ELECTRICAL COMMUNICATION

JULY 1930 No. 1 VOL. 9

ELECTRICAL COMMUNICATION

A Journal of Progress in the Telephone, Telegraph and Radio Art

H. T. Kohlhaas, Editor

Published Quarterly by the

International Standard Electric Corporation

Head Offices
67 BROAD STREET, NEW YORK, N. Y., U. S. A.

European General Offices
CONNAUGHT HOUSE, ALDWYCH, LONDON, W. C. 2, ENGLAND

G. E. Pingree, President L. N. Rock, Secretary H. B. Orde, Treasurer

Subscription $3.00 per year; single copies 75 cents

Volume IX JULY, 1930 Number 1

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1829 1929

To

Den Polytekniske Læreanstalt, Kobenhavn.

From

The International Standard Electric Corporation.

GREETING: On the occasion of the Centenary of the foundation of DEN POLYTEKNISKE LÆREANSTALT, KOBENHAVN, the INTERNATIONAL STANDARD ELECTRIC CORPORATION desires to offer cordial CONGRATULATIONS to all Members of your noble Institution.

The Centenary recalls the immortal Triumph of HANS CHRISTIAN ØRSTED who having in 1820 wrested from Nature the Secret now known as Electro-magnetism, established in 1829 with the support of the Royal House of Denmark, your College that has ever cast lustre upon the cause of physical science.

From the crucial experiments of ØRSTED were in due time developed the Electro Magnetic Telegraph, the Dynamo, the Telephone & a mighty array of other Discoveries of incalculable service to Mankind, concerning which this Celebration is an appropriate Reminder of the Significance of the Work of Members of DEN POLYTEKNISKE LÆREANSTALT who throughout the Century have in various ways contributed so conspicuously to the Advance.

The INTERNATIONAL STANDARD ELECTRIC CORPORATION welcomes this opportunity to express admiration long felt for the Response of DEN POLYTEKNISKE LÆREANSTALT to the Needs of the present age in Technical Learning, Mathematics, Research and Scientific Literature appertaining to Electrical Communication throughout the World.

With Confidence may DEN POLYTEKNISKE LÆREANSTALT OF KOBENHAVN go forward, assured that the Resource, the Perception and the Zeal that have made illustrious your past achievements will be in evidence in successes even more brilliant in the Centuries that await your Efforts.

Dated this 30th day of August 1929.

President.

Vice President.

Vice President.

Black and White Reproduction of the Illuminated Address Tendered by the International Standard Electric Corporation to the Royal Technical College, Copenhagen, on the Occasion of its Centenary Celebrations.

A Link with Örsted

Centenary Celebrations at the Royal Technical College, Copenhagen

AMONG the first of the technical colleges opened during the early part of the nineteenth century was The Royal Technical College (Den Polytekniske Laereanstalt) in Copenhagen, Denmark, which was founded in 1829 by Professor H. C. Örsted, the discoverer of electro-magnetism. From the outset, the thoroughness of the training afforded drew favourable attention to this College, and the research work carried out in the laboratories by some of its most eminent professors has secured for it an enviable reputation in the scientific world. It is not surprising, therefore, that the centenary celebrations elicited congratulatory messages from other colleges and from scientific and commercial institutions the world over.

It is of interest to recall that the College was instituted by order of King Frederik VI of Denmark, and that the founder, Hans Christian Örsted[1] became the first principal of the College, a position which he occupied with distinction until his death on March 9, 1851. The present principal is Professor P. O. Pedersen.

In the first year the College had only 22 students, who received instruction from six teachers, a staff which seems ample but for the fact that three of these instructors held professorial posts, one was a lecturer at the University of Copenhagen, and another an art school professor. In the centenary year, however, the College housed approximately 1,000 students, while the teaching staff included thirty-six professors, twelve assistant professors and lecturers, sixty-two instructors, a considerable number of laboratory assistants, machine hands and others.

For sixty years the College remained near the University, where it was started by Örsted, and during this period all available space in the neighbourhood was used for extensions. When this space was outgrown, the College was moved, in 1889, to its present site, and was installed in entirely new buildings consisting of four wings enclosing a square; to this group have been added the further extensions which house the College today.

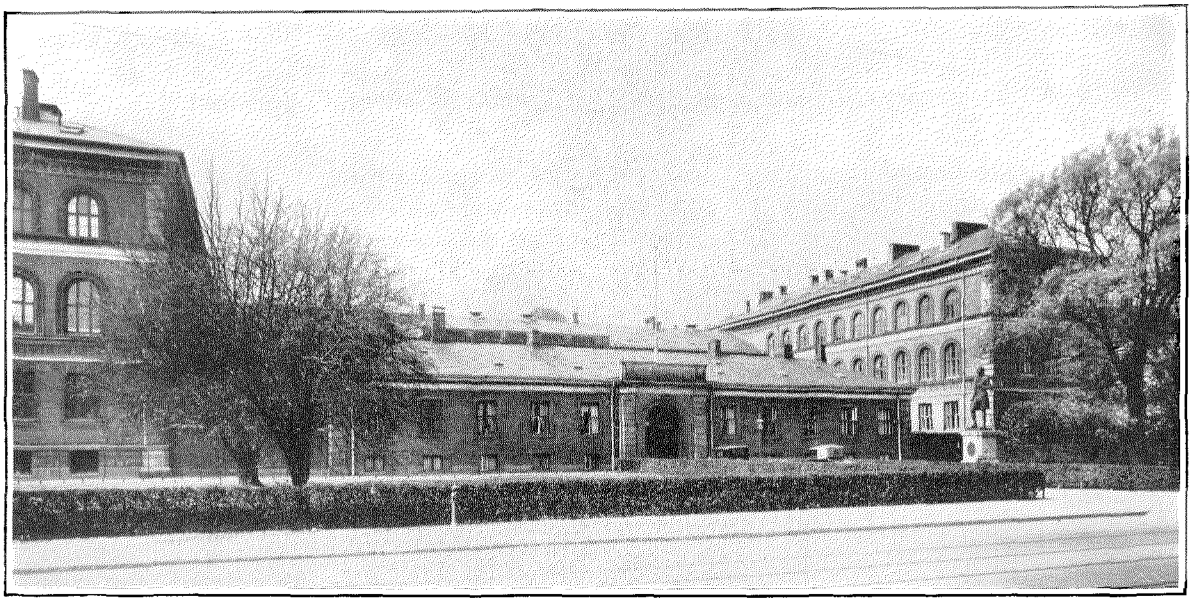
At the time these premises were completed, there were 235 students, for whom there was ample accommodation in the new buildings. The steady influx of students soon raised the problem of additional accommodation, and in 1906, by which time there were about 800 students, two more wings, for instruction in power plant and electrotechnics, respectively, were added to the original buildings.

In its centenary year, with its roll of students increased to 1,000, the work of the College again became handicapped for lack of space. Fortunately, however, a large piece of ground adjoining the College has recently become available for building, and on this site are planned extensions which, when completed, will represent a capital expenditure of about £500,000. A start has already been made on the new extension, and a large building, expected to cost about £60,000, is now under construction, for the teaching of chemistry. With the completion of the latest extensions, the College will again be in a position to offer the best and most up-to-date training that the resources of a comparatively small country will allow.

Officially the centenary day was January 27, 1929, as it was on this day a hundred years ago that the Royal Assent to the foundation of the College was given. But owing to the large amount of pressing work on hand at the time, the celebrations were postponed for some months. The postponement gave ample time for the formulation of an attractive programme, which was attended by many prominent guests from various parts of the world.

To mark the occasion, the Danish Engineers' Society organised a Congress of Engineers from the Northern countries, and Danish scientists arranged a meeting of Northern naturalists. Official congratulations were received from colleges and universities in sixteen different countries, and from a number of home and foreign technical and commercial institutions.

[1] For an account of Örsted, the reader is referred to *Electrical Communication*, April, 1928, pp. 181–196.



The Buildings of the Royal Technical College, Copenhagen, as Seen from the Roadway.

Norway, Sweden, Finland, Iceland, and Denmark itself were well represented at the celebrations, the attendance from these countries including about seven hundred engineers.

The celebrations started with an opening ceremony at the first session of the Engineers' Congress held in the Palace Theatre. Short speeches were delivered by the Presidents of the representative bodies, these being followed by lectures delivered by Professor H. Kreüger, of Sweden, and Professor P. O. Pedersen, of Denmark. In the afternoon, separate meetings

A View Inside the Square Which is Surrounded by the Four Wings of the Premises Built in 1889 to House the Royal Technical College, Copenhagen.

were held by the different engineering sections, and in the evening a series of sectional dinners were held.

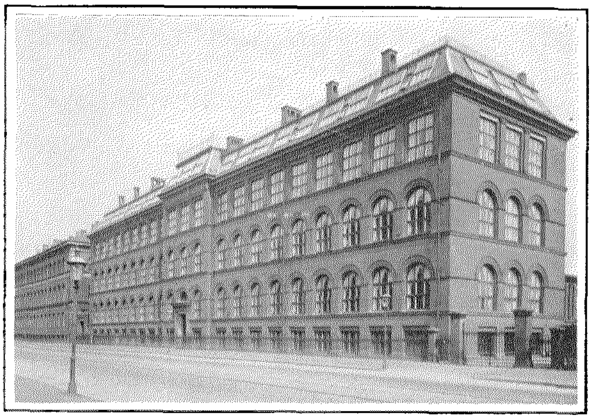
Sectional meetings occupied the morning of the second day, and these were followed by a luncheon at The Royal Technical College. About one hundred electrical engineers were guests at an informal luncheon arranged by the International Standard Electric Corporation at Wivel. The guests were received by Vice President E. A. Brofos, who presided, and by Messrs. J. Bache-Wiig and S. M. Gelberg.

In the afternoon, the foundation stone of the new chemistry building was laid in the presence of the Danish Prime Minister and a large number of the foreign guests. After the ceremony, excursions were arranged to various industrial establishments in or near Copenhagen. In the evening, special performances were arranged in the Royal and Scala Theatres.

The third day was devoted to the special centenary celebrations of the College. These were divided into two parts, the first of which occupied the morning, when there was assembled in the large Forum Exhibition Hall an audience of about three thousand people. King Christian X, Queen Alexandrine, Prince Valdemar, the Duchess Thyra of Cumberland, and members of the Danish Royal Family honoured the assembly by their presence.

Music composed for the occasion was played by the band of the Royal Guards, and a cantata was sung by students of the College. The principal, Professor P. O. Pedersen, then gave a short account of the history of the College, and twelve honorary doctorates were conferred.

Next followed the tendering of congratulations by the official deputations, who also offered for acceptance many beautifully illuminated addresses and other gifts. In view of the costly nature of the new buildings, it was appropriate that some of the gifts took the form of cash to



The Electrotechnical Wing, Which Was Added to the Royal Technical College, Copenhagen, in 1906.

a total amount of about £35,000, which sum was largely supplied by Danish industrialists and by funds for the advancement of science.

The second part of the celebrations opened with a banquet in the Forum, at which about 2,300 guests were present, including the foreign representatives, the Danish Ministers and many other officials.

For the following day, an excursion to the old castle of Kronborg was arranged for a party of about 1,000 persons. The East Asiatic Steamship and Trading Company had placed the *Fionia*, one of their large Diesel motorships, at the disposal of the College. At Kronborg a final meeting of the Engineers' Congress was held in the Knights' Hall of the Castle, and Professor E. B. Schieldrop, of Norway, gave a lecture on "The Position of the Engineer in the Technical Age." After a luncheon, at the Marienlyst Hotel, the party returned to Copenhagen on board the *Fionia.*

The celebrations were brilliantly concluded the same evening, when nearly 2,500 of those who had participated in the meetings were the guests of the city of Copenhagen at a reception and dance in the City Hall.

Carrier Systems in Spain

By O. C. BAGWELL and J. R. GOPEGUI

Compañía Telefónica Nacional de España

SUMMARY. *This article describes the rapid growth in toll service that resulted from improved local and long distance telephone service furnished by the Compañía Telefónica Nacional de España. By 1928 the growth of toll traffic was such that a very much broader program of toll construction had to be adopted. This included extensive carrier system installations as the quickest and most economical means of providing the increased number of circuits required. Tests and transpositions on existing lines to insure their suitability for carrier operation and the maintenance practice adopted are indicated. Results obtained by carrier operation have been most satisfactory.*

CARRIER systems for providing additional toll facilities have been considered as emergency measures, as a relief for postponement of the installation of cable, and as a permanent part of the toll network. In Spain carrier systems have filled all of these conditions besides being the means of increasing the toll facilities more rapidly than could have been done economically by the construction of additional open wire circuits.

During the year 1929, 16,950 kilometers of carrier circuits were placed in service in Spain, and the present program, which will be completed during 1930, calls for approximately the same amount of additional circuits, to bring the total to about 34,000 kilometers.

Telephone Development in Spain

To justify this development which at first seems abnormal, it is necessary to take a glance at the history of the telephone development in Spain.

In the year 1877 the first telephone was installed in this country. The line was run from a point in Barcelona to the castle on Montjuich, a distance of some four kilometers. The castle is situated on the mountain where the famous Exposition of Barcelona is located. In 1884 the first exchange was opened with seven subscribers. From that time until 1925, the growth of telephone service was slow due to the fact that the service was controlled by a large number of small companies and toll service was established only where there was the most urgent demand. It was impossible to talk from the cities situated at considerable distances apart, such as Barcelona and Sevilla, Vigo and Valencia, Bilbao and Málaga.

This state of things started to disappear when the Compañía Telefónica Nacional de España took over the operation of the network the latter part of 1924, and inaugurated an intensive program of reconstruction which to date has hardly slackened in intensity. The following table shows

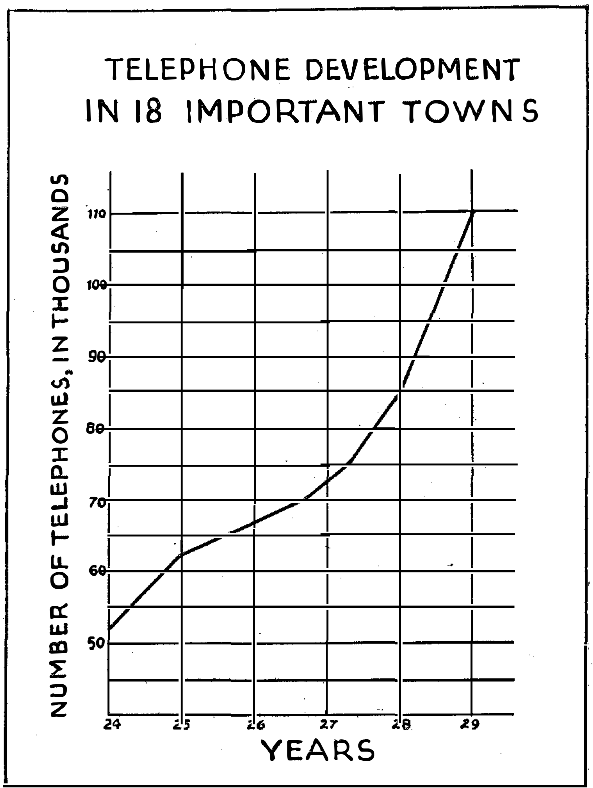


Figure 1—Growth of the Telephone in Eighteen Important Towns of Spain.

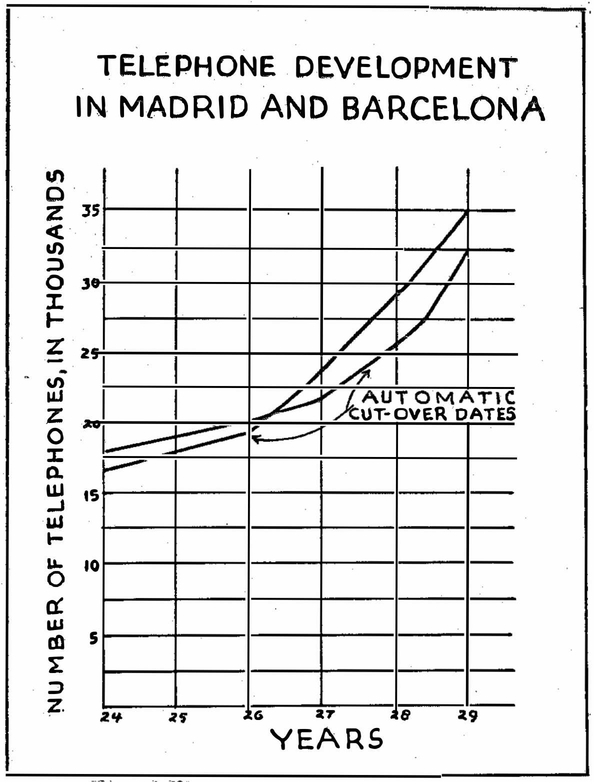


Figure 2—Growth of the Telephone in Madrid and Barcelona.

the growth of toll service during the five years the present company has been in operation:

Year	Number of Toll Calls	Per Cent. Over Previous Year
1925	3,187,000	......
1926	4,560,000	43.4
1927	5,655,000	24.2
1928	7,354,000	29.8
1929	10,145,000	37.9

A large part of this growth in toll traffic can be attributed to the improvement in the local telephone service, a marked increase in toll traffic having occurred in each of the 18 cities where automatic equipment was provided for the local service. These 18 cities represent the larger cities and in each case reconstruction includes the provision of a complete new outside cable plant as well as central office and subscribers' station automatic equipment.

Figure 1 shows the growth of telephones in eighteen important cities for the five-year period. Figure 2 shows the growth in Madrid and Barcelona and shows more clearly the growth coincident with the inauguration of the automatic service.

Growth in Toll Traffic

The rapid improvement of local telephone service, together with the improvements made in the toll lines, insuring a more rapid service and better transmission between toll centres, was followed by a rapid growth in toll traffic as shown by the table. By the middle of the year 1928 the trend of growth of toll traffic was found to be such that a very much broader program of toll construction was necessary in order to meet the future requirements of traffic, both normal and abnormal.

In view of this condition the Traffic Department were constantly asking for more circuits for relief, hardly daring to ask for the circuits which they considered necessary for two or three years' growth. The following table shows the number of circuits in service in some of the more important groups in 1928 and the number of circuits which were then considered necessary for the beginning of 1930:

Route	Existing in 1928	Required, 1930
Madrid-Barcelona..........	13	22
Madrid-Bilbao.............	6	12
Madrid-Granada...........	1	4
Madrid-León..............	2	4
Madrid-Málaga............	1	4
Madrid-Oviedo............	2	10
Madrid-Paris..............	2	7
Madrid-Sevilla............	3	13
Madrid-Valencia..........	3	9
Madrid-Vigo..............	1	4
Madrid-San Sebastián......	2	7
	36	96

Carrier Installation Program

After considerable study it was decided to adopt an extensive program of carrier system installations in addition to a normal program of new wire stringing as being the quickest and most economical means of providing the increased number of circuits shown to be necessary.

The map, Figure 3, gives the layout of the systems as planned for installation as rapidly as the equipment could be delivered. Up to December 14, 1929, the following systems were placed in service:

Route	Type of Systems	Km. of Channel	Repeaters	Date in Service
Madrid-Paris	C-3-S	1803x	2	Nov. 26, 1928
Madrid-Paris	C-3-N	1803x	2	Dec. 31, 1928
Madrid-Sevilla	C-3-S	1533	2	Feb. 12, 1929
Madrid-Sevilla	C-3-N	1533	2	Feb. 12, 1929
Madrid-Valencia	C-3-S	1122	1	May 13, 1929
Madrid-Valencia	C-3-N	1122	1	May 7, 1929
Madrid-Bilbao	C-3-S	1110	1	July 12, 1929
Madrid-Bilbao	C-3-N	1110	1	July 22, 1929
Madrid-San Sebastián	C-3-S	1758	1	Aug. 25, 1929
Madrid-San Sebastián	C-3-N	1758	1	Aug. 25, 1929
Madrid-Vigo	C-3-N	2298	3	Dec. 14, 1929

x—In Spanish territory.

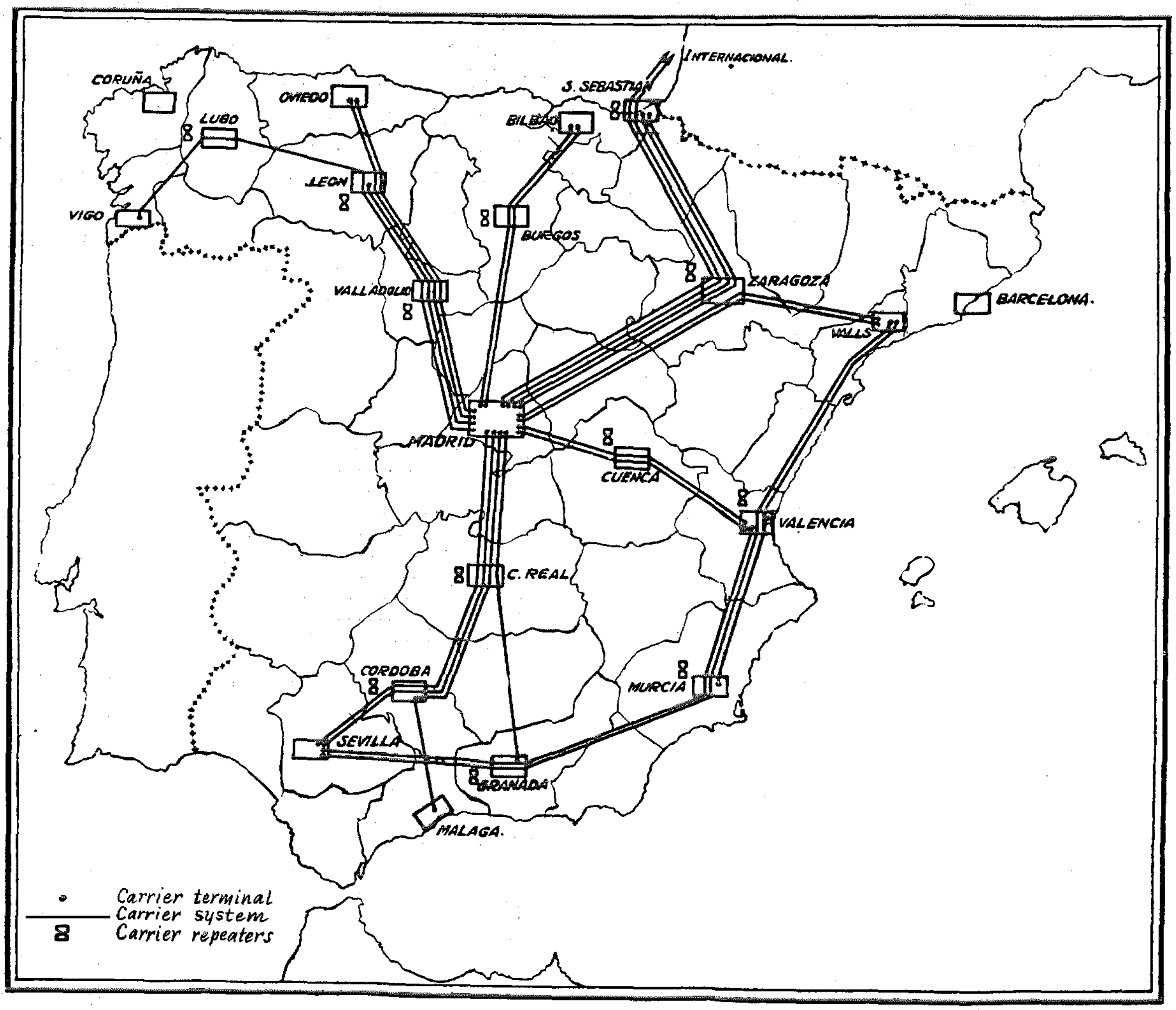


Figure 3—Carrier Channel Schematic, Representing 34,520 Kilometers of Channel.

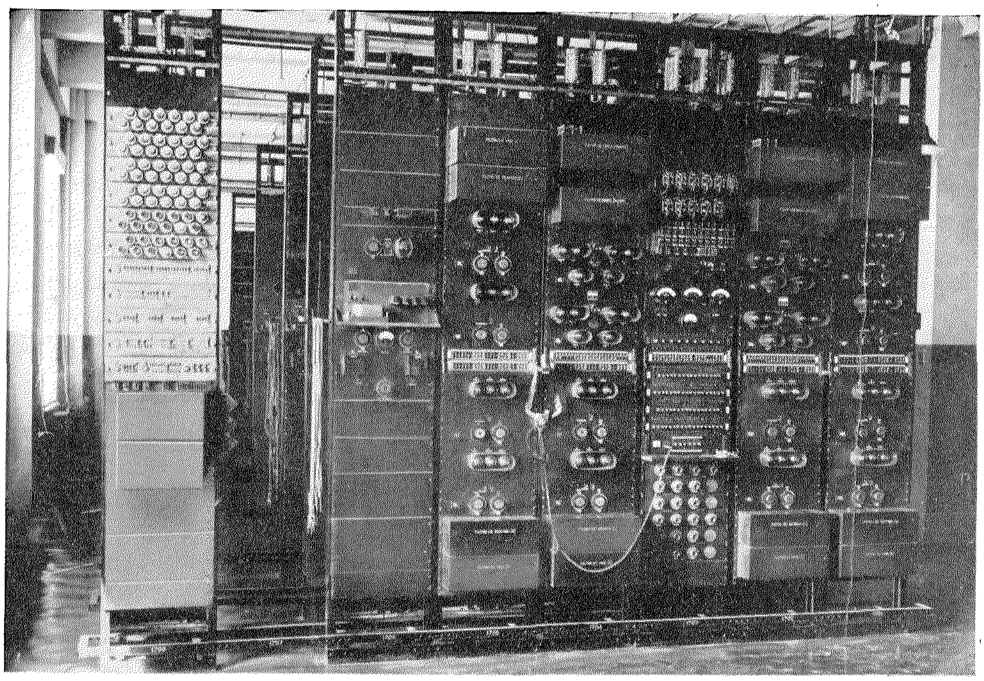


Figure 4—Carrier Terminal Equipment, Gran Vía Office, Madrid

The systems to be installed during the year 1930 are:

Route	No. of Systems	Km. of Channel	Repeaters
Madrid-Granada.....	1	1419	1
Madrid-León........	1	1086	1
Madrid-Málaga......	1	1677	2
Madrid-Oviedo.......	2	2844	2
Barcelona-Murcia....	1	1506	1
Barcelona-Sevilla.....	1	3102	3
Sevilla-Valencia......	1	2250	2
Madrid-Barcelona....	2	3276	1

Figure 4 shows the lineup of carrier equipment in the Gran Vía office of Madrid. Each line of bays contains all of the terminal equipment except the line filters and ringers for two systems. One bay consists of the fuse and lamp panels and the battery filters, one bay contains the pilot channel equipment, another the battery supply equipment, and four the modulators and demodulators, equalizers, and band filters.

Line Conditioning for Carrier

Before placing a carrier system in service it is necessary to know that the line conditions are such that proper operation will be assured. A comprehensive program of tests was carried out on the lines to be used, from which data were secured to determine the general characteristics of the lines and also any specific conditions which would need to be remedied to meet the requirements of carrier operation. These tests included measurements of attenuation, impedance, and crosstalk for the frequency range used in the carrier systems. Tests and studies were also made of cable entrances, where these existed, to determine where loading or other changes would be required.

The pole line construction methods are practically the same as those used in the United States. Three millimeter copper wire is used for the majority of the principal toll circuits with pin spacing of 30.5 centimeters on crossarms 3.1 meters long. The pole spacings average 50

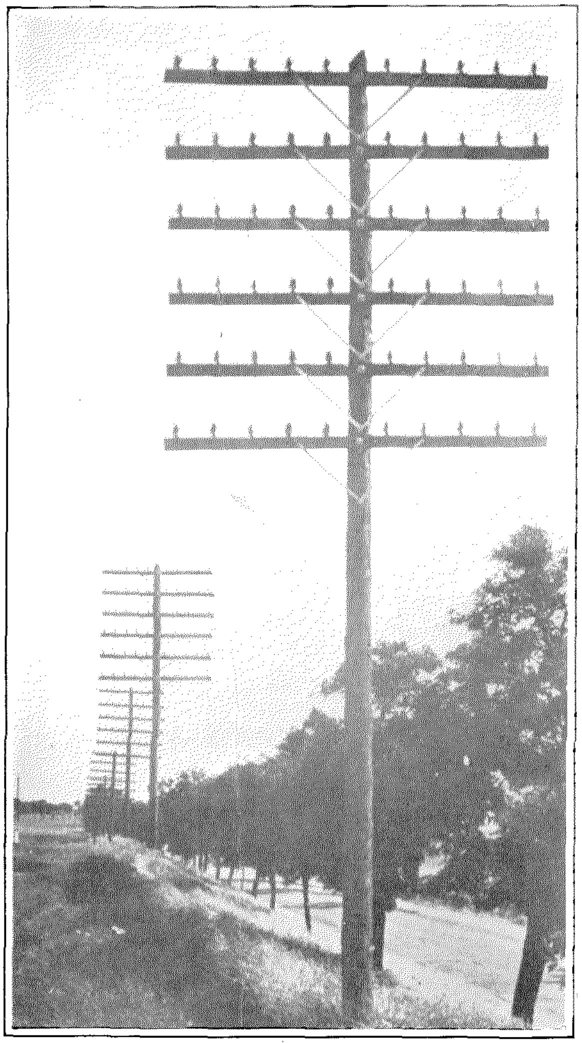


Figure 5—Toll Line near Madrid.

meters except in the mountain areas where snow and ice are apt to be encountered. Figure 5 shows a typical Spanish toll line in the congested area around Madrid.

Figures 6, 7, 8, and 9 give an idea of the characteristics of the open wire circuits over which the carrier systems will operate. The particular test results shown were those obtained on the section between Madrid and Ciudad Real, a distance of 187 kilometers on circuits located on the top crossarm of the lead.

Figure 6 shows the impedance of a circuit with a termination of 620 ohms, being the approximate characteristic impedance of the circuit as shown by tests with open and short termination.

Figure 7 shows the attenuation over the range of carrier frequencies and Figures 8 and 9 the near end and far end crosstalk between circuits on opposite ends of the crossarm.

Circuit Transpositions

These circuits are transposed to the exposed line system of transposition known as the E. and L. systems with approximately 400 meters between transposition points, corresponding to eight pole spans. This spacing has a distinct advantage where it is necessary to transpose for carrier operation as was done between Madrid and Zaragoza, a distance of 320 kilometers, and between Madrid and León a distance of 360 kilometers.

In the two sections of line just mentioned, it was necessary to operate four systems on the top crossarms and therefore necessary to retranspose the line to reduce the interference between the systems. As stated above, the present voice transpositions are on eight pole spacings and the superposition of the additional transpositions was accomplished without rearranging the present transposition on the other crossarms, having been placed on the second and sixth poles in each present eight pole section.

The physical circuit transpositions were made using the point transposition brackets, with which the turn over of the wires is completed at one pole, as illustrated in Figure 10.

The installation of these transpositions was carried out by first installing all brackets with the circuits in service. It was then necessary

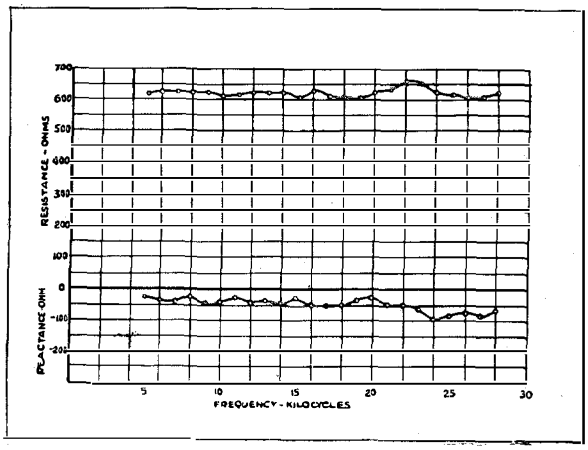


Figure 6—Impedance Measurements, Ciudad Real-Madrid 3 mm. Circuit Terminated at Ciudad Real by 620 Ohms.

to remove the circuits from service during the time necessary to transfer the wires. One phantom group was taken at a time and the work completed on this group for a convenient distance, some 20 kilometers, when this group was returned to service and the other group completed for the same section. The wires were untied for a distance of 12 to 16 poles on each side of a fixed point, usually a phantom transposition pole and the wires rolled at successive poles starting at the centre point until the wires occupied their proper places. The wires were then pulled to the proper tension and tied in. By this method a gang of 12 men was able to

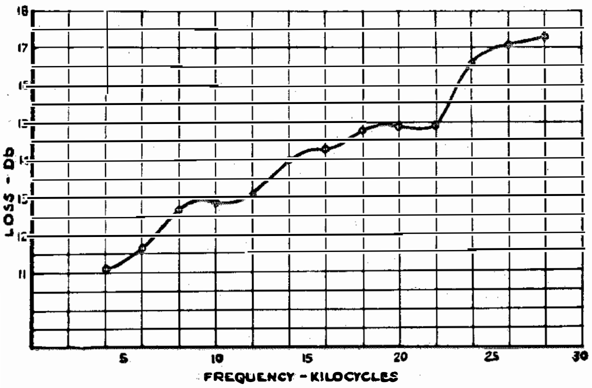


Figure 7—Transmission Measurements, Ciudad Real-Madrid 3 mm. Circuit Terminated at Ciudad Real by 616 Ohms.

complete an average of six kilometers of phantom group per day.

Concentration of Terminals at Madrid

With Madrid at the geographical centre of Spain and a number of main toll leads radiating in all directions, it was possible to concentrate all but three of the proposed systems with one terminal at Madrid. This is a distinct advantage from the standpoint of maintenance, as all routine tests are controlled from one point.

The longest distance from terminal to terminal of any system is from Sevilla to Barcelona (Valls), a distance of 1,034 kilometers, with three intermediate repeater points, namely, Granada, Murcia, and Valencia. The shortest system is from Madrid to León, a distance of 362 kilometers, with one repeater point at Valladolid.

The concentration of terminals at Madrid

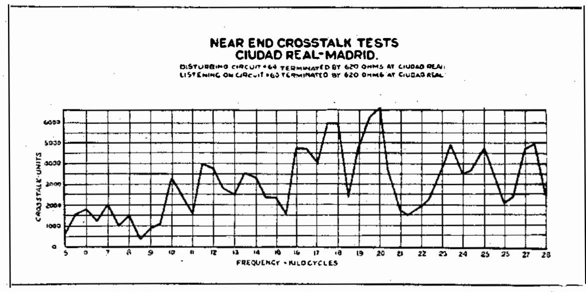


Figure 8—Near End Crosstalk Tests, Ciudad Real-Madrid Disturbing Circuit No. 64 Terminated by 620 Ohms at Ciudad Real. Listening on Circuit No. 60 Terminated by 620 Ohms at Ciudad Real.

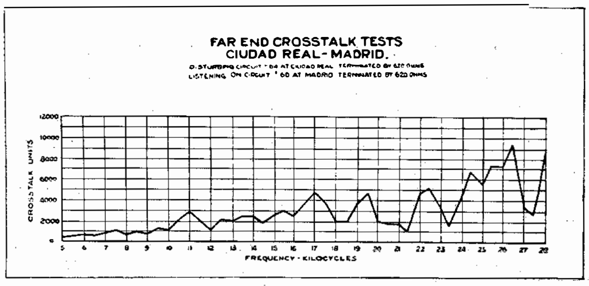


Figure 9—Far End Crosstalk Tests, Ciudad Real-Madrid Disturbing Circuit No. 64 at Ciudad Real Terminated by 620 Ohms. Listening on Circuit No. 60 at Madrid Terminated by 620 Ohms.

required special consideration for proper entrance facilities. These were provided by carrier loading eight quads in each of two entrance cables, one to the north with a length of 7.4 kilometers and one to the south with 6.7 kilometers. Both cables were 16-gauge quadded cables comprising both aerial and underground sections. The location of the loading points was

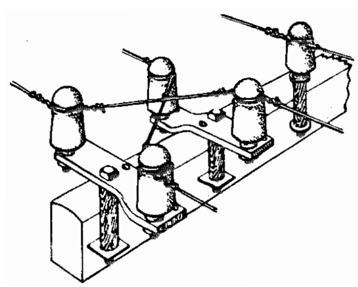


Figure 10—Physical Circuit Transpositions Using Point Transposition Brackets.

greatly aided by the fact that through the congested part of the city the cables are brought through large underground tunnels which carry the water supply pipes for the city. As the cables are racked on the walls of the tunnel and are exposed for the entire length, it was possible to make accurate measurements of

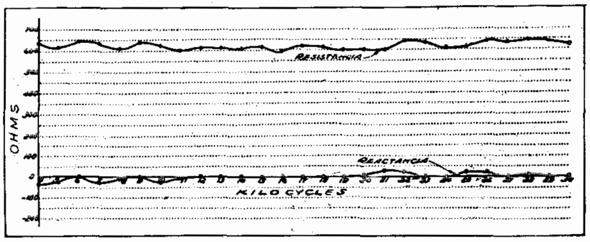


Figure 11—Impedance on Carrier Loaded Pairs. Termination 620 Ohms.

cable lengths and locate the loading pots at any point desired, thus avoiding the necessity of building out for capacity.

Figures 11, 12, and 13 show test results for impedance, attenuation and crosstalk on carrier loaded pairs in the south cable.

Pilot Channels

For the overall supervision of the transmission on the carrier systems, pilot channels are provided on the general basis of having a pilot channel on each carrier system having two or more intermediate repeaters and one pilot channel for each two carrier systems on the same lead and with both terminals located in the same office at each end and with only one intermediate repeater. This apparent generous use of pilot indicator systems is justified on the

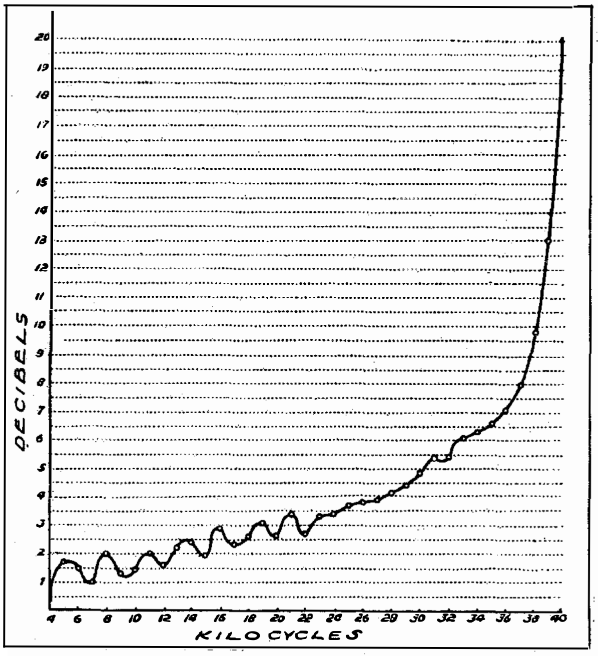


Figure 12—Attenuation on Carrier Loaded Pairs.

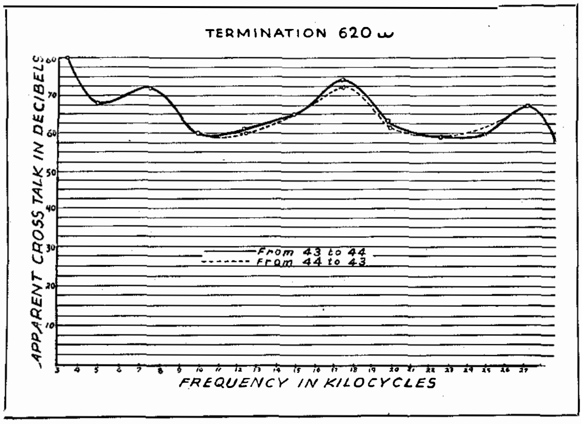


Figure 13—Crosstalk Between Carrier Loaded Pairs Nos. 43 and 44.

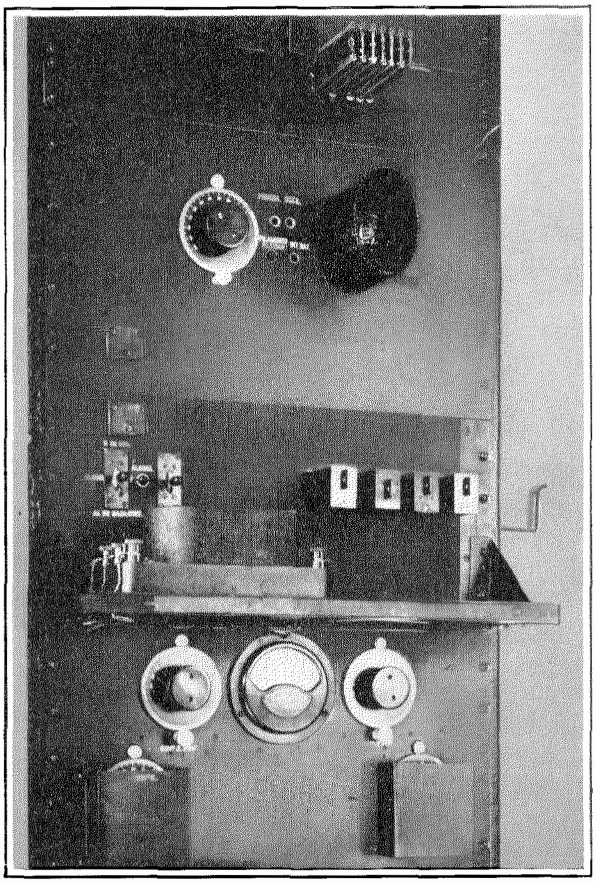


Figure 14—Pilot Channel Equipment at Terminal Station.

basis of the importance of the circuits and the fact that the maintenance was placed in the hands of a personnel inexperienced in the maintenance of this class of equipment. The visual indicators at the terminals and the repeater stations and the alarm at the terminal insures a close attention to the overall condition of the carrier circuits and a quick means of readjustment in case of variation.

Figure 14 is a photograph of the pilot channel equipment at the terminal station. The upper panel is the oscillator for the current to be transmitted to the distant station. The middle panel with the voltmeter relay contains the alarm equipment which gives an alarm when the loss over the circuit varies by about one and one-half decibels above or below the normal. The lower panel contains the tuning condensers and the meter which gives a visual indication of any variation in the overall loss of the circuit.

Maintenance

At the time of placing the first systems in service, a simple instruction was issued to the maintenance men in charge of the stations giving only the detailed method of making the various routine tests to be carried out, without any explanation as to the general operation of the circuit. This enabled the most inexperienced mechanic to carry out routine tests as instructed from the central office. After becoming familiar with the methods of making various tests and studying the circuit drawings, aided by a traveling inspector, the men soon became proficient in properly maintaining the carrier equipment and in locating troubles. More general and descriptive instructions are being prepared further to aid and develop the maintenance personnel.

Experience with Carrier Operation

The results obtained by the intensive program of carrier installation in Spain eloquently demonstrate the importance of careful consideration of its possibilities in all toll networks involving long open wire routes. Time lost on the carrier channels has averaged less than that on the physical circuits.

The Gamewell Fire Alarm and Police Telephone System Installed in the City of Liverpool

By E. M. S. McWHIRTER

Standard Telephones and Cables Limited, Hendon

SUMMARY. *This article describes the requirements of a combined Fire Alarm and Police Telephone System and the methods adopted for meeting these requirements. In addition, the layout of the area, the equipment, and apparatus are described and the circuit features indicated.*

THE operating principles and apparatus employed in the Gamewell Fire Alarm System were described in *Electrical Communication*, issue of April, 1928. Since that time, a combined Fire Alarm and Police Telephone System has been manufactured and installed for the City of Liverpool. As the requirements laid down by the Corporation Authorities were in some respects novel, considerable development work was necessary to secure the desired results. The requirements, broadly, were as follows:

1. The Fire Alarm System to be operated on the Closed Circuit Principle.
2. All Fire Alarm Calls, transmitted in code repeated twice, to be simultaneously and automatically received at the associated District Fire Station and at the Central Fire Station.
3. All Fire Alarm Calls to be received without interference; and, in the event of two or more boxes being operated in the same circuit simultaneously, no interference shall occur, the boxes transmitting the calls in succession.
4. In the event of a fire alarm box circuit being broken, the apparatus shall automatically set itself in a condition for receiving alarm calls over the broken lines, the feature of non-interference and succession, as in 3, being fully retained.
5. The Police Telephones to be operated over the same street lines as those used for the Fire Alarm System, but the Fire Alarm System to be in no wise interfered with or delayed by the operation of the telephone system, the telephone boxes being mounted back to back with the Fire Alarm Boxes.
6. Facilities for calling the Central Police Exchange from any Telephone Box on the system and for the Central Police Exchange to be able to connect any box to any Police or Fire Station on the system or to any other box.
7. A few of the Police Telephone Street Boxes to be equipped so that the Central Police Exchange can call attention to the box by lighting a lamp and also operating a visual signal.
8. A few of the Police Telephone Street Boxes to be equipped with a key displayed behind glass so that a member of the public can by breaking the glass obtain access to the police telephone.
9. The Fire Alarm Boxes to be designed so that it is only required to break a glass and pull the handle, so exposed, to transmit the alarm call.

Layout of the Area

The area of the City of Liverpool is divided into eight districts for the purposes of fire protection, seven being served by a District Fire Station and the eighth being the area around the Central Fire Station, which constitutes the Brigade Headquarters. The Corporation Authorities decided initially to equip the City with 200 street alarm points and these are distributed over the eight districts to the best advantage, so that the distance from any building to the nearest alarm point is a minimum. The lines connecting the District Stations to the Central Station and the lines forming the street box circuits are rented from the General Post Office, which stipulated a maximum of 70 volts for the battery pressure for these lines which are of 20 lb. copper or its equivalent. This voltage limitation, coupled with the possibility of future extensions, governed the length of the line circuit possible to enable a current of 100 milliamperes to be maintained. The most economical arrangement was found to be to arrange the 200 street points in 17 box circuits.

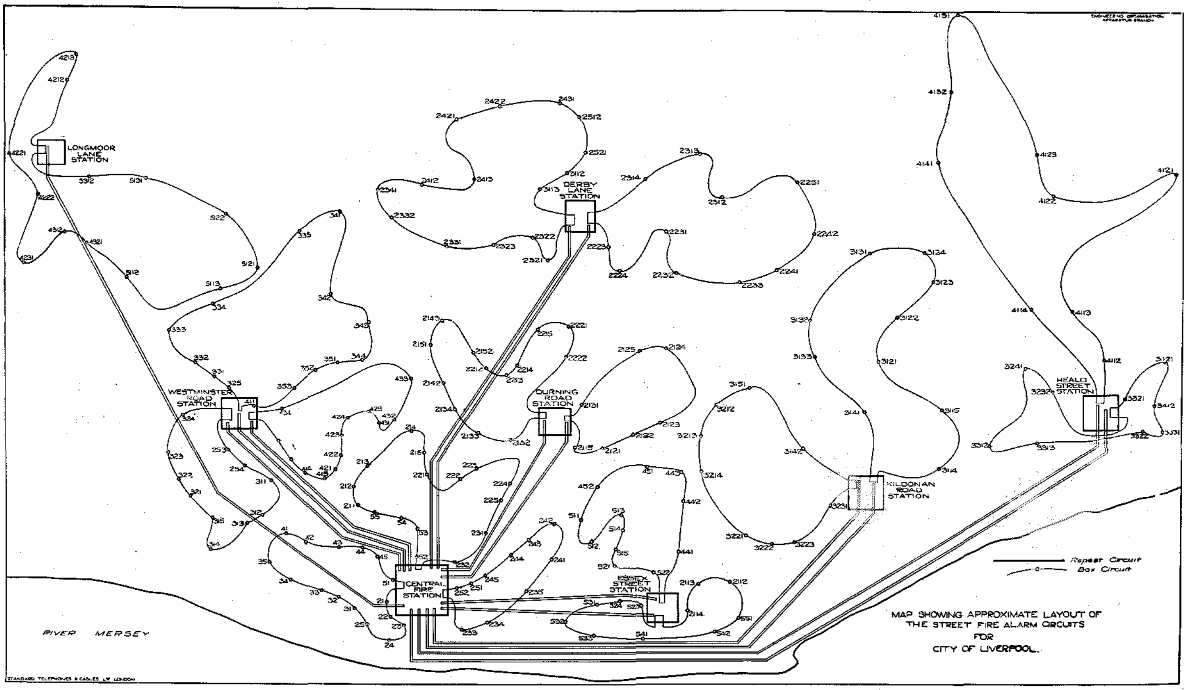


Figure 1—Layout of Street Fire Alarms.

The layout of these box circuits and the positions of the stations are shown on a map of the City, Figure 1. The box circuits form closed loops commencing and terminating at the same station. Each box circuit is complete with its own batteries and recording apparatus. To transmit the alarm calls received at the District Fire Stations to the Central Station, a pair of line wires for each box circuit is provided, connecting the District Station to the Central Station and forming a Repeat Circuit. Thus each box circuit has an associated repeat circuit, the alarm calls received in the box circuit being relayed on to the repeat circuit at the District Stations to operate recording apparatus at the Central Station. The batteries for the repeat circuits are all located at the Central Fire Station, and the alarm calls are automatically timed and dated at this station.

Fire Station Equipment

The control switches, rheostats, meters, battery-charging apparatus, etc., required for the operation of each box circuit and each repeat circuit are mounted upon polished grey marble panels which are individual to each circuit. By this means each circuit becomes a unit complete in itself and independent of any faults or troubles that may occur in neighbouring circuits.

In the District Fire Stations, where two or three box circuits are employed, two or three of these panels are mounted side by side in a walnut framework. A typical substation board is shown in Figure 2.

At the Central Fire Station there are 14 Repeat Circuit Panels for the 14 circuits associated with the District Station Box Circuits; 3 Box Circuit Panels associated with the circuits covering the Central Station area; and 1 Panel for the 22-volt circuits for the bells, time stamps, clock, etc., required at this Station. These 18 panels of polished grey marble are arranged around three sides of the Watch Room and mounted in a polished walnut surround. A partial view of the arrangement is shown in Figure 3.

The relays associated with each circuit are mounted beneath the marble switch panel and are protected by a removable panel fitted into the walnut surround. Thus all the switchboards are in effect divided into vertical sections, each

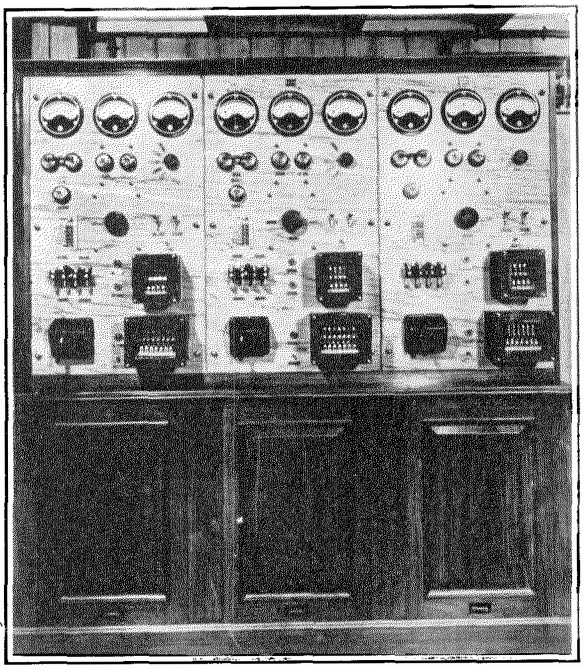


Figure 2—Typical Sub-station Switchboard.

of which deals with one circuit completely, either box circuit or repeat circuit.

The Registers for recording the alarm calls by punching holes in a paper tape, together with the Take-Up Reel for collecting the used tape, are each mounted on a shelf or pedestal so as to be at a convenient height and are covered by a hinged glass case. For the box circuits at the District Stations and Central Station the registers are directly connected in the line circuits and record only the calls received in that circuit in which they are connected. For the calls repeated from the District Stations into the Central Station a register is used which records the alarm calls from four circuits on one tape, the register coils not being directly connected in the repeat circuit but being operated in a 22-volt circuit by a relay, the winding of which is connected in the repeat circuit. Together with these registers are mounted the Time and Date Stamps, and thus one stamp can record the time of the calls from four box circuits. The three box circuits which terminate at the Central Station are relayed into one of these mult-circuit registers so that these circuits are similar to the box circuits terminating at the District Stations, except that no repeat circuit lines are required.

Batteries

The batteries for all circuits are supplied in duplicate so that one may be in service whilst the other is being recharged, the changeover being made by means of a switch on the circuit switchboard. The currents required are comparatively low; the drain from the box circuit batteries being of the order of 200 milliamperes, comprised of 100 milliamperes for the continuous line current and about 100 milliamperes for the relays associated with the repeating of alarm calls and the telephone calling system. In the case of the repeat circuits, the relay drain is not so heavy, although a continuous drain of 100 milliamperes for the line circuit is required. The battery capacity for box circuits is 20 ampere hours and that for the repeat circuits 10 ampere hours, giving discharge periods of approximately 3 days and 2 days, respectively.

For the 18 circuits terminating at the Central Station there are 36 batteries and these are situated in the battery room beneath the Watch Room. A general view of this battery room is shown in Figure 4, which illustrates the double tier construction adopted, the racks being of wood, resting on porcelain feet. This construction lends itself admirably to maintenance as every cell can be inspected with ease.

The power for charging these batteries is obtained direct from the City D. C. supply mains, which are available at the Central

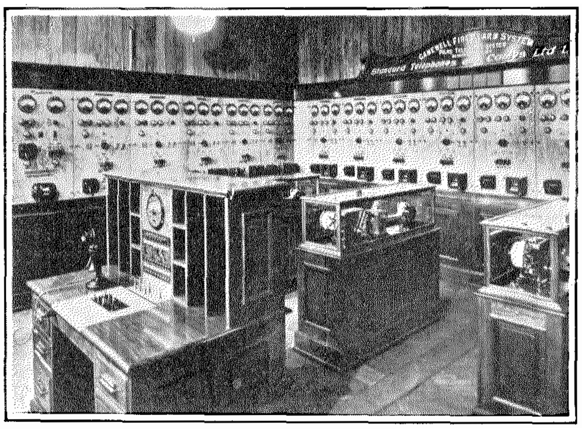


Figure 3—Partial View of Watch Room, Central Fire Station.

Station, the necessary resistances being mounted at the back of the panels. In the case of some of the District Stations it has been necessary to supply rectifying sets, a D. C. supply not being obtainable.

At the District Stations the batteries required are not nearly so extensive of course as at the Central Station, consisting of only two batteries per box circuit terminating at the stations. These are housed in small rooms adjacent to the Watch Rooms, the same double tier construction in wood being used.

Telephone Communication

Telephone communication is accomplished by repeating coils in the box circuits and repeat lines connected in series with a condenser to bridge the station apparatus. The repeat lines at the Central Station are similarly fitted with repeating coils and condensers which transmit the speech currents to lines terminating in jacks on the Central Police Station Exchange, this being situated in another part of the same building as the Central Fire Station. In the case of four District Police Stations, they are situated adjacent to the District Fire Stations and the repeating coil bridges on the box and repeat line are led into the Police Station P.B.X. Hence telephone calls from boxes on these loops are received at the District Police Station, which either deals with them or by a through cord connection, plugs through to the Central Station P.B.X. over the repeat circuit lines. Where there exists no District Police Station close to the Fire Station, the telephone calls from the boxes go straight through to the Central Police Station for routing, as required.

Circuits

The principle of the Gamewell Fire Alarm Circuit, *i.e.*, a closed metallic series circuit in which a current flows continuously unless interrupted by a box signalling or a break in the line, has been adhered to for the repeat circuits and for all other circuits at either District or Central Stations upon which the signalling of a fire call is in any way dependent, as well as for the box circuits themselves. This principle enables an immediate signal to be given automatically as soon as any of these vital circuits develops a break and thus no part of the fire alarm circuits can be inoperative without the knowledge of the Brigade. Further, in the event of a break occurring in the street lines forming

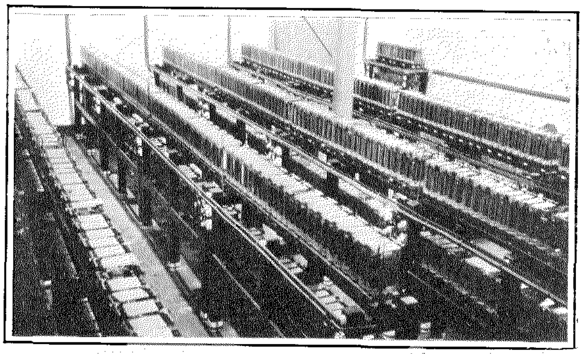


Figure 4—The Battery Room at Central Fire Station.

the box circuits or the repeat circuits, facilities are provided by which earth return working is established until the fault can be located and repaired. Switches at a District Fire Station automatically operate and connect the two sides of a broken box loop circuit to one pole of the line battery at the same time earthing the other pole; while in the case of a broken repeat circuit, manual operation of a switch by a press button at the Central Fire Station and an automatic switch at the District Fire Station concerned provide the necessary circuit changes to allow operating via an earthed battery until the line is repaired. This provision of fully automatic operation at the District Station, coupled with the automatic repeating of calls to the Central Station, enables the complete personnel of a small station to answer an emergency call in its vicinity with complete reliance on the fact that a subsequent call will not be unattended even though a line circuit becomes broken during the time when the Station is unattended. Manual operation at the Central Fire Station of the switches on the repeat circuits enables the duty man to discriminate between a broken box loop and a broken repeat loop, since a break in the box loop is signalled over the repeat loop, but there is no necessity of operating the switch for the repeat loop for this condition.

The alarm mechanism is designed so that it will function and establish an earth connection when operated on a broken line; it does not, however, introduce an earth on the circuit during normal working. This enables the normal circuits to be operated independently of any earth connections and thus provide:

1. A system immune from faults arising out of stray earth currents.
2. Immunity from faults or false signals, should a line become earthed.
3. A simple method for testing for earth faults by a voltmeter test to earth at the station battery.

The telephone circuits are superimposed on the fire alarm circuits but arranged in such a manner that there is no possible chance of the fire alarm service being interrupted or delayed. The calling from a telephone box is accomplished by the operation of a special form of key in the box which momentarily introduces a resistance into the fire alarm box circuit. The resistance is of such a value that the normal current flowing is reduced from 100 milliamperes to 70 milliamperes, which reduction is insufficient to release or interfere with the correct working of the fire alarm apparatus but enables a marginal relay at the fire station to release and transmit the signal to the police station. The key is so designed that it is impossible for this resistance to remain in circuit for more than a fraction of a second. The "clear" signal is given by the same key which is again operated when the door is closed, the signal being a momentary introduction of the same resistance. These signals are received by a relay circuit which causes them to operate an eye-ball signal on the Police P.B.X. associated with the circuit. By arranging the apparatus so that the key can only be operated once each time the box door is opened and so that the box door must be closed and opened again before a second calling signal can be sent, a clearing signal must always succeed a calling signal on any one box loop and hence the signals will be maintained in their correct sequence.

The circuit of the street telephone box is arranged so that with the outer door closed the whole of the apparatus is short-circuited; also, after opening the door, the receiver is not introduced into the circuit until the calling key has been operated. The transmitter and the primary winding of the induction coil are then introduced into the line circuit. The receiver is connected across the secondary winding of the induction coil.

The telephone boxes fitted with visual signals for calling the nearest police officer number eight only at present. These are situated at the main cross roads leading out of the city. The signals are operated by the transmission from the police station of ringing earthed current which operates an alternating current relay connected between the box loop and earth through a condenser at the signal boxes. The operation of this relay then closes the circuit for the operation of the electro-magnet which releases the signal. The lamp circuit is closed when the signal moves to the operated position where it is locked mechanically. The signal then indicates white and the lamp remains alight until the signal and lamp are restored to normal by the constable operating by hand a lever in the box. The visual signal is for police purposes and not for fire. The fire alarm is given by smashing the glass.

It is not proposed in this article to enter into a full description of the complete circuit for guarding against false operation or breakdown under all possible conditions, but merely to describe briefly the circuit of the boxes, both fire alarm and telephone, together with a simplified circuit indicating the box loops, repeat loops, telephone connections thereto, and the switching scheme for changing these circuits to enable earth return working if a box loop breaks.

The circuit for a street point complete with fire alarm, telephone box, and signal is shown in Figure 5. In the top half of the figure is shown the actual wiring connections with the apparatus arranged more or less in relative positions. The two squares on the left enclose the telephone and signal apparatus, the left square representing the inner box and the centre square the door of this box mounting the transmitter and receiver. The box shown on the right represents the fire alarm box (which is actually mounted back to back with the telephone box), the apparatus in the circle being the signalling movement proper. It will

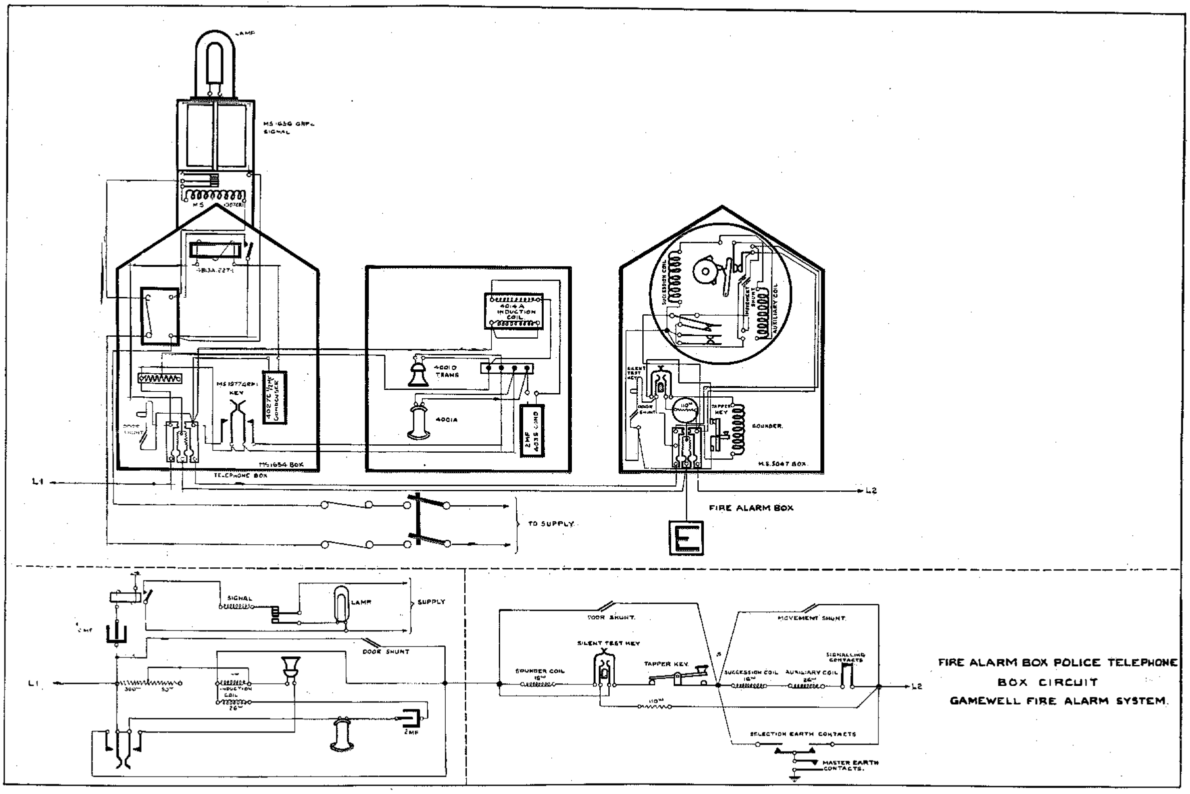


Figure 5—Circuit Diagram of a Street Point.

be seen that the line wires incoming and outgoing for each box are connected to specially shaped terminal plates mounted on each side of a saw tooth-edged terminal plate which is connected directly to the earth plate mounted beneath the post. This provides a discharge path for any high tension surges such as lightning, which may be induced in the lines, and also makes provision for the insertion of a round tapered plug to connect conveniently either line to earth or to short-circuit the complete box at the line terminals for the purposes of testing, etc.

The M.S. 1977 group 1 key shown is the special telephone calling key and actually in service this must have either its left-hand contacts or its right-hand contacts closed, it being impossible to leave it in a position in which both contacts are open.

The lower half of Figure 5 shows the schematic circuit of the two boxes. Referring to the police box circuit shown on the left, the $300^\omega + 50^\omega$ resistance in series with the 17^ω winding of the induction coil is momentarily introduced into the circuit when the calling key operates, opening the normally closed left-hand contacts and closing the right-hand contacts. Further, when the right-hand contacts of this key are closed, a circuit can be traced from line 1 (L.1), through the key, transmitter, 17^ω winding of the induction coil out to line 2 (L.2), through the fire alarm box shunt contacts. Also it will be seen that the 26^ω winding of the induction coil, a 2 m.f. condenser and the receiver are then in parallel with this circuit and that the 300^ω resistance is also in parallel. This arrangement provides a thoroughly satisfactory speech circuit whilst at the same time ensuring that the fire alarm circuit cannot be open-circuited by the telephone apparatus.

At the conclusion of the conversation, shutting the door of the box automatically changes over the calling key so that the right-hand contacts open and the left-hand close, again introducing the resistance and signalling the clear; whilst the door shunt, which consists of heavy contact springs bridging the whole circuit, are also automatically closed.

The alternating current relay connected from L.1 through a ½ m.f. condenser to earth closes the circuit for operating the electro-magnet of the signal whenever ringing current to earth is transmitted over the line.

The fire alarm apparatus shown on the right-hand side of the drawing includes two parts:

1. The testing apparatus normally shunted out by a door operated shunt.

and

2. The signalling apparatus consisting of two electro-magnets, signalling contacts and selective earthing contacts, normally shunted by a heavy movement shunt, which is open only when the mechanism is operating.

The testing apparatus includes the coil of a sounder and a "silent test key," and it can be seen that when the latter is operated the signalling mechanism is shunted by the sounder coil and a 110^{ω} resistance. Operation of the mechanism under these conditions does not allow the signals to be transmitted to the Fire Station since by virtue of the shunt resistance the alarm circuit is not opened and the current is not reduced sufficiently to allow the recording apparatus or the telephone calling signals at the Station to release. The code of the box is, however, signalled to the man who is testing by the operation of the sounder. This Silent Test key is designed so that the box door cannot be closed without restoring it to normal and, therefore, the box cannot be inadvertently left out of action.

By imagining the conditions which arise when two or more boxes are operated on the same section of a broken line it can easily be seen that this method of working caters for complete succession working under these conditions; since if a box near to the station establishes an earth connection and commences to signal those farther out along the line will be shorted out until this box has completed its call; whilst the condition of one box signalling and a second nearer to the station having been operated creates normal working conditions over the section of the line and the succession electro-magnet functions in the ordinary manner to prevent interference.

A box circuit complete with the connections to the police telephone exchange and with its associated repeat circuit is shown in Figure 6, whilst Figure 7 shows the rearrangement of the box circuit which occurs when the line wire breaks. The circuit shown illustrates the principles utilised and is simplified from the actual circuit employed, the relays operating the telephone calling apparatus battery change over switch and automatic switch for changing the circuit when the line breaks being omitted. The Box Circuit is shown on the right of the diagram and may be traced as a closed circuit from one side of the battery out to the line, through the street boxes in series, and through the rheostat telephone signalling relay, milliammeter, gong, register, and alarm signalling relay back to the other side of the battery. The rheostat is adjusted so that a current of 100 milliamperes is flowing continuously in this circuit. The alarm signalling relay transmits the interruptions in this circuit into the repeat circuit shown on the left of the diagram. This again is a closed series circuit with a current of 100 milliamperes flowing continuously from the battery at the Central Station through the alarm signalling relay, milliammeter, telephone signalling relay and adjustable rheostat at the Central Station and then over the repeat circuit lines to pass through the contacts of the alarm signalling relay at the District Station. As the relay in the Box Circuit is energised and de-energised due to an alarm box opening and closing the line circuit, its contacts will open and close the Repeat Circuit causing the alarm signalling relay at the Central Station to pulse in synchronism. The contacts of this relay open and close the circuit through the associated electro-magnet of the Multi-Circuit Register which records the code simultaneously with the recording on the Single Circuit Registerand Gong at the District Station.

The telephone bridge between the Box Circuit and associated Repeat Circuit is shown passing through break jacks which enable the District Police to receive telephone calls from boxes in their area or to plug them through to the Central Police Station via the Repeat Circuit. The connections from the box circuit to the jack are taken through condensers so that the fire alarm apparatus is not shunted. There

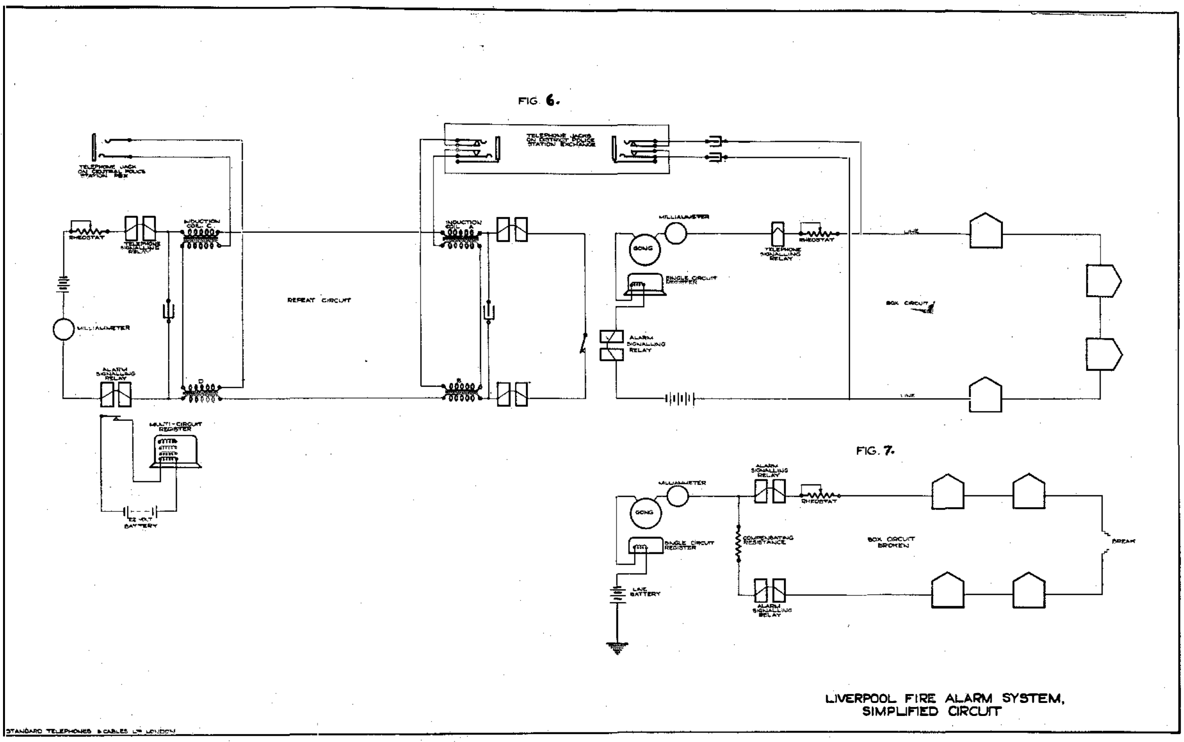


Figure 6—Simplified Circuit Diagram—Normal Circuit.

Figure 7—Simplified Circuit Diagram—Broken Box Circuit.

is no direct metallic connection between the box and repeat circuits, the speech currents being transmitted to the repeat circuit by two induction coils shown at A and B, one winding of each being connected in the bridge circuit and the other in the repeat circuit itself. A condenser connected across the repeat lines enables the speech currents to by-pass the two relays in this circuit at the District Station. At the Central Station a similar method is used for transmitting the speech currents from the repeat lines to the lines connecting to the associated jack on the Police P.B.X., the induction coils being shown at C and D.

As regards telephone calling, only the relays in each circuit have been shown, it being understood that upon the release of these relays, due to the current falling to 70 milliamperes momentarily in their respective circuits, a circuit is set up which causes an eyeball signal associated with the jacks in the P.B.X. to operate. This method of calling is adopted both for the street boxes calling the District Station and for the District Station calling the Central Station. For the Central Station to call the District Station or a box fitted with a visual signal the operator throws a key to transmit ringing current over the lines, operating an eyeball signal at the District Police Station, or, in the case of calling a box, operating the visual signal.

The circuit shown in Figure 7 illustrates the changes which occur in the box circuit upon the operation of the automatic switch when a broken line is signalled. The circuits for the operation of this switch discriminate between a broken line and the ordinary interruptions for normal alarm calls by timing the period during which the circuit is broken. If this considerably exceeds the longest period of no current obtained during fire alarm signalling a pair of contacts operated by the single circuit register close, and the switch operates, changing the box circuit as shown. The changes connect the milliammeter, gong, single circuit register and line battery in series between the two halves of the line commoned together and earth. In addition, a second alarm signalling relay is introduced into the circuit so that one relay is in each half of the circuit. These relays now transmit the fire alarm impulses received over their associated parts of the line by means of auxiliary relays into the repeat circuit, the auxiliary relays (not shown) being so interconnected that only one can operate at a time even though one side of the break is earthed. Thus, if alarm boxes are operated on both sides of the break, the boxes on one side are held up until those on the other side have sent in their complete signals. This enables complete succession working to be maintained between the two parts of the line, the boxes automatically catering for the succession feature on their respective parts of the line. The gong and register at the District Station being in series with both sides of the line, automatically record calls from both sides of the broken line.

The signalling apparatus when operated under normal conditions transmits its code by means of the contacts marked "signalling contacts" opening and closing as the toothed code wheel revolves. These contacts are connected in series with the "Succession Coil" and "Auxiliary Coil" directly in the line circuit. Thus, when they are closed the line current of 100 milliamperes flows through the coil windings causing the armatures of the electro-magnets to be attracted against the force of their retractile springs. The succession electro-magnet through the movements of its armature controls the mechanism in such a manner that, although the starting lever has been tripped, the signalling contacts do not commence to transmit the code until the armature has been continuously in the attracted position for a certain "testing period." For this condition to be obtained the coils of the succession electro-magnet must receive current continuously during this testing period which is only possible if no other box on the same circuit is signalling and the fire alarm circuit is normal, that is, the line is not broken.

In the majority of cases there is only one box operated on the circuit and the alarm is, therefore, transmitted immediately the testing period (which lasts for approximately 1 second) is concluded. When the case arises in which a box is already signalling when a second mechanism is tripped, the box that is signalling will open the line circuit at least once during the testing period of the second box. This causes the succession armature to release under the pull of its retractile spring which withdraws it out of the effective field of the electro-magnet. This movement locks the signalling contacts closed and the revolving codewheel has no effect on them. At the end of the first revolution of the codewheel the armature is mechanically restored to the cores of the electro-magnet. This recommences the testing period and if the first box has completed its call, the armature will be held continuously during this test, and this will enable the codewheel to operate the signalling contacts, transmitting its alarm. Had the first box not have finished, then the second box would have been locked out as before until the third testing period occurred after another complete revolution of its codewheel. Thus the mechanism tests at each revolution of its code-

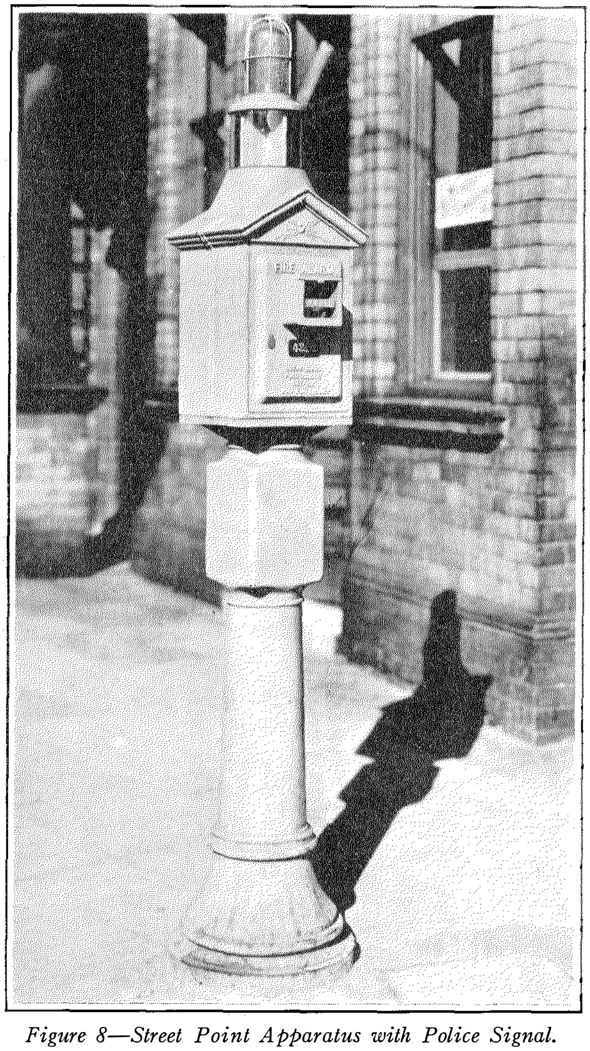


Figure 8—Street Point Apparatus with Police Signal.

wheel until it obtains a successful testing period when it proceeds to transmit its code twice and then automatically stops, the shunt contacts reclosing to short out the coils of the electro-magnets and signalling contacts until the next operation occurs.

From the foregoing description it will be seen that when a box circuit is broken the continuous current required through the succession windings during the testing period cannot be obtained unless the battery at the station be earthed and also means for establishing an earth connection at the box be provided. As already stated, the battery associated with a broken box loop is earthed at one pole by an automatic switch as soon as the break is signalled, and the two parts of the broken line are connected to the other pole of the battery. When an alarm mechanism is operated under these conditions it receives no current to energise its succession electro-magnet during the first testing period and consequently its signalling contacts are locked, closed for the first revolution of the codewheel.

The selective earthing mechanism, which controls the selective earthing contacts, is operated only when the auxiliary electro-magnet is not energised for a period longer than the maximum time of open circuit which occurs during normal signalling of an alarm. Whenever this auxiliary electro-magnet is energised its armature is attracted and this trips the drive to the selective earthing mechanism. This drive is automatically restored at the commencement of each revolution of the codewheel.

Under normal conditions, therefore, the drive is tripped at the commencement of signalling or, if another box is already signalling, at the first closure of its signalling contacts after the starting lever is tripped, and thus the selective earthing mechanism is never operated. Under broken line conditions, however, the auxiliary electro-magnet cannot be energised until the mechanism has closed one or other of its selective earthing contacts to establish an earth connection on that side of the mechanism which will permit current to flow from the earthed station battery over the unbroken part of the line through the succession and auxiliary coils and signalling contacts to the earth connection

Figure 9—Street Point Apparatus Without Police Signal.

at the box. This causes the auxiliary electro-magnet to energise, tripping the drive to the selective earthing mechanism and at the same time locking it in the position which will maintain the earth connection closed. This occurs during the first revolution of the codewheel and when, therefore, the mechanism tests again at the end of this revolution the succession electro-magnet is energised for the testing period and the box proceeds to transmit its code. At the conclusion of the sending of the alarm the mechanism restores to normal and in so doing trips the selective earthing device, releasing the earth connection and restoring to normal.

By means of the automatic switch, a compensating resistance is brought into that side of the line which does not include the adjusting rheostat in order that, should the break have occurred close to the station on the corresponding side of the line, the current that flows when a box is operated will not exceed about 250 milliamperes. Telephone communication cannot be established over a broken line and the telephone signalling relay is not, therefore, included. In order to re-establish this service expeditiously it is the practice to locate the break as early as possible and then earth the line at the nearest boxes on each side of the break, thus restoring a closed loop. The Station is then informed that this has been accomplished and the automatic switch is restored to normal, thereby creating normal working conditions and leaving the broken section of line free to be repaired without again interrupting the fire alarm or telephone service.

Apparatus—

Street-Box Apparatus

The construction of the various units of apparatus, street boxes and mechanisms, including recording registers and gongs at the stations embodies the robustness of design and principles of operation that are necessary for the absolute reliability demanded for fire alarm apparatus. The finish of the various parts, particularly in the street box apparatus, is also of the utmost importance, in order that deterioration due to corrosion shall not occur. Consequently wherever possible rustless steel is used in the alarm mechanism, and where iron has necessarily to be employed, such as for the magnetic parts of the electro-magnets, a heavy zinc plating is used. The gear wheels are of brass throughout and heavily lacquered, whilst the terminals and contacts are insulated throughout by porcelain. Silver contacts for the signalling springs ensure that even if oxidation does occur the contact resistance will not be increased, since the oxide of silver is practically as good a conductor as the metal itself. For this reason the shunt springs are of phosphor bronze heavily silver-plated in order that they shall provide a reliable contact, together with heavy spring pressures.

Figures 8 and 9 show views of the street apparatus, one of the type complete with police signal, and the other of the more common type without police signal. Figures 13 and 14 show a police outer box with its door open, and a Fire Alarm outer box with its door open.

The glass protection over the pull handle is mounted in a special drop frame so that when the glass is shattered it is carried outwards and downwards by the frame (which is hinged along its lower edge), leaving the pull handle clear and obviating any risk of cut hands. This is shown in Figure 9, in which the drop frame can be seen hanging downwards after the glass has been broken.

The outer and inner boxes are both of cast iron and finished with a very high grade of paint, varnished over the outer coat. The paint is sprayed on to boxes and post and a thoroughly robust finish is obtained, the paint being specially mixed to prevent colour deterioration.

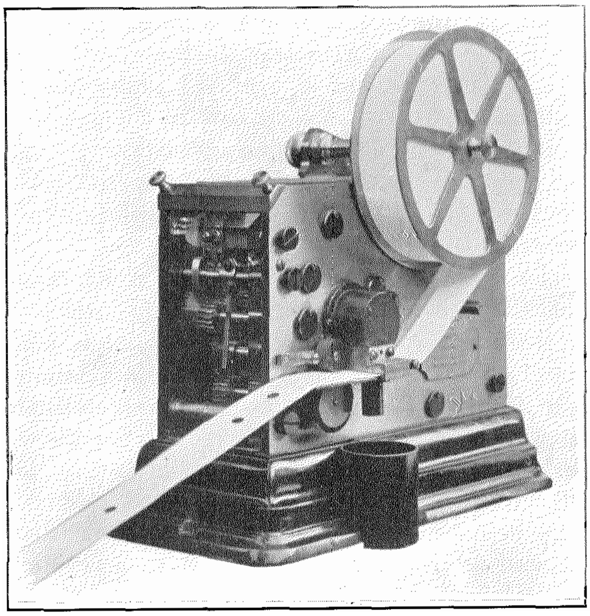


Figure 10—Single Circuit Register.

The pull handle mechanism of the Fire Alarm Box is shown in Figure 14 and consists of a vertical lever to which is attached a rod passing through the door to the pull handle. The lever is pivoted at its lower end so that the operation of the pull handle causes it to rotate towards the door. A small roller pivoting on a pin in the side of the lever is thereby caused to operate the bell-crank lever, the end of which presses downwards on the movement starting lever,

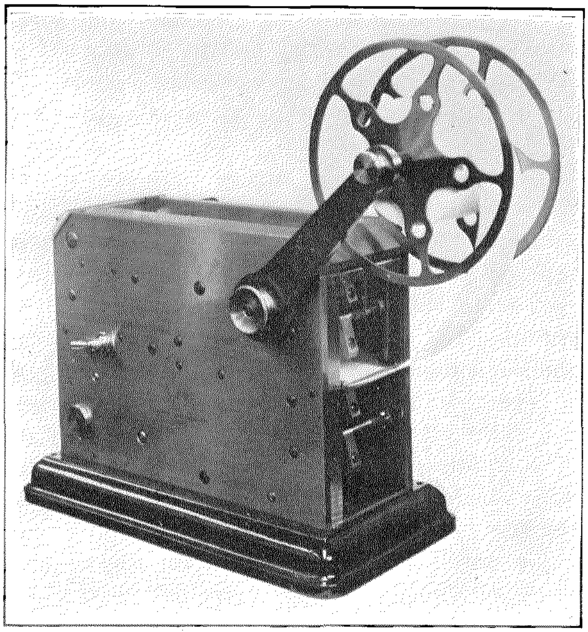


Figure 11—Multi-Circuit Register.

shown projecting through the inner box door, and thus trips the mechanism.

The street point shown in Figure 9, with visual signal and lamp, has a design of post modified from the standard type. This is to include a watertight switch and fuse box for the main's supply to the lamp and signal, enabling the supply to be cut off should a fault develop in the wiring, etc.

Fire Alarm Recording Apparatus

With regard to the recording and signalling apparatus at the stations, which is all of the type embodying the principle of electrical con-

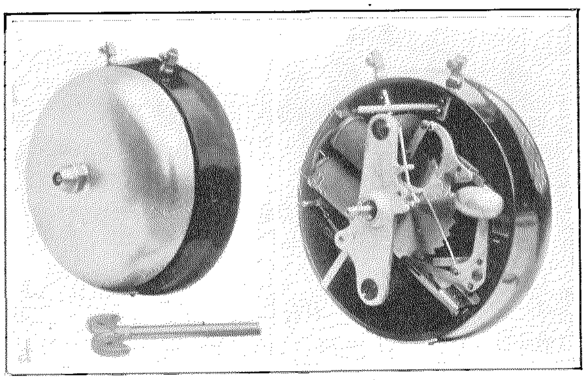


Figure 12—Gong and View Showing Bell Removed.

trol of a spring-driven mechanism, the registers connected in each box circuit are shown in Figure 10, whilst Figure 11 illustrates the type of register used in the repeat circuits terminating at the Central Station and Figure 12, the gongs, one of which is included in each box circuit. The two types of register differ in three main respects, viz.:

1. The single circuit register punches its paper tape in accordance with the interruptions in one fire alarm circuit only, whilst the multi-circuit register punches its paper tape in accordance with the interruptions received over four repeat circuits.

2. The energy for operating the punch in the case of the single circuit register is obtained from the main spring, whilst in the case of the multi-circuit register an electro-magnet associated with each repeat circuit recording into the register supplies the energy to perforate a triangular hole in the paper at each interruption.

and

3. The electro-magnet of the single circuit registers are connected in their respective alarm box circuits operating directly by the interruptions in the 100 milliamperes flowing in this circuit, whereas the multi-circuit register coils are operated in a 22-volt local circuit by the contacts of a telegraph relay, the windings of which are connected in the repeat line circuit.

Apart from these differences the registers are very similar in that they each consist of a spring-driven mechanism for driving the paper feed wheels, this mechanism being released to run at a steady-controlled speed for a definite time at each operation of the electro-magnet. Both the speed at which the paper feeds and the amount fed out at each operation of the register are adjustable, the usual settings adopted being arranged to give half-an-inch spacing between successive punches in the same digit of a code number, with about five to six inches of paper fed out after the last hole has been punched.

Both types of registers are provided with a set of contacts which are closed once only at the completion of a fire call or once after a break in the line has been signalled. In the Multi-

Circuit Registers these contacts are used to close the circuit of the electro-magnet of the Time and Date Stamp, causing the paper tape to be marked with the date and time of the conclusion of the call. The contacts in the single circuit Register are utilised to close the circuit of the trip coil for the automatic earthing switch

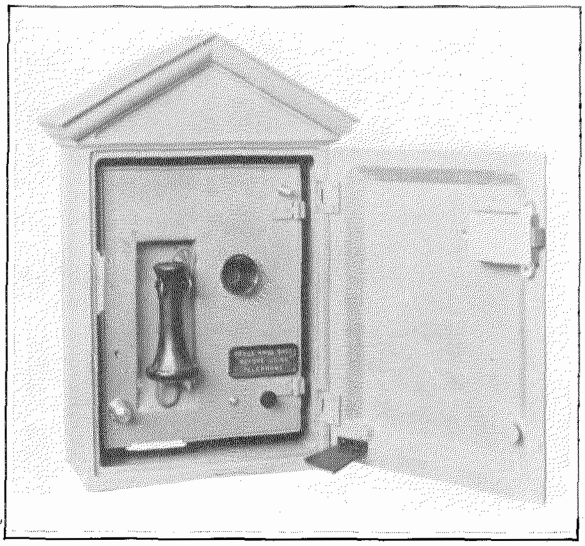


Figure 13—Police Box—Outer Door Open.

when a break in the alarm circuit is signalled.

The alarm gongs are of the single stroke electro-mechanical type, the mechanism being completely enclosed by the 6″ bell. For rewinding the main spring the key is inserted into the bell fixing nut in the centre of the gong, and the gong will sound between ten and fifteen complete alarm signals before requiring rewinding.

The principle of operation of the gong is simple and reliable. Upon the interruption of the current in the street alarm circuit the electro-magnet in the gong, which is connected in the circuit, de-energises and releases its armature which, due to the pull of its retractile spring, moves to release the hammer of the gong. The hammer is driven by two pawls, which engage in turn with the main driving wheel, one driving the hammer towards the centre of the gong, where the second pawl takes control, to drive the hammer outwards to strike the bell. In the outward movement of the hammer the mechanism resets and is not released until the next interruption in the line current occurs.

One gong is included in each box line circuit and is usually mounted in the station engine room so that the engine crew can recognise the alarm code coming in as they take up their stations on the machines.

Mounted with each register whether of the single or multi-circuit type is a mechanical Take-up Reel which automatically winds up the paper tape as it is fed out by the Register and is so positioned relative to the Register that a horizontal strip of the paper is maintained between the Register and Take-up Reel of sufficient length to expose the full code, repeated once, of the last alarm received. These Take-up Reels consist of a simple clockwork reduction drive from a main spring to a brass reel, the revolutions of the reel being controlled by the tension in the paper actuating a lever brake on the edge of the reel. Thus, when an alarm call is received the Register commences to feed the tape, relieving the tension on the strip between the Register and the Take-up Reel and releasing the brake on the reel which immediately commences to revolve, winding in the paper at the same rate as it is fed out.

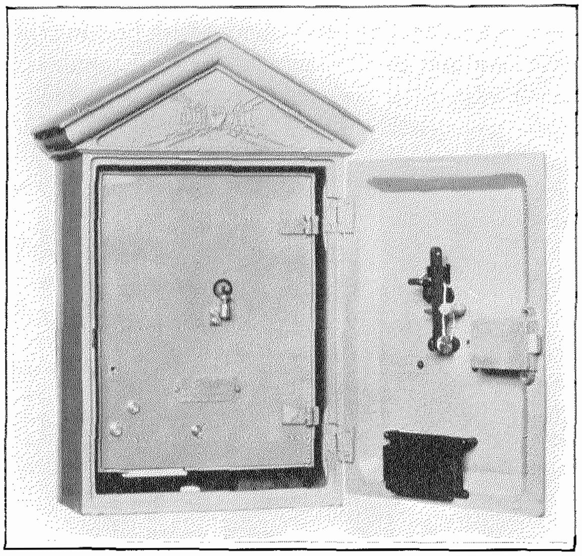


Figure 14—Fire Alarm Box—Outer Door Open.

The Time and Date Stamps associated with each Multi-Circuit Register at the Central Station consists of a train of geared wheels, driven by a main spring, and revolving, in chronological order, the minute, hour, day, month and year type wheels, the mechanism being released to step once each minute by the operation of an electro-magnet controlled from the minute impulsing contacts of a master electric clock. The paper feeding out from the Register passes immediately underneath the type wheels and an inked ribbon. On the completion of an alarm call the contacts in the Register close the circuit through a second electro-magnet in the Time and Date Stamp, which presses the paper against the ribbon and type wheels, thereby imprinting the time and date of the call on the paper. The train of gear wheels is interesting in that it provides automatically for long and short months, together with leap year day, for twenty-four years without requiring any adjustment. After this period it would be necessary, of course, to change the year wheel, when the stamp would be suitable for another 24 years' service.

Telephone Apparatus

The Telephone Apparatus is of the ordinary design throughout, solid back transmitters and bell receivers being fitted in the street boxes as well as for the Station Desk Sets. The Central Police Station Exchange was installed prior to the installation of this system and only one section had to be modified to include the eyeball signals and cord circuits necessary for the system. In the District Police Stations a small pony board is fitted to include the signals and cord circuits necessary for switching calls from the street boxes to the Central Police Station. In the Watch Room at the Central Fire Station a walnut desk has been fitted equipped with the signals, jacks and cords for receiving calls from the boxes switched through from the Central Police Exchange. This desk is illustrated in Figure 3, showing the Central Station Watch Room, whilst a street telephone box is illustrated in Figure 13, in which two views are shown, one of the outer and inner box having the outer box door open exposing the receiver, transmitter, and calling button, and the other of the inner box only with the door open. In this latter view the special calling key is shown mounted in the right-hand lower corner of the box. This key is a modified type of lever key in which the handle has been replaced by a heavy bob which is thrown to one side or the other by deflecting a wire spring which is clamped to move with the lever pivoting in the contact spring support. This lever is operated by the button on the door to originate a call, and in the reverse direction, to clear, by the cam screwed to the outer door. The line terminal block mounting the door shunt is shown in the left-hand lower side of the inner box, the smaller ebonite terminal block above it, mounting a fuse, being that for the lighting supply mains for the visual signal, when such is fitted. The illustration also shows the anti-vibration transmitter mounting, which consists of a stout rubber strip suspended between two clips screwed to the door. This is particularly necessary where the box is mounted at a busy street corner, for otherwise the vibration due to traffic would render speech almost impossible.

Results Obtained

The System is being maintained entirely by the Fire Brigade Staff, except for the maintenance of the outside lines by the Post Office local authorities, and the operation of the telephone switchboards by the police staff. The Authorities have expressed their complete satisfaction with the system, all fire alarm calls being received within 10 seconds and the telephone system providing excellent transmission efficiency even over the lengthy circuits obtained when a call is put through from a box on one circuit to a box on another at the opposite end of the City.

A Development in South African Broadcasting[1]

By C. McQUILLAN

International Telephone and Telegraph Laboratories
(Late Chief Engineer, African Broadcasting Company)

WITH the recent installation of a high-power station in Johannesburg, it is hoped that broadcasting in South Africa has begun a new and more successful era.

Difficulties in the way of establishing in South Africa an effective broadcasting service, able to support itself economically, are numerous. In the first place, from a physical point of view, the country with its great distances and scattered population is not ideal. The total area of the Union of South Africa is about four times that of the British Isles, and the white population is only about one-fifth that of London. Moreover, for six months of the year, Nature provides South African listeners with some of the worst "static" in the world. In the summer there is a thunderstorm nearly every day, and because of this all stations close down with the friendly advice, "Goodnight everybody, and don't forget to earth your aerials." For the other six months of the year the daily sunshine figure is 9½ hours, and the wonderful climate, which affords much encouragement for outdoor recreation, does not assist in popularising indoor listening.

There is also a strictly limited supply of broadcasting talent available—this is one of the chief difficulties; and, since residents in South African cities possess metropolitan rather than provincial tastes, they are well provided with competitive forms of entertainment in the theatre, the cinema, and the concert hall. Capetown presents its own particular problem; few cities of the world are so beautifully situated, but the majestic mass of Table Mountain, which forms such a magnificent setting for Cape Town, is a formidable obstacle in the path of the broadcast engineer faced with the task of serving a community which has built its city around a mountain. Finally, the settler in the backveldt, to whom broadcasting should prove an inestimable boon, is the most difficult type of listener to recruit; he is not easily attracted by the weird assembly of knobs and tuning dials of the multi-valve receiving set with, for him, their serious battery upkeep problem. There are many other difficulties, but on the other side of the balance there is a vast amount of enthusiasm and determination to "see it through."

South Africa follows close upon the older and more settled countries of the world in keeping up with modern progress—she was not slow in entering the broadcasting field. The first station was at Johannesburg, where a 500-watt Western Electric plant was installed and put into regular operation in July, 1924.[2] Other stations of 1 Kw. antenna power were installed soon afterwards at Capetown and at Durban. The Johannesburg station was operated by the Associated Scientific and Technical Societies, the Capetown station by the Capetown Publicity Association, and the Durban station by the Durban Municipality. The initial response was good, but progress at first was not satisfactory, and the Johannesburg station in particular found it difficult to carry on. Although reasonable license fees were charged, the illicit use of unlicensed receivers was widespread, and the degree of popularity of the services could not be adequately judged by the number of licenses. In the Johannesburg area alone, in a period of 18 months, there were over two hundred "piracy" convictions, and in most cases the penalties imposed were not substantial enough to combat the evil.

In April, 1927, the African Broadcasting Company was formed with the object of coordinating the individual stations under one control. Since that time considerable progress has been made, and the present outlook is more promising. The new Company at once decided to erect a high power station at Johannesburg, to have a much greater covering area than the then existing station, and an order was placed with Standard Telephones and Cables Limited

[1] The topical pictures for this paper have been kindly furnished by the courtesy of the South African Railways.

[2] F. H. Amis, "Broadcasting in South Africa," *Electrical Communication*, January, 1925.

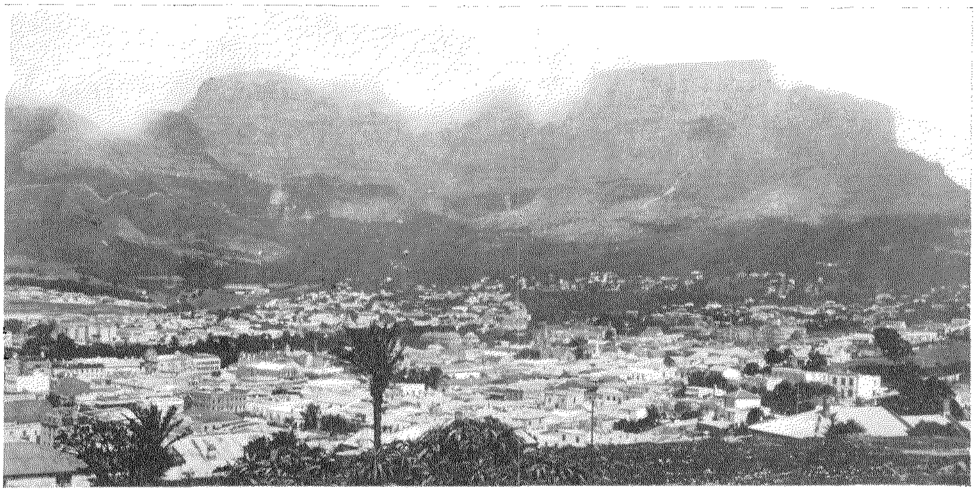


Figure 1—Table Mountain and Cape Town.

for equipment having an output of 10 Kw. unmodulated antenna power. As this equipment is similar to that recently installed in Japan,[3] it is unnecessary here to describe it in detail.

The site chosen for the station is about eight miles to the west of the city, on one of the highest points of the Witwaterstrand, below which the Gold Reef extends to depths of 8,000 feet. The transmitter is connected by overhead lines to the studios located in the centre of the city. Certain precautions were therefore necessary to eliminate the effects of the severe lightning experienced on open wire lines during the summer season. Special attention was given to erecting a highly efficient radiating system. The antenna system, which is of the multiple tuned type with three downleads, is supported on self-supporting lattice steel masts 160 feet high, spaced 300 feet apart. The earth system consists of about 15 miles of heavy gauge copper wire laid out in the form of a herringbone pattern, and buried at a depth of about one foot below the surface. The installation of this earth system in virgin soil, which had just been subjected to the annual six months' drought, was no easy task; but, since the radiated power from the station is probably greater than that of a 20 Kw. transmitter with the more usual type of radiating system, it is considered that the undertaking was well worth while.

The new station was officially opened by the

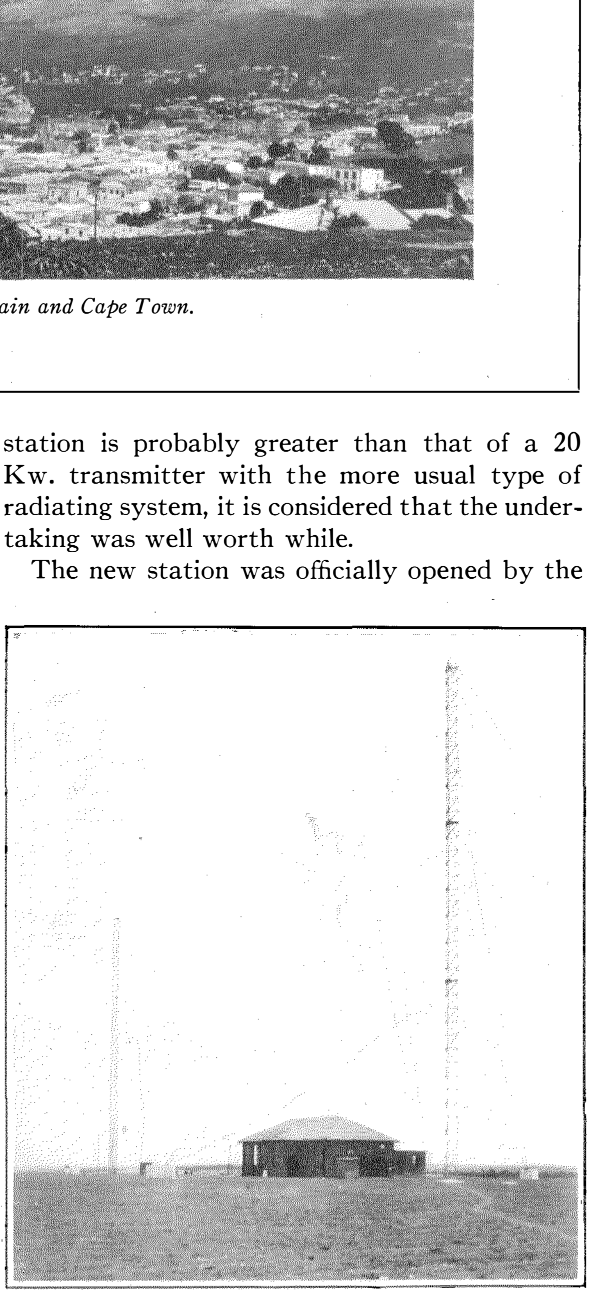


Figure 2—Johannesburg Broadcasting Station.

[3] V. H. G. Parker, "Development of Broadcasting in Japan," *Electrical Communication*, October, 1929.

Minister of Posts and Telegraphs on October 22, 1928. At the time of its inauguration it was the second most powerful station in the British Empire, second only to the Daventry station—a fact that indicates much for the progressive policy of the African Broadcasting Company. Under favourable conditions, the transmissions from the Johannesburg station are heard all over the Union, and most listeners now have a choice of at least two programmes.

With the three stations operating under one control, it has been possible, by an interchange of talent, to provide an improved programme service. On four evenings of the week, for two hours, Johannesburg sends simultaneous broadcasting (S.B.) to Durban or vice versa, and on occasions of national importance the three stations are linked together. Capetown and Durban have always been famous for their orchestras. They are subsidised by the Civic authorities, and both the Capetown Orchestra and the Durban Municipal Orchestra perform regularly in the studios, and are relayed from the concert halls under contract with the African Broadcasting Company. Simultaneous broadcasting takes the Durban Orchestra to Johannesburg. Outside relays of light music from the cafés, dance music from the hotels and dance clubs, and vaudeville artists from the theatre are regular programme features. Few of the many people of note who visit South Africa are allowed to leave without addressing the microphone at at least one centre, and a portable microphone is always present at any event of public importance. Perhaps the most popular outside broadcasts are the relays of sporting events. Your true South African is a sportsman, and he would rather listen to a broadcast commentary on a football match or on a "big fight" than any lecture of an "uplift" nature. Although Rugby football owes its origin to the playing fields of Rugby, the greatest exponents of the game today are the South African "Springboks," and the simultaneous broadcast of the recent Test Matches between the "Springboks" and the New Zealand "All Black" was received with enthusiasm.

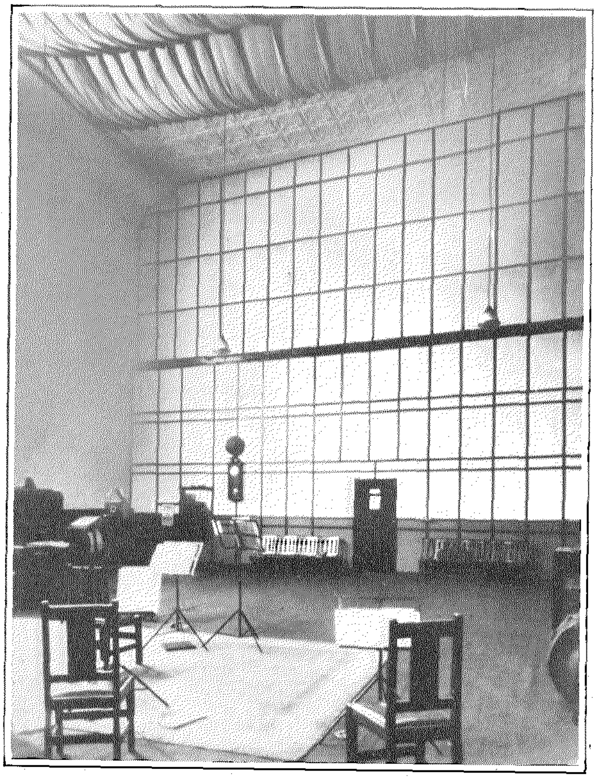


Figure 3—A Corner of the Main Studio—Johannesburg Broadcasting Station.

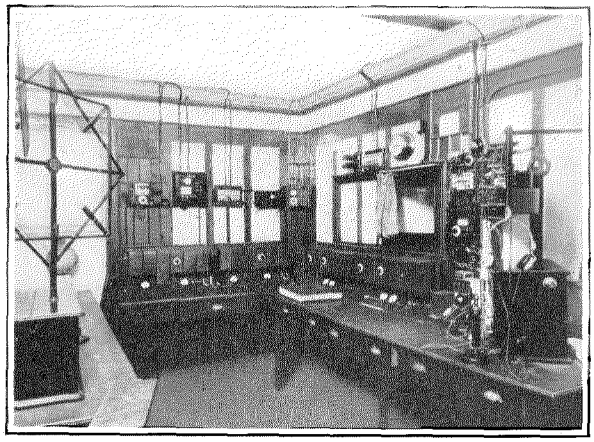


Figure 4—Control Room—Durban Broadcasting Station.

A good example of the value of broadcasting as a medium for the prompt dissemination of news was provided during the illness of His Majesty the King. The official bulletins, which were issued in "British Official Wireless Press," were received by the African Broadcasting Company engineers via the Rugby Radio Telegraph Station of the British Post Office, and were broadcast in South Africa within fifteen minutes of posting at Buckingham Palace, well ahead of newspaper publication. The bulletins

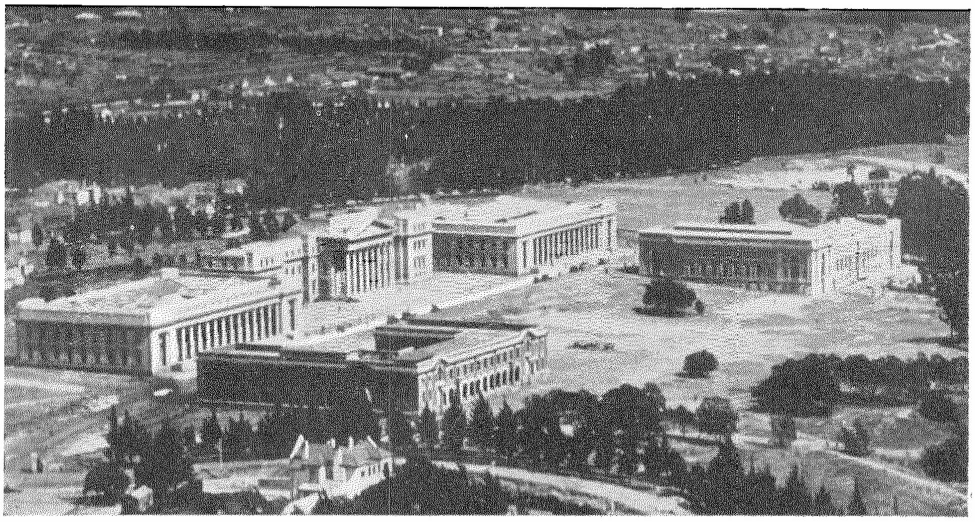


Figure 5—Aerial View of University Building—Johannesburg.

were regularly broadcast during the long illness of His Majesty, and were followed with great interest and sympathy by the South African public.

Despite the progressive policy adopted by the African Broadcasting Company, the improvements brought about by the co-ordination of effort have not been accompanied by a satisfactory increase of licenses, and the service is not yet founded upon a secure, economical basis. In April, 1927, the total licenses stood at 13,000, and in April, 1929, they had been increased to about 17,000. Piracy is still very prevalent and no effective means have been found of eliminating this practice.

That the African Broadcasting Company is progressing along the right lines there is no doubt. Today, the whole of the country is well served, and the standard of transmissions from a technical point of view is a high one. The principal problem is now one of finance and the efficient collection of revenue.

The writer is among those who hold the opinion that South Africa will, in course of time,

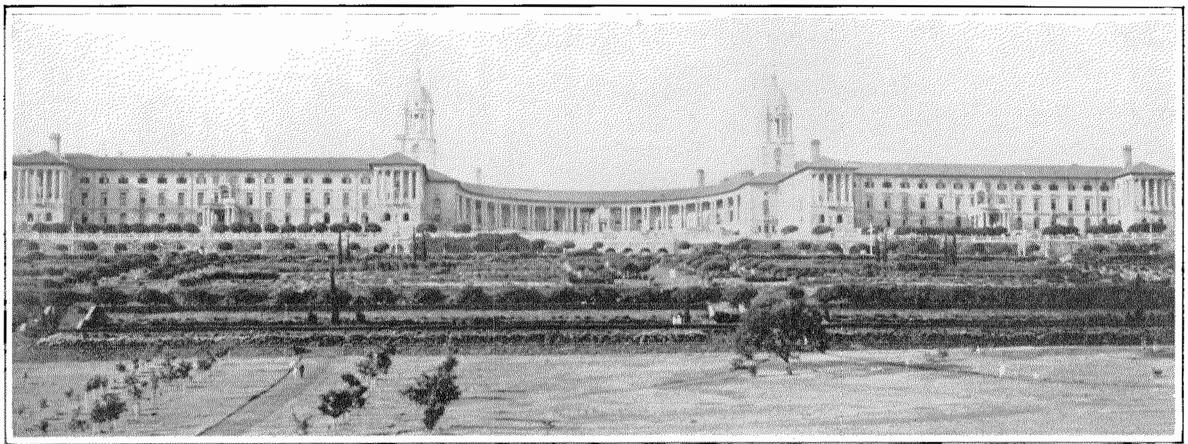


Figure 6—The Union Buildings, Pretoria, a Seat of the Government of South Africa.

find a successful solution to all its broadcasting problems. To the country which has inspired a Rhodes, which has built up from the bare veldt of little more than 40 years ago the present city of Johannesburg with its annual output of £40,000,000 of gold, and which already has provided itself with a Cathedral, a University, and an Art Gallery, surely nothing is impossible. South Africa is a land of sunshine, of great charm, and of peculiar fascination. Few people who visit it leave without wishing to return.

Figure 7—A Typical Mine Dump, Johannesburg.

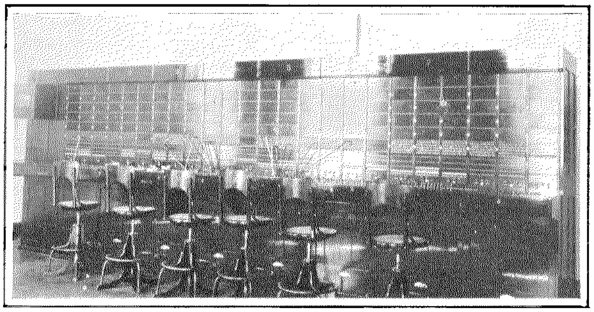
No. 2011 Central Battery Switchboard Equipment in Chile

By H. A. ARNOLD

Director of Traffic, Chile Telephone Company

EARLY in 1928 the administration of the Chile Telephone Company was taken over by the International Telephone and Telegraph Corporation and Chile fell in step with the world movement toward improved telephone communication facilities. The Chilean problem was a large one, involving a complete and thorough reorganization and rebuilding campaign. Preliminary surveys and subsequent studies indicated the need of new buildings, new central office equipments and new outside plants in all parts, from the northern desert regions to the southern fertile valleys. An antiquated and inadequate system was serving a prosperous and progressive country and the time was ripe for radical and extensive changes.

Chillán Central Office Building.



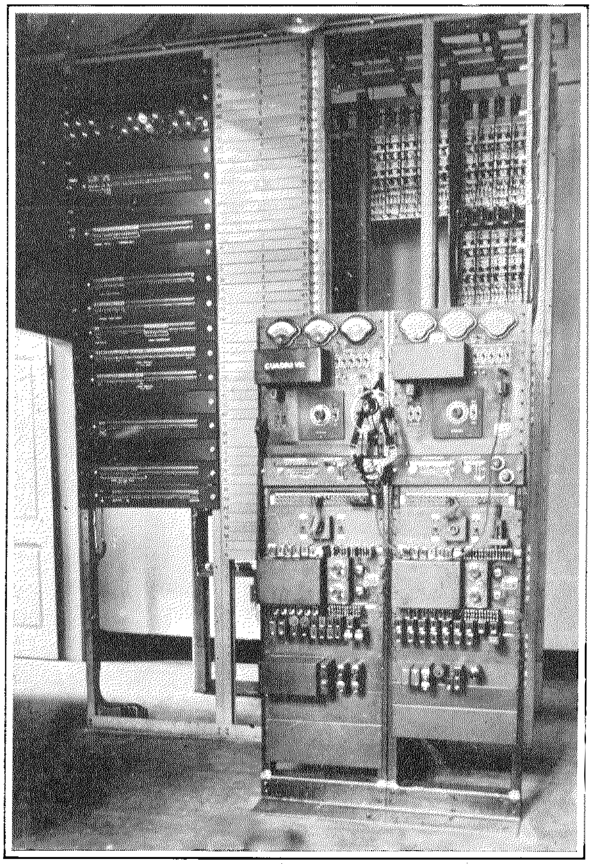
No. 2011 Switchboard—Chillán.

One of the many problems involved was that of providing a modern and satisfactory local service in the larger and more promising centers of Chile. Automatic service was reorganized and extended in Santiago, Valparaiso and Viña del Mar, and central battery plans in Iquique, Antofagasta and Concepción were carried to completion. The important cities of La Serena, Chillán, Temuco and Talca remained with inadequate and obsolete equipment and resulting deficient service.

In June, 1928, the detailed specifications for new buildings, new outside cable plants and new central office equipments were submitted for these four cities. The Antwerp type No. 2011 Central Battery switchboard and allied inside equipment was decided upon. This type is identical with the No. 11 type board manufactured by the Western Electric Company in the United States.

On April 13, 1929, the first new switchboard of this type was placed in service in La Serena. This board included one trouble position, two toll positions, and five local positions with initial equipment for 520 local lines. On August 11, 1929, an identical board was cut over in Chillán. Service from the same type of equipment for the cities of Temuco and Talca was arranged for the early part of 1930.

The new type No. 2011 board embodies many improvements and refinements not provided in previous Central Battery switchboards, some



Repeaters—Chillán.

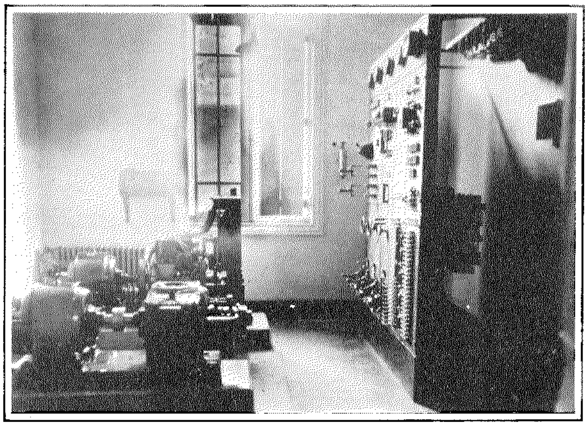
of which can be briefly stated. One of the radical departures from the old type board is the combination of answering and multiple jacks. The multiple field is also used as the answering field, lamps being associated with the multiple jacks throughout the board. This arrangement has the obvious advantage of flexibility, permitting any line signal to be answered from any position, at the same time eliminating the necessity of board balance. The subscriber's cord circuit provides several advanced improvements such as automatic speaking, automatic ringing, four-party line ringing, coin box control, flashing recall and dialing to automatic offices. The operation of this circuit is very simple and allows for rapid dispatch of traffic. When a subscriber's line signal appears the operator plugs in with her answering cord, her telephone being connected automatically to that pair of cords, and receives the order from the subscriber. The call is completed to another local line by plugging into the required multiple jack with the corresponding calling cord and pressing the master ringing key. The operation of the ringing key disconnects the operator's telephone circuit from this pair of cords and leaves the operator free to attend to another call.

When a toll call is requested, the subscriber is connected to the toll operator over transfer lines. In establishing this connection the local operator presses the trunk key instead of the master ringing key in order to set up the circuit for speaking without sending out ringing current, the calling in this case being effected through the sleeve of the plug.

Due to the multiple appearance of the answering jacks, it is possible for several operators to plug into the same jack in answering signals. To prevent confusion in this respect only the first operator who plugs in is able to talk with the subscriber, the others receiving a tone indicating that the call has been answered.

In case a subscriber wishes to recall the operator for any reason during the course of a conversation, it is necessary only to press down and release the receiver hook. This action sets up a flashing recall circuit which produces a continuous flash on the corresponding supervisory signal. When the speaking key is thrown in answer to this signal the operator's telephone is connected with the cord pair.

The toll positions are fitted with semi-universal cord circuits employing manual ringing. Once a toll line is taken up on the cord circuit any further ringing on the line sets up a continuous flashing on the supervisory signal. The toll cord



Power Room—Chillán.

circuits are fitted with monitoring keys which permit supervision without interruption of conversation.

The Chilean urban subscriber now enjoys advanced automatic and central battery service, and, incidentally, takes full advantage thereof, as indicated by high calling rates. He has forgotten those days not long ago when the use of the telephone was a serious menace to the national disposition.

La Serena Central Office Building.

Principal 7-A Rotary Automatic Central Office

By C. P. RAPP

Chief Engineer, Mexican Telephone and Telegraph Company

THE Mexican Telephone and Telegraph Company's association with the International System, approximately five years ago, inaugurated an era of expansion and improvement representing a long stride towards the fulfillment of Mexico's telephone needs. Results obtained to date, in fact, illustrate forcibly the basic influence of modern telephone service in promoting national prosperity, as well as social and international harmony.

The long-distance network in Mexico has been expanded from Mexico City to connect Tampico and Vera Cruz, important ports on the Gulf of Mexico; Monterrey, the leading industrial city which is an intermediate point on the International circuits terminating in Nuevo Laredo on the northern border, together with Guadalajara, León, and Aguascalientes, in the interior of the country. These key cities are generally connected by direct trunks, supplementing the backbone toll network. It is possible for subscribers of the Mexican Telephone and Telegraph Company in virtually all these cities to communicate with those in Cuba, United States, Canada, and Europe, including Spain, as well as with subscribers of the International Companies in Argentina, Chile, and Uruguay.

Expansion and improvement in the local network, both in outside plant and in central office equipment, while less spectacular, have been equally important. Local telephone systems increased from 23 in 1925 to 36 in 1929. Automatic central office equipment has been installed in Tampico, the important oil port on the Gulf of Mexico, in Guadalajara, known as the key to the west coast of Mexico; and in Mexico City itself. The inauguration on December 21, 1929, of the Principal Central Office, described in the present paper, witnessed the completion of the last of the four automatic exchanges comprised in the original program for converting the entire system in the Federal District to automatic operation. The ultimate capacity of these exchanges is 100,000 lines.

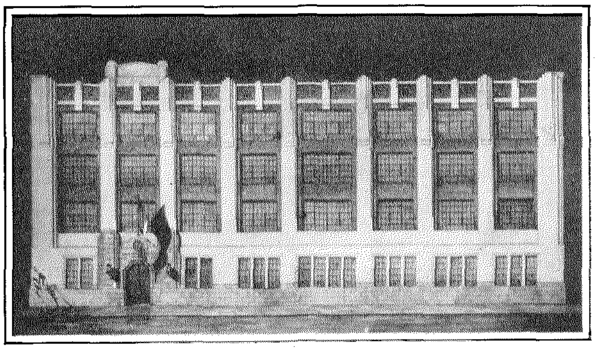
The Principal Central Office cutover, with 15,000 lines installed initially and with an ultimate capacity of 40,000 lines, involved the following distinct operations requiring close coördination:

1. Displacement of six widely separated magneto central offices, as shown in the accompanying drawing.
2. Replacement of two large No. 1 manual central offices, namely Juárez and Neri.
3. Replacement of the original toll central office located at Juárez Exchange Building. This included the complete toll board, test table, repeaters, carrier equipment, information and complaint desks.
4. The establishment of modern underground outside plant, displacing the original plant consisting mainly of open wire supported on roof fixtures.

Due to the peculiar subsoil conditions in Mexico City, building construction requirements vary greatly from those where bedrock or solid earth are encountered. Test drillings showed the following conditions:

Depth	Soil	% of Water Content
1 Meter		
2 Meters	Clay	
3 Meters	Topsoil	38.3
4 Meters	Volcanic	47.5
5 Meters	Cinders	51.4
6 Meters		58.6
7 Meters	Soapy Earth	68.0
8 Meters		90.0
9 Meters	Mud	90.0
10 Meters		90.0
11 Meters	Clay	49.0
12 Meters	Mud	90.0
13 Meters		41.0
14 Meters	Clay	53.4

Under these conditions it was decided that a floating cantilever construction should be used for the foundation. An excavation approximately $2\frac{1}{2}$ meters deep was made and filled in with closely packed crushed rock to a depth of $1\frac{1}{2}$ meters. A reinforced concrete slab of 20 centimeters thickness was poured over this fill, the reinforcing bars being carried down the concreted sides and across the floor of the cable vault. This slab extends approximately $1\frac{1}{3}$ meters beyond the finished building walls on all sides. On this slab were constructed intersecting reinforced concrete walls, resembling a checker-board, and the floor slab placed on these walls leaving the finished floor at the street level. The building is of steel and brick construction, trimmed with cut stone and finished above with stucco. A ceiling height of 13′ 2″ clear under beams gives ample head room for the equipment.



Principal Central Office.

A cable vault 18′ 0″ wide by 9′ 10″ high, running the entire length of the north end of the building, is provided and equipped with galvanized racks through the center and on both walls for supporting the lead-covered entrance cables. An automatic pump is provided for removal of drainage water.

Along the front of the building are located the toll operating room, rest room, toilets, and the entrance foyer. The south side of the building is divided by partitions forming the toll terminal and repeater room and the battery room, while a separate wall at the rear forms the high tension and transformer chamber. The power room, which is between the high tension and battery rooms, is separated from the main terminal room only by an iron pipe railing.

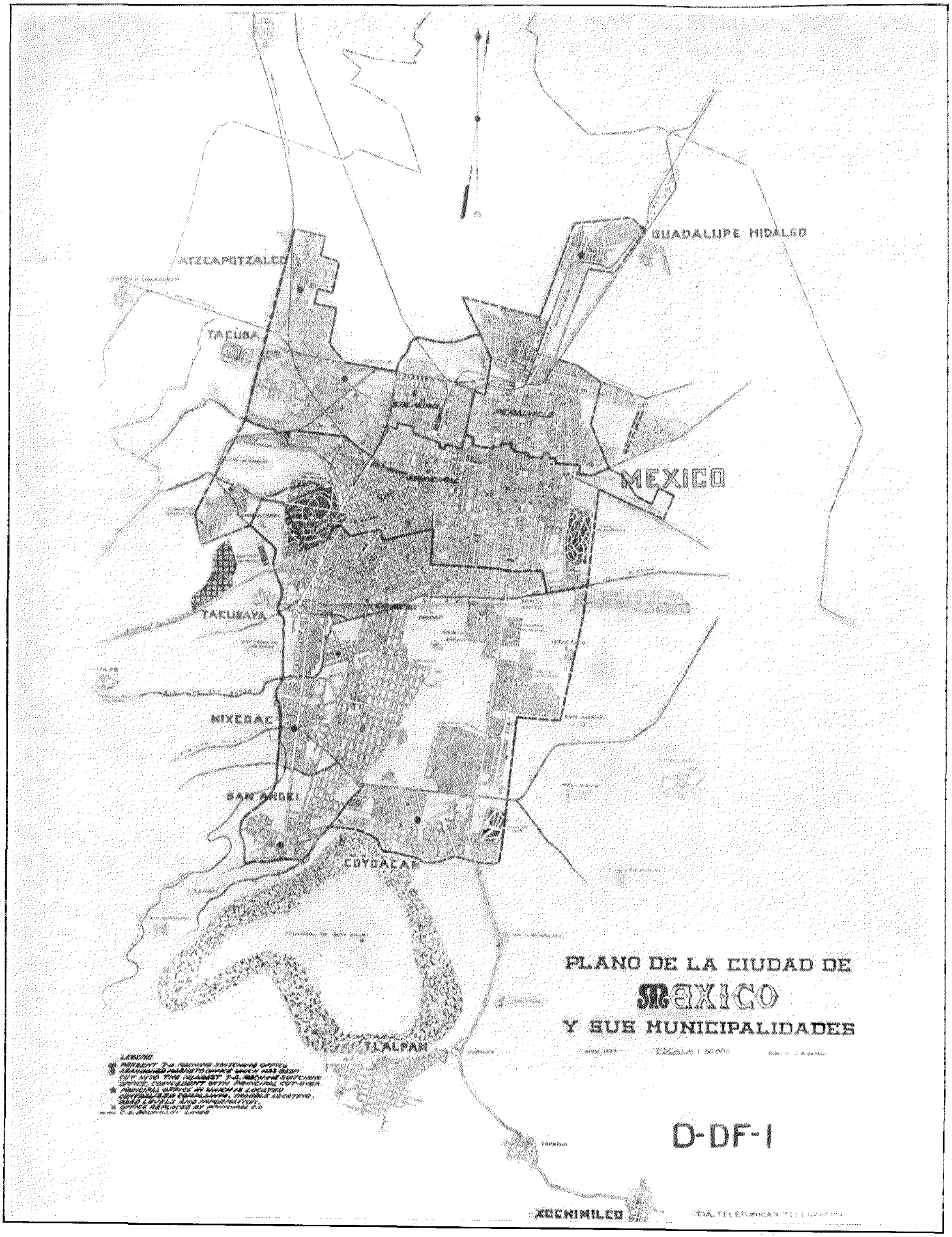
The main frame, with a present capacity of 27,270 pairs, consists of 90 bays, of which the first 15 are used for trunk and miscellaneous circuits. Both sides of the frame are equipped with rolling ladders, which give quick and easy access to all parts of the frame. The ladder superstructure is held in place by beam clamps which extend beyond the track on either side of the frames to support the conduit and fixtures equipped with angle reflectors for flood lighting both sides of the frame.

The switching equipment consists of 26 switchracks which are located on either side of a central aisle and which contain the 140 registers, the line finders, selectors, automatic toll switching trunks, and miscellaneous circuit equipment.

Automatic routine frames are provided for the regular routining of the equipment. With this equipment a repeated series of tests can be made on the apparatus of one circuit for locating intermittent trouble, or the same series of tests can be made in sequence on all of the circuits of a group. Suitable alarms are provided to announce a failure of the circuit under test and to show the progress of the test at the time of failure, the routining being automatically stopped at this point pending release by the Maintenance Attendant.

The local test desk consists of six positions, one position being used for a central cable test board. Test lines from each position are provided to multiple jack appearances on both the vertical and horizontal sides of the main distributing frame. The positions are provided with visual dial testers for testing the speed of subscriber's dials from the subscriber's instrument over the cable pair. Trouble locating as well as dispatching of trouble shooters for the entire Federal District is done from this test desk.

Four positions of monitor and service observation desk are mounted on bays near the local test desk. At these positions are made observations on calls passing through the office and tests on the outgoing trunks. The positions are equipped with voltmeter and howler for testing and with pen register equipment for recording dialed pulses. Busy keys are provided for the outgoing trunks to allow temporary reduction of the size of a group or to busy any trunk on which trouble develops. A limited number of traffic meters register total calls or overflows



Plan of the City of Mexico and Its Municipalities.

on various classes of equipment, and groups of lamps indicate overflow and occupation of second line finders and connecting circuits.

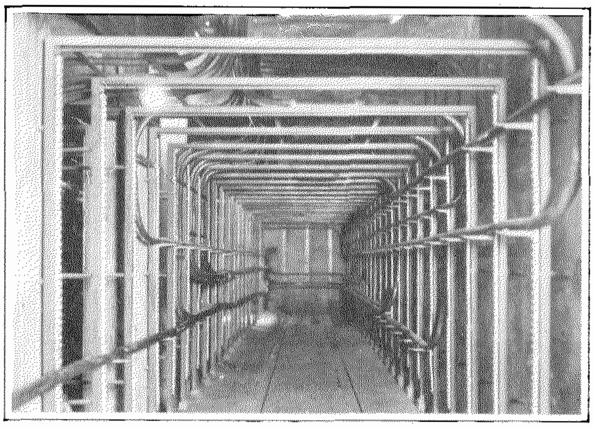
Dead line, changed number and dead level selectors are provided to route calls to unassigned terminals to an operator. Special code selectors route two digit calls for fire, police, information, Official P.B.X., complaint, wire chief, rural, time-of-day, and long distance service to the respective P.B.X.'s and desks, ringing tone being placed on the line to the originating subscriber until the call is answered. These selectors are also arranged for revertive ringing to provide for furnishing two-party service at a later time.

One bay of 425 traffic meters is permanently connected to the critical circuit groups in the exchange. These are arranged with cutoff key to avoid operation of the registers except when traffic readings are desired. With this equipment complete traffic charts can be prepared to show the actual load on each circuit group, and from these accurate studies of calling rates, load distribution and requirements for additional equipment can be readily made.

For supplying power for the exchange, three motor generators are provided. One of these is used to float the 48-volt load, one for the 24-volt load, and one as an emergency. In case of A.C. failure a 48-volt emergency motor alternator set is automatically cut into service to supply alternating current for the switchrack motors, the ringing machines and the emergency lighting throughout the building. Two mercury arc rectifiers are provided for floating the load during hours of light traffic. Two alternator-driven ringing machines supply ringing and tones for the exchange and are equipped with filters to avoid radio interference.

The power service supplied by the Electric Light and Power Company is 3,000 volts, 50 cycles, three phase. This is fed through oil switches having an overload and no voltage release to transformers, where it is stepped down to 220 volts A.C. for use in the power equipment and switchrack motors. A duplicate set of oil switches and transformers is provided with the necessary high tension switching arrangement for emergency use.

To supply power in case of a continued power service failure a 220-volt, 62 KVA alternator direct connected to a 110 H.P. gas engine is provided, an excess of 30 H.P. being required on account of the altitude of 2,300 meters at Mexico City. This alternator has its own direct connected exciter and furnishes power direct to the A.C. busbars of the power supply



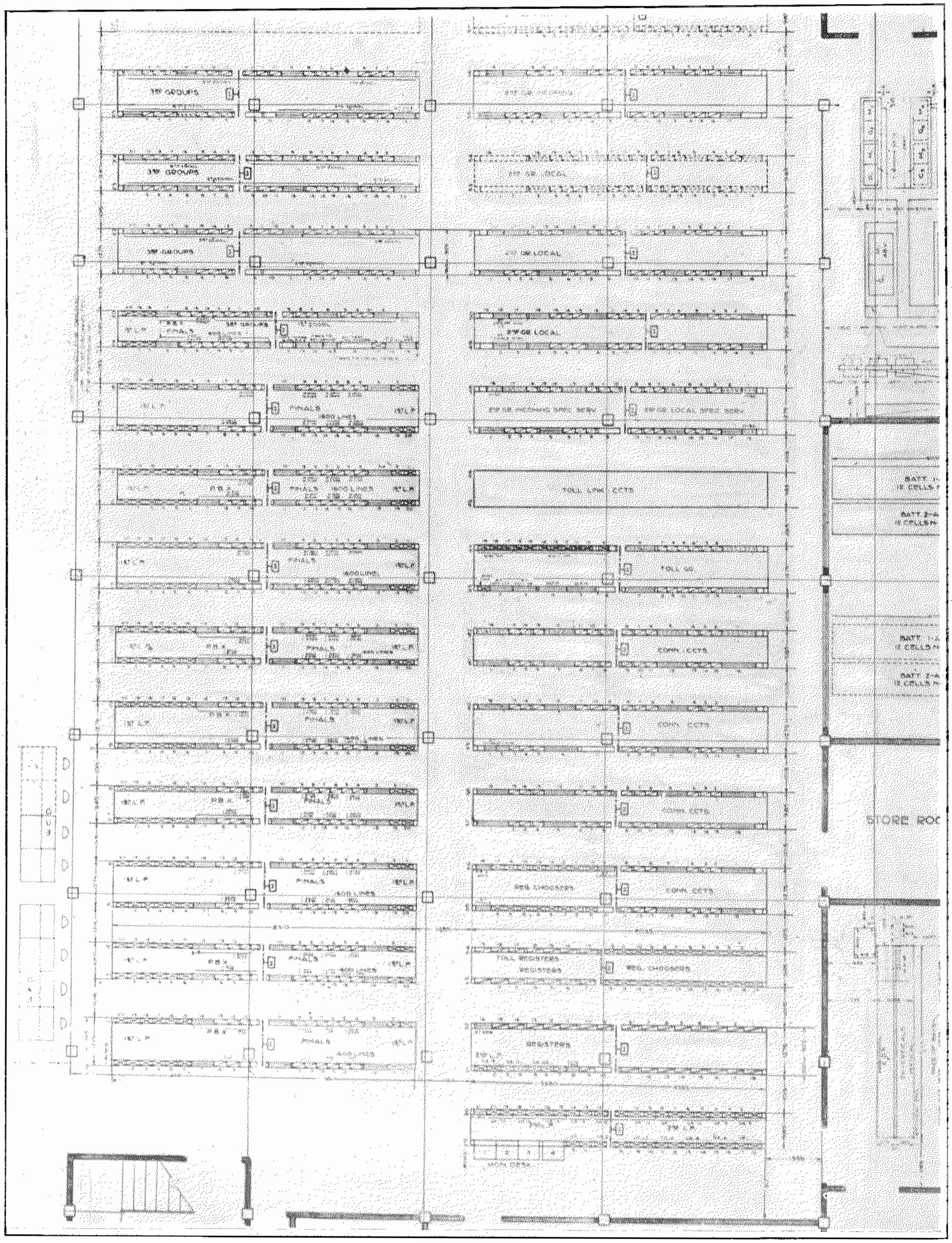
View of One Side of the Cable Vault.

panel. Complete power alarm and power fuse alarm equipment indicates a failure of any kind in the power supply, charge, discharge or ringing current feeders. Large single stroke and continuous ringing gongs announce the operation of any alarm and indicate in general the type of failure.

For charging the combination telegraph and telephone repeater plate battery, two alternator-driven 175-volt D.C. generators are furnished. Electrolytic filters are provided to eliminate noise on the repeater plate voltage supply leads. The tube filaments are fed from the 24-volt tap of the main office battery.

In the battery room are mounted two 48-volt batteries of lead-lined tanks with three emergency cells for voltage regulation. Voltage control is provided at the power board with manually operated switches. High-low-voltage alarms indicate the need for cutting in or out the emergency cells.

Two sets of 130-volt positive and 130-volt negative batteries in glass jars are provided for telegraph and repeater plate battery; also two sets of 60-volt batteries in sealed type glass cells for the key sets on the long-distance operating positions.



Part of Floor Plan—Principal Central Office. Main Distributing Frames, Transformer, Power and Battery Room, Toll Terminal, Toll Operating Room and Operators' Quarters, Not Shown Because of Space Limitations.

Switchracks in Principal Central Office.

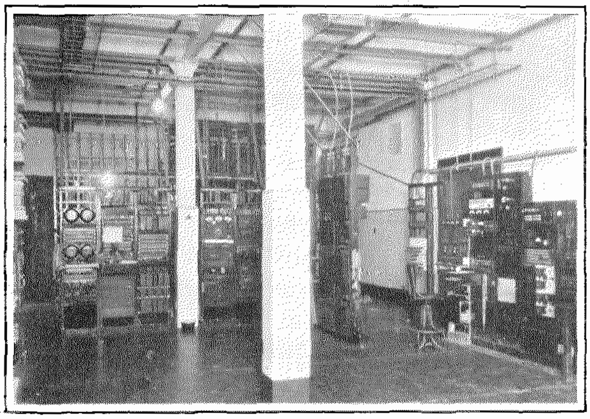
Operating Room in Principal Central Office Showing Chief Operator's Desk, Complaint Desk, Time-of-Day Position and Toll Switchboard.

The operating room contains the ten position #2003 type long-distance switchboard, the information desk and the complaint, intercepting and time-of-day service desk.

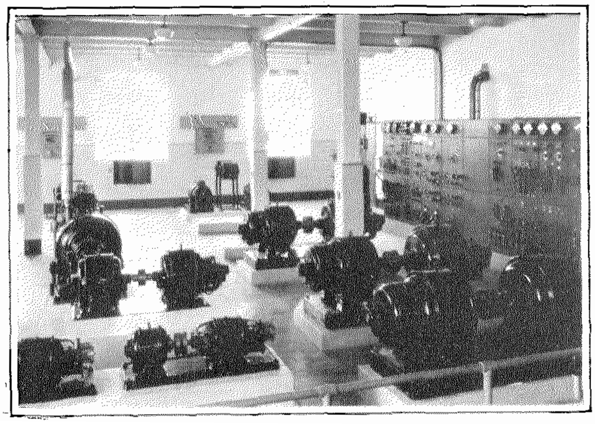
The toll board is of the modern type arranged for combined line and recording operation and having the first two positions equipped with repeater cords. Ten button key sets are used instead of dials for setting up calls over the automatic toll switching trunks to the various offices. The jacks for these trunks are individual and are selected by position finders associated with the toll switching link circuits whenever a jack is taken up by an operator.

The information desk of six positions furnishes information service for the whole city. It consists of table type sections having the keys of the key-ended incoming trunks depressed in the keyshelves. The records are contained in large rotary leaf files, one on the rear of each desk, the desk being staggered to make three files available to each operator. The centralized complaint and intercepting desk consists of six positions, one of which is equipped with incoming trunks over which the subscriber may obtain the correct time from the attending operator. Key-ended, multipled trunks on positions two to six are used to answer calls from the complaint level of the special second selectors.

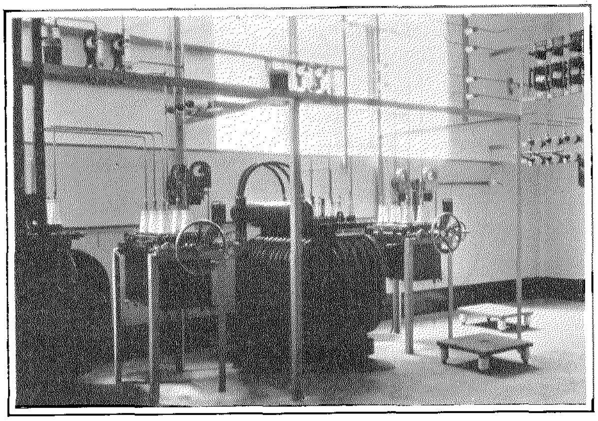
The complaint desks have a wide writing shelf, in the rear of which the keys are mounted on a narrow sloping panel, leaving the top of the desk free for record books and necessary stationery. On the desks are multipled, also key-ended trunks from the changed number and dead level



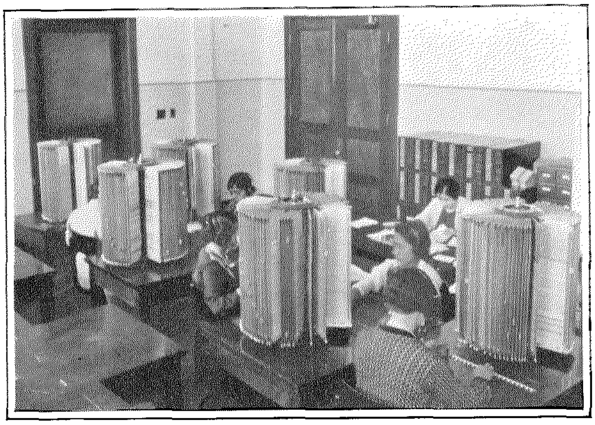
Repeaters, Telegraph and Carrier Equipment, Principal Central Office.



Power Room, Principal Central Office.



Power Transformer Room, Principal Central Office.



Central Information, Principal Central Office.

selectors from the different offices, giving a centralized intercepting service for the whole city.

In the double-sided turret of the chief operator's desk are mounted monitoring jacks for the various operating positions and miscellaneous incoming and outgoing trunks to the various desks and to terminal numbers of the automatic equipment.

The toll terminal equipment is located in a separate room from the automatic equipment. The toll line entrance cables are here terminated on a combination distributing frame. Relay rack mounted equipment is used throughout. Speech input equipment is provided for the transmission of radio programs. Duplex telegraph circuits are used for intercommunication for maintaining the circuits. For testing, a #2005 toll test board is installed, associated with which is a transmission measuring set and a voice frequency oscillator. Four-cycle open location test equipment is provided and is used jointly with the cable test position of the local test desk.

Double level superstructure supported to the ceiling beams with beam clamps is provided in the toll terminal room for supporting the distributing frame, the relay racks, fuse panels and cable racks. This practice is of great advantage due to the ease with which supports can be added and changed without interference with the installed equipment or damage to the buildings, walls, or ceilings.

Complete rack lighting is installed in the switchracks. Six 60-watt lamps in each aisle and three on the interior of each frame are used, and all wiring is run in conduit. The aisle lamps are mounted directly on the conduit fixtures at ceiling height and are equipped with high-grade glass reflectors. Control is obtained from toggle switches at each end of each switchrack. Three sets of outlets are installed along the top of the switchracks in each aisle for light and soldering iron extensions. Three sets of outlets are also provided along the guard rail, at the bottom of the switchracks in the interior of each rack.

Due to different power rates for light and power a duplicate system of conduit is required over the whole exchange. This requires a large amount of conduit, and it was determined to use threadless conduit fittings in order to reduce the installation expense. These fittings eliminated the necessity for threading of conduit and proved very satisfactory.

To overcome serious dust conditions the entire concrete floor, with the exception of the power and battery rooms, has been covered with brown battleship linoleum.

The cutover of this rotary automatic equipment, together with the associated new outside plant, and the introduction of a definite preventive maintenance routine, has resulted in greatly improved telephone service. When the present offices require relief, fundamental plans provide for additional automatic units.

The Four Frequency Signalling System

By T. S. SKILLMAN, M.A.

Introduction

THE four frequency signalling system is one of several recent developments which have resulted from an extended investigation by the International Telephone and Telegraph Laboratories into the problem of providing economical methods of switching long telephone connections.

Hitherto the operating methods in use on long telephone lines have been determined chiefly by the available signalling facilities, which were limited to the transmission of a single ringing signal, but with the introduction of the four frequency system operating methods can be chosen on economic grounds alone. The system is sufficiently flexible to cope with almost any method. This means that any of the operating methods now in use on short junction circuits can be applied to toll* lines. In particular, automatic working can be used; and it is more especially as a means of enabling long distance connections to be completed automatically under the control of one operator that the four frequency system claims attention.

Automatic working on long lines, however, involves a risk of reducing the traffic-carrying capacity due to the fact that the line remains idle while waiting for the subscriber to reply and while attention is being given to busy subscribers or to trouble conditions on the automatic plant. The development of the four frequency system has been directed particularly towards eliminating this difficulty; and, as a result, the adoption of automatic methods, besides giving quicker service to subscribers and besides providing very large reductions in the operating cost, is able in the great majority of cases actually to give a considerable increase in the revenue earning capacity of the lines. The present article gives an outlined description of the system and an account of its possible applications, followed by a brief discussion of the economies which it is expected to produce.

*Note: The word toll is used throughout this paper to refer to any type of interurban connection, irrespective of length.

Why Four Frequencies Are Used

The system employs voice frequency currents of four frequencies—lying within the range 400–1,000 p.p.s.—for signalling over the lines. The currents are detected by means of a group of four voice frequency relays of a new type. Each relay is tuned to one of the four frequencies.

The use of voice frequency currents for transmitting signals is necessary primarily in order to avoid the use of special relay arrangements at repeater stations. The considerations underlying this are already well known and have led to the general adoption of a voice frequency current of 500 or 1,000 p.p.s. for ringing purposes on all except short lines. The immediate problem which arises is that of protecting the signalling equipment from false operation by voice currents, noises, tone signals and bangs and clicks containing voice frequency components. In the single frequency ringing system this is solved by

(a) making the signalling equipment selective so that it will respond only to 500 or 1,000 p.p.s. current interrupted at a rate of approximately 20 p.p.s., and

(b) making the signalling circuits slow to respond so that the interrupted 500 or 1,000 p.p.s. current has to be applied for approximately 500 milliseconds before the apparatus responds.

Consequently, the ringer panels now in use include a good deal of special apparatus whose sole purpose is to protect the equipment against false operation. The development of a reliable and cheap voice frequency relay makes it economical to avoid false operation by using signals which consist of combinations of several frequencies. Advantage is thus taken of the fact that the voice does not normally produce a number of separated frequencies simultaneously for any length of time. In the four frequency system, four voice frequency relays are bridged across the line and these are operated in different combinations by different signals. Voice currents, however, will not operate the relays in correct combinations for a sufficient length of time to affect the circuits. A guard action is also obtained by arranging the circuits so that the operation of any relays other than those required for the signal has the effect of disabling the circuit. Even if the voice currents contain the required frequencies, they will also contain other frequencies which will operate some other of the four voice frequency relays and in this manner prevent false operation of the equipment.

Figure 1 shows how simply the protection is obtained in practice. Each signal is obtained by connecting a single four winding relay with the four voice frequency relays, W, X, Y, Z. The figure shows how different relays, A, B, and C may be controlled from the four voice frequency relays to carry out different operations under the control of a sending circuit at the distant end of the line. A, B, and C are normally energised and are released only by the particular combination of two frequencies indicated on the diagram. Relay A has all four windings open only when relays W and X are operated and Y and Z released. If W or X release for a short time, or if Y or Z are operated for a short time (for instance, by voice currents), then the windings of relay A get a fresh supply of energy from the battery and the relay will therefore remained energised for a further short period. A, therefore, can only be released if W and X remain energised and Y and Z de-energised for a period equal to its release time. It has been found in practice that if the release time of A is not less than 300 to 400 milliseconds, then complete freedom from false operation by voice or noise currents can be obtained.

It will be seen that in this way immunity from false operation is obtained without any of the special apparatus which is needed on single frequency systems and that all vibrating relays, 20 cycle relays, or relays with accurate timing requirements have been eliminated. This in itself (on the grounds of simplified maintenance, improved reliability and shorter signalling times) might be sufficient to justify the system. The great advantage is, however, that the same four voice frequency relays can now be used to obtain not one signal, as in the case of the single frequency ringer, but some fourteen different signals, all of which are useful. As a result, the signalling facilities which can be obtained are practically unlimited. Figure 1 shows how

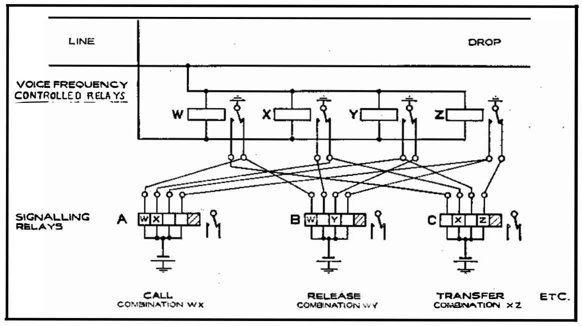


Figure 1—Schematic Showing Method of Obtaining Signals.

three different combinations can be used in a very simple way to provide calling, releasing and transfer signals, while others can be obtained by adding further four winding relays. To obtain these three by means of a single frequency would, of course, involve long relay trains and some means for either counting impulses or distinguishing between long and short pulses.

The simplicity of the equipment is illustrated by Figure 2 which shows the circuit of a ringer panel using the four frequency system. This, it will be seen, is much simpler than that of a single frequency ringer and the mounting space required is considerably less. The difference between the two becomes more and more marked as the signalling requirements become more complicated and greater use is made of the possibilities of the four frequency system (as in the case of automatic working).

The advantage of being able to use a series of different relays such as A, B, and C in Figure 1 will be readily appreciated by circuit designers. It is from the design point of view equivalent to providing some fourteen wires between stations on each circuit instead of two, and means that very simple, flexible circuits, adaptable for connection with any type of toll board and any type of automatic equipment can readily be produced.

The fact that fourteen different signals are available enables numbers to be transmitted in the form of codes instead of in the form of dialling impulses and thus the four frequency system, as well as enabling dialling to be carried out, also permits key-sending to be used. In this case, an operator may set up a distant register circuit directly over a long distance line by means of a strip of ten digit keys which send out different combinations of four frequencies for each digit. The use of ten of the fourteen combinations for key-sending does not, of course, prohibit their use for other purposes also, since the key-sending impulses are only effective while a register is connected, and the same combinations may be used for other purposes after the register is released.

The reasons for the use of four frequencies may, therefore, be conveniently summarised as follows:

(1) Freedom from false operation by voice currents and noise currents is obtained without providing any special apparatus.
(2) A large number of different signals are obtainable in a manner which demands very little apparatus and which involves no accurately timed relays. Consequently the system
(a) is very flexible and enables changes of operating methods to be carried out without changes in the equipment;
(b) is able to work in with existing toll boards and existing automatic equipment without difficulty and with the minimum of modification to existing circuits;
(c) provides key-sending facilities which are very valuable from the operating point of view and which, from the maintenance point of view, have the big advantage that all impulsing relays are eliminated.
(d) provides a number of special facilities (such as calling in a helping operator and breaking down connections locally busy) and thus enables the traffic carrying capacity of the lines to be increased far more than would otherwise be possible.
(e) provides very quick signalling, so that operators' time and line time are not wasted.

Description of the System

The essential components of the system are the four frequency generator, the line panel and the test panel. These are shown in Figures 3, 4, and 5. All work from the exchange 24-volt or 48-volt battery and require no other power supplies. No vacuum tubes are used, and there is no other apparatus requiring periodical replacement involved.

The generators are sufficient to supply the whole of the station, so that two only are needed at any one terminal point, one for working and one in reserve. Voice frequency current is supplied to each line through individual supply resistances to prevent inter-action between lines and cross connection between the different frequencies.

Figure 4 shows a typical line panel. One of these panels is connected to each terminal of each line which is to be worked on a four frequency basis. The panel consists of a mounting plate, carrying four voice frequency relays, a group of direct current relays and a sending transformer which serves to provide impedance matching and to ensure that the sending circuit is properly balanced to ground.

The test panel is shown in Figure 5. It consists of a simplified time measuring bridge by means of which the sending times and response times of the different signals which pass between the line panels at the two ends of the circuit can be measured. The test panel is connected to the line panels automatically by means of a test relay as soon as the line panel test jacks are plugged up. The tests are applied by operating the keys on the test panel and checking to make sure that the signal times are all within specified limits. Typical limits are 250–350

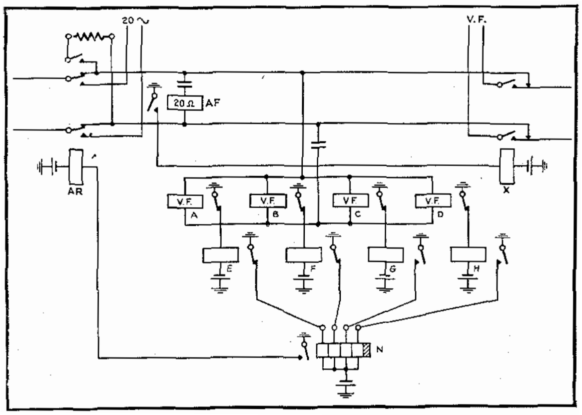


Figure 2—Circuit of Four Frequency Ringer Panel.

milliseconds response time and 375–475 milliseconds sending times, and it will be seen that these limits are such that the adjustment is easy and needed only infrequently. The test panel also places certain overall tests on the line panel. In addition, it provides facilities for adjusting the impulsing relays, if any, and the relays which work from the voice frequency relays. All other relays are ordinary duty relays and no special adjustment test is provided.

A typical installation of four frequency equipment, in this case for 34 lines, is shown in Figure 6.

The system will work over lines having any attenuation between zero and 15 db. For circuits of higher attenuation a single stage amplifier is required. Such an amplifier working from 24 or 48 volts is available; but, in view of the general tendency to keep attenuations down to a maximum of 12 or 13 db., it is expected that the amplifier will very seldom be needed. One of the big advantages of the four frequency system is the rapid service which it enables administrations to give to subscribers; however, the resultant increase in traffic which is always to be expected in such cases will certainly be deferred if the attenuations of the circuits are such that conversation cannot be carried out with ease. This, of course, in practice is determined by talking under noisy office conditions so that an attenuation of 15 db. can reasonably be considered a maximum for any large amount of long distance traffic. This point of view now seems to find fairly general acceptance.

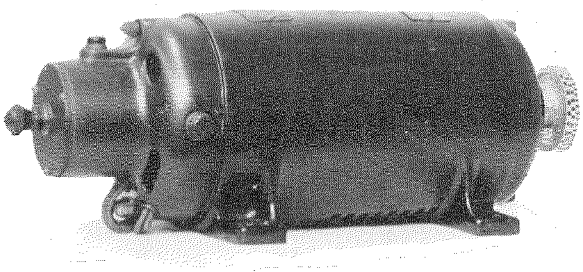


Figure 3—Four Frequency Generator.

The application of the four frequency system to existing telephone networks does not vary with the operating method or with the type of network. In each case it is necessary only to install a pair of generators in each exchange and the line panel on each line. This line panel will provide the signals necessary for any ordinary operating method. It can give ringdown working by means of the circuit shown in Figure 2, and can be modified to provide dialling or key-sending by an operator directly into distant automatic equipment. In addition, it provides supervision of the called subscriber and busy flash if the called subscriber is busy. A number of special facilities, described later, can be given to the operator and a number of specialised operating methods are available. This means that the four frequency system can be economically incorporated in a telephone network in the very early stages of development in the secure knowledge that as the traffic grows the same line equipment can be used with only minor modifications to take care of all changes in switching practice.

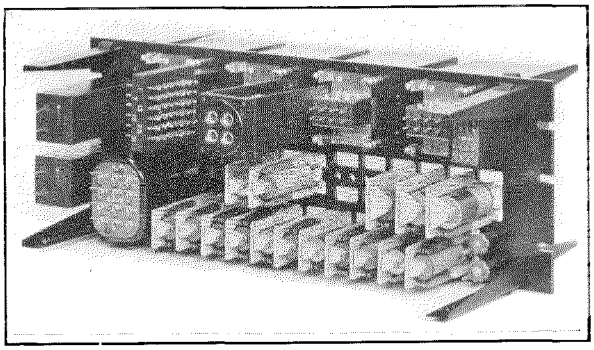


Figure 4—Line Panel, Covers Removed.

In order to elucidate the operation of the system it is interesting to follow out its application to a group of, say, 30 lines at present worked on a ringdown basis. These lines are now to be converted so that the operators at one end may dial directly into the automatic exchange at the other end and vice versa. The circuits will be used for both way traffic and busy signals will be added so that the operators

Figure 5—Test Panel.

at each end will not attempt to pick up the same circuit. Since for every connection the operator at the incoming end will be eliminated, it will be possible to reduce the number of operators at each end. An additional saving will be obtained, also due to the fact that each operator has no external delays. The external delays experienced on the manual system are due chiefly to the fact that one operator has to wait for the other to reply; during the busy period it often happens that the distant operator is engaged with a subscriber at the time she is required and hence the originating operator loses appreciable time waiting for her. Delays of this kind are of course entirely eliminated by the automatic method, thus not only reducing the number of operators required for a given group of circuits but also tending to increase the traffic carrying capacity of the group.

It will be seen therefore that the conversion of the postulated group of 30 circuits with the necessary changes in operators' positions at each end involves the following:

(a) addition of one line panel to each terminal of each of the 30 circuits.
(b) provision of common exchange equipment consisting of two generators and a test panel at each terminal.
(c) modification of operators' positions at each terminal, involving concentration of the required number of lines per position, the addition of a dial, and perhaps in some cases an increase in the number of cord circuits (the concentration of lines on positions will, of course, not be required on a toll board with a directly accessible toll multiple of the type used for C.L.R. traffic).
(d) In some cases, the modification of the automatic circuits at the point where the lines are connected, to provide supervision of the called subscriber. This does not apply to most automatic systems, where a supervisory signal is already available; and, in any case, means the addition only of a single relay or small relay group for each long-distance line.

The method of operation used is then as follows:

The operator, upon receiving a ticket, plugs into a free line and dials the required number. She obtains her local subscriber by any of the usual methods, either by dialling into the local automatic equipment or by way of an intermediate operator. On C.L.R. working, of course, she already has access to the subscriber and will make out a ticket herself. She receives supervision of both subscribers by means of the lamps on her cord circuit and is thus able to see without waiting on the circuit when they reply and when they hang up. If the subscriber is busy she will get busy flash, assuming this is provided by the automatic equipment. If busy flash is not provided she will observe that the subscriber has not replied and will find busy tone upon entering the connection. She is able, by pressing

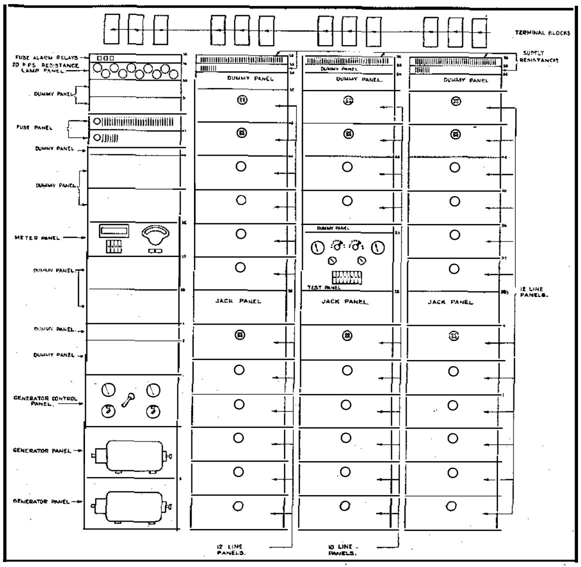


Figure 6—Typical Installation for 34 Lines—Rack Layout.

a common key mounted near her dial, to offer a long-distance connection just as is now done by the incoming operator. That is to say, she may do this automatically if the automatic switches permit; or, if not, she may call in an auxiliary operator who will carry this out for her. When she observes by the lighting of the two supervisory lamps, that the conversation has finished, she pulls out her plug and the connection is automatically released.

The signals necessary to provide these facilities are transmitted from terminal to terminal of the line as pulses of voice frequency current. The duration of each pulse is of the order of 300 milliseconds and the pulse will consist of two frequencies or perhaps three frequencies sent simultaneously. A pulse of one combination is sent out from the near line panel when the operator plugs into the line and another pulse of a different combination is sent when she pulls out her plug to release. These pulses

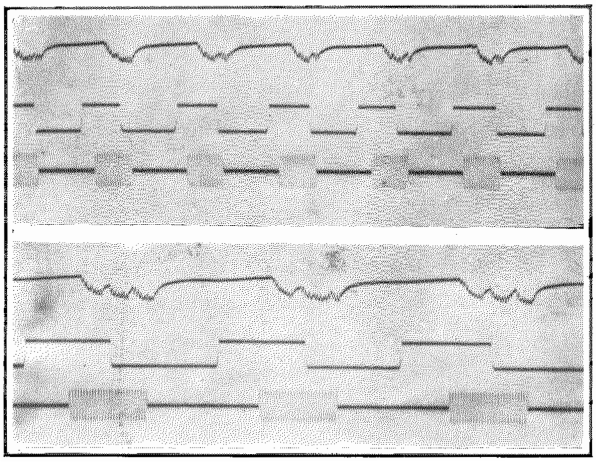


Figure 7—Impulsing Oscillograms Taken from a Voice Frequency Relay—Average Conditions.

are measured off by slow release relays in the line panels. At the distant line panel each pulse produces a momentary release of a particular relay such as A, B, or C in Figure 1, and these momentary releases are used to prepare and release the automatic equipment, or, in the reverse direction, to control the supervisory lamps and so forth. Dialling is carried out by transmitting a succession of short impulses of voice frequency current of a single frequency. These impulses follow the direct current impulses obtained from the dial. Typical impulses are shown in Figures 7 and 8. The circuit is so arranged that during dialling it is cut off from the local circuit so that no interference with the impulses can be produced.

If the group of 30 lines considered above were converted to key-sending instead of dialling, a further economy in operators could be expected, since the time taken for an operator to dial some five or six digits for both distant and local subscribers is quite considerable. Further, since the time spent on each call is reduced appreciably by the elimination of the distant operator, the dialling time now represents quite a large proportion of the total operators' time occupied by each connection. The use of a key-set reduces this dialling time considerably and thus has a distinct effect in reducing the load per line on the operator. The key-set, of course, has engineering advantages also, since it eliminates all dialling relays and thus removes from the system all relays which are likely to have any accurate adjustment requirements. The digits are transmitted each as a different combination of the four frequencies and no close limits as to the time of duration of these pulses are involved. The highest key-sending speed normally obtainable is 8 per second and the shape of the impulses is not important, while dialling impulses must be transmitted without serious distortion up to speeds of fourteen steps per second. Consequently, without reflecting on the reliability of dialling circuits, it will be clear that key-sending circuits must always be more robust and have wider adjustment limits.

Views of typical key-sets are shown in Figures 9 and 10.

Voice Frequency Relay Characteristics

The essential part of the system is, of course, the voice frequency relay. A photograph of the relay is shown in Figure 11. It will be seen that it consists of an assembly which is used to drive a tuned reed. Resting on this tuned reed is a small mass which is provided with contacts

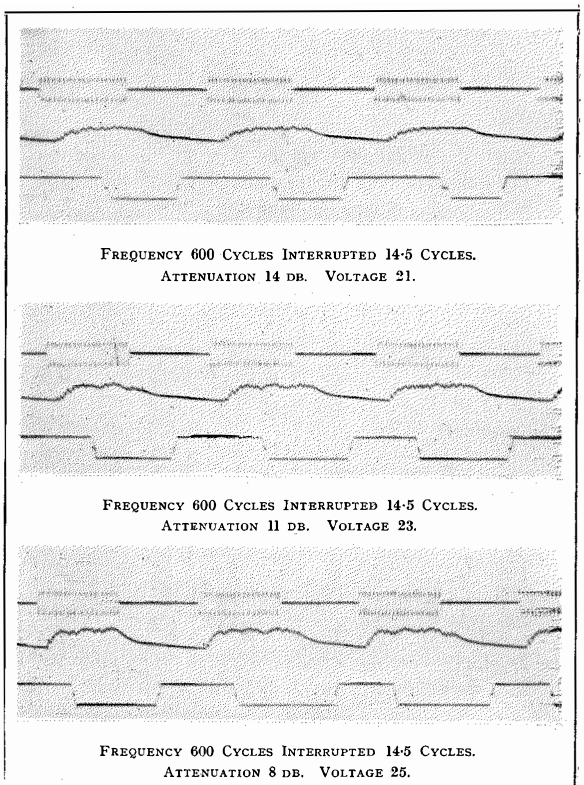


Figure 8—Impulsing—Limiting Conditions.

of a special alloy. When voice frequency currents of the correct frequency are received by the relay they cause the reed to vibrate in resonance and as a result the electrical contact

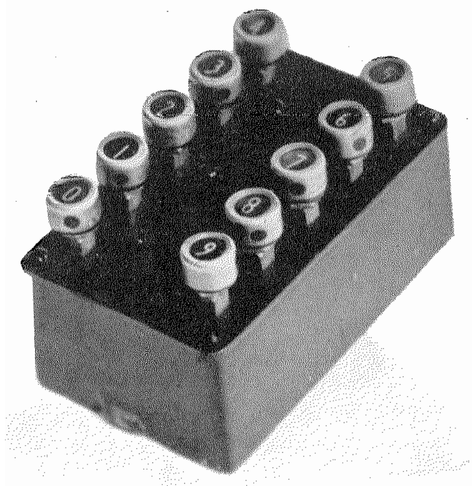


Figure 9—Typical Key-set—Small Pattern.

between the mass and the reed is intermittently opened. This contact is used to control a direct current relay in a local circuit which includes the reed and mass contacts.

This very simple device has one rather remarkable characteristic, which is that its out-

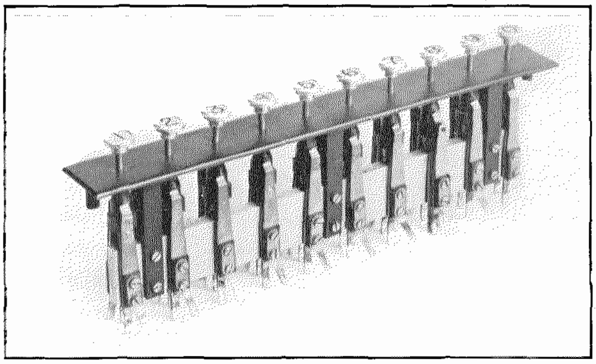


Figure 10—Typical Key-set—Large Pattern for Use Where Toll Board Space Permits.

put current is almost independent of the input current over quite a wide range. This is illustrated in Figure 12. The ordinates in this figure show the current which is received by the direct current relay following the voice frequency relay and the abscissae show the level of the voice frequency current which is applied to the voice frequency relay. The level is referred to one milliwatt in 600 ohms and it is assumed that the voice frequency relay, which is a high impedance relay, is bridged across the 600-ohm circuit. The abscissae consequently represent the changes of condition which would be applied to voice frequency relays bridged across a telephone line when the attenuation of that line varied by the values indicated. It will be seen that with a variation of attenuation from zero down to 16 db. the current in the direct current relay changes by only 2 milliamperes in 13. This should be compared with the output of a vacuum tube rectifier, where change of line

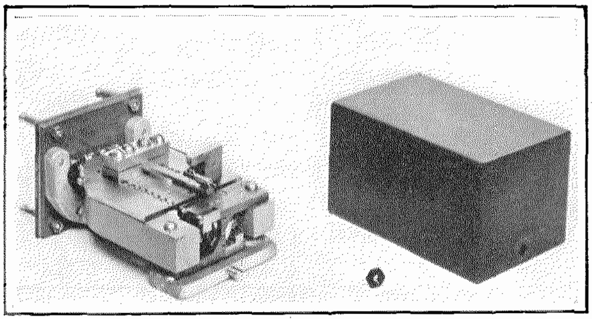


Figure 11—Voice Frequency Relay.

attenuation of this order results in a very much greater change in output current and where the direct current relay is proportionately difficult to maintain. With the present arrangement it will be seen that the variations to which the

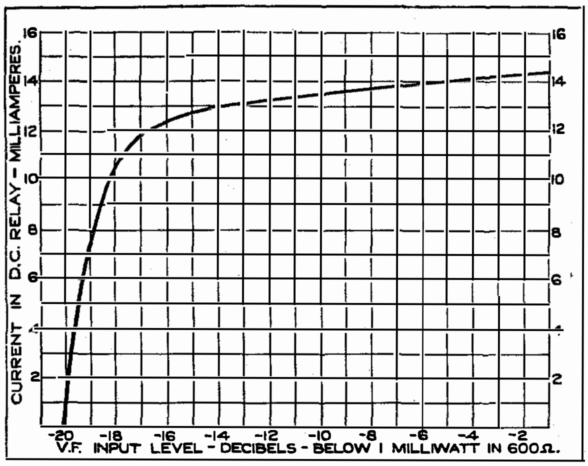


Figure 12—Output Characteristic of Voice Frequency Relay.

direct current relay are subject are so small that a very rough adjustment only is needed.

This independence of changes in the voice frequency level is more important than appears at first sight, since there are a number of causes tending to vary the voice frequency level impressed on the receiving relays. During parts of the connection the line is open circuited, while at other times it may be closed by quite a low impedance subscriber's loop or by another low impedance line. The level consequently may vary by 6 or 8 db. Secondly, the attenuation of the line itself may vary, in some cases possibly as much as 6 db. Thirdly, the voltage of the generator may vary. It will be seen that the total variation is very considerable and would, without some current limiting device such as that which is automatically obtained from the voice frequency relay, be a source of considerable maintenance difficulty.

The power output from the relay contact is sufficient to enable any ordinary type of relay to be used in all cases except dialling. For dialling, it is desirable, although not essential, to use a polarised relay. (The impulsing shown in Figures 7 and 8 were obtained with a non-polarised relay of the new Universal type.)

Figure 13 shows the tuning characteristics of the group of four voice frequency relays. The ordinates represent the minimum level at which each relay operates. The scale refers to the attenuation below 1 milliwatt in 600 ohms and consequently represents the changes of condition which would be produced by changes of attenuation of a telephone line across which the voice frequency relays are bridged. The four relays in the present case are tuned to 500 p.p.s., 600 p.p.s., 750 p.p.s. and 900 p.p.s. In practice, the sending energy lies between the limits of 2 milliwatts and 3.5 milliwatts so that the level of—12 db. in Figure 13 represents a line attenuation of approximately 15 db. In practice, the relays would not be worked at lower levels than this.

The mechanical construction of the voice frequency relay has certain valuable features. By using a gravity controlled contact automatic adjustment is obtained and no spring bending or screw adjustment is needed. Further, the mode of vibration of the small weight is such that very violent rubbing actions take place at both supporting points and consequently the contacts are self-cleaning. It is possible to shower the contacts with dust and yet after operating the relays for a few moments to obtain perfect contact. This action, however, disappears if any grease is placed on the contact and consequently it is desirable not to touch the weight with the fingers. The relay is enclosed in a dust-proof cover so that this should never be necessary.

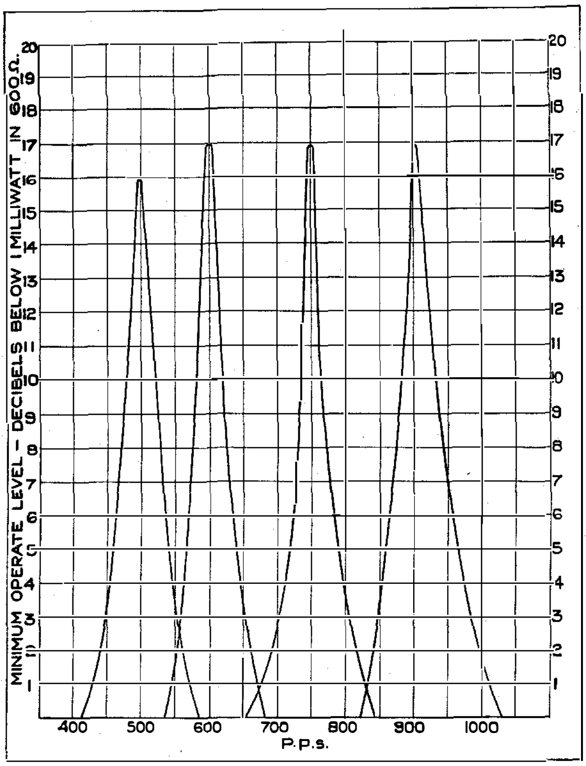


Figure 13—Tuning Characteristics of Four Frequency Relay Group.

The resonant system of the relay consists of the reed which can be seen in Figure 11 coupled to a pin which connects at its bottom end to the armature of the motor. Part of the armature can be seen in the photograph between the two triangular pole pieces. This system is very rigid and is rigidly clamped by means of the large clamping pieces and large base plate shown in Figure 11, and as a result secondary resonances are very slight. With this construction also variations of the resonant frequency are practically eliminated. The chief source of variation which might be expected is changes in the magnet strength, which will have consequent effects on the effective elasticity of the armature and its support. This, however, is so very small compared with the stiffness of the reed that its effects on frequency are negligible. Field experience so far indicates that it is possible to close up the relay and leave it in operation indefinitely without adjustment or attention. The robust construction makes it quite unaffected by rough shipping treatment or other jars.

The timing characteristics of the relay can be gathered from Figures 7 and 8 which show impulsing from a typical relay. In these figures the voice frequency impulses in the line circuit are shown in one trace of the oscillogram. The second trace of the oscillogram shows the current which is supplied to the direct current relay from the voice frequency relay. It will be seen that this shows the normal growth and decay curves of an impulsing relay with the superposition of a small ripple due to the contact of the voice frequency relay. The third trace on the oscillogram shows the impulses which are obtained from the contacts of the direct current relay. It will be seen that the impulses under limiting voltage and attenuation conditions are practically free from distortion. The direct current relay used in taking these oscillograms was one of the Universal type, having a moderately long operate and release time. The operate time and release time of the voice frequency relay are of the order of 8 or 10 milliseconds. This time varies of course with the voice frequency level which is supplied to the relay but in no case does the time become sufficiently long to cause circuit difficulties in operation. The timing characteristics are obtained very largely by a special construction of the contacts of the small mass which enables efficient damping to be obtained and which is due to Mr. Van Rijn of the Bell Tel. Mfg. Co., Antwerp. The construction enables the weight to be assembled without the risk of damaging the contacting surfaces or introducing dirt or solder flux.

Facilities Provided

Some of the operating facilities which the four frequency system provides are illustrated diagrammatically in Figure 14.

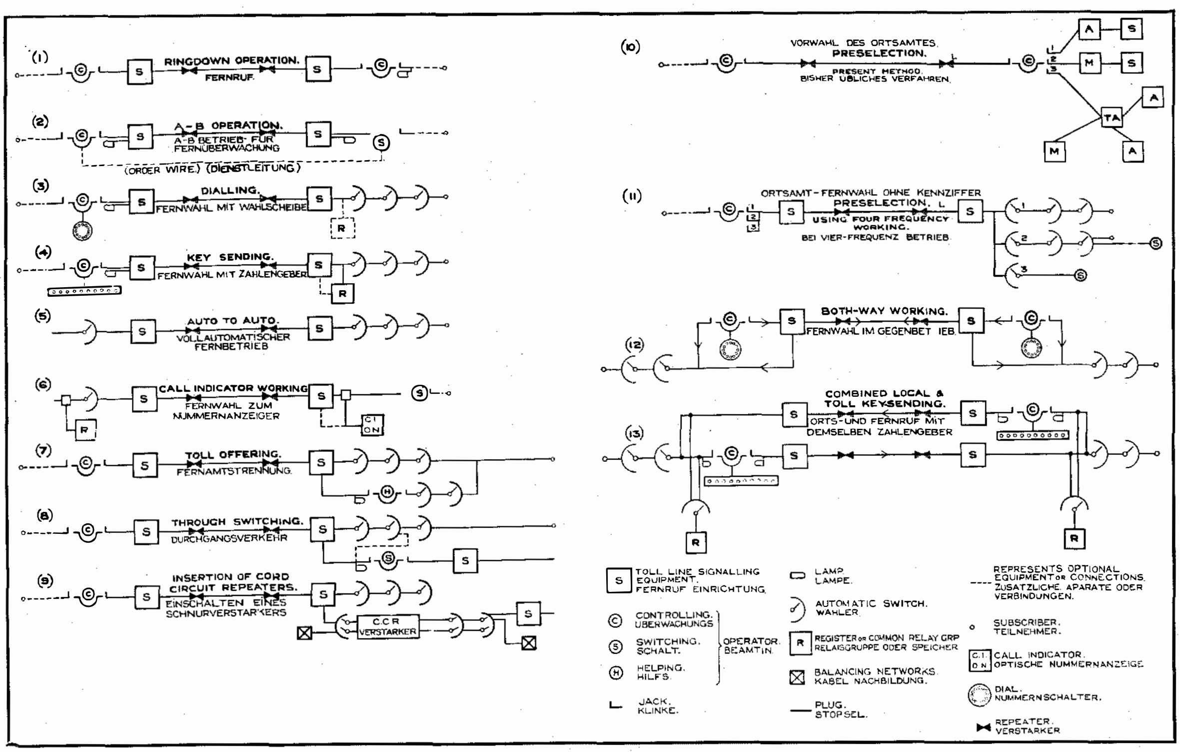


Figure 14—Diagram Showing Operating Methods and Special Facilities Available by Means of the Four Frequency System.

Diagram 1 (Figure 14) shows the present common method of handling long distance calls on a ringdown basis with an operator at each end of a small group of lines. Each operator obtains her local subscriber, and the only signalling required over the line is a ring to enable the two operators to get into communication. The four frequency system provides the very simple form of line equipment shown in Figure 2, which gives this facility and which replaces the present 500 p.p.s. ringer panel. The new equipment occupies less space than the present ringer panels, and has, of course, the very big advantage that it can easily be modified later to give automatic working.

Diagram 2 shows how the four frequency system can be used to simplify the work carried out by the incoming operator on a manual switching basis. The signalling facilities are the same as those given on an A-B local junction, and the incoming operator is a switching operator who only needs to plug through the line as requested. The full control of the connection remains with the outgoing operator, and supervision is passed back to her.

Diagram 3 shows dialling using four frequency line equipment. This has already been described in detail. When the automatic equipment permits toll offering, breakdown, and re-ring, this can be carried out in the normal manner by the originating operator.

Diagram 4 of Figure 14 shows the key-sending application, which is recommended for use under most conditions. In this case the originating operator is provided with a key-set so that, by means of coded impulses over the toll line, she may set up the automatic apparatus in a distant exchange directly. The timing requirements, as already mentioned, are very elastic with this method, since considerations of impulse distortion do not arise.

Diagrams 5 and 6 of Figure 14 show the application of the four frequency system to provide full automatic working and working into a call indicator over a long distance line. Arrangements of this kind are distinctly valuable during the period of conversion from manual to automatic working.

Diagram 7 of Figure 14 shows how a helping operator can be called in. One of the major difficulties experienced in providing automatic working over long lines arises when the called subscriber is found busy, since in this case an expensive line is held idle until the call has been offered to the local subscriber, the call accepted and the local connection broken down. The four frequency system, besides providing a method of carrying out toll offering and toll breakdown directly over the line when the automatic switches permit, also enables this to be done by transferring the connection to a helping operator at the incoming end. This helping operator may either be a special operator who handles trouble conditions for a large group of lines, or may be the long distance operator who controls traffic in the opposite direction (and who, therefore, already has the lines in question on or near her position).

This facility of calling in an operator without delay and without dialling special numbers is useful for several other purposes. It is particularly valuable when a called subscriber delays a long time before answering his telephone. Instead of holding the line for this time the originating operator can call in a distant operator, ask the latter to obtain the subscriber and then proceed to use the line for other purposes. Similarly, if trouble conditions occur in the local plant the traffic can be handled temporarily through the two operators on the old manual basis.

Diagram 8 of Figure 14 shows a further facility which enables the difficulties presented by through working to be overcome. When the originating operator desires to put through a call over a number of long distance lines in tandem, she is able to transfer the line directly to the transit positions without the intermediary of any automatic switches. This avoids any additional transmission loss on through calls, and enables the call to be completed very quickly. (This, of course, does not affect the ultimate conversion of the plant to give automatic tandem connections, if this is required.)

Diagram 9 of Figure 14 shows a similar arrangement designed to introduce cord circuit repeaters automatically under the control of the originating operator.

Diagrams 10 and 11 apply to the conversion of mixed manual and automatic areas, or of areas where incoming long distance calls are routed by the incoming operator directly to the individual local exchanges. In cases such as these the introduction of automatic working would normally involve adding group selectors to provide the selection previously carried out by the incoming operator. With the four frequency system, however, some of the spare signals available can be used to enable this preselection to be carried out by the originating operator, who plugs into different jacks at the outgoing end, or throws different keys according to which exchange she requires. In this way re-routing the junctions at the incoming end is avoided, and the addition of a whole stage of automatic switches, possibly with rearrangement of the register circuits, is avoided.

Diagram 12 indicates that the four frequency system can be used to provide both way working with any type of operating method. That is to say, it can be arranged so that an operator at town A can dial or key-send directly into town B, while an operator at town B can dial or key-send directly into town A over the same line.

Diagram 13 in Figure 14 shows a modification of the key-sending principle which is particularly valuable in a fully automatic area where operators are needed only for long distance connections. With this modification the voice frequency equipment is located in the register circuit, or in a special common group of relays where no registers are available. It is then used by the operators for the local side as well as for the long distance side of the connections. One common set of registers or relay groups is provided, both for traffic from the nearby operator's position, and for traffic from incoming long lines. The operator then plugs simultaneously into a local junction and a long line, and key-sends, first over the line to the distant subscriber and then to the local subscriber. After this she has no other operation to perform, and she receives complete visual supervision of both subscribers by means of lamps in her cord circuit. This method has a further considerable advantage, in that the equipment which carries out the numerical operations is located at a common point, and any simple form of signalling equipment can be used on the lines themselves. For this purpose 50 p.p.s., 500 p.p.s., or a simplified form of four frequency equipment, can be used.

The only costs of installing this remarkably rapid system are those covering conversion of existing line equipment, and the addition of a number of special registers. Very little change is required on the toll boards, and this can readily be carried out.

Field Experience

The system was first tried out under the auspices of Mr. Delpino of the Società Telefonica Tirrena, between Rome and Florence,

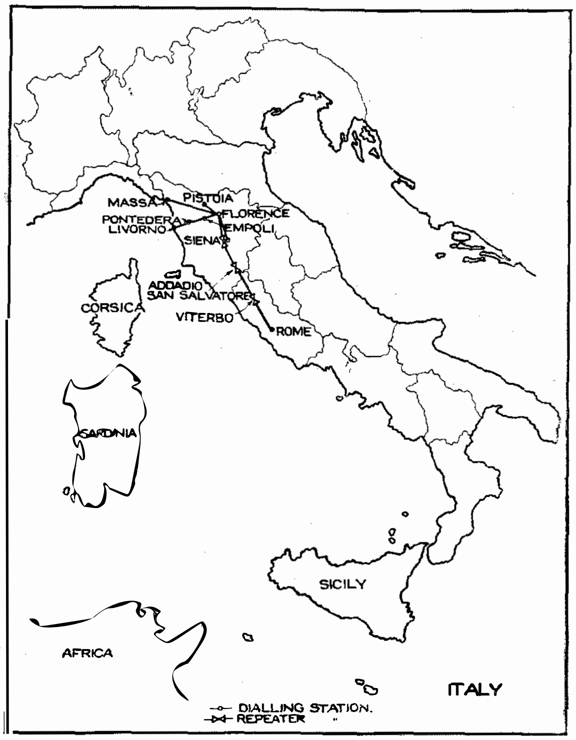


Figure 15.

last November, and a description of this trial appeared in the April number of *Electrical Communication* for this year. The trial was a complete success, dialling being carried out from Rome into Florence and by way of Florence out to a number of other centres which are indicated in Figure 15. These routes were made available as a result of the new "Celere" switching system which has been developed by the Società Telefonica Tirrena and which is now working in their territory.

The four frequency system was demonstrated last March at the C.C.I. exhibition at Düsseldorf. Figure 16 is a view of the exhibit. The exhibit comprised two terminals of a line equipped on a four frequency basis, two operators' positions and a model automatic exchange. The four frequency equipment itself at each terminal consisted of a single line panel and a four frequency generator. One such panel was connected to each end of a line which extended from Düsseldorf to Bingenbrück and back by way of two repeaters at Andernach. By means of the terminal line panels the facilities listed below were demonstrated. These were all obtained entirely by means of voice frequency signalling and no apparatus was located at the repeater stations. As explained in the above description the same line panels could have been used to provide any other required arrangements.

(1) From the operator's position on the left of the equipment, it was possible to plug into the line jack and dial directly into the three automatic switches on the right, which represented an automatic exchange. The removal of the plug immediately released the automatic equipment. The operator received supervision of the called subscriber as well as of the calling subscriber.

(2) The operator, instead of using a dial, was able to use a key-set and thus to set up the register located just below the automatic switches on the right. This register then sent out impulses to the automatic switches. With this method of operation the operators were able to send out a number very rapidly. The calling, releasing and supervision were obtained as before.

(3) The operator at the left-hand position was able to call in the operator at the right-hand position. At the demonstration this procedure was followed when the called subscriber was busy. When this happened the left-hand operator received busy flash on her supervisory lamp. She then pressed a common key on her position and this automatically released the automatic apparatus and lit the calling lamp in front of the right-hand operator. This operator was then able to offer the call to the busy subscriber.

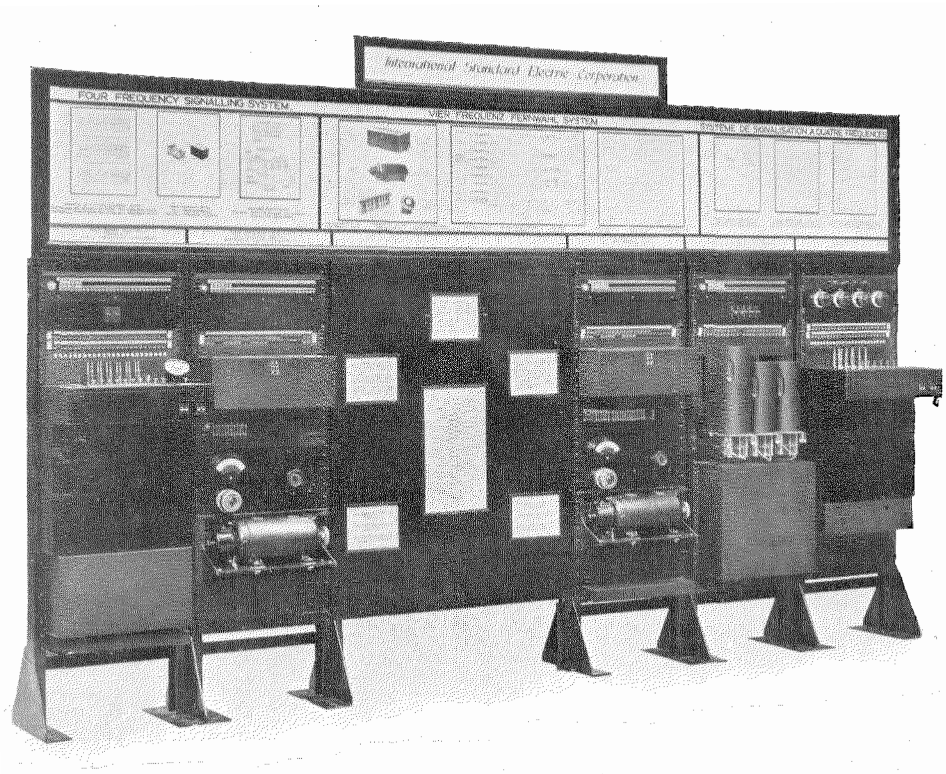


Figure 16—Demonstration Model at C. C. I. Exhibition, Düsseldorf.

(4) Dialling was also carried out both from the operator's position and directly from the subscriber's set into the Düsseldorf exchange. In this way any Düsseldorf subscriber could be dialled by way of the repeatered line to Bingenbrück and back. This is a good illustration of the flexibility of the four frequency system since until the equipment was installed it was not known what type of automatic exchange was in use at Düsseldorf.

(5) The method of working toll lines on an A to B basis, shown in Diagram 2 of Figure 14, was also demonstrated. In this case the right-hand operator acted as an ordinary intermediate or "B" operator and complete supervision and control of the called subscriber was handed back to the originating or "A" operator using the same two line panels as for the other methods of working described above.

Economies of the System

While the true value of the four frequency system can only be determined accurately after some years' service, it is interesting to note that in most cases so far investigated the total cost of the equipment appears to be recovered in well under two years.

It is hoped to publish detailed traffic data upon the operating economies of the system within the near future.

Conclusion

Although the system was only released from the Laboratory this year, it is already in process of being installed in Italy, Germany and Great Britain.

The merits of automatic working are now receiving recognition. The tardy introduction of these methods hitherto has been due not so much to the technical difficulties as to considerations of cost. Before the introduction of the four frequency system it was probable that there would be a loss of traffic-carrying capacity which would outbalance the operating saving, while the complicated nature of the new equipment and the expenses of converting existing equipment were such that automatic methods did not promise to be economical. Further, the degree of reliability required for long distance traffic is considerably higher than that which can be tolerated on local traffic, and administrations have naturally been very chary of installing equipment which might increase even slightly the switching errors obtained on these circuits. These points have had very careful consideration in the development of the four frequency system, as a result of which the equipment has a high degree of reliability without being expensive; and at the same time the facilities available enable operating methods to be used which ensure that there shall be no loss of traffic-carrying capacity.

Acknowledgement must be made to Mr. Delpino and Mr. Zanni of the Società Telefonica Tirrena not only for the facilities which were provided at the Rome-Florence trial but also for the advanced planning of their network, which permitted the immediate extension of the system to surrounding towns; to very many officials of the Deutsches Reichspost, of the British Post Office and of the Società Telefonica Tirrena for their help in planning and testing, and for the facilities that have so readily been afforded us; and to Dr. E. K. Sandeman and Mr. B. B. Austin and many other members of the International Telephone and Telegraph Laboratories for assistance in the development work.

Ship-and-Shore Terminal Equipment

Equipment and Operation of the British Post Office Stations

By LT.-COL. A. S. ANGWIN, D.S.O., M.C., B.SC., M.I.E.E.

THE successful development and commercial operation of radio-telephony between Europe and America very naturally directed endeavours to attempt the solution of the problem of maintaining telephone communication between the larger passenger vessels on the Atlantic route.

Following successful tests made between the Laboratories of the International Telephone and Telegraph Laboratories Incorporated, and the S.S. *Berengaria* it was agreed to undertake a co-operative full scale experimental trial between the British Post Office and the International Marine Radio Company, and from this has resulted the commercial service now in operation.

It was recognised from the results of investigations already made by the engineers of the Bell Telephone Laboratories in America that the problem of maintaining communication between ship and shore when the ship is comparatively near to the land presented the greatest difficulty. This fact had led the American Telephone and Telegraph Company to decide on the installation of a special shore station situated immediately upon the seacoast.

It was considered, however, that to meet the special conditions in this country, where the ports of departure and arrival of the principal liners are widely scattered, very appreciable gains in economy of maintenance and operation would result from placing the shore stations at Rugby and Baldock where the transmitters and receivers for the British Post Office "point-to-point" radio services are situated.

Efforts were first concentrated on establishing a service over the major portion of the trans-atlantic steamer track, followed later by the solution of the short range problem after investigations had been made into suitable frequencies and modified types of arrays had been designed.

The provision made for the service at the land stations has been on the same general lines as that for long distance point-to-point radio telephony working, and it is proposed to indicate in this article the features peculiar to this particular service.

Choice of Frequencies

In the interests of facility of operation and the endeavour to keep the apparatus, particularly on board ship, as simple as possible, the use of the minimum number of frequencies is desirable. The frequencies now in constant use, and which experience has so far shown to be adequate for continuous communication, are:—

	Ship Transmitter	*Rugby Transmitter*	
(a)	4430 kc/sec	4975 kc/sec	(60.3 m.)
(b)	8860	8375	(35.8 m.)
(c)	12380	12780	(23.47 m.)
(d)	16440	17080	(17.56 m.)

Of these (a) is effective for about one day's steaming from the English port; (b) for the second, and part of the third, day out; (c) in Mid-Atlantic and up to one day's steaming distance from New York, when (d) is normally brought into use.

Array Systems

The wide angle subtended by the limits of the ship's positions traversing the ocean route prevents the use of a highly directive system, and a compromise has therefore been necessary in determining the angle of direction and the aperture of the directive systems provided both for transmitting and receiving.

Figure 1 shows the limits of the routes taken by liners crossing the Atlantic in relation to the great circles from Rugby. The zones in which the various frequencies are normally operative are also shown, together with the angles actually selected for the direction of propagation of the different wavelengths.

The types of arrays in use at Rugby are indicated in Figure 2, and Figure 3 gives a general photographic view.

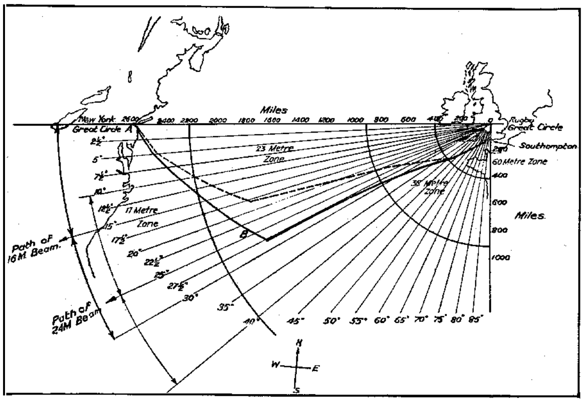


Figure 1—Southampton-New York Sea Route.
------Most Northerly Route. ——Most Southerly Route.
Divergence of Sea Routes from Rugby-New York Great Circle.

The 17080 kc/sec. transmitting array is directed at an angle of 15 degrees south of the RUGBY-NEW YORK great circle. It consists of 32 horizontal half wave doublets arranged in eight stacks of four doublets spaced half a wavelength above each other. An identical reflector is spaced a quarter of a wavelength behind. The polar diagram (Figure 4) indicates that within an angle of about 30 degrees there is an appreciable gain over a non-directive aerial.

The transmitting array for 12780 kc/sec. is similar to that mentioned above except that each of the eight stacks is composed of only three doublets.

For the 8375 kc/sec. alternative types of horizontal aerials, and also a vertical aerial are used; experience has not yet determined conclusively what is the most effective arrangement.

The 4975 kc/sec. array is directed 20 degrees west of Southampton, and consists of eight horizontal half wave doublets arranged in four stacks of two. A similar reflector is fixed a quarter of a wavelength behind. The objective in this case is the production of high angle radiation with a horizontal polar diagram of wide angle.

It is clear from the fact that high values of field strength have been obtained by this arrangement at close ranges, and from the apparent absence of "skip" distance effects, that reflection from a nearly vertical angle of incidence is produced.

The results indicate that a comparatively steady and high level of field strength is produced, and there is little indication of the anomalous results which were previously obtained with a vertical aerial on the same frequency. An efficient commercial telephone service is being obtained by the arrangements adopted when the ship is within the harbour at Southampton, and during the first day out.

The Transmitter

The transmitter installed at the Rugby Station, which is shown in Figure 5, was supplied by Standard Telephones and Cables, Ltd., and is of the type described in the February issue of *Electrical Communication.* It employs piezo-electric quartz crystal oscillators which are provided with interchangeable crystals for the different wavelengths. The various stages of the transmitter are adjusted to the frequency in use by changing the tuning coils and resetting the tuning condensers. Low power modulation is employed, the final stage of the modulating

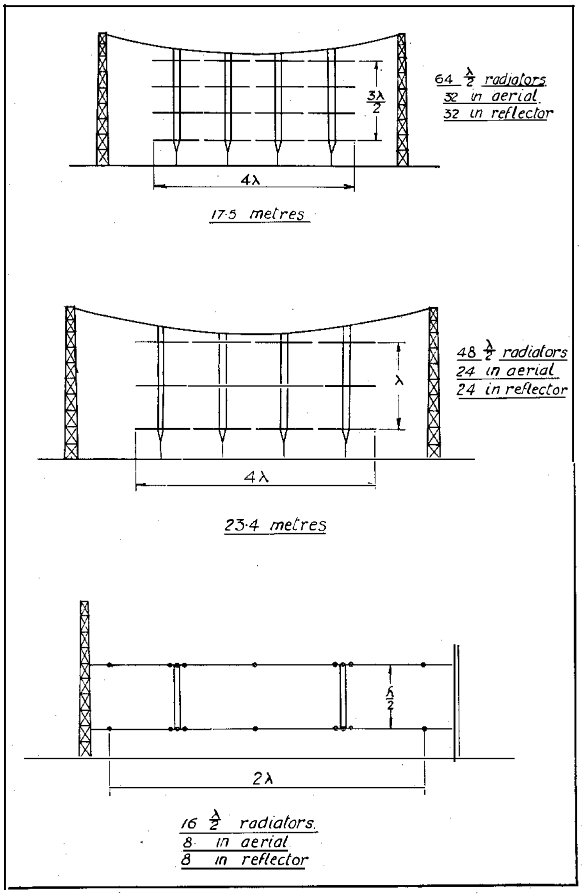


Figure 2—Ship-and-Shore Arrays—Rugby.

equipment having an anode power of about 200 watts. Two further stages of push-pull amplification raise the output to 3.5–5.0 kilowatts of high frequency carrier with a low frequency

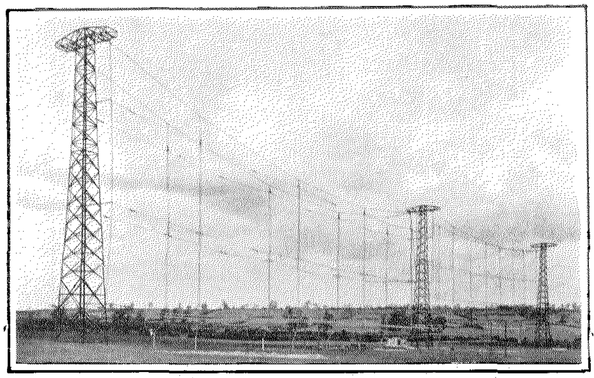


Figure 3—General View of the Arrays Used at Rugby.

modulation of 90% without distortion. The output from the final stage is connected directly to the aerial feeder lines. The land lines incoming from the London Trunk Exchange are terminated in an equipment which includes a volume indicator, an amplifier, the gain of which can be varied, and a variable attenuator to enable the transmitter to be lined up and fully modulated by the normal line current.

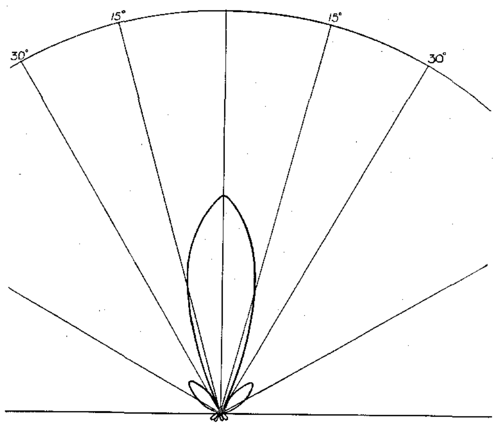


Figure 4—Polar Diagram of Transmitting Array, Ship-and-Shore Telephony.

A general view of the Rugby Radio Station site, with the main building in the background, is shown in Figure 6.

Receiving Station

The receiver at the Baldock Station was also provided by Standard Telephones and Cables Ltd., and is similar to those described in the article previously referred to, with the addition of a two-stage transformer-coupled, high frequency amplifier. A photograph of the receiver is reproduced in Figure 7. The receiving arrays are directed at the same angles as the transmitting arrays. They are of the double frame or zigzag type erected on poles. The effective gain over a single half wave vertical aerial is of the order of 13 decibels. The transmission lines from the receiving array are terminated by the receiving apparatus in their "characteristic" impedance on an antenna input panel. The re-

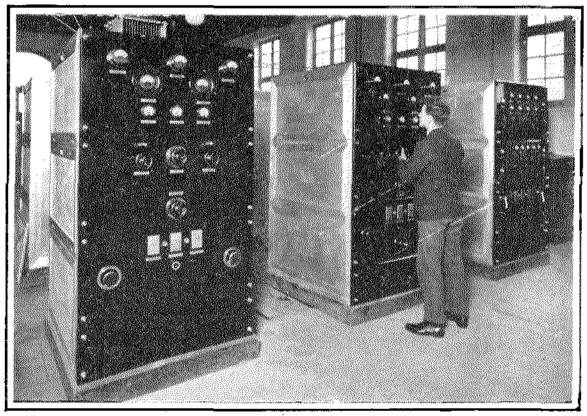


Figure 5—The Transmitter, Rugby Station.

ceiver is of the double detection type, and is provided with an automatic gain control device to overcome the effects of fading.

Land Line Connections

The overall circuit for ship-and-shore telephony is the equivalent of a four-wire circuit, i.e., separate paths are used for the transmitted and for the received speech. The connection from the Rugby transmitting station to London is through 85 miles of extra light loaded underground cable, and the receiving station at Baldock is similarly connected by about 30 miles of unloaded and equalised underground cable. The terminal equipment is situated at the London Trunk Exchange, the requirements to be met being similar to those of a normal point-to-point radio telephony circuit.

The terminal equipment in London is grouped on two racks. One comprises all the panels for which manual adjustment is required, and is known as the technical operator's position; it is illustrated in Figure 8. The other associated equipment and the voice-operated device is mounted on a special rack, and forms a complete unit apart from the main equipment; it is illustrated in Figure 9. The voice-operated device in use is of the type developed by the British Post Office Engineering Department, and operates entirely as a vacuum tube system without mechanical relays. An explanatory diagram of the apparatus is reproduced in Figure 10.

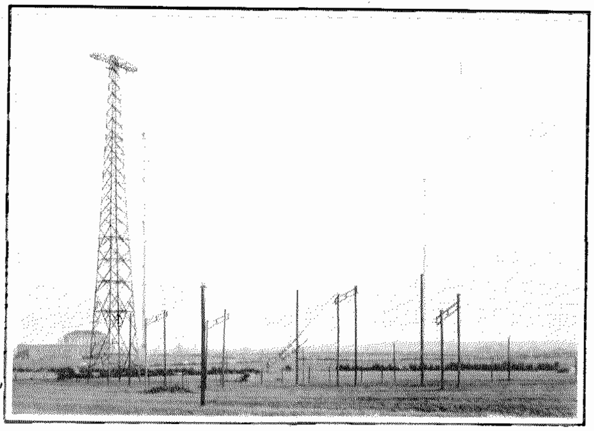


Figure 6—General View of the Rugby Station Site with Main Building in the Background.

Prevention of Singing

Unless special means are adopted there exists a local singing path in the transmission of the four-wire portion of the radio circuit when the repeaters in the "GO" lines have high gains to accommodate weak subscribers. The hybrid loss which is involved in the balancing of the subscriber's extension against an artificial network, or speech or noise in the "Return" lines, produce in the go lines a practically instantaneous, and perhaps also a delayed, echo.

To nullify the singing effect in both the local and overall circuit without reducing the speech levels in the go and return lines, it becomes necessary to introduce other artificial losses at the end of the circuit. The principle upon which these loss-introducing or anti-singing devices is based is, that only one of the two speech channels is operative at any one instant.

The method actually consists in the necessary loss being introduced in the go lines. It is necessary that speech to be transmitted on this line shall, by voice operation, remove this loss, render the line operative, and simultaneously transfer the loss to the return line, that is, when the go line is inoperative the return line is normal, and vice versa. Care is taken so to design the voice operated switching system that singing is also prevented during the transition period.

The repeaters M and N—installed at London—have regulating networks at their inputs so that their gains may have values from 10 to 40 decibels and 20 to 10 decibels, respectively, the normal settings being 15 decibels in each case. The repeaters at K and L, by means of voice operation, may have either zero or about 100 decibels loss, corresponding to the operative and inoperative conditions respectively.

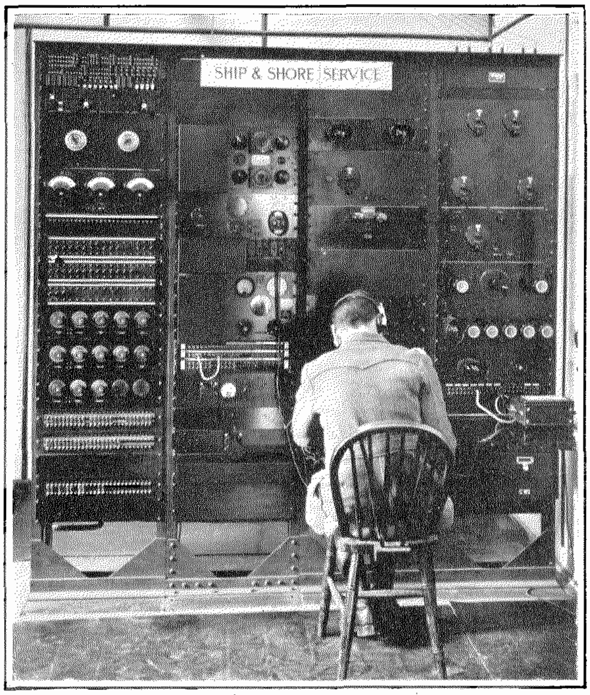


Figure 7—The Receiver, Baldock Station.

Time of Operation

A feature distinct from sensitivity in connection with the operation by the voice is the time

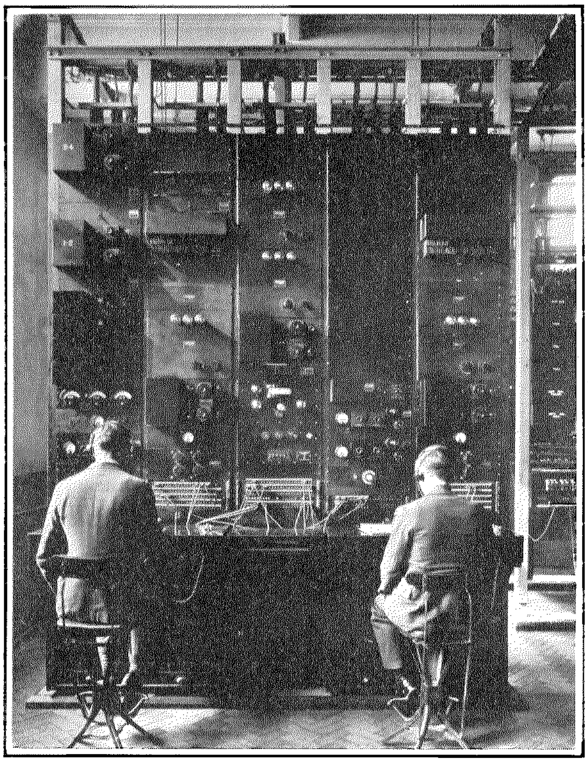


Figure 8—Ship-and-Shore Terminal Equipment, Technical Operator's Position at London.

taken to perform the switching function. The time allowable without detectable initial clipping was determined by experiment, and it was found that if the average time is reduced to the order of a few milliseconds, any deterioration in speech quality is not noticeable, bearing in mind that the time duration of a syllable may be three or more tenths of a second. A hang-over feature, associated with the transmitting side, confines the possibility of clipping to the beginning of speech only. The Post Office voice-operated device is designed upon the basis that the time of rendering the go line operative is of the order of 3 milliseconds, while the receiving echo-protection operation from the return to the go line can be applied instantaneously. This is accomplished solely by the use of a vacuum tube system.

Considering the main four-wire circuit when a conversation is not taking place, the singing is prevented by means of the repeater X in the go line. In these conditions the grids of the first stage tubes of this repeater are negatively primed sufficiently to cause the production of a transmission loss of the order of 100 decibels as against zero loss when the repeater is operative. When X is inoperative, the repeater Y in the return line is operative, and vice versa.

Speech from a subscriber connected to London is received on the two-wire extension at B, whence it is transmitted to C via the amplifier P, thence through R and S to the rectifier T. Thus, while the London subscriber is actually speaking, there is generated an uni-directional voltage which, by means of a condenser resistance combination, is maintained at a value which may slowly vary between 5 and 40 volts.

During the rise of the voltage, and as it reaches 5 volts, its application to the receiving suppressor repeater Y renders the latter inoperative as in normal echo-suppressor operation, and, after an infinitesimally short period of time, a higher uni-directional voltage, applied to the valve W causes the removal of the large grid bias, and the transmitting suppressor repeater X thereby becomes operative for the period of transmission of speech.

After the cessation of speech from the London end, the fall of the voltage will cause the repeater X to become inoperative, after which Y becomes operative; this condition remaining until London again speaks. It will be seen that during each

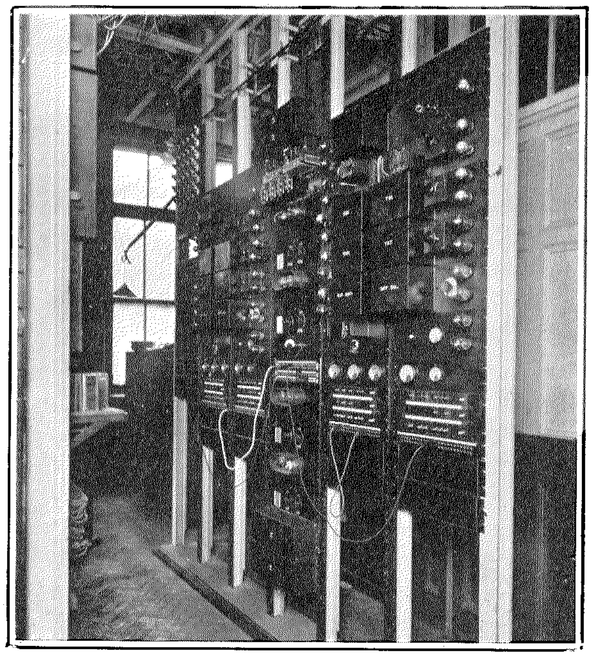


Figure 9—Ship-and-Shore Terminal Equipment, Including Voice-Operated Device.

transition period, an interval occurs when both repeaters are suppressed.

Speech from the ship passes via the amplifier Q to R, where it is rectified, and the uni-directional voltage, generated across a resistance and resistance-condenser combination in R prevents voice currents arriving at "C" from being transmitted. That is to say, during the passage of current in the receiving line and for a certain length of time after its cessation, a bias of a proportionate magnitude is impressed on R to retard or completely to suppress the effect of any voltage at "C" which would otherwise cause a false operation of the device.

The amplifier Q, by means of which the magnitude of the bias is controlled, is necessarily provided with potentiometer-gain control, so that, in the presence of bad atmospherics the gain or receiving sensitivity is reduced to prevent clipping of outgoing speech; if atmospherics are very weak the gain is set at a high value.

From the terminal position the operation of the ship-and-shore service follows standard telephone practice, and through communication can be established not only to the British Post Office system but to the European systems.

The inauguration of a commercial telephone communication service to ships on the Atlantic route in so short a period after the first experiments were undertaken has only been possible by the closest cooperation between the two organisations concerned, the International Marine Radio Company and the British Post Office.

The service to the *Majestic* was opened on February 14, 1930, for incoming calls only and, subsequently, for both incoming and outgoing calls. It was extended by stages first to London and later, including other liners, to the whole of Great Britain, France, Germany, Belgium, Holland, Spain, and Switzerland.

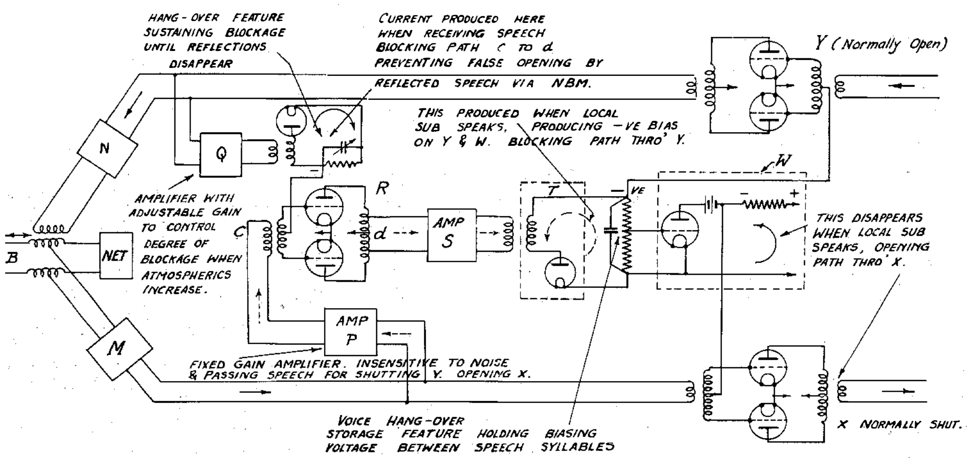


Figure 10—Schematic of Ship-and-Shore Terminal Equipment.

Notes on the World Engineering Congress and World Power Conference

Tokyo, Japan—October 29, 1929, to November 7, 1929

By DR. YASUJIRO NIWA

FOREWORD By FRANK GILL

The value to the entire world of the eminently successful World Engineering Congress and World Power Conference hardly needs emphasis. There is, however, one feature that deserves to be especially mentioned, namely, the enthusiasm of the overseas visitors in their praise of the admirable arrangements so thoroughly worked out and the extraordinary kindness showered on the delegates by our hosts. To me, and I am certain to many of my fellow delegates, the hospitality of our Japanese friends will remain a most precious memory of this delightful visit to Japan. It was a never to be forgotten experience.

IN March, 1925, the late Dr. Elmer A. Sperry and certain other distinguished engineers in the United States suggested that at as early a date as possible, a World Engineering Congress should be held at Tokyo under Japanese auspices. This suggestion met with the hearty approval of Japanese engineers, and the Engineering Society of Japan (Kogakkai) representing a federation of twelve Japanese technical associations immediately undertook the work of preparing a program and making arrangements for a World Engineering Congress to be held in Tokyo in the Autumn of 1929. It was the first World Engineering Congress to be held in the Far East.

Simultaneously plans were laid for a Sectional Meeting at Tokyo of the World Power Conference on the general subject of "Development of Power Resources." Preparation of the program and arrangements for this Conference were made by the Japanese National Committee of the World Power Conference in close coöperation with Committee for the World Engineering Congress. Both conferences were finally scheduled to open on October 29th and close on November 7, 1929.

The officers of the two conferences were practically identical. His Imperial Highness, Prince Chichibu, was Patron of both conferences, and the honorary officers included His Excellency, the Prime Minister of Japan, and His Excellency, the Minister of Commerce and Industry of Japan as Honorary President and Honorary Vice-President, respectively. These honorary officers indicate the marked interest shown in the Engineering Congress and the Power Conference by the Japanese Government and People.

Executive officers of the Congress and the Conference were as follows:

President: Baron Koi Furuichi, D. Eng., President of the Kogakkai (Engineering Society of Japan); Privy Councillor.

Vice-Presidents: Baron Takuma Dan, D. Eng., Director-General, Mitsui Gomei Kaisha (All Mitsui Combined Interests); Director-General, Industry Club of Japan.

Baron Chuzaburo Shiba, D. Eng., D. Sc. (Rutgers College), M. I. Mech. E. (London): M. I. N. A. (London); Director of the Aeronautic Research Institute; Chairman of the Board of Directors of the Imperial Marine Corporation; Member of the House of Peers.

Baron Takafusa Shijo, Vice-Minister of the Department of Commerce and Industry.

Assisted by several committees, these Executive Officers worked out detailed plans for both conferences. Sectional meetings of the conferences were so arranged as to prevent conflicting engagements as far as possible, and an elaborate and very attractive program of excursions and inspection tours was prepared. Plans for the entertainment of delegates and their guests also included numerous receptions, garden parties, and dinners, notable among which were the President's Reception on October 28th, the Prime Minister's Reception on October 29th, and His Imperial Highness Patron Prince Chichibu's Garden Party on October 31st. An Auxiliary Ladies' Committee arranged very attractive programs for visiting ladies, so that they could be pleasantly occupied while delegates were attending sectional meetings of the conferences.

This very comprehensive technical and social program resulted in a large attendance of overseas delegates. Overseas participants in the World Engineering Congress consisted of 343 engineers with 157 guests, a total of 500 visitors coming from not less than 23 nations. A total of 736 technical papers was submitted to the World Engineering Congress and of these 414 were prepared by engineers of 19 countries overseas and 322 by Japanese engineers. In the appendix are shown detailed figures of the attendance and number of papers presented at both conferences.

The opening session of the World Engineering Congress took place in the new Municipal Auditorium on the morning of October 29th. His Imperial Highness, Prince Chichibu, as Patron of the Congress, honoured the Congress with his presence and delivered the following address:

"Your Excellencies, Ladies and Gentlemen: It is a very real pleasure to meet here such a large gathering of distinguished specialists, many of whom have come from far-off countries, and to speak a few words to them on this occasion of the opening of the World Engineering Congress.

"It is a trite observation, that the development in our time of so many and various industries, has materially enhanced the importance of the bearing which engineering exercises on the economic life of the population, nor need I emphasize the fact that the progress of engineering is constantly making ever increasing contributions to the development of those industries. But it is also evident that the promotion of further research, and the continuous acceleration of advance, both in the theory of constant co-operation on the part of the world's engineering science and in the practice of industrial technique, presupposes a candid and constant co-operation on the part of the world's scientists and captains of industry.

"Moreover we see in all countries that these questions of industrial economy constitute the keystone of every problem, national and international alike, and that there are not wanting signs of a growing spirit of economic emulation among the nations. It is obviously most important, therefore, that all the countries of the globe should maintain in their industrial activities a harmonious concord and co-operation, each paying due regard to the principle of a fair participation by all in international industry and international commerce.

"In the light of these considerations, I am convinced that the benefits to be derived from the work of this Congress will not be confined to the field of the world's engineering and industry alone.

"In conclusion, I desire to express my appreciation of the enthusiastic support afforded by the participating countries, and of the trouble which many of you have taken in traversing distant seas. It is my earnest hope that this Congress, by virtue of your co-operation, will succeed in making a worthy contribution towards the furtherance of the welfare of mankind."

His Excellency the Prime Minister of Japan, Mr. Hamaguchi, then made the following address:

"Your Imperial Highness, Your Excellencies, Ladies and Gentlemen:

"With the permission of Your Imperial Highness, our gracious patron, I have the honour of speaking to you at this opening session of the World Engineering Congress.

"It is not too much to say that there is nowadays scarcely a single civilized undertaking that is not based on engineering. The advancement of engineering leads to the development of various industries, which in turn augment national resources, consolidating the foundations of national prosperity. It is a natural conclusion, then, that engineering and industry should in these days be held in high esteem. The plain fact in the present stage of the world's history is that the strength of a nation depends in large measure on activity in this branch of human endeavour. The intellectual development of mankind and the continued increase in the world's population never cease to lend impetus to the promotion of that activity.

"In all countries experts are engrossed in the process of discovery and invention, while those carrying on trade and manufacture indefatigably bend their energies to the rationalization of industry and to the enhancement of efficiency. This is a very welcome phenomenon, but if there is a shortcoming to be observed in this connection, it is that no special machinery has hitherto been in existence for facilitating research and direction on an international basis. As national boundaries still remained, without there being adequate arrangements for international collaboration, scientists and men of affairs in all countries had little opportunity of obtaining mutual benefit by an exchange of their opinions. This fact has not been without its effect on the progress of engineering and industry.

"At this juncture the proposal for the organization of a World Engineering Congress was brought forward and adopted, and it was decided that this great gathering should be held in Japan in the autumn of 1929. Thanks to the suggestion made by the United States and the good-will of all the countries interested, the venue of the Conference has been fixed in Tokyo. This is a most opportune event, and we Japanese deeply feel the honour done to us by according us the role of hosts.

See No Precedent

"International Conferences are not rare, but there is no precedent for an international assembly gathered to discuss engineering subjects of such extensive scope as that of this Congress. All the members here assembled are influential scholars and men of affairs in the various countries interested, and that so many great authorities should meet in a single hall and open the stores of their minds in papers and discussions, freely and frankly exchanging opinions, should not only impart many lessons and much benefit to Japan, but will also make a very great contribution to the development of civilization and to the security of the world's peace.

"I may even say without any risk of exaggeration that this Congress is a momentous event, destined to mark a new era in industrial history. If, as I hope, the World Engineering Congress is hereinafter maintained as a permanent international institution, I am persuaded that it will serve a most useful purpose which could not well be dispensed with. I earnestly hope that, just as the League of Nations is a permanent institution in world politics, so the World Engineering Congress will be maintained as a permanent institution in world industry.

His Imperial Highness Prince Chichibu, Patron of the Congress, Listening to the Discussion.

"The members here present have come from every corner of the globe, from China to the Union of South Africa, twenty odd countries being represented—an assembly unprecedented in magnitude. We in the Orient have from ancient times a saying—'Nothing is more pleasant than to have friends come from a distance.' But the word 'distance' by no means does justice to the case of the visiting delegates; some of you have come across the seas from lands tens of thousands of miles away. Nor is the word 'pleasant' adequate to express what we feel. It is perhaps a little nearer the truth to say that we are deeply stirred by irrepressible sentiments of joy and appreciation.

Feels Responsibilities

"At the same time, we are fully sensible of the heavy responsibility devolving upon us, and have been doing all in our power in order not to disappoint your expectations. But, as you may be aware, the earthquake and fire of 1923 destroyed overnight almost all the equipment of civilized life in the capital and its vicinity, and I greatly regret that we are without proper means of entertaining you. The work of reconstruction is in steady progress, but it has not yet been brought to completion. It is my deep regret that we should not be able to extend such facilities as we would wish to our distinguished guests who have come from such distant countries.

"Foreign tourists often praise Japan for her beautiful scenery, and for her richness in places of historical interest. I do not think that such words of admiration are always to the point, but, if in your tours and excursions you meet with such scenery as will please your eye even in the slightest degree, I shall be more than satisfied. My satisfaction will be even greater if you will extend your tours to Korea, South Manchuria, and Formosa, and see with your own eyes what results are being achieved in those localities by the pains and efforts of the Japanese people.

"In July last year Prince Chichibu signified his pleasure to be the Patron of this Congress, and has honoured us with a gracious address at this opening session. As one of the officials of the Congress on the part of the convening country, it is my determination to do my utmost, in all sincerity, for the attainment of its object. I desire to extend the sincerest welcome to the visitors from overseas, and earnestly hope that all the members present will extend full measures of co-operation toward the realization of our united aims."

Following the Prime Minister, Baron K. Furuichi, President of the Congress, delivered his Presidential Message as follows:

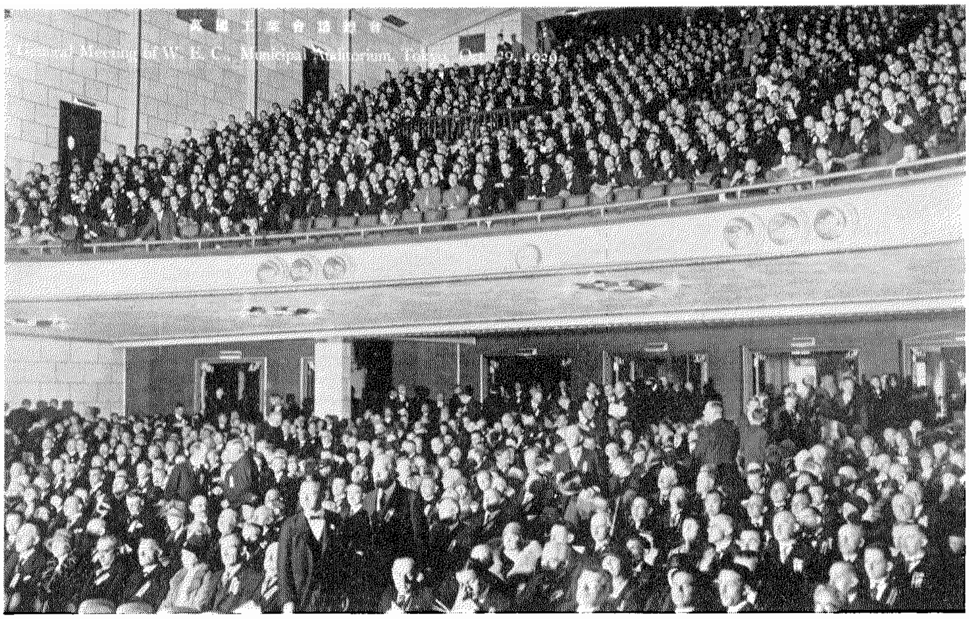
"Your Imperial Highness, Your Excellencies, Ladies and Gentlemen:

"It is a great honour for me as President to address you on this auspicious occasion of the opening of the World Engineering Congress in the August Presence of Your Imperial Highness.

"This country has a history and civilization of more than 25 centuries, but it is only half a century since we were introduced to what might be called modern industry. That in this comparatively short space of time we have been able to attain our present position in engineering and industry is due partly to the protection and encouragement given by the Government to the sustained efforts made by scholars, engineers, and business men, and to the favourable condition of business and industry which has fortuitously occurred at times,—but over and above these causes we should by no means lose sight of the generous assistance which we have received from foreign countries both directly and indirectly.

"In the early stages of our industrial career, we were engrossed in transplanting Western engineering to our soil. This plant, so to say, took root, and has become well acclimatized with the lapse of time; and its present state of growth has now afforded us the opportunity of holding this World Engineering Congress in Tokyo.

His Excellency the Prime Minister of Japan, Mr. Hamaguchi, at the Reception.



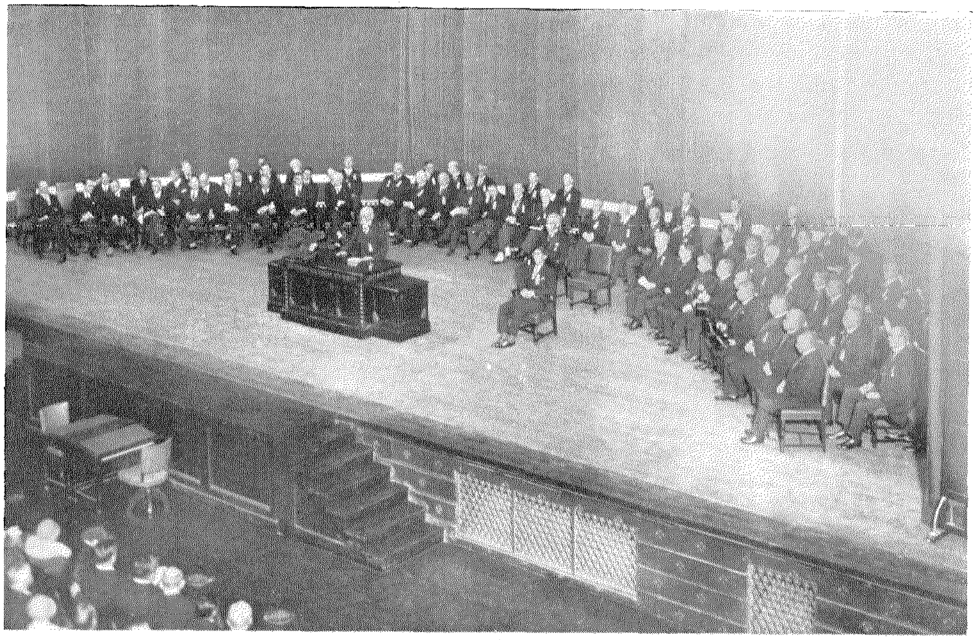
General Meeting of World Engineering Congress, Municipal Auditorium, Tokyo.

"At every great international conference held in the past on industrial subjects, this country has been represented either officially or unofficially. The benefit which we have derived from this participation is immense, but at the same time it has often been said how immeasurably greater the benefit would be if we could hold a similar conference in this country, invite our friends from abroad, ask them to inspect our industrial conditions at first hand, and obtain their frank and unreserved opinions.

Aware of Difficulties

"We had much hesitation in making such a proposal, because we were aware of the many difficulties—perhaps more serious than our guests might imagine—which would attend its acceptance, owing to the difference in language and in manners and customs, coupled with geographical considerations. In March, 1925, Dr. Sperry, who is here with us today, and other influential scholars in the United States, recommended that a World Engineering Congress should be held in Tokyo under Japanese auspices within the next five years. This recommendation was in accord with the desire we had at heart, and Government authorities, scholars, and business men unanimously agreed to assume the pleasant task of acting as hosts to this distinguished gathering.

"In these circumstances the preliminary preparations at home for this Congress proceeded in the most satisfactory manner, but we were not without concern as to the support and participation of foreign countries. I am very glad to say that this anxiety has proved to have been quite uncalled-for. This assembly itself eloquently testifies to the understanding, sympathy, and enthusiasm with which the Governments and peoples of foreign countries have supported us in our task. We have received from abroad valuable papers to the number of over four hundred, while no less than twenty-six nations are represented here by some six hundred guests who have come from so far away. All of us who are gathered here are the closest of intimate friends, linked together by the



Baron Koi Furuichi, President of the World Engineering Congress, Speaking at the Opening Ceremony.

bond of engineering and industry. I can hardly express, and I can only ask you to imagine, the appreciation and satisfaction which the Japanese members feel at having so many great friends come from distant lands."

The opening meeting of the World Power Conference took place in the Municipal Auditorium on the afternoon of the same day, October 29th. His Imperial Highness, Prince Chichibu, honoured the Conference with his presence and spoke as follows:

"It gives me extreme pleasure to know that in holding the Tokyo Sectional Meeting of the World Power Conference, we have met with such willing support from so many countries, with the result that I have before me this great assembly, including so many visitors from abroad.

"The development of that element of power, the very mainspring of industrial activity, has an immediate repercussion on the economic condition of the public at large and exerts, consequently, an influence on the welfare of mankind, the importance of which it is not easy to overrate. It is in recognition of this fact that this World Power Conference has been organized by common co-operation from various countries, and at the different meetings which have been held, many specialists have contributed their profound learning to the discussions, in an earnest endeavour thereby to promote the good of humanity.

"It is most opportune that on the occasion of the convocation here of the World Engineering Congress, this Sectional Meeting of the World Power Conference should now be held in Tokyo with the participation of such a large number of eminent authorities, both foreign and Japanese. The publication of the results of this elaborate research and the exchange among themselves of their valued opinions will be of immense scientific utility, and it is a foregone conclusion that the Conference will effect a great contribution to the progress of civilization throughout the world.

"I desire to express my appreciation of the praiseworthy energy which those of you who have come from abroad have expended on the attainment of the object of this Conference, and my hope that the visiting members will take this opportunity of studying at first hand the conditions prevailing in this country and among its people, and by that means extend the boundaries of international friendship."

The meeting was then addressed by His Excellency, the Minister of Communications, Mr. Masajiro Koizumi, and Baron K. Furuichi as President of the Conference.

Sectional Meetings of both the Conference and the Congress continued daily until November 7th. Owing to the large number of papers presented and the fact that many were received just prior to the opening of the conferences, only a portion of the papers could be printed in full, though printed abstracts of all papers were available. Furthermore, in view of the restricted period in which meetings could be held, only a portion of the papers could be read and discussed. Other papers were presented by reading the respective abstracts. However, the papers read in full were of the greatest interest, and in many cases provoked lively discussions.

Both Conference and Congress closed on November 7th as scheduled. Messages from His Imperial Highness, Patron Prince Chichibu, and from the President of the United States were read, and farewell speeches were delivered by Baron K. Furuichi, President, and by the heads of the National Delegations from overseas.

At the general meeting of the Congress held at 9.30 A.M. on November 7th in the auditorium of the House of Representatives in the Diet Building, Baron C. Shiba, one of the three Vice-Presidents of the Congress, presided as Chairman of the meeting and made a brief address.

Mr. S. Inada, Director-General of Telegraph and Telephone Engineering of the Ministry of Communications, presented the report of the Sessions Committee and Mr. A. F. Enstrom, Chairman of the Resolutions Committee, presented the report of the Resolutions Committee. Eight resolutions had been presented for consideration of the Committee, but the Committee decided to report favourably on but three of them. These three resolutions were adopted, and are as follows:

Resolution No. 1

"Be it resolved, that the delegates of the various nations be requested to explore the situation, with a view of ascertaining the opinion, in their own countries, as to the advisability and practicability of bringing forward for action some plan aiming at the World Engineering Federation; and that this subject should have an important place allotted to it at the next World Engineering Congress."

Resolution No. 2

"Whereas it is understood that the Netherlands Royal Institute of Engineers is willing to take the lead in the investigation of certain irrigation questions of international importance, be it resolved that this Congress favours an international investigation, to be carried on under the auspices of said Institute, Division Netherlands East India, for report to the next World Engineering Congress on the following question: What subsidies, direct and indirect, are paid by various governments to secure construction of large irrigation and flood control and drainage works and with what justification?"

Resolution No. 3

"Be it resolved, that the attention of engineering societies in the various countries participating in this Congress be directed to the importance of a full understanding of hydrostatic uplift, internal stresses and other factors affecting the safety of dams, and that the American Society of Civil Engineers be requested to invite the co-operation of the committee on dams of the International Navigation Congress, also the World Power Conference and the engineering organizations of the other countries represented at this Congress, in a study of this problem."

Dr. E. A. Sperry, on behalf of the visiting delegates, proposed the following resolution:

"Whereas the delegates and members of the World Engineering Congress now concluding its sessions in Tokyo have derived much profit and pleasure from the opportunity afforded the engineers of the world of gathering together in this great common council,

"Be it resolved, that a vote of thanks be and is heartily given to our hosts, the Japanese

Government, the engineering societies of Japan and the officers of this Congress for the organization and extremely effective conduct of the Congress, and

"Be it resolved, that the officers of this Congress be and they are hereby requested to convey an expression of deep appreciation for the delegates and members of the Congress and their families to the numerous hosts, both public and private, who through a multitude of entertainment, have done so much to make our visit to Japan one of extreme pleasure."

This resolution was seconded by Mr. Allen Hazen for the United States, Dr. Koettgen for Germany, Mr. E. F. C. Trench for Great Britain, Senator Luigi Luiggi for Italy, Mr. Jean de Berc for France, Mr. J. V. Bagtas for the Philippine Islands, Mr. Wouter Cool for the Netherlands, and the Dutch East Indies, and Mr. R. M. Abramovitch of Jugoslavia for the Slav Nations, and was adopted unanimously by acclamation.

In reply, Baron Shiba, Vice-President of the Conference, spoke as follows:

"I am sure that we of this organization have endeavoured to do all in our power to further the interests of this Congress, yet I may say that we are fully sensible of our many shortcomings. In spite of this, this meeting has been good enough to pass this resolution. It fills me with deep gratitude and, in the capacity of Vice-President, I wish to thank you heartily for the compliment you have paid us."

The first World Engineering Congress to be held in the Far East was thus closed. The World Power Conference closed on the same date.

Mr. Frank Gill, Vice-President of International Telephone and Telegraph Corporation and official delegate of the Institution of Electrical Engineers of Great Britain, represented the Parent Company at both gatherings. Mr. Gill served as Chairman of one Sectional Meeting of both conferences, was a member of the Resolutions Committee, and took a prominent part in all activities. During his visit Mr. Gill was honoured by the Japanese Government with the decoration of the Third Class of the Order of the Sacred Treasure.

The author of these Notes, the Chief Engineer of Nippon Electric Company, Limited, was Secretary of the Communications Section of the World Engineering Congress, and several of his associates in the Nippon Company were members of the Congress.

Engineers in the International System presented eight papers to the World Engineering Congress, as follows:

The Calculation of the Articulation of a Telephone Circuit from the Circuit Constants*
By John Collard

Progress in Subscriber's Transmission Apparatus†
By L. C. Pocock

A New Contribution to the Rational Design of Telephone Cables*
By D. P. Dalzell

Sur l'Utilisation des Quarts Piezo Electrique en Radio Electricité
By M. Tournier

High Tension Underground Cables in Great Britain
By T. N. Riley

A System of Picture Transmission†
By Y. Niwa

A System of Supervisory Control
By Y. Shimazu

An Electrical Frequency Analyzer†
By M. Kobayashi

**Electrical Communication*, January, 1930.
†*Electrical Communication*, April, 1930.

For Appendix to this article, see following page.

APPENDIX

World Engineering Congress

TECHNICAL PAPERS PRESENTED AT THE CONGRESS

(Received up to September 10, 1929)

Country	Received	Country	Received
Australia	3	India	
Austria	1	Italy	86
Canada	4	Java	3
China	13	Philippine Islands	0
Czechoslovakia	8	Sweden	16
Denmark	3	Switzerland	6
Egypt	1	United States	107
France	18	U. S. S. R.	8
Germany	52		
Great Britain	81	Total of Foreign Papers	414
Holland	2		
		Japan	322

CLASSIFICATION BY SECTION

Section	Subject Classification According to "Technical Program"	Number	Totals
1	General Problems Concerning Engineering	32	
	Miscellaneous	4	36
2	Engineering Science	39	
	Precision Machines	11	
	Aeronautical Engineering	20	
	Engineering Materials	12	82
3	Architecture and Structural Engineering	46	46
4	Public Works	58	58
5	Railway Engineering	88	
	Transportation	9	97
6	Communication	52	52
7	Power	24	
	Electrical Engineering	44	
	Illumination Engineering	16	84
8	Mechanical Engineering	46	
	Refrigerating Industry	5	
	Textile Industry	5	
	Automotive Engineering	8	64
9	Shipbuilding and Marine Engineering	30	30
10	Chemical Industry	47	
	Fuel Combustion Engineering	14	61
11	Mining and Metallurgy	117	117
12	Scientific Management	9	9
			736

World Engineering Congress

NUMBER OF FOREIGN MEMBERS AND GUESTS

(Registered at September 14, 1929)

Country	Member	Guest	Total	Country	Member	Guest	Total
Argentina	1	0	1	Great Britain	35	10	45
Austria	1	1	2	Italy	13	2	15
Australia	3	3	6	Netherlands East Indies	3	3	6
Belgium	11	3	14	Poland	1	0	1
Burma	1	0	1	Philippine Islands	6	1	7
Brazil	1	0	1	Straits Settlements	2	0	2
Canada	4	0	4	South Africa	2	0	2
China	51(7)°	1	52(8)°	Sweden	9	5	14
Czechoslovakia	3	1	4	U. S. A.	131	111	242
Denmark	9	4	13	U. S. S. R.	9	0	9
Finland	1	0	1				
France	8	0	8	Total	343(7)	157(1)	500(8)
Germany	38	12	50				

°Aliens in China.

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Le Materiel Telephonique .... *Paris, France*

Bell Telephone Manufacturing Company .... *Antwerp, Belgium*
Branches: Berne, The Hague, Brussels.

Ferdinand Schuchhardt Berliner Fernsprech-und Telegraphenwerk, Aktien-Gesellschaft .... *Berlin, Germany*

Standard Electric Aktieselskap .... *Oslo, Norway*
Branch: Copenhagen.

Standard Electric w. Polsce .... *Warsaw, Poland*

Standard Electric Doms a Spolecnost .... *Prague, Czecho-Slovakia*

United Telephone and Telegraph Works, Ltd .... *Vienna, Austria*
Branch: Tallinn.

Standard Villamossagi R/T .... *Budapest, Hungary*

Standard Elettrica Italiana .... *Milan, Italy*
Branch: Rome.

Standard Electrica, S. A. .... *Madrid, Spain*
Branches: Barcelona, Bilbao, Sevilla, Santander.

Nippon Electric Company, Limited .... *Tokyo, Japan*
Branches: Osaka, Dalny, Seoul, Taihoku.

Sumitomo Electric Wire & Cable Works, Limited .... *Osaka, Japan*

China Electric Company, Limited .... *Shanghai, China*
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