance speaking which will be of the greatest value to the Press of the World."

Toward the end of the experiment the loud speaker was used successfully. At four a.m. Greenwich time, the following message was sent by Mr. Gill, European Chief Engineer of the International Western Electric Company, and President of the Institution of Electrical Engineers : " Loud speaker now being used—good results—great enthusiasm. Your interview on loud speaker came through fine." A final message from Mr. Gill read as follows : " On conclusion of these most successful and historic tests which have made a profound impression, all those assembled at the London end wish to congratulate most heartily the American Telephone and Telegraph Company and the Radio Corporation of America."

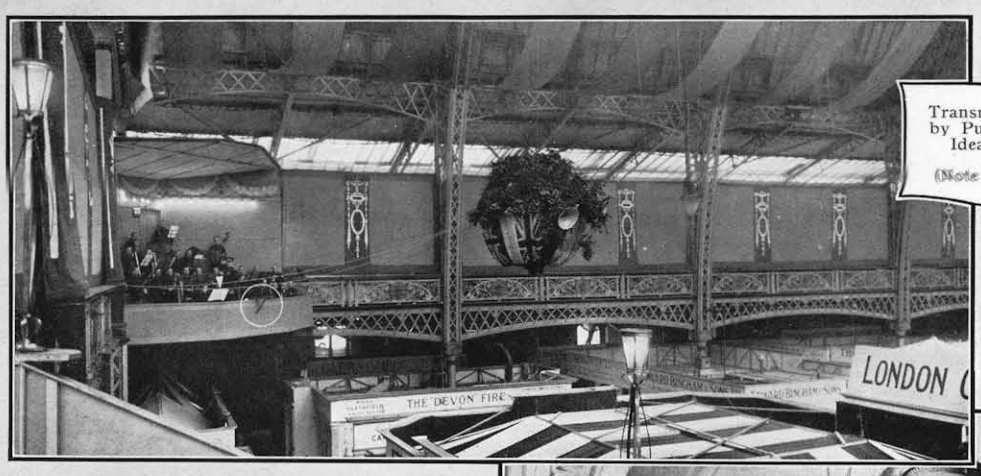
At the conclusion of the experiment Mr. Thayer issued a statement. He said : " These experiments are part of our effort to determine to what extent the radio telephone may ultimately be employed in talking across great bodies of water where talking through telephone wires is not feasible. We are making steady progress, but there is much more to be done before we can speak definitely about establishing practical commercial radio telephone service across the Atlantic.

" The tests we are now conducting are adding a great deal to the knowledge of the art. Some very important data has been obtained from the work of the American engineers sent to England, and of those here. The tests have been very rigorously conducted, and for weeks our scientific staff has been sending signals of many kinds under a great variety of conditions. Selected words with no context as a guide to their meaning have been repeated thousands of times. The quality of transmission at all times, and under all circumstances, and the functioning of the special receiving apparatus set up in England, as well as that in America, has been observed with extreme scientific care."

With this speech ended one of the most brilliant feats of scientific engineering that the world has seen.

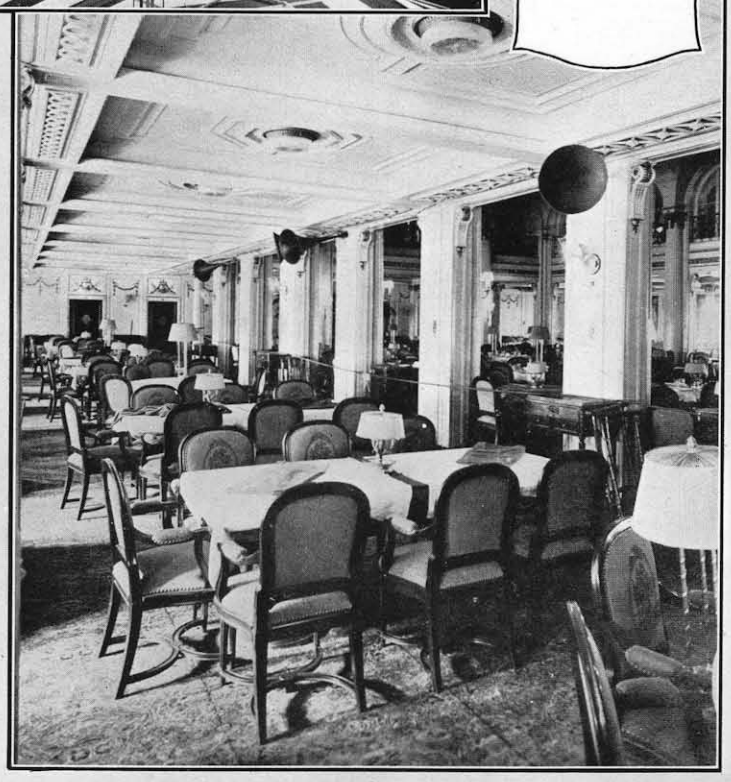
A Portion of a Sheffield crowd listening to the Public Address System

H.R.H. The Prince of Wales arriving at the Victoria Hall, Sheffield



Transmission of band music by Public Address System. Ideal Home Exhibition, Olympia
(Note Microphone in circle)

Public Address System installed in the *S.S. Leviathan*



The installation at the Polytechnic Sports, Stamford Bridge

A group of projectors in the Royal Gardens, Ideal Home Exhibition, Olympia

THE PUBLIC ADDRESS SYSTEM

Public speaking still plays an important part in our modern social and political life, and the introduction of a device which effectively overcomes the natural limitations of the power of the human voice must certainly be regarded as an epoch in recent scientific advancement of the telephone art.

The apparatus which accomplishes this remarkable feat is known as the Western Electric Public Address System and it will so magnify and distribute the voice as to enable a speaker to address an audience of several hundred thousands of people.

An exceedingly sensitive microphone forms the heart of the system, and by the skilful application of Thermionic Valves the necessity of speaking close up to the microphone has been eliminated, consequently the speaker has perfect freedom of movement during his address. Powerful amplifiers arranged in several stages with power vacuum tubes in parallel where necessary, together with many ingenious devices to prevent distortion of the sound wave currents, are used to magnify the feeble currents taken from the microphone. Finally, loud speaking projectors adjusted at the correct angles, distribute the sound waves uniformly over the area covered by the audience.

Through the medium of the Public Address System, many outdoor and indoor functions have been materially assisted, and an account of some of these activities may be of interest. At Lyons' Athletic Sports Meeting and at the Polytechnic Sports Meeting, announcements were made to the spectators through this system ; at the annual dinner of the Institution of Electrical Engineers in March and at *The Times* companionship dinner, the system was employed to convey the speakers' voices to every part of the hall ; in the latter case throughout five halls simultaneously. During the Brighton Carnival week the music of a single band was rendered audible along the sea-front, over a distance of one to two miles. By means of Western Electric loud speakers the Duke of York, speaking from Buckingham Palace, delivered an opening address to an assembly at the Agricultural Hall, Islington, and on the 30th May, 1923, H.R.H. the Prince of Wales gave his answering speech to the vast crowds who welcomed him in the streets of Sheffield. On this occasion loud speaking projectors erected in an adjacent hall enabled an additional assembly to hear His Royal Highness' reply.

The application of the Public Address System at Olympia, where orchestral music was distributed to all parts of the building including the new hall and the vestibules, is also worthy of notice.

THE WAR EFFORT

During the war years, the Western Electric Company, in common with all other patriotic engineering firms, devoted the whole of its resources to the assistance of the Allied fighting forces. The achievements of the Company were numerous, its inventions covered an enormous field, and to write down a record of them would be merely to compose a catalogue. We will therefore confine our remarks to a few of the more striking features of its works, the inventions perfected to combat the scientific devices of destruction which were being employed by the German armies.

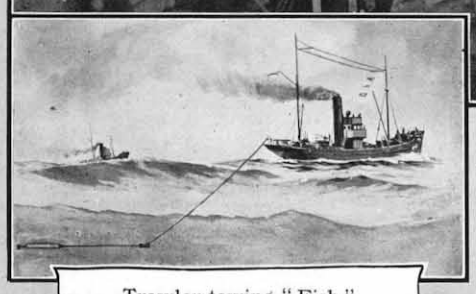
In 1915 it was discovered that a German listening post, using the then comparatively unknown valve detector, was picking up telephone messages concerning important British operations. The Western Electric Company investigated this problem, and after some research by the engineering department, Mr. G. Howard Nash, C.B.E., their chief engineer, successfully demonstrated to the War Office the working of a " Sound Barrage," a device which created continuous buzzing, and jammed reception in the German listening post.

The introduction of this system at a very critical period of military operations was an achievement of enormous value. During the same year, the Western Electric Company was engaged upon an even more important work, the detection of German subterranean mines, which were then wreaking enormous destruction amongst the Allied troops.

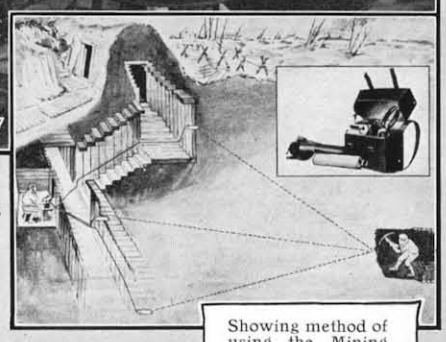
The Company's engineers were again successful, and the Western Electric Mining Detector was produced, which enabled our troops to locate the direction and the exact position of enemy mining operations.

It is not too much to say that this invention gave our tunnellers a complete ascendancy over the enemy. But it is not only towards land warfare that the Company's energies were directed. Probably its most important contribution to the war effort was a naval work—the invention of the Submarine Detector.

View of Trawlers showing "Fish" installed on deck

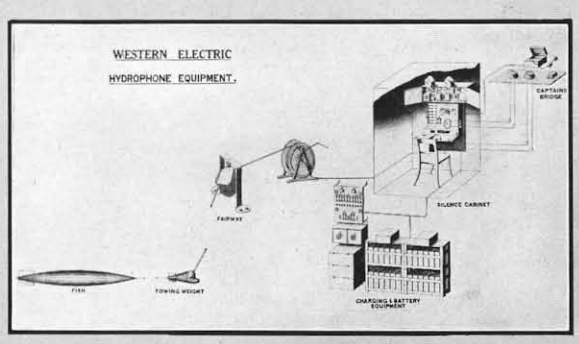


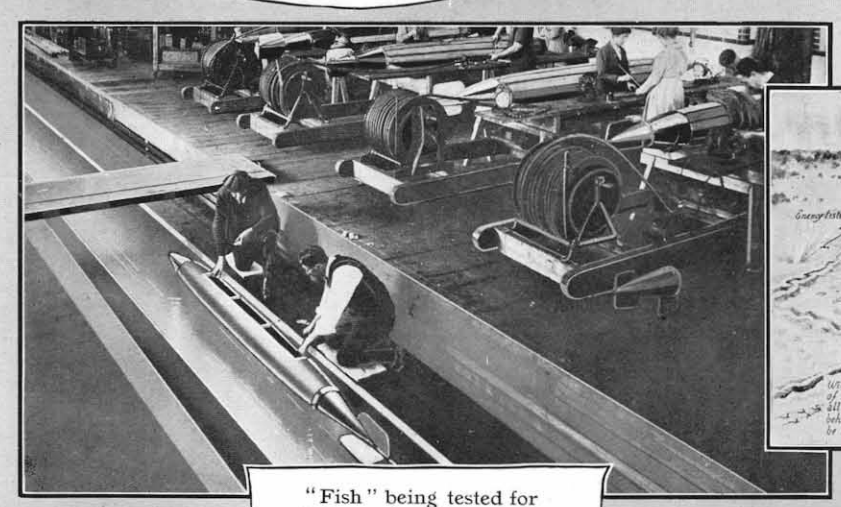
Trawler towing "Fish"



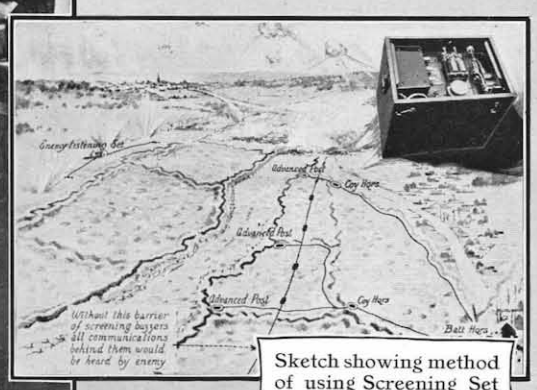
Showing method of using the Mining Detector

"Fish" Instructional Class Admiralty Training School





"Fish" being tested for balance in water tank



Sketch showing method of using Screening Set

Mr. G. H. Nash and his assistants again applied their ingenuity to a difficult problem, and again they triumphantly solved it. After considerable painstaking research, the Nash " Fish," a new form of hydrophone, was produced, and like its fellow inventions, this device was a complete success.

The Nash " Fish " hydrophone consisted of specially designed hydrophones fixed in a torpedo-shaped body, having buoyancy chambers at its extreme ends. The main body was filled with water, and the whole was towed from a cable suspended over the ship's stern at a given distance beneath the surface of the sea. The hydrophone was placed in a water-filled body in order to overcome interference from water noises outside. This hydrophone fulfilled practically the same conditions as the mining detector, enabling the listener to ascertain not only the presence of a submarine, but also its distance from the listening position.

The Admiralty fitted the " Fish " to over 200 trawlers and destroyers, and established a special school at Portland for training officers and men in the use of this gear. The ships thus equipped were also fitted with special depth charge throwing devices, and three patrols of submarine hunters were established ; North-East of the Shetlands, South of the Devon coast, and in the Adriatic Sea.

The enemy submarines suffered heavily, and the knowledge of this new, unerring detector with its auxiliaries of death, the depth-charges, had an overwhelming effect on the *morale* of the crews.

There are numerous other war inventions of the Western Electric Company, but these three stand out pre-eminently. Judged on them alone, the value of the Company's war service appears immense—almost incalculable.

EPILOGUE

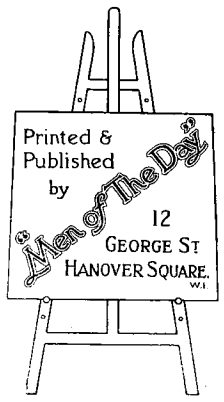
The story we set out to narrate is ended, and all too soon. On glancing back through this manuscript we feel that the record therein is insufficient, so much has been condensed, and so much omitted. Yet in these fragmentary pages alone there is a wealth of effort and achievement, the value of which it is impossible to estimate. Research, failure, investigation, disappointment, and discovery—all these have had a share in each undertaking until the ultimate success has been recorded, the product tested, and found good.

Your imagination must overleap the barriers of barren fact and coldly printed detail. There is life behind them all, the life of a vital organisation, the Western Electric Company, Limited.

The measurement of success achieved by the Company has been made possible through the work of the individual alone. It is difficult to be wholely conscious of this relationship to world progress, yet every man who does his job to the best of his ability is contributing something to the advancement of the world, every man who has something to design, manufacture, or sell, or whose job is in any way connected with the marketing of telephone equipment is helping people to talk with each other and thereby to understand each other to the end that there may be a greater and wider universal understanding.

It is the corporate spirit that produces such achievements, the sense of brotherhood and service in a vast community whose united aim and ideal is to build something which will last and will leave the world a little better off than we found it.

Realising this, we appreciate the worth of the Company, not only in perfecting the art of world communication, whereby nations are helped to understand nations, and the path to world peace cleared and built anew, but in the binding of man to man upon a common endeavour seeking in unity a common ideal—the advancement of international communication.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