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G. E. Pingree, President   S. G. Ordway, Secretary   Joseph A. Redegeld, Treasurer

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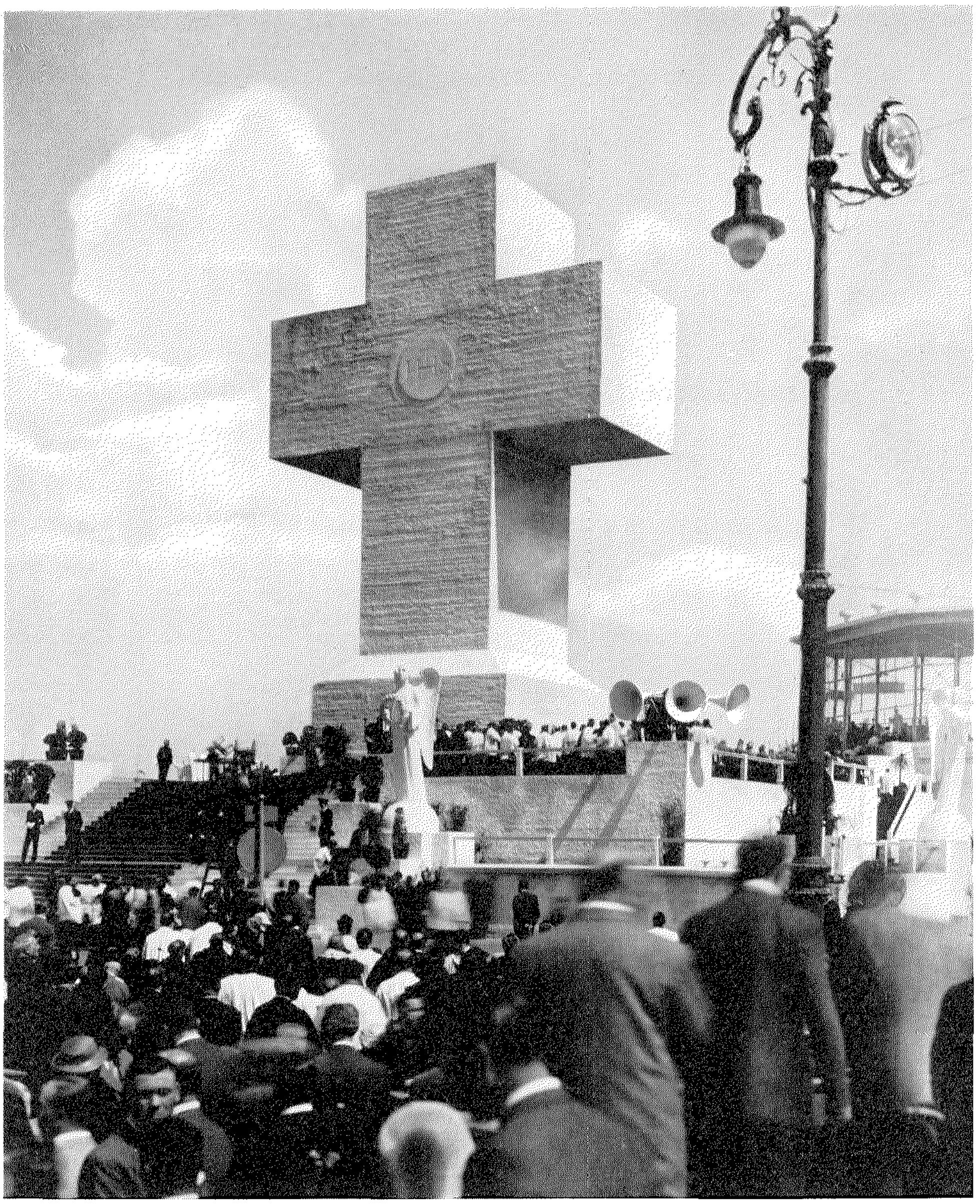


CROSS CONSTRUCTED OVER THE SPANISH MONUMENT IN PALERMO. THE PLATFORM FOR THE CHOIR IS AT ITS BASE. ON THE EXTREME RIGHT THE MAIN ALTAR AND PULPIT ENCLOSED IN GLASS ARE PARTIALLY VISIBLE. A CLUSTER OF THREE LOUD-SPEAKER HORNS OF THE PUBLIC ADDRESS SYSTEM MAY BE SEEN TO THE RIGHT OF THE BASE OF THE CROSS.

Transmitting the Program of the Thirty-Second International Eucharistic Congress

By KENNETH McKIM

Assistant Vice-President, International Telephone and Telegraph Corporation

How the coordination of the public address system, local and national telephone facilities, submarine and transandean cables, and the radiotelephone made possible the largest and most widely diffused religious congregation in history, is described in this article. The following article in this issue of Electrical Communication *covers the public address systems and corollary installations for the Thirty-Second International Eucharistic Congress. An article to be published shortly in this journal will describe the radiotelephone system employed for the international broadcast of this Congress.*

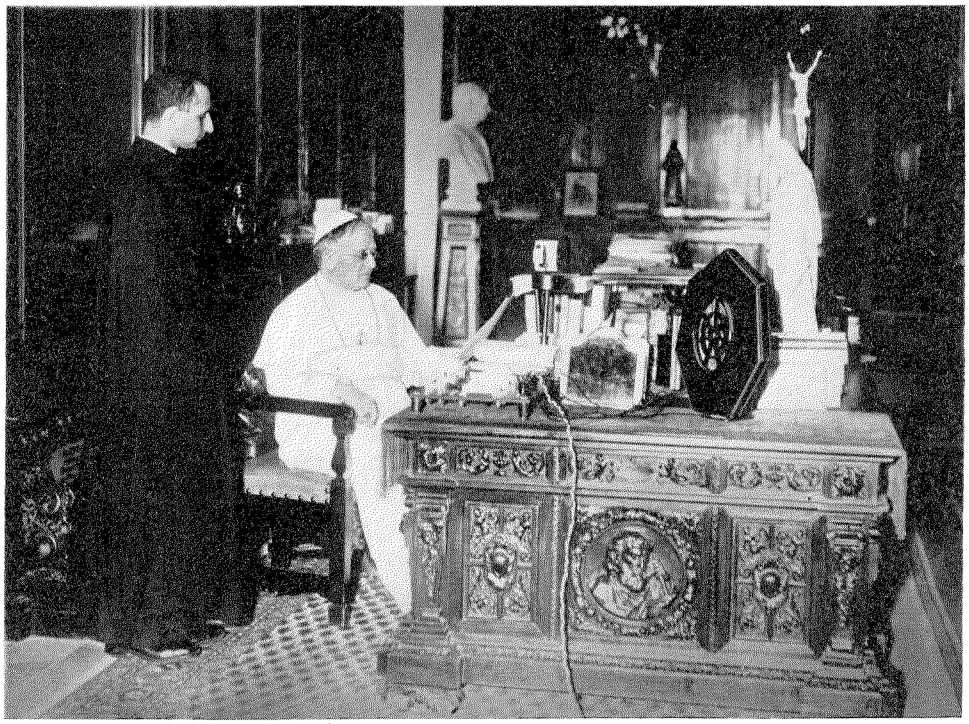
MOST comprehensively international of any biennial gathering of world Catholicism was the Thirty-Second International Eucharistic Congress held in Buenos Aires, October 10-14, 1934. The statement is made without reference to considerations other than the vast geographical proportions of the congregation which, unrestricted for the first time to local confines, listened to features of the program by virtue of the wire and radio facilities of the International System and connecting services utilized for the transmission of words and music. Listeners included not only the multitude in actual attendance at the Congress but also, by means of an intercontinental broadcast hook-up, countless millions throughout South and North America, Europe, and other parts of the globe.

On the closing day, following the eloquent address delivered by the Papal Secretary of State, His Eminence Cardinal Eugene Pacelli, Pontifical Legate to the Congress, from the main altar in Palermo Park, Buenos Aires, His Holiness Pope Pius XI, speaking into the microphone on his desk in the Vatican, contributed the emotional climax to what has been generally pronounced the most imposing and successful of all Eucharistic assemblages, by conveying verbally the Apostolic message not only to upwards of a million worshippers kneeling in the streets of the Argentine capital but also, by means of retranmissions from Buenos Aires to broadcasting stations on three continents, to a very considerable proportion of the clergy and laity at large.

Thus has the cooperation of science and religion, the combination of permanent facilities for the electrical transmission of sound in daily commercial life with temporary installations of specially engineered and manufactured equipment for pick-up, amplification and local loudspeaker reproduction of the entire program, transformed these International Eucharistic Congresses from conventions of delegates from many nations, closely huddled and with straining ears, into magnificent religious ceremonies in which the layman is the preponderant factor in a congregation that knows no restrictions of cathedral walls or park boundaries, of national frontiers or the ocean's broad expanse.

At the previous International Eucharistic Congress in Dublin, successful use had been made of a public address system[1] specially designed and manufactured by Standard Telephones and Cables, Ltd., London, and installed and operated by that Company's engineers in cooperation with those of the Irish Post Office, both in enabling the huge gathering in Phoenix Park to hear distinctly the services conducted from the main altar, and in the transmission of music along the line of march of the processions. This experience established the necessity of providing similar local facilities for future Congresses, and suggested means whereby a public address system might be even more amply utilized for the smoother and greater control of

[1] "Vast Public Address System at Thirty-First International Eucharistic Congress, Dublin, June, 1932," by W. L. McPherson, *Electrical Communication,* April, 1933.



His Holiness Pope Piux XI before the Microphone in the Vatican Delivering the Apostolic Message to the Eucharistic Congress in Buenos Aires. Standing behind the Supreme Pontiff is Rev. Father Filippo Soccorsi, Director of the Vatican Radiotelephone Station.

tremendous masses of humanity and the conduct of ceremonies upon an unprecedented scale.

In Buenos Aires, the problem presented physical aspects even more difficult than in Dublin, particularly with regard to handling the public. The site originally considered near the New Port was later rejected in favor of a spot in a fashionable residential district, between the Zoological Gardens and Palermo Park, where the city's main boulevard, Avenida Alvear, widens at the intersection of the Avenida Sarmiento to circle the majestic Spanish Monument. Completely covering this monument, a mammoth wooden cross was erected, and around its base was constructed the main altar and platform for the choir; official tribunes were built on the other edges of Avenida Alvear flanking the altar, and benches were installed for the public in the roped-off portions of the boulevard.

The police and the Congress officials cooperated closely in the use of the public address system in directing and controlling the immense traffic occasioned by the ceremonies at the main altar, the processions, and the services held in the Plaza de Mayo facing the Cathedral. One of the most notable demonstrations of the effectiveness of the loudspeakers for this purpose was their employment in managing the hundreds of thousands who attended the midnight mass for men on October 11, when a congregation that began assembling by 10 P.M. and did not disperse until after 4 A.M. densely packed not only the expansive Plaza de Mayo but all of the dozen streets that converge there, and solidly filled for several blocks the broad Avenida de Mayo, principal business thoroughfare of the city. Both police and Church authorities publicly declared that the absolute absence of disorder, accidents, or casualties resulting from crushing by a restless crowd, so universally characteristic of immense concentrations of the general public in street gatherings of any nature, was largely attributable to the existence and the high technical quality of the public address system. Reference is made to the technical quality, because the perfect synchronization of the loudspeakers, the lack of distortion and the modulation in the transmissions, the volume maintained without echo, interested and pleased the public, had a quieting influence, compensated for inability to see what was taking place, and carried the proper note of solemnity into the outskirts of the crowd, where restlessness and disturbances normally are most likely to originate purely for reasons of distance from the center of interest.

Buenos Aires presented serious difficulties as to where and how to manage the large attendance certain to be drawn to such grand religious events in a metropolitan area of some three million inhabitants, mostly adherents to the Catholic faith. Fortunately, however, the Compañía Standard Electric Argentina, with whom the order was placed for the public address system, was able to count upon the wholehearted and technically efficient cooperation of such associated companies as the United River Plate Telephone Company, Ltd., operating the telephone service in Buenos Aires and in most of the more populated areas of the Argentine Republic, and the Compañía Internacional de Radio (Argentina), with its short wave transmitting and receiving stations at Hurlingham and Plátanos on the outskirts of the Argentine capital. These stations provided the connecting links between the subscribers of the former company and the rest of the world, with the exception of Uruguay (reached by a subfluvial cable), and Chile, Peru, and Colombia, connected by means of a transcontinental land line and a chain of three radiotelephone stations,

Distribution of Loud Speaker Horns in the Plaza de Mayo. The Presidential Palace Appears in the Background.

A Section of the Congregation in the Avenida Alvear at the Opening of the Thirty-Second International Eucharistic Congress.

all a part of the International System.

The existing facilities of the United River Plate Telephone Company, Ltd., included a first class underground cable plant in which special broadcast circuits were available; an abundance of Standard Electric vacuum tube repeaters in the Buenos Aires long distance office and at the terminals of the loaded underground toll entrance cables that connect with the circuits extending to the north, west, and south of the Republic; conveniently located telephone exchanges for installing certain amplifying units of the public address system; special circuits, with their associated amplifiers, to all Buenos Aires broadcasting stations which, by law, are located in the suburbs of the capital and are, consequently, widely scattered; and a large and competent technical staff, entirely familiar with the whole range of problems that complicated and elaborate transmission undertakings may present. The telephone company, also, had long distance circuits for a national broadcasting chain hook-up, as well as broadcasting circuits to Santiago, Chile, and Montevideo, Uruguay, and the established connections for building up an intercontinental broadcasting hook-up with most of the other countries of South America, and all of North America and Europe.

One matter of considerable importance to the Church dignitaries, as well as to the Argentine Government, the public, and the International System, was the provision of reliable facilities for the transmission of the Papal message from Vatican City. Prior to the Congress, commercial telephone service between Vatican City and South America did not exist. While several possibilities for the transmission by roundabout circuits existed, it was considered preferable to establish a direct shortwave circuit with the Buenos Aires stations of the Compañía

Internacional de Radio (Argentina). By constructing new antenna and making other additional installations at the Plátanos station as a further guarantee of success, the Buenos Aires-Vatican City commercial telephone service was inaugurated in the first days of the Eucharistic Congress, thus constituting one of the permanent and practical monuments to the Buenos Aires meeting.

Associated companies of the International System cooperated generally for the purpose of placing at the disposal of the Thirty-Second International Eucharistic Congress the most extensive and satisfactory transmission facilities, locally, nationally, and internationally, that had ever been mobilized for any South American event, if not, indeed, on any occasion in whatever part of the world.

Among the associated companies called upon to play special roles in the arrangement of the international broadcast, besides those already mentioned, were: Standard Telephones and Cables, Ltd., All America Cables, Inc., Companhia Radio Internacional do Brasil; Compañía Internacional de Radio, S.A. (Chile); Compañía Internacional de Radio (España); Mackay Radio and Telegraph Company; Companhia Telephonica Rio Grandense; Compañía de Teléfonos de Chile; Compañía Peruana de Teléfonos, Limitada; Compañía Telefónica Nacional de España; Montevideo Telephone Company Ltd.; and Standard Elettrica Italiana. General supervisory assistance was rendered by headquarters of the International Telephone and Telegraph Corporation at New York and the South American headquarters of the International Telephone and Telegraph Corporation (Sud America) in Buenos Aires. Valuable cooperation was given by various other entities, including the American Telephone and Telegraph Company, the British Post Office, the German Reichspost, and the French Department of Posts and Telegraphs.

Insofar as the Compañía Standard Electric Argentina was concerned, its obligation, of course, consisted of providing an adequate Public Address System for the streets of Buenos Aires where ceremonies were to be conducted or processions were to move. But the spirit of rendering the best possible service to a client, coupled with that of collaboration with worthy institutions, movements, the public, and the governments, prompted a united and energetic endeavor on the part of the International System to make the electrical communications feature of the Thirty-Second International Eucharistic Congress an achievement surpassing all precedent, a cause for complete satisfaction upon the part of the Catholic Church, and a source of pride for the Argentine Republic as host to that distinguished assemblage.

To that end, the International System assumed responsibility not only for the transmission facilities and technical operation, but also for arrangements for reception and rebroadcasting, placing such of its own facilities as might be involved in the creation of the radio hook-up unreservedly at the disposition of the Eucharistic Congress for the maximum success of the Buenos Aires session.

The Public Address System and Corollary Installations for the Thirty-Second International Eucharistic Congress

By RICARDO T. MULLEADY, B.Sc.

Assistant Chief Engineer, United River Plate Telephone Company, Ltd.,

and W. WHITE

Chief Installation Engineer, Compañía Standard Electric Argentina

THE Technical Committee of the Thirty-Second International Eucharistic Congress, after receiving the proposal of the International System made through the United River Plate Telephone Company, Ltd., specified that the electrical communications service should be distributed: (1) to the congregations present at the ceremonies; (2) to the broadcasting stations of the city of Buenos Aires; (3) to the broadcasting stations of the principal cities of Argentina; and (4) to a hook-up of more than a hundred of the main broadcasting stations of the outside world.

It also specified a complete telephone service, consisting of a P.B.X. and fifty stations, to be distributed in special booths along the avenues for the use of the traffic police in controlling the crowds, and for the emergency medical service.

In order to comply with the above requirements, it was found necessary to provide and distribute the system equipment as follows:

(a) A microphone and loudspeaker installation in Palermo Gardens for the ceremonies taking place at the main altar, and a street system for use during the procession between Recoleta and Palermo, a distance of some 3,000 meters.

(b) A microphone and loudspeaker installation in Plaza de Mayo, and microphone points in the Cathedral, for the services at these two places.

(c) A street loudspeaker installation along Avenida de Mayo and in Plaza Congreso for the midnight procession from the latter point to the Plaza de Mayo, a distance of some 2,000 meters.

(d) A microphone and loudspeaker installation at the landing stage of the port of Buenos Aires, for use in connection with the arrival and departure of the Cardinal Legate.

(e) A microphone and loudspeaker installation at the Colón Theatre for the gala performance celebrated on Columbus Day.

(f) Amplifying equipment at the Buenos Aires long distance office, known as "Cuyo," for distributing the service to the other stations of the system and to all the broadcasting companies interested in the transmission of the program; and a P.B.X. installation for the telephone service requested.

Fig. 1 shows in schematic form the general layout of the system used, indicating the number of microphones and loudspeakers installed at the various places, the names of the Argentine towns to which the ceremonies were transmitted, and of the foreign countries where the service was distributed by land line and radio.

As shown in the schematic, each pick-up system could work independently of the others, all the stations being linked by circuits in underground cables to Cuyo office, which acted as the main distributing point for the system, and for the national and international chains feeding the broadcasting stations.

The manual P.B.X. for the telephone service at Palermo was installed at Cuyo office, taking advantage of some fifty pairs of 16 A.W.G. cable available on the international cable Cuyo-Colonia (Uruguay). This cable crosses the River Plate quite close to the Zoological Gardens and was reached from the temporary pavilion built for amplifying equipment in a corner of the gardens by a lateral connection.

Preliminary Tests

Before forwarding specifications to Standard Telephones and Cables, Ltd., London, it was necessary to conduct certain tests on site. These were carried out with apparatus available from the stock of Compañía Standard Electric Argentina. The tests consisted in lining up half a dozen loudspeakers in the avenues, separated by various distances and with horns at different inclinations, to establish a uniform distribution of sound to cover all the congregation area and thus avoid wherever possible dead spots and zones where two or more loudspeakers might be heard with sufficient time lag to cause effective interference. The results of these tests indicated that, due to the very directional effect of the projectors, with an angle of distribution of approximately 20° on each side of the axis, the best results would be obtained by distributing the loudspeakers in a straight line along the avenues 75 meters apart and placing the projector poles some 15 to 20 meters inside the street curb line in the grass margin of the gardens. The tests also indicated that the most suitable height for mounting the projectors was about 6 meters from the ground, at an angle of some 40° to the axis of the road. The inclination of the projectors with respect to the vertical axis varied from 10° to 5° below the horizontal, according to the respective widths of the avenues.

The tests for the distribution of the loudspeakers in Avenida de Mayo, a thoroughfare 35 meters wide and lined with tall buildings from Plaza de Mayo to Plaza Congreso, indicated that the best results would be obtained by placing the projectors along the center of the avenue and mounting them on the electric light columns 60 meters apart. The inclination of the horns was sufficiently downward to avoid a long throw of sound that would have caused the production of zones in which the interference effects would have been annoyingly prominent. By maintaining a convenient acoustic output, this arrangement produced the desired results to a most pleasing degree.

The tests at Palermo and Recoleta were made in the winter, when there was no foliage on the trees, with horns shorter than those used during the ceremonies, and with the ground occupied only by the normal street traffic. Consequently, for the final performance some allowance had to be made for these factors. The decision, therefore, was based on the polar distribution of the field given by the loudspeaker horns during the tests, allowing a factor of safety for the longer horns and for the absorption and reflection of the crowd, as well as for the abundant foliage of the late spring. The satisfactory results obtained during the ceremonies confirmed the tests and assumptions in every way. The whole of the vast field was well covered with sound, the intensity of which was kept at convenient volume within the radius of the avenues and gardens, no interference effects being reported.

The general layout of the loudspeaker and microphone positions in and around the Spanish Monument is shown in Fig. 2, which gives the distribution of the microphones in the main altar, choirs, speaker, and traffic control room,

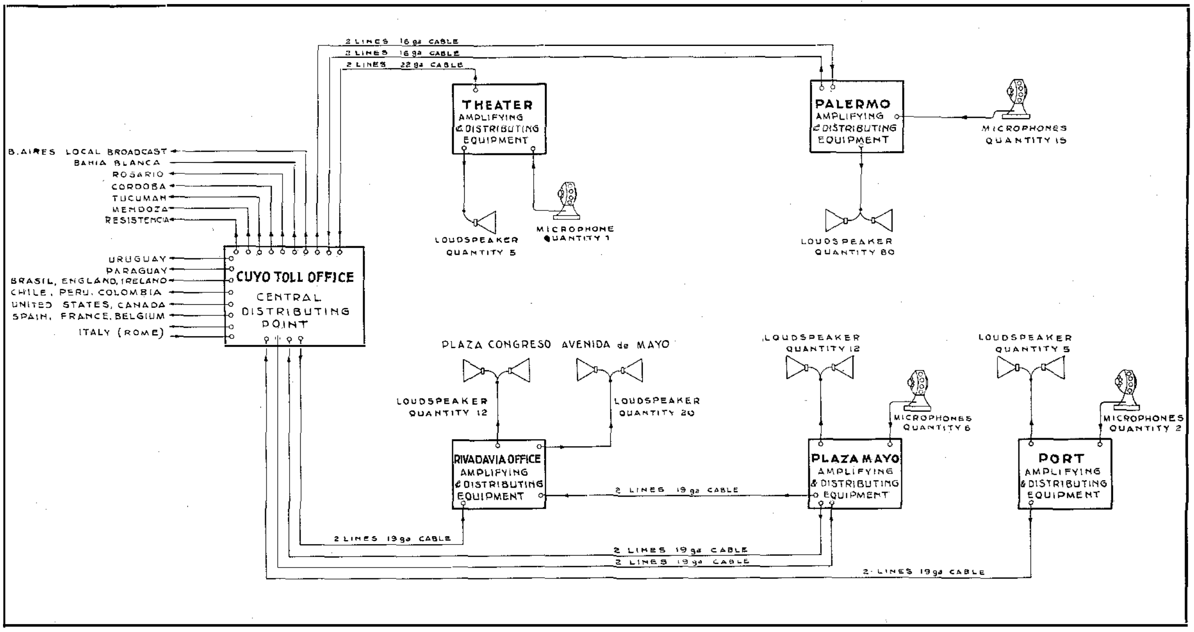


Figure 1—Layout of the General System.

and also the special microphone that was installed on the roof of the public address system pavilion for the use of an announcer, who transmitted direct from Palermo to the United States comments on the opening and closing ceremonies.

The microphones used during the preliminary tests were of the No. 4014 double button carbon type. The ones used throughout with the definite equipment were of a more modern design: No. 4017 moving coil type with permanent magnet, having a sound to noise ratio some 15 db. better than the best condenser microphone. The microphones were mounted on table supports for the altars, on pedestal supports for the speakers, and on suspension type mountings for the choir.

Fig. 3 shows two of the microphones used in connection with the ceremonies at the main altar.

The fifteen microphone points were connected to the equipment by lead covered single-pair 22 A.W.G. cable conductors.

The loud speakers used during the street tests were of the low impedance No. 555 type, moving coil with polarized magnet system associated with 6 foot exponential horns. The ones used throughout the whole system were of a later design, No. 30150 low impedance moving coil type with permanent magnet associated with 7 foot 6 inch exponential horns. Figs. 4 and 5 show the type of horns used in the street systems and the method of mounting on the poles. Each loudspeaker was connected to the low winding of a step-down transformer fixed at the pole, the primary of the transformer being connected to the transmission line. Ten loudspeakers were

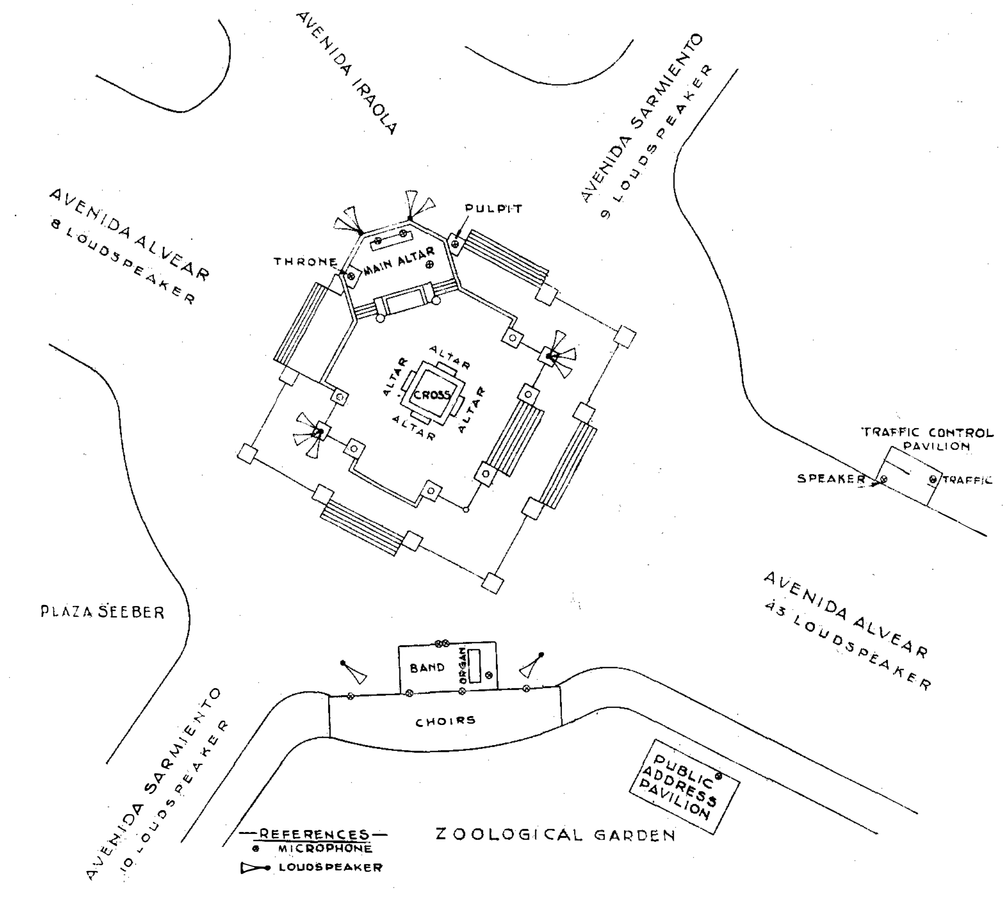


Figure 2—Microphone and Loudspeaker Layout at the Monument in Palermo.

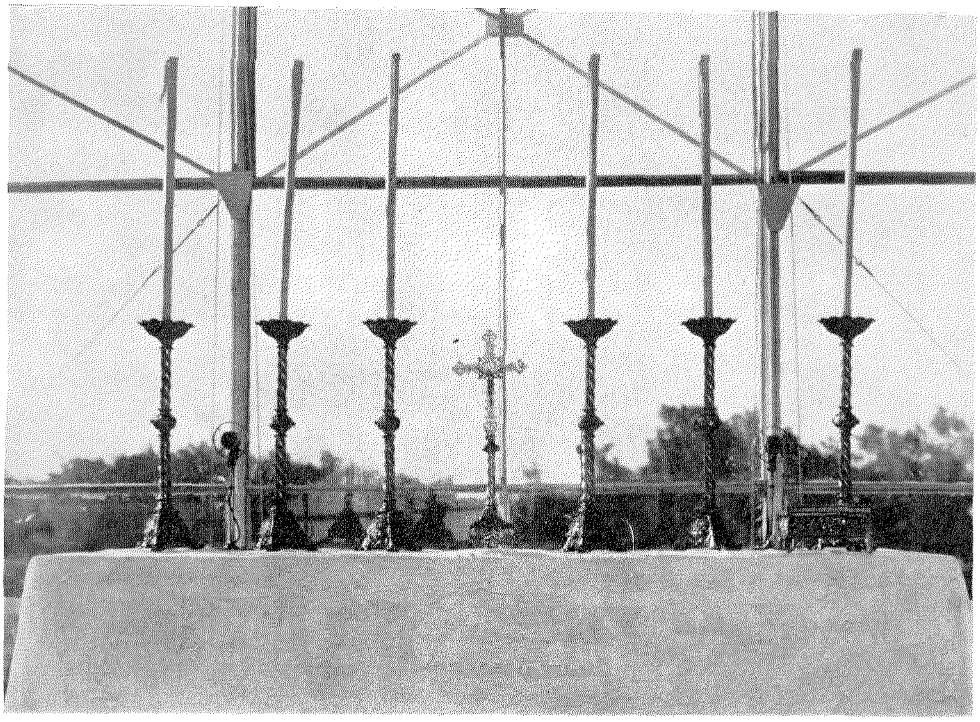


Figure 3—Main Altar Showing Two Microphones in Position.

connected per line in alternative manner; i.e., one line feeding ten odd loudspeakers and another feeding ten even loudspeakers. The eighty loudspeakers in the Palermo system were thus fed in an alternative way by eight aerial lines of stranded insulated wire, each line formed by two separate weatherproof conductors. To protect the loudspeaker elements from the rain, it was found desirable to cover them with rainproof cloth.

Palermo Park System

Palermo Park, where the main altar was erected and the principal daylight services were celebrated, is situated some 6 km. northwest of the Plaza de Mayo, where the night ceremonies took place.

Fig. 6 is an aerial view of the site of the main altar, showing at the intersection of the avenues the Spanish Monument, which, as previously stated, was completely covered by a structure in the form of a huge cross, a view of which is shown in the Frontispiece. This cross had a height of 31 meters, and was consequently visible from a considerable distance along the intersecting avenues. Around the fountains that surround the Spanish Monument, a large platform was built to a height of some 3 meters. On this platform, four small altars were mounted at the foot of the cross; and at a point outside the central axis of the platform, so that it could be seen from all directions, a temple was erected for the main altar and pulpits, the altar being at a height of 6.50 meters from the road level.

The area reserved for the congregations was that embodied in the Avenues Alvear and Sarmiento, about 900 meters on each side of the cross. This area and the space for special enclosures reserved in the gardens, covered some 180,000 square meters, which were fully occupied during the various services.

The most important portion of the whole system was that installed at Palermo Gardens for the service at the high altar, and consisted of the

Figure 4—Line of Loudspeaker Horns Along the Avenida Alvear.

necessary speech input and power equipment for fifteen microphone pick-up points and eighty loudspeakers. The equipment was located in a pavilion built inside the Zoological Gardens in the angle nearest to the cross. Since it was the central point of the whole system, an elaborate microphone switching arrangement had to be provided, together with suitable amplifiers for feeding the park loudspeaker system and relaying the transmission to Cuyo office, where the ceremonies were transmitted to the loudspeakers of the other parts of the public address system and, by physical circuits and radio, to other Argentine cities and foreign countries. Accordingly, a group of five bays was installed, with complete duplication of amplifiers, giving switching and mixing facilities for the fifteen microphone in use. These racks carried a series of amplifiers, arranged in the manner shown in schematic form in Fig. 7 and in the photographic reproduction of Fig. 8, for the purpose of raising the sound power picked up by the microphones to sufficient electric power to drive the 100-watt amplifiers feeding the loudspeakers. The speech input equipment consisted of six microphone amplifiers, two "A" and two "B" amplifiers, including the spares, and a group of three "C" amplifiers.

The microphones could be switched by means of keys to the corresponding microphone amplifiers which were connected, through mixers, to the battery of amplifiers, "A," "B," and three "C's," in parallel. These latter distributed the energy to the 100-watt amplifiers feeding the loudspeakers, and to the Cuyo office. The microphone amplifiers MS. 2460-3 employ No. 4019-A valves; they are single-stage with a fixed gain of 12 decibels, an input impedance of 25 ohms, and an output impedance of 200 ohms.

Amplifier "A" is a three-stage retardation coil coupled amplifier, having shielded input and output transformers. It gives a maximum gain of 70 decibels, has an input impedance of 50 ohms, and an output impedance of 200 ohms. It uses two No. 4020-A valves and one No. 4019-A valve, with a capacity in the output valves of 50 milliwatts. The valves are mounted in non-microphonic sockets in order to avoid vibration.

Amplifier "B" is a two-stage retardation coil amplifier designed to operate from a 600 ohm input circuit to the inputs of the "C" amplifier. The combination of this amplifier and the "C" gives a maximum gain of 45 decibels, using No. 4020-A and 4019-A valves. As in the case of the "A" amplifier, the valves are mounted on non-microphonic sockets.

Amplifier "C" is a single-stage push-pull amplifier arranged to operate from the "B" amplifier. It has an input impedance of 6,000 ohms, which corresponds to the output impedance of the "B" amplifier, and an output impedance of some 600 ohms, capable of being varied in the transformer to values of 75 and 30 ohms.

In all these amplifiers the gain-frequency characteristic could be adjusted for a variation of about plus or minus .5 db. from 20 to 10,000 cycles.

It was observed that while all these amplifiers were being operated at full gain, the main volume control being a separate unit between "A" and "B" amplifiers, no sign of instability was noted, and that due to the method of suspension of the valve sockets and the design of the quarter ampere filament repeater valves used, the equipment was entirely free from microphonic trouble, no floor covering being found necessary to avoid vibration.

The whole of this speech input equipment was operated by d-c. supplies, each amplifier being fed by a panel containing two metal rectifying groups and the necessary filters. The racks carrying these rectifiers are shown in Fig. 9. The two rectifying units in each panel for the 12 volt and 130 volt supplies were fed from transformers, each transformer having an individual secondary for each panel, one low tension and the other high tension. These transformers were provided in duplicate, as can be seen in Fig. 9, which also shows in the middle portion of the rack the switching arrangement for changing over any one or the whole of the secondary windings. The filtering arrangements were such that the hum level was found well below normal valve noise and the operation was of a very high order. The ballast lamps used in the low tension rectifiers maintained a constant e.m.f. over normal supply voltage variations

The 100-watt amplifiers used, were two-stage, the first stage being a class "A" push-pull driving a parallel push-pull class "B" output stage. All power supplies were obtained from a unit individual to each amplifier, providing high and low tension and separate grid bias for the class "B" stage; the class "A" stage being automatically biased. Owing to both stages being push-pull, single wave rectification was used on the high tension supply of the output valves, obtained from a mercury type rectifier; the first stage was fed from a full wave metal rectifier. As in the case of the speech input equipment, the filters were found to be very adequate, and the system entirely free of any trace of power hum. This 100-watt amplifier is capable of delivering 85 watts

Figure 5—Loudspeakers Installed in Avenida Sarmiento.

Figure 6—Aerial View of Palermo Gardens with the Spanish Monument at the Center.

output with 5% harmonic distortion, requiring an input of 50 milliwatts.

The Palermo installation consisted of three of these amplifiers mounted above their power supply units, as can be seen from Fig. 8. Each amplifier had sufficient power to feed forty loudspeakers, the three inputs being arranged in parallel. The Palermo system comprised eighty loudspeakers arranged in two groups of forty, each of which could be connected to any amplifier by means of a double-throw switch.

The performance of these amplifiers was excellent, each supplying forty loudspeakers at full volume without any sign of overload, and giving a quality which left nothing to be desired. Association of each valve with an individual plate current meter proved very useful in operation, as the spare amplifier was put into service whenever variations from normal were noted on these meters, thus avoiding any possible case of interruption during the ceremonies.

A separate system, consisting of a microphone amplifier, two 4041 amplifiers in cascade, one 4042, and one 4043 as output stage, with its corresponding microphone and loudspeakers, was installed to pick up, amplify, and distribute the music for the choir. The music was originated in a small motor-driven harmonium and amplified to the volume of a cathedral organ, two loudspeakers with 4.30 meter horns being used to transmit the amplified music to the five hundred and sixty components of the choir. This system was very satisfactory, particularly from the point of view of the choir master, who made extensive use of the organ microphone to give instructions to the choir.

The 50-cycle, 220-volt single-phase main power supply was taken from the city's light service. Inside the Zoological Gardens, however, a petrol electric generating set was provided as a standby in case of supply failure. This set was kept working during the ceremonies though it was not required.

Reference to the arrangement of the Palermo system will indicate that one of the greatest difficulties presented for operation of the equipment was that of coordinating the ceremonies on the altar with the switching of the microphones, and working of the mixing panels in the amplifier pavilions. Owing to the location of this room, it was impossible to obtain any view of the proceedings. It was, therefore, necessary to design a signal system which permitted the master of ceremonies, located in a glass cabin close to the high altar, to operate, in any desired order or combination, signal lamps placed over the actual switching keys on the speech input equipment bays. This visual signalling was accompanied by a single stroke on a gong located in the amplifier room for calling the attention of the attendants. As a further safeguard against the possibility of burnt-out lamps, a parallel system of lamps was used on a signal board located above the three power amplifiers. This board (Fig. 8) served the dual purpose of checking lamp failures, and also of giving the man in charge of the room a complete picture of the condition of the system at any moment, inasmuch as this signal chart also carried signal lamps operated from the off-normal contacts of the mixers, thus informing him that any microphone requiring service into the system had been allocated a mixer channel. Although these arrangements proved satisfactory, they nevertheless were supplemented by a small telephone system that permitted the verification of all switchings requested, as well as telephonic communication between choir master, announcer, director of traffic, master of ceremonies, and amplifier room. The system proved of great value in the smooth transmission of the ceremonies.

Plaza de Mayo System

The equipment for this system was installed in a temporary cabin on the Plaza de Mayo, quite close to the Pyramid Monument where the altars were erected. The installation of the speech input and power equipment to operate three microphone pick-up points and twelve loudspeakers consisted of duplicate R-124 amplifiers followed by one R-125 power stage, the R-124 pre-amplifier being a high gain three-stage unit. The first and second stages were resistance coupled, using in the first stage one 9-A1, in the second stage one HLA-2 valve, and in the power stage two 4033-A valves in push-pull, high tension being provided for all stages from an R-3 rectifier valve. The R-125 30-watt amplifier was a single power stage consisting of four 4011-B valves in

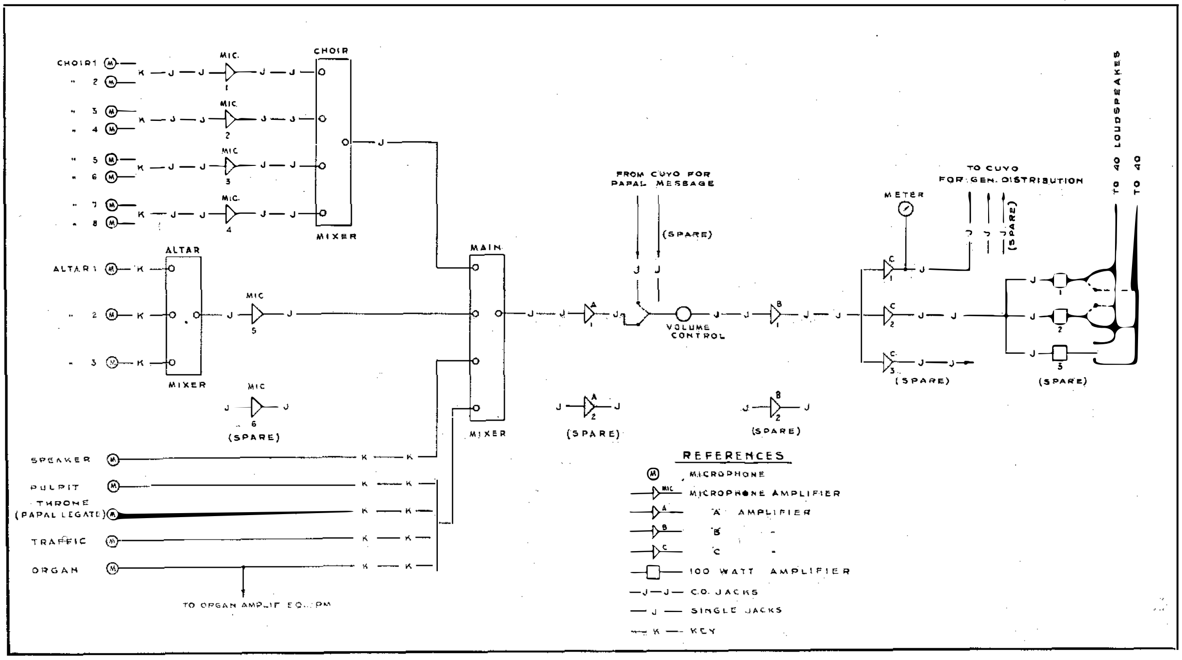


Figure 7—Schematic of the Palermo Equipment.

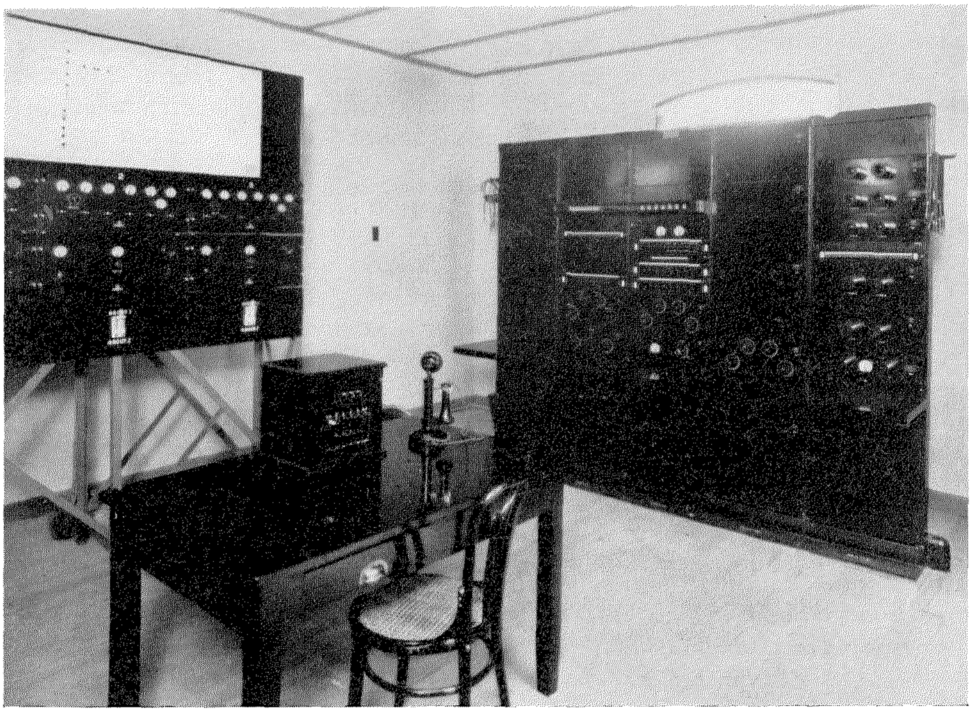


Figure 8—Main Amplifying and Speech Control Equipment at Palermo Park.

parallel push-pull with a separate output for each push-pull pair. The general layout of the equipment is shown in Fig. 10.

Since the midnight mass for men was celebrated in this Plaza, arrangements had to be provided for microphone control and switching. To this end, a three-channel mixer panel was installed, feeding the input of the R-124 amplifier, which in turn fed the R-125 30-watt amplifier. For the purpose of feeding the sixteen loudspeakers fitted in Plaza de Mayo, a series arrangement of these outputs was used in order to match the line impedance. This gave ample volume and good quality.

As a precaution against any failure in the amplifiers, the above-mentioned groups were provided in duplicate, as will be seen from Fig. 11, which shows the front view of the Plaza de Mayo amplifier station.

For the reception of the Papal Legate and for the men's midnight mass, pick-up arrangements had to be provided to transmit these ceremonies, not only to the Plaza de Mayo itself but to the Rivadavia exchange for feeding the Avenida de Mayo loudspeakers and, also, in the first mentioned case, to the Palermo system. For these requirements, jack arrangements and mixing panels were provided, as may be seen in Fig. 10. It will be noted from this schematic that the arrangement is completely flexible, permitting reception of transmissions from other points, and transmission from the Plaza de Mayo itself.

An organ amplifying system had to be provided for the men's midnight mass. An MS-3029, Group 1 OB amplifier was used with a microphone located alongside the small organ, the amplifier driving a 4043 type amplifier feeding two 13 type horns fitted with double elements, thus providing ample volume for the male choir of two hundred voices. As in the case of Palermo, this microphone was much appreciated by the choir master, who was thus able to give all the necessary instructions to the choir.

The equipment described above gave entire satisfaction, the quality being excellent, and the volume sufficient to meet the demands of the tremendous crowds congregated on the night of the men's mass. It was in service during the entire Congress and transmitted all of the Palermo ceremonies, the general public finding this installation of great interest.

From a purely technical standpoint, the design of these amplifiers is interesting, the power output being surprisingly high for the small space required. They are also completely self-contained, all connections being made with heavily armoured plugs; they are easily portable, and are not likely to suffer damage, as the case is entirely of metal.

As in the Palermo equipment, the hum level was well below that of valve noise, the filtering arrangements provided being fully satisfactory.

Avenida de Mayo System

The equipment for this system, intended to feed thirty-two loudspeakers on the Plaza Congreso and Avenida de Mayo, was installed in the Rivadavia telephone exchange, about midway between Plaza Congreso and Plaza de Mayo and a short block from the Avenida de Mayo. Since no pick-up was required at this point, the switching arrangements were simpler than those described previously, as can be seen from the schematic of Fig. 12.

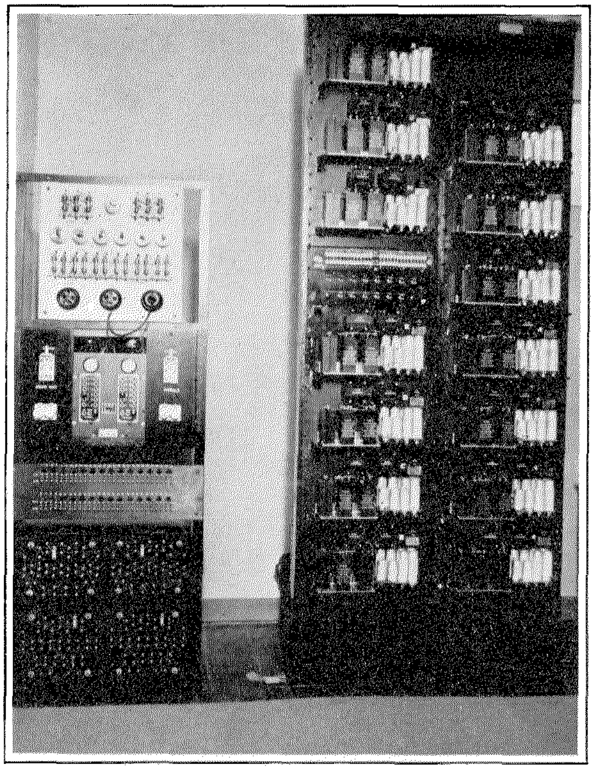


Figure 9—Power Board and Power Supply Panel.

The equipment consisted of duplicate amplifying systems, each comprised of one MS-3029, Group 1 outside broadcasting amplifier driving one 28 LU-2-C amplifier, duplicate sets being

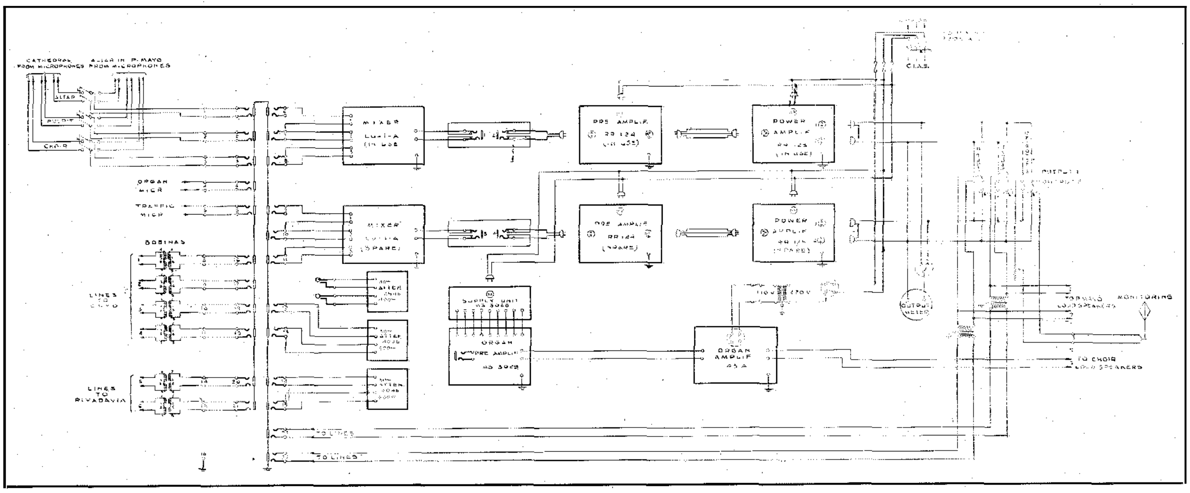


Figure 10—Schematic of Plaza de Mayo Equipment.

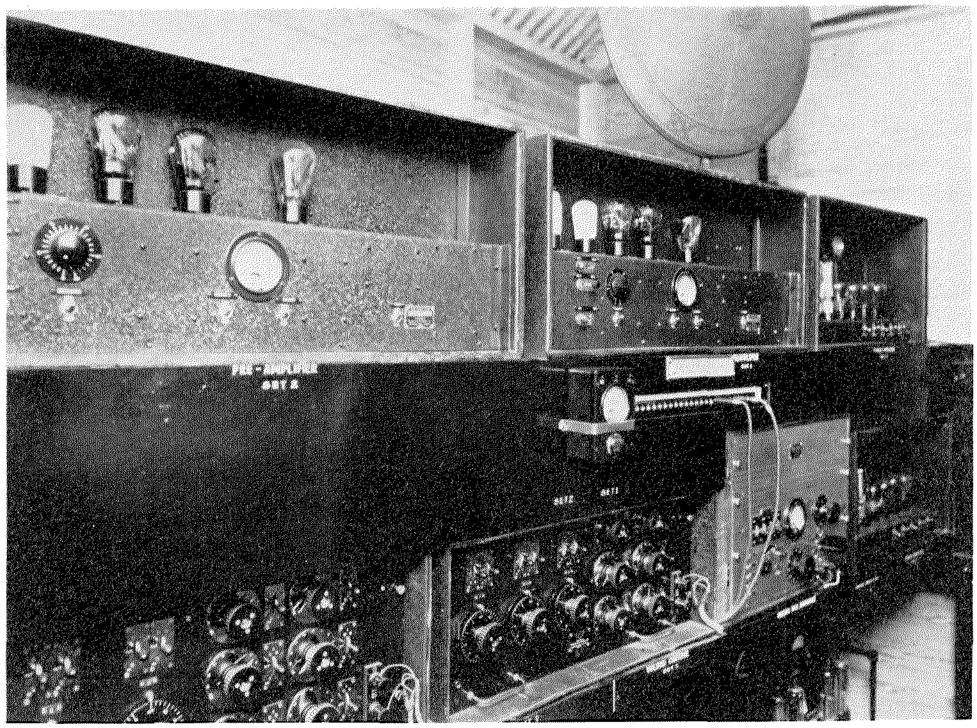


Figure 11—Front View of the Plaza de Mayo Amplifier Station.

provided in order to ensure continuous service in case of any failure of tubes or amplifiers. The MS-3029 outside broadcast amplifier used for driving the power amplifier, consisted of three resistance coupled stages using permalloy input and output transformers, the maximum gain of the amplifier being about 74 db. but continuously adjustable by means of a potentiometer.

As the inputs required arrangement for low impedance microphones, impedance changing pads were used to match the line to these amplifiers, and all power supplies were provided from a 3028, Group 1 supply unit. This supply unit was fed directly from the main supply and, by means of metal rectifiers and smoothing circuits, the necessary high and low tensions of the amplifier were provided. It was found that this amplifier, used to drive the 100-watt power amplifier described in the Palermo equipment, gave fully satisfactory results, no difficulties being experienced in maintaining the required level with good quality.

Port and Theatre Systems

For ceremonies of short duration, two portable equipments were prepared. The first system was used at the ceremony of welcome upon the arrival of the Papal Legate at the Port of Buenos Aires. This transmission was distributed locally over the loudspeaker system installed at the landing stage of the port, and by land line to Cuyo office for retransmission to broadcast stations and the entire public address system of Buenos Aires. To carry out this transmission an MS-3029 broadcast amplifier, previously described, was used for pick-up purposes, having two microphone points, it in turn operating No. 4042 in cascade, with a 4043 type power amplifier for feeding the loudspeakers and the telephone lines. A similar installation was used at the farewell ceremony to Cardinal Pacelli at the same landing stage, and also on board the S.S. Conte Grande, on which he made the voyage to and from Buenos Aires. This transmission was distributed in a similar manner to that previously described.

A special transmission took place from the Colón Theatre on Columbus Day, consisting of speeches by various high ecclesiastical dignitaries. Three loudspeakers were installed above the stage, and were operated by equipment similar to that used for the port, the results being highly satisfactory.

Cuyo Equipment

Since it was required that service originating at any pick-up point be transmitted to the other parts of the system, besides being transmitted to the broadcasting stations, it was necessary to link up Cuyo office with all the stations of the system by incoming and outgoing lines, as indicated in Fig. 1. These lines were terminated by means of No. 4012 repeating coils in the jack panel existing at this office for the permanent broadcasting service.

The equipment consisted of an assembly of eight MS-2723 program repeaters in parallel, associated with a gain control and a program meter, these amplifiers being assigned to the outgoing lines feeding the stations of the local system, the Hurlingham radio station and the local, national, and international chains of broadcasting. On each of the three broadcasting chains a total of twenty branching amplifiers of the 4202-F type were further distributed for feeding the transmitting stations of the broadcasting companies.

By means of patching cords the input of this assembly of amplifiers could be connected to the lines incoming from any of the pick-up points of the local system, and to the Plátanos station of the Compañía International de Radio (Argentina) for the reception of the Papal message from Rome.

Besides the equipment previously described as forming part of the vast public address system used at Buenos Aires, and the permanent amplifier equipment at Cuyo office, the transmission of the service by land lines to the most important towns of the Argentine and to the neighboring countries of Uruguay and Chile, made necessary the installation of special broadcast amplifiers at various repeater points of the toll system and the equalization of the lines for faithful reproduction of the service.

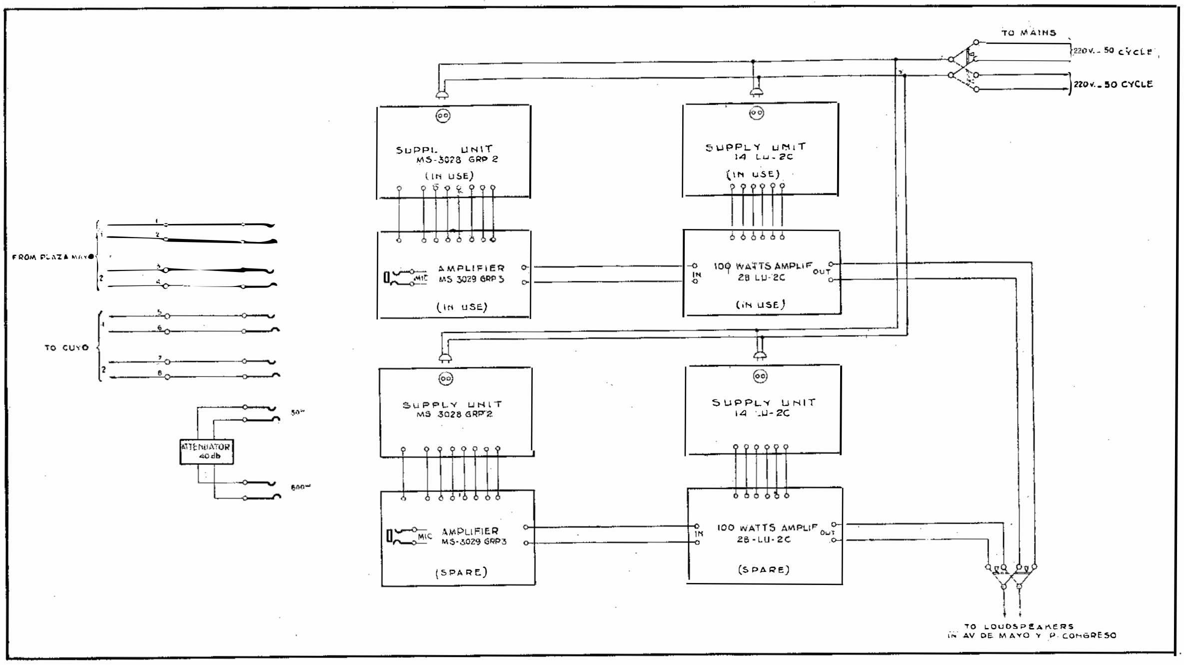


Figure 12—Schematic of Rivadavia Equipment.

In the toll offices and along the toll lines it was also necessary, during the five days of the Congress, to maintain an emergency organization well equipped to attend to unforeseen troubles, and to restore service with the promptitude required by the special circumstances. Every part of the vast network performed without the least inconvenience, the transmission of the service of this Congress being considered as probably the most nearly perfect ever made from Buenos Aires. The ambition of the Congress authorities that the service should have an international diffusion was realized beyond their expectations, both as to the vast area covered by the network and the excellent quality of the transmission delivered to the congregations, to the local broadcast stations, and to the national and international channels that received the program.

The Congress Committee has expressed its highest appreciation and satisfaction for the contribution of electrical communications to the brilliant success of the ceremonies, and has shown in letters of congratulation and publications in the press its gratitude for the manner in which the transmission of the services was handled, especially for the reception of the Papal message.

Developments in Subscriber Sets

By L. SCHREIBER

Bell Telephone Manufacturing Company

This article describes subscriber set developments, including the advantages of the new bakelite moulded type of set utilizing the same components for both the wall and the table sets, and continuing the earlier practice of mounting all the components within the set housing. Manufacturing, testing, and inspection methods, as applied to subscriber set manufacture, are outlined.

THE Bell Telephone Manufacturing Company, for many years, has been one of the outstanding suppliers of telephone subscriber station equipment, and subscriber sets of its manufacture are to be found in many countries of Europe, Asia, South America, and Australia. The sets are in operation in the networks of state owned telephone administrations and private companies, including operating companies of the International Telephone and Telegraph Group.

Manufacture of subscriber sets has been organized by the Bell Telephone Manufacturing Company in line with modern progressive operating practices. Recently the Company has undertaken the manufacture of a bakelite moulded set with a three-piece type of microtelephone.

Earlier Developments

The first line of the all metal subscriber sets of microtelephone type, which to a great extent has superseded the fixed transmitter type set with bell type receiver, is illustrated in Figs. 1 and 2. It is of interest to note that all the components are contained within the housing of the set—the so-called "unit type" of set designed by the Bell Telephone Manufacturing Company in 1912. Figs. 3 and 4 show a later form of set designed in 1927, and Figs. 5 and 6 represent the latest type which will be fully described hereinafter. These three types each represent a distinct stage in the progress which has been made in manufacturing methods in connection with large quantity commercial production.

Sets of the 2650-2652 types (Figs. 1 and 2) were developed at a time when it was not yet generally accepted that full automatic switching systems would some day completely supersede the then existing manual or semi-automatic systems. The sets were furnished with or without dial, as required; but customers, still attached to manual working, would hardly be expected to accept a set with a non-occupied dial housing in the body, as on the sets of later design described hereinafter.

Furthermore, the sets, in accordance with Figs. 1 and 2, were designed and manufactured during the period when parts made by punch press and automatic screw machine operations were the easiest to produce. The set case and base are made from punched and drawn sheet iron, heavily japaned. Notwithstanding the simple form of the case and cradle, the number of machine operations to produce these parts amounts to fifty-two for the wall set and seventy-seven for the table set. The lack of esthetic taste, as regards appearance, resulted from the necessity of keeping down the number of machine operations to the minimum, more pleasing forms entailing complications in the drawing tools.

The microtelephone of these sets, although containing the fundamental features of the up-to-date apparatus, i.e., use of a hygienic mouthpiece and a curved handle, which helps to make the modal position of the receiver and transmitter agree with the essential factor of satisfactory efficiency for the average subscriber, require forty-five machine and finishing operations.

Considering these two types of sets, wall and table, from the viewpoint of operating organizations with respect to stocking and maintenance facilities; and from the manufacturing viewpoint, with respect to the minimum number of parts

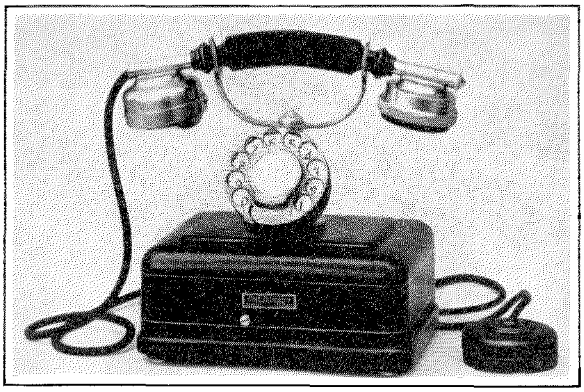


Figure 1—No. 2652 Subscriber Set with All Components Contained Within the Case. Designed in 1912 by the Bell Telephone Manufacturing Company.

contained in the two sets: interchangeability of main components is realized only in the case of the induction coil and condenser. Since the ringer gongs are inside the housing of the table set and outside the housing of the wall set, the lengths of their clapper rods are different. The gravity switch is cradle type in one case and hook type in the other, constituting another case of lack of interchangeability and involving an unnecessary number of different piece parts. Microtelephones could easily be converted for table or wall set use; nevertheless, it was observed that capsules in wall sets where the microtelephone is suspended vertically, have a greater tendency to packing than is the case with table sets, where the microtelephone is moved from a horizontal to a vertical position, and inversely. Moreover, in the case of the vertically suspended microtelephone, the impact when placing it in position is in general greater than when it is removed, so that the transmitter granules are shaken loose less readily than is the case when the normal position of the microtelephone is horizontal.

Sets of the Nos. 2712-2713 types (Figs. 3 and 4), designed in 1927, represent the outcome of considerable development work, undertaken with a view to producing a set smaller in size and more in agreement with the tendency towards simpler forms. A redesign of the components, such as induction coil, condenser, and ringer, was made at the same time.

This type of set is adapted to satisfy additional requirements which can be summarized as follows:

(1) A built-in dial, full automatic systems tending to become generalized.
(2) Full interchangeability of the components of wall and table sets.
(3) A microtelephone (No. 2284) identical in form and location for both sets.

The introduction of this type of set represented an important advance for the Manufacturing Department in the application of the die casting and bakelite moulding processes, the latter being confined to the microtelephone parts.

The housing of the set is composed of two parts, a metal punched skirt and a die cast upper body forming the microtelephone cradle and the mounting for the dial. The microtelephone as supplied with this set is composed of five bakelite parts: the handle, with metal connections between the receiver and the transmitter case moulded in; the transmitter and

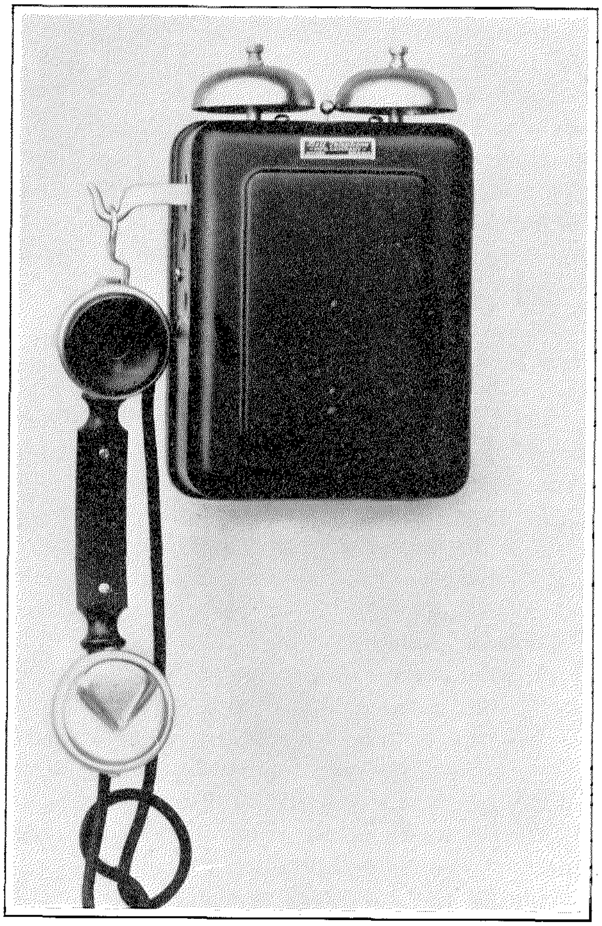


Figure 2—No. 2650 Subscriber Set.

Figure 3—No. 2712 Subscriber Set.

receiver cases; the earpiece and the mouthpiece. The total number of machine operations involved in producing the housing for this set is only fourteen, whereas the five-part microtelephone requires thirty machine operations.

With this set, an improved type of dial (7019 type) was introduced, the main features of which were the use of a die cast body and finger plate. The diameter of the finger holes was enlarged from 12 to 13.5 mm., thus rendering the use of the dial more convenient. It also included an interesting feature for correcting the main spring tension from the front of the dial.

The redesign of the set construction and form, as well as of the components, was accomplished simultaneously. The introduction of the closed core type induction coil with silicon steel laminations and the use of enameled wire in the windings in place of silk insulation, made it possible to produce a small and efficient induction coil. Thinner material for the plates and dielectric of the condenser and the change from 2μf. to 1μf. capacity made possible a considerable reduction in the volume of the condenser. The ringer was made more compact, but retained the efficiency of the larger type. Fig. 7 illustrates the relative sizes of components of the Nos. 2652 and 2712 types of sets (Figs. 1 and 2; 3 and 4).

Fig. 8 shows the relative sizes of the Nos. 2652 and 2712 types of sets and the important reduction in volume of the latter. Figs. 9 and 10 depict the No. 2712 type of table sets built for His Holiness, The Pope, and for His Majesty, The King of Siam. The sets are gold-plated, covered with etching with coloured enamel inlay.

The sets illustrated by Figs. 3 and 4 (Nos. 2712 and 2713) met with considerable favour, but it was considered advisable, nevertheless, to find means for providing a permanent finish in all climates, as well as for reducing the cost of the sets and at the same time rendering the interchangeability of the sets for wall and table use more complete.

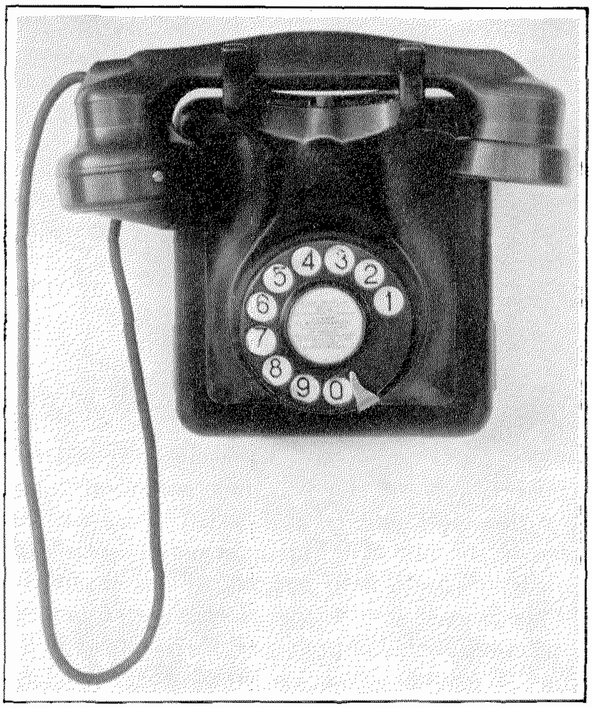


Figure 4—No. 2713 Subscriber Set.

Figure 5—No. 2724 Subscriber Set.

Figure 6—No. 2725 Subscriber Set.

New Bakelite Moulded Sets

It was at first thought advisable to realize full convertibility of the two sets, wall and table, but this could only be done at an increase in the cost of the sets. For this reason the sets shown in Figs. 5 and 6 were designed. The components of the Figs. 3 and 4 type of sets are employed, but moulded bakelite is used for both set housings. With the exception of the dial, the base plate carries all components, including the gravity switch. Rubber feet are used on table sets and metal distance pieces for wall sets. These feet are easily interchanged. The base can be used interchangeably with the housing of both the wall and table sets, a feature which is important for operating organizations, inasmuch as it facilitates stocking and maintenance. For the manufacturing organization, the use of the same base with wired components offers considerable flexibility in scheduling production and in manufacturing. The same base units are run through the assembling chain whether intended for table or wall sets, the housing and feet being attached at the final stage of assembly. Fig. 11 illustrates an assembled base plate, also the rubber feet and distance pieces.

The five-piece microtelephone (No. 2284) of the former type of set has been supplied with the moulded sets, but is being replaced by the three-piece microtelephone (No. 2290) shown in Fig. 12. In the latter, the receiver and transmitter cases are moulded integrally with the handle; the moulded cap and mouthpiece are screwed into place and suitably positioned. A capsule type receiver and transmitter are used. Although the non-capsule type of receiver has required little if any attention in service, it is a fact that the capsule type receiver shown in Fig. 13, offers some advantages. In the capsule receiver the diaphragm is not clamped between the body of the receiver case and the earpiece; therefore, the receiver is free from the influence of shrinkage or expansion of these parts. Moreover, danger of rattling due to possible untighten-

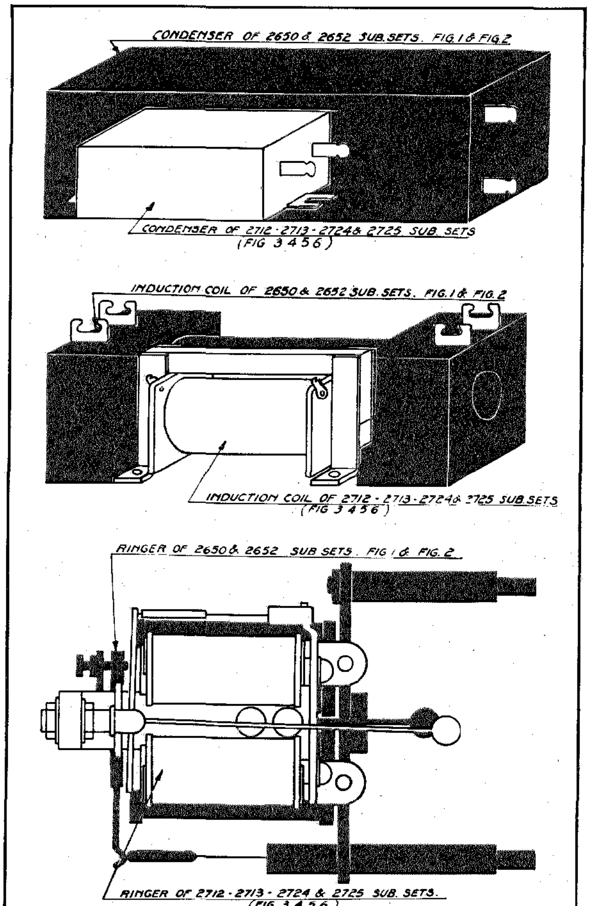


Figure 7—Relative Sizes of Components of Nos. 2652 and 2712 Sets.

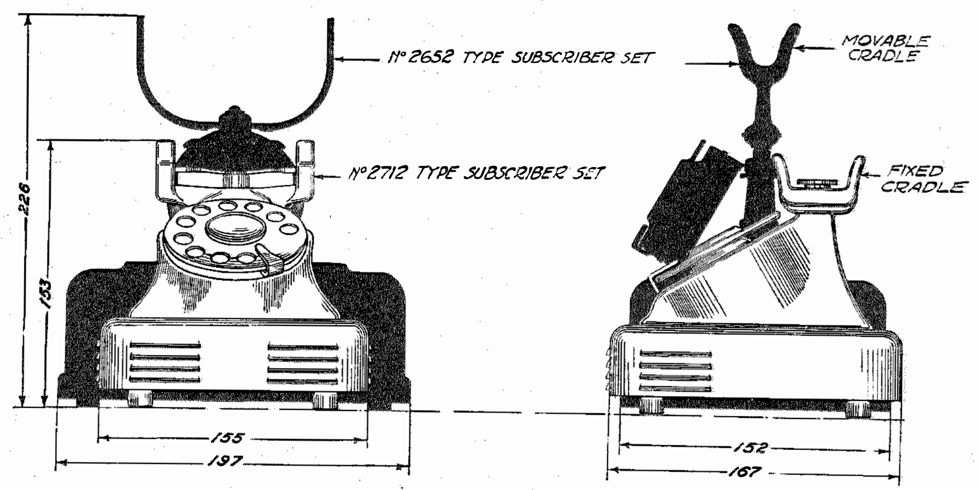


Figure 8—Relative Sizes of Nos. 2652 and 2712 Subscriber Sets.

ing of the earpiece by the subscriber is eliminated. Greater facility of replacement in case of breakdown of winding or other disturbances is also achieved.

With the introduction of the moulded set, the new transmitter capsule (No. 2038) illustrated in Fig. 13, was produced, with an efficiency some 5.5 decibles higher than that of the earlier No. 2030 capsule used in the five-piece No. 2284 type microtelephone. The subscriber set circuit was modified in order to prevent increased side tone becoming objectionable on short lines.

The circuit adopted is of the anti-side tone type with a three-winding induction coil (Fig. 14-C). As a matter of comparison, Fig. 14-B illustrates the booster circuit of the Figs. 3 and 4 type sets: Fig. 14-A, the circuit of the Figs. 1 and 2 type sets.

A filter to prevent radio interference between the subscriber set and the radio receiving set is available. It is connected in the circuit as indicated in Fig. 14-D, and is easily mounted in sets of the type of Figs. 3 and 4, as well as of Figs. 5 and 6.

When subscriber sets are required for use on two-party lines, it is necessary to remove the ground connection of the ringer during dialing to prevent improper operation of the stepping relay. This is accomplished with the addition of a break contact to the gravity switch (Fig. 14-E).

Tests by the C.C.I. Laboratories in Paris, showed that the Reference Equivalents of the

Figure 9—Table Set Built for His Holiness, The Pope

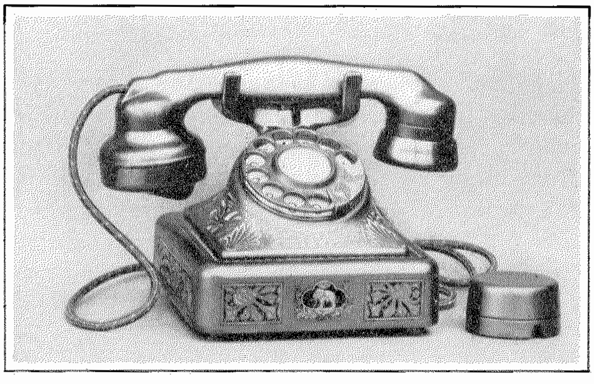


Figure 10—Table Set Built for His Majesty, The King of Siam.

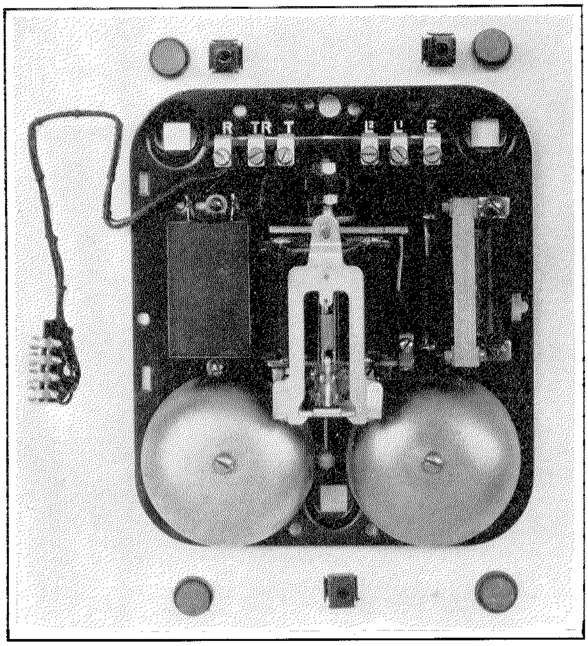


Figure 11—Base Plate for Nos. 2724 and 2725 Sets Assembled; Rubber Feet and Distance Pieces are shown Separately.

No. 2724 moulded type set, illustrated in Fig. 5, but fitted with a five-piece microtelephone with non-capsule type receiver, were as follows:

Transmitting	4.2 db.
Receiving	2.3 db.
Overall	6.5 db.

The sets in these tests were connected to the Standard Test Circuit (SETAC) with a 300 ohm local line.

The above-described sets are of the "straight line" type, by which is meant the normal subscriber set for a subscriber having no facilities other than straight exchange connections.

Sets for Special Requirements

The Bell Telephone Manufacturing Company recently has undertaken the manufacture of coloured sets of the moulded type, of different shades, such as grey, red, green, cream, white, as well as imitation wood. They are supplied with a dial having a chrome-plated finger-plate. These sets are pleasing in appearance and are intended for use in private houses, hospitals, etc.

To satisfy other demands, a complete line of different types are produced. These can be classified as:

(1) Magneto sets of meta for table, and wooden sets for wall use (Figs. 15 and 16).
(2) Main sets for use on exchange lines in association with auxiliary sets (Fig. 17) arranged for magneto calling between main and auxiliary sets.
(3) Series sets (Fig. 17) permitting the connection of a number of sets in series on the same line. Means for local calling between these sets is provided.
(4) Special service table sets (Fig. 18) for use on two exchange or P.B.X. lines:
   (a) The double line set is connected to two city lines with means for calling either of the two lines whilst holding the calling line.
   (b) The call-back set is connected to a city line and to a P.B.X. line. The city line can be held if desired when calling on the P.B.X. line.
(5) Call-back sets for use with P.B.X., equipped with call-back feature. Set has a push button for calling another party whilst holding the first line.
(6) Ten line interconnecting sets using components of the Nos. 2724 and 2725 sets (Figs. 5 and 6). Capacity ten lines with five simultaneous connections. These sets are also furnished in coloured bakelite. Auxiliary one line sets are also provided for use with these sets (Fig. 19).

The sets above referred to can also be furnished with features making them specially adapted for use in tropical climates where protection against moisture and also against attacks from insects is necessary.

Rationalization of Production

Die cast and moulded types of sets are particularly adapted to modern rationalization of production. The introduction of new materials has provided means for simplifying designs and has shortened the manufacturing processes involved in the production of individual piece parts. At the same time, it has proved possible to meet all reasonable demands for delivery. To keep investment down, however, stocks of piece parts must be restricted; hence they must be produced by the machine departments at short notice, notwithstanding the fact that, under present conditions, they must be ordered in smaller quantities and consequently on more "repeat" orders, with the disadvantage of machine resetting. Stocking of the most important parts, such as die cast or bakelite bodies, is practically discontinued; and implies the necessity of producing the parts at least at the same rate as that of the assembling of the complete sets. This coordination is especially important in connection with the production of moulded parts, such as set bodies and microtelephone parts.

Efforts to save time extend to the methods of assembly in order that the total period required to complete the apparatus may tend to approximate as closely as possible the sum of the periods required to execute the single operations, thus reducing lost time to the minimum.

Since partial assemblies are no longer carried in stock, machine operations required on them, such as riveting and reaming, as well as drilling and spinning in certain cases, are performed at the proper stage in the Assembly Department. Progressive assembly methods are applied, based on careful analyses of the time required for performing the various operations when adequate means are available to the operator in the form of well adapted tools and assembly fixtures, as well as piece parts readily accessible and so located that unnecessary movements are eliminated.

The organization of the Assembly Department may be easily understood by reference to the schematic of Fig. 20. It will be noted that the parallel assembling benches all face the piece part stores at the right end of the department. These stores feed, at the rate determined by the time studies, the piece parts required by the different assembling groups. These groups function as follows:

(a) Cut, form, and finish the cord ends.
(b) Assemble the transmitter capsule.
(c) Assemble the receiver capsule and microtelephone.
(d) Assemble the dial.
(e) Assemble the induction coil.
(f) Assemble the ringer.
(g) Assemble the gravity switch unit.
(h) Assemble the terminal strips.
(i) Form the cable form.

Items from groups (a), (b), and (c) reach, by band conveyor, group (j) which finally assembles the microtelephone. Those from groups (f), (h),

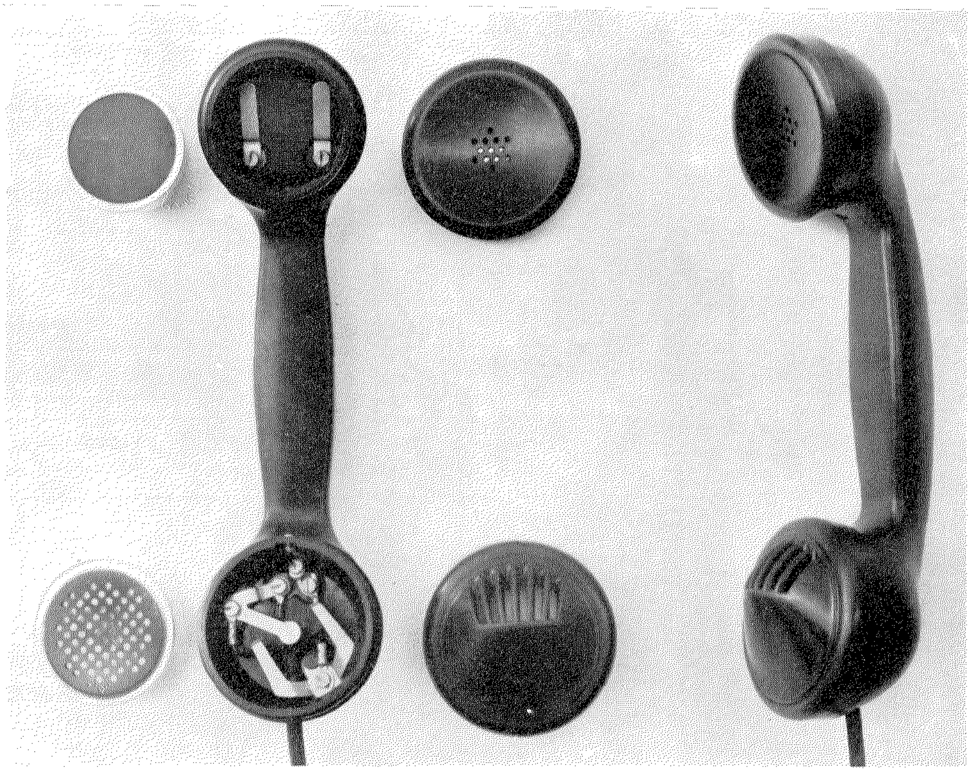


Figure 12—(Right) No. 2290 Microtelephone. Figure 13—(Left) No. 2290 Microtelephone with Components.

(g), and (i) converge at group (k) which mounts the inside components and solders the wiring.

In the case of the latest design of moulded set, the assembled bases are carried over the running belt to group (l), where the dial, microtelephone, and set body are mounted on the base. The complete set moves on the main belt to group (m) which takes care of the adjustment of gravity switch and dial contacts; then to (n) for mechanical and electrical inspection, and to (p) for a transmission test in the standard testing booth. The final stage is the packing before conveying to the Shipping Department.

In groups assembling the components, each part is inspected and tested before it is passed to the next group in the chain.

Condenser manufacture is special in nature and does not form a part of the subscriber set assembly section. For reasons of plant layout, it is located close to departments where impregnation and sealing in enclosed spaces is necessary.

Since the latest designs of subscriber sets are made of bakelite moulding, it will be appreciated that the function of the Moulding Department in their production is of great importance. A future article will describe the application of bakelite moulding in the telephone industry, but a reference to Fig. 21 illustrating the actual layout of this department may be of interest. This figure shows how, by means of belt conveyors, the parts when removed from the mould are carried to the operators along the main belt line and automatically distributed to them for finishing processes, such as removal of the fins, drilling, tapping, polishing, etc. Gangs of operators handle the products of different presses according to the size and number of parts moulded simultaneously. Loading, unloading, and cleaning of the inserts of the moulds are done in front of the presses. Six microtelephone handles are moulded simultaneously in the same mould; similarily, six set cradles, and fifteen pressels. The moulds are constructed to take the brass inserts for attaching the base to the set bodies, wire connections in the handle of the microtelephone, the metal plunger in the switch

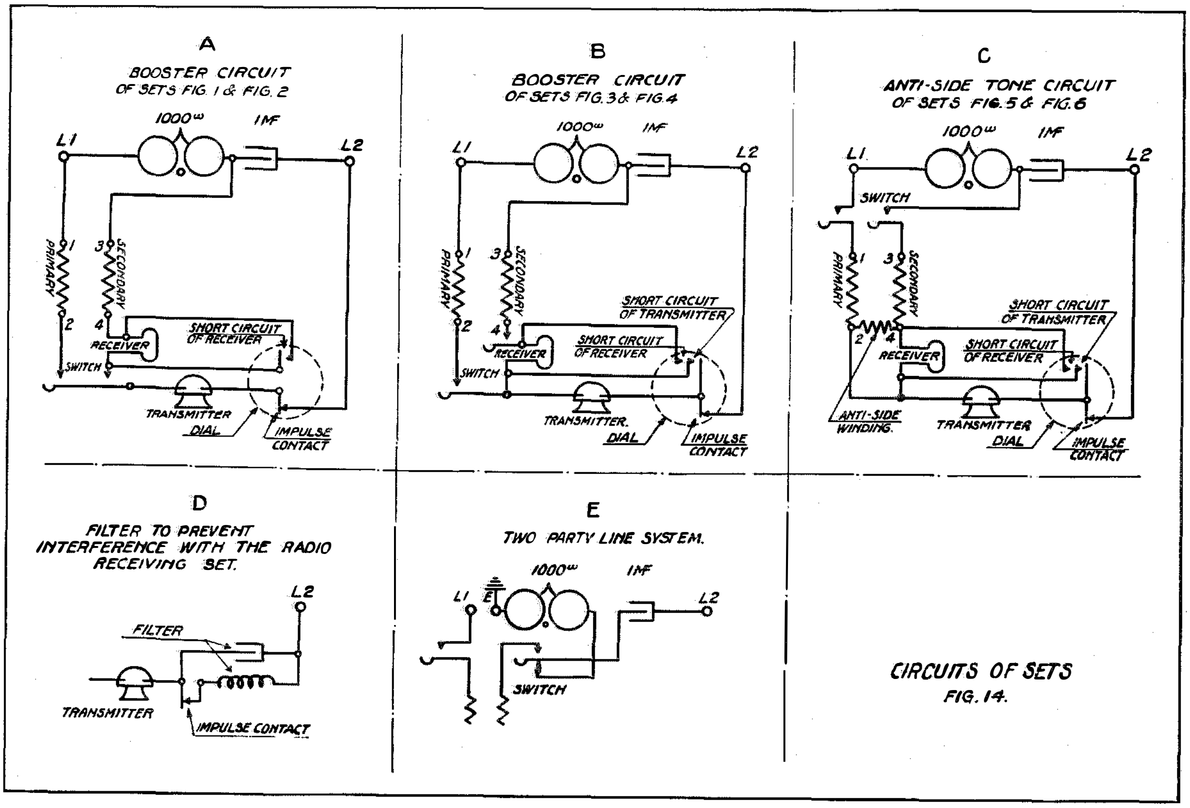


Figure 14—Circuits of Sets.

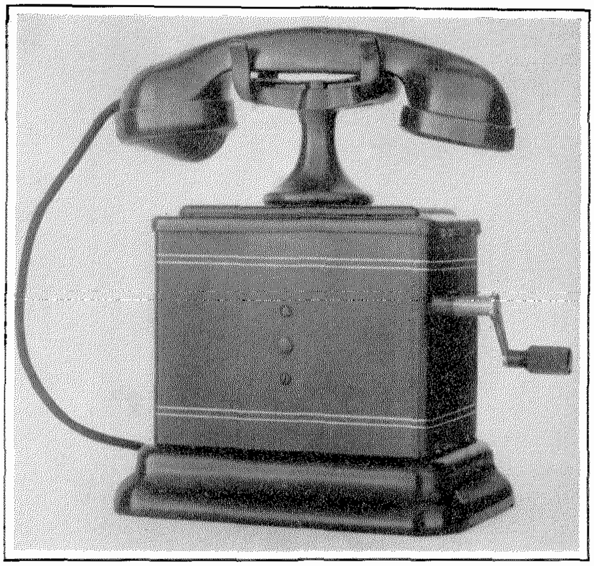


Figure 15—Table Magneto Set.

pressel, etc. The moulding cycle takes an average of 6 to 13 minutes, depending on the cross section of the parts. The average time for a set of moulded bakelite parts to be moulded, undergo additional machine operations, and be ready for use in assembling the apparatus is approximately 20 minutes. Metal parts, on the other hand, necessitate starting from the bar or sheet cutting stage and unavoidably require multiple machining and metal finishing operations; the cycle of operations with metal parts, therefore, must be far from attaining a time limit comparable with that achieved with moulded parts.

The layout of the Subscriber Set Assembly Department is illustrated in Fig. 22. By different symbols the kind of machines inserted in the chain is indicated. Fig. 23 shows a view of the actual department. As at present constituted, the department has a capacity of about two thousand sets a week, but it is sufficiently flexible to handle smaller quantities economically.

Inspection and Testing

To guarantee quality, it is essential that the product be inspected and tested 100% for all of its features.

A method of making inspection tests on each transmitter capsule by means of several teams would be impractical for economic reasons, whilst voice inspection carried out by a single team might show substantial departures from the average efficiency of the transmitter capsule. For this reason a transmitter testing machine has been designed in order to provide means for quick and reliable testing of volume, quality resistance, and packing resistance of the capsule.

Transmission efficiencies and resistances observed under definite conditions serve as an indication of the transmission characteristics and may be read off directly from two meters calibrated, respectively, in decibels and in ohms. The machine is calibrated to give readings representative of the transmitter average efficiency, comparable to the results that might be expected from a large number of voice tests carried out according to standard methods by different testing teams.

The machine (Fig. 24) is composed of a vacuum tube band frequency oscillator which generates a current continually varying in frequency over

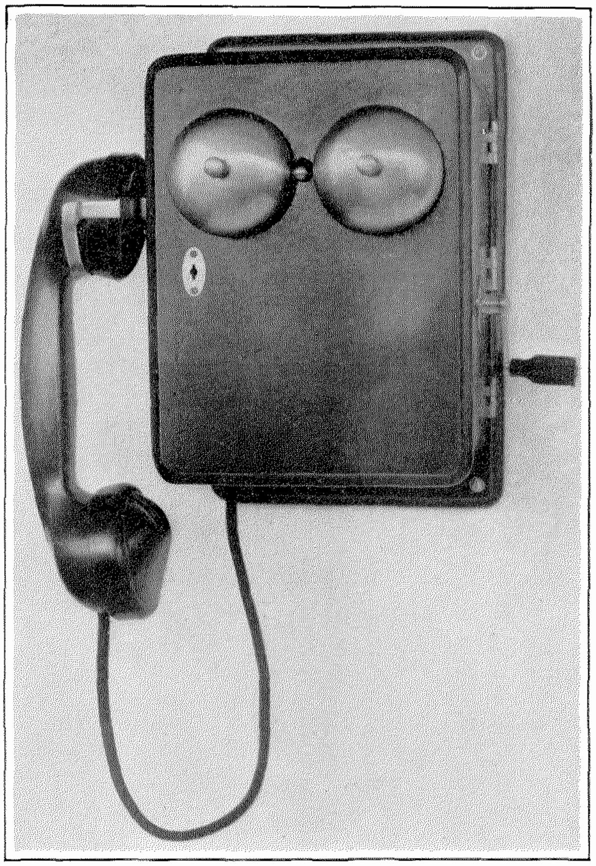


Figure 16—Magneto Wooden Wall Set.

a range of 600 to 1,600 p:s by means of a motor driven variable inductance. A fixed inductance, which can be connected in parallel with the inductance by means of a key, provides another variable frequency band of 1,300 to 1,600 p:s for quality testing.

A special checking circuit consisting of an attenuation network, calibrated positively and negatively in decibels from an arbitrarily placed zero, a one-stage amplifier, a rectifier, and an output meter calibrated to correspond with the

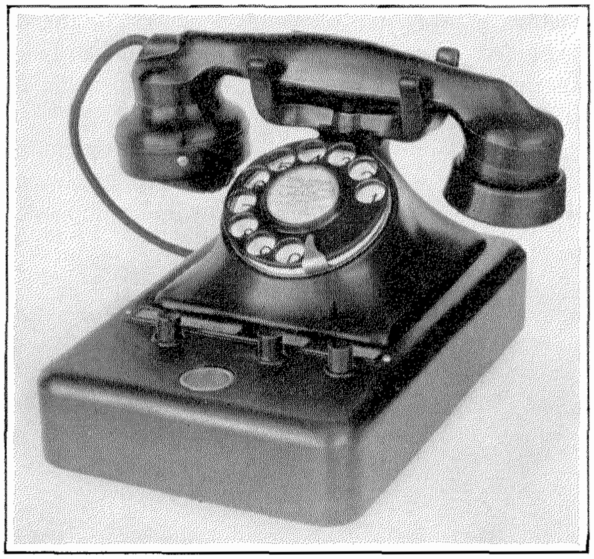


Figure 17—Main Table Subscriber Set—Series Type Set.

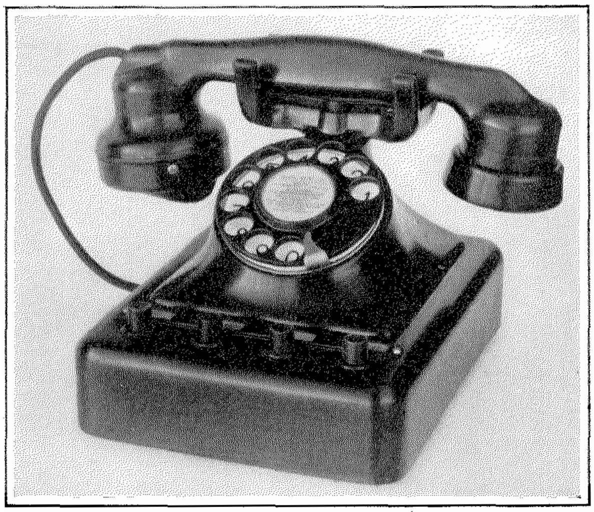


Figure 18—Double Line Set—Call-Back Set.

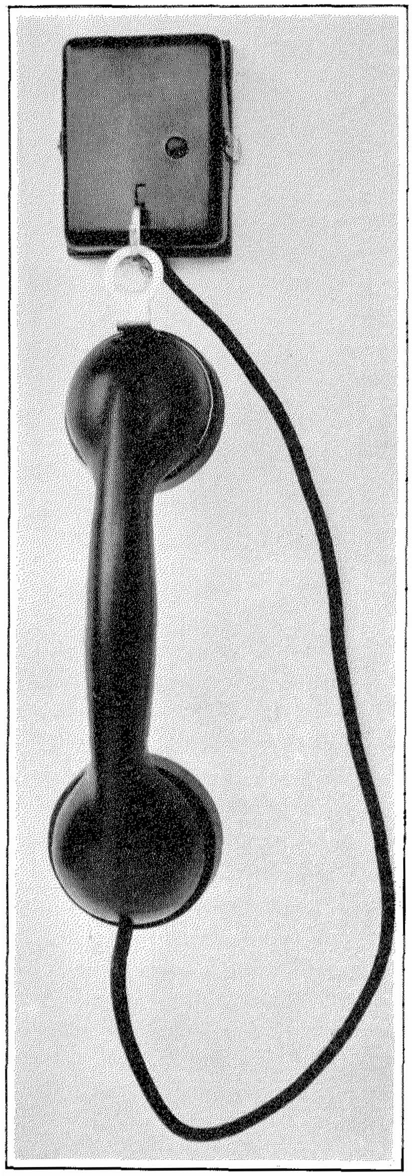


Figure 19—Auxiliary One-Line Set.

network, gives a direct reading of the output of the transmitter capsule under test.

The machine is provided with a special checking circuit for indicating fluctuations in the oscillator or measuring circuit after calibration.

The transmitter capsule under test is acoustically coupled with a calibrated receiver in a soundproof chamber, and is connected to the measuring circuit. D-c. is applied to the transmitter under test and is adjustable to the required value.

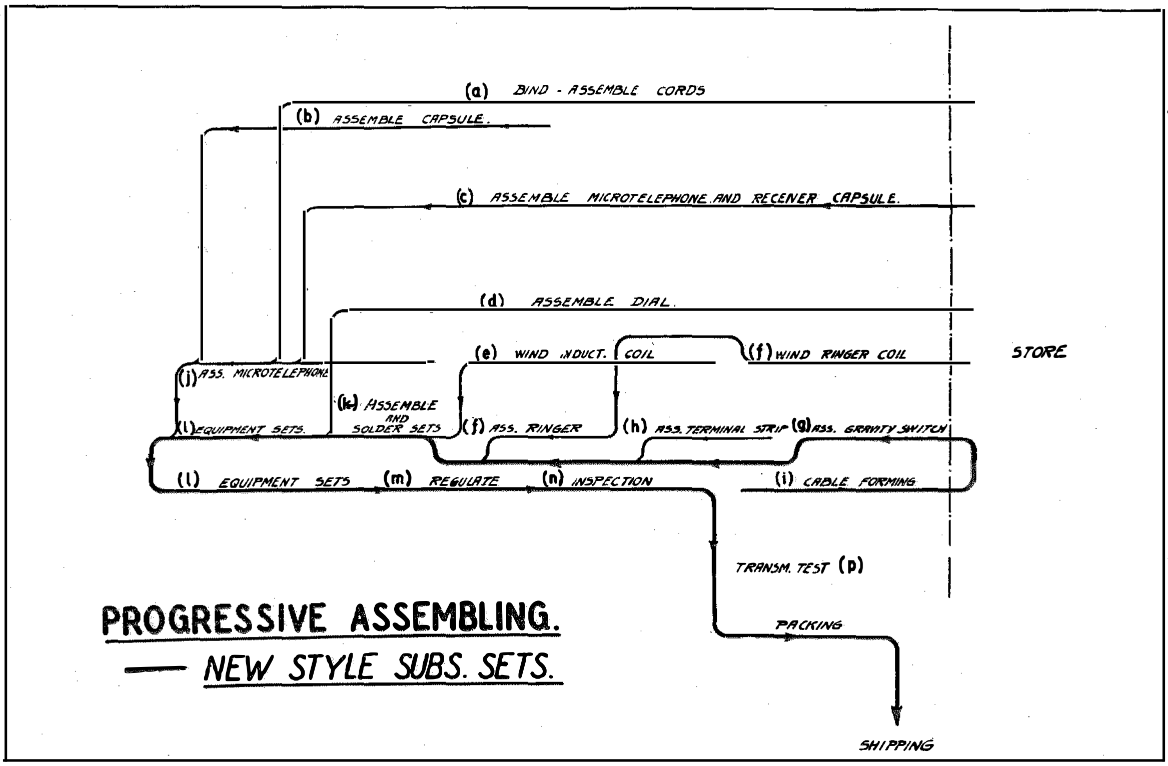


Figure 20—Schematic Layout of Assembly Department.

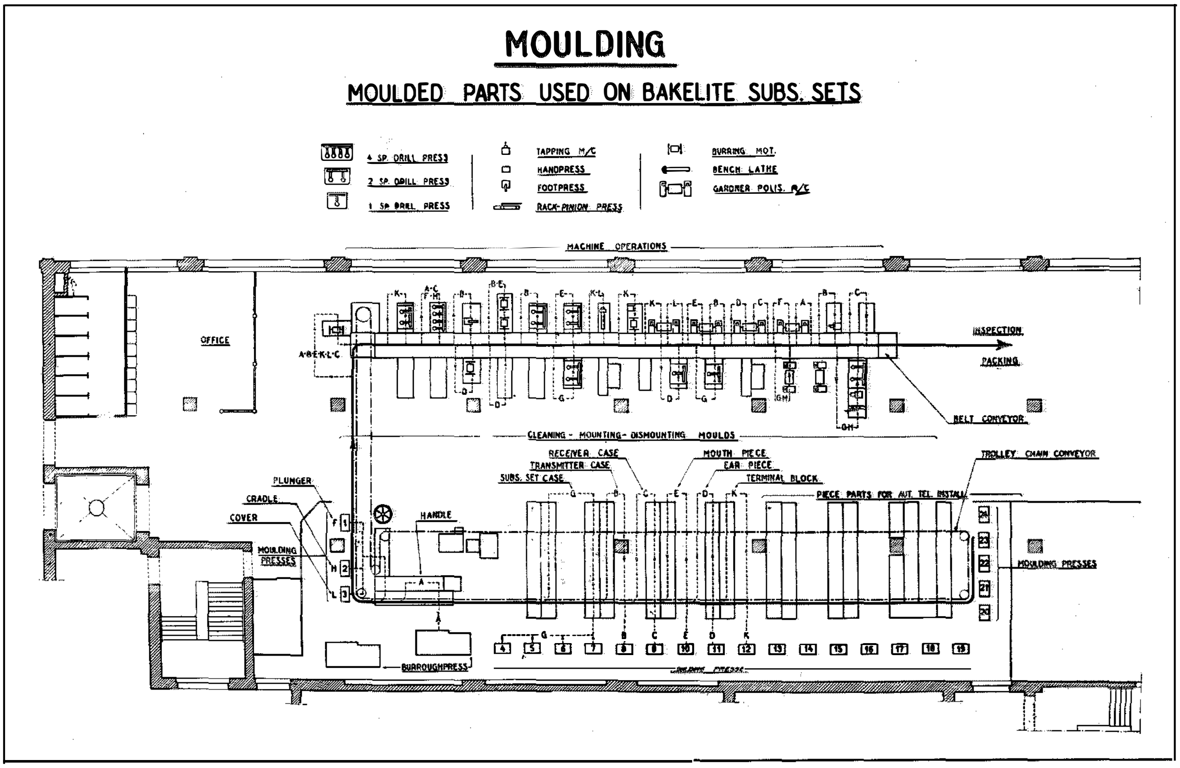


Figure 21—Layout of the Moulding Department.

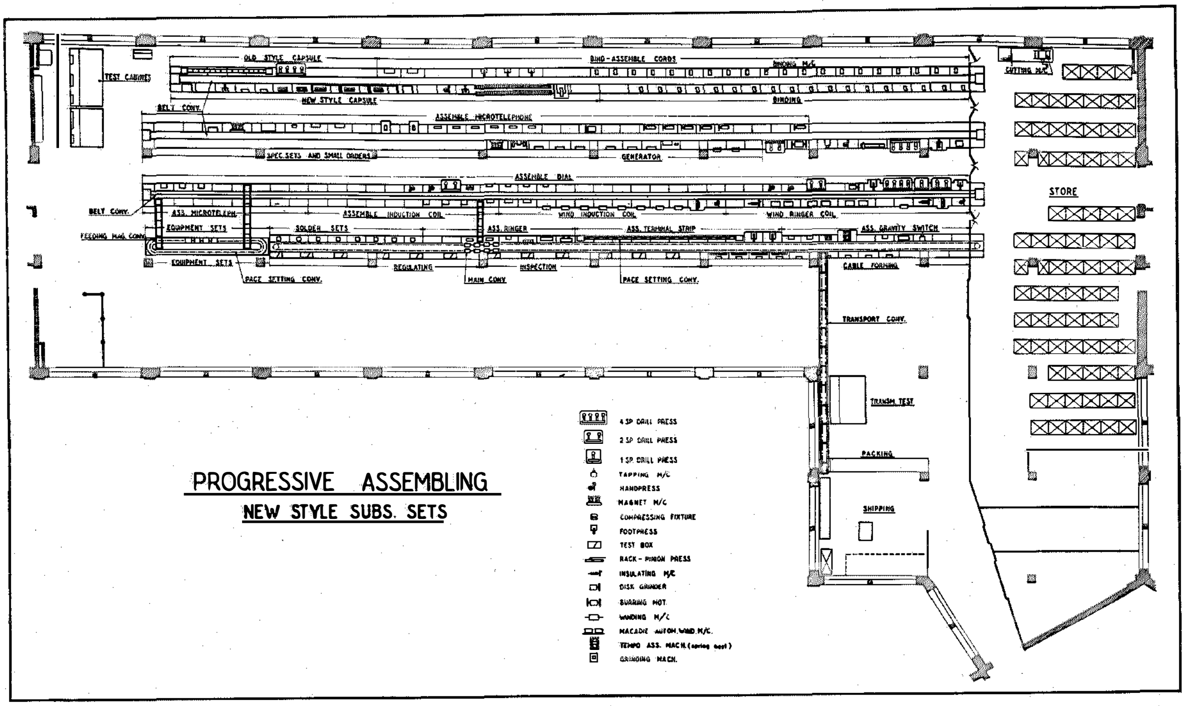


Figure 22—Layout of the Subscriber Set Assembly Department.

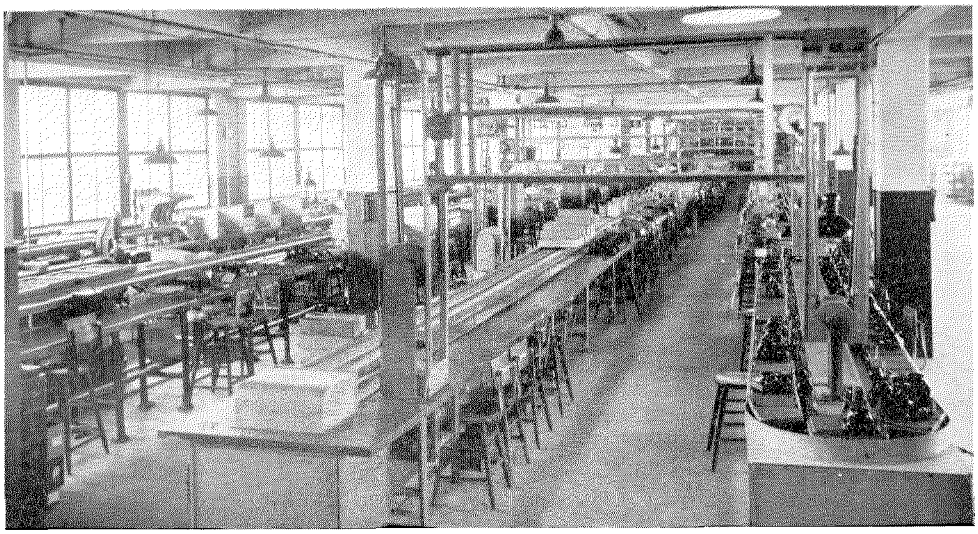


Figure 23—View of the Subscriber Set Assembly Department.

Quality tests are based on the location of frequency peaks of the capsule.

Packing tests are made by increasing the current through the transmitter and short-circuiting the receiver in the soundproof chamber. After a few moments normal conditions of test are restored, but with reduced sound level. Efficiency readings then give required indications on packing conditions.

For testing the efficiency of the receiver, a special test machine consisting of a neon tube oscillator applies a defined level to the receiver which, during the test, is closely coupled to an electromagnetic microphone. After amplification the resulting e.m.f. is read directly from a meter.

The induction coil of the closed core type, with silicon steel laminations, is tested in a special fixture in which each separate winding is connected to a calibrated a-c. bridge and measured for both effective resistance and effective inductance. In this way the magnetic quality of the iron used for building up the core and the air gap between the L shaped core parts are effectively checked. All winding terminals of the coil to be tested are connected by means of quick acting connecting clips; and, by means of switching keys, either the primary or the secondary winding is brought in the X arm of the measuring bridge. Windings of coils having a third winding, the so-called anti-side winding, are measured in the same way, but are submitted to a supplementary effective inductance test in series with the secondary winding for polarity control. The bridge is operated at a constant frequency of 900 p:s.

Finished dials are checked for impulse ratio and speed immediately before mounting them in the subscriber sets to avoid disturbance of adjustment by handling or transport.

The fully equipped, mechanically adjusted sets are passed to the inspection position installed in the assembling chain and are connected to the testing fixture (Fig. 25) which offers facilities for a rapid overall check of the operating features of the sets. Thus the operator is enabled to detect faults without dismounting or disconnecting any of the component apparatus.

By means of this testing fixture, the sets are consecutively tested for the following features in a well determined sequence:

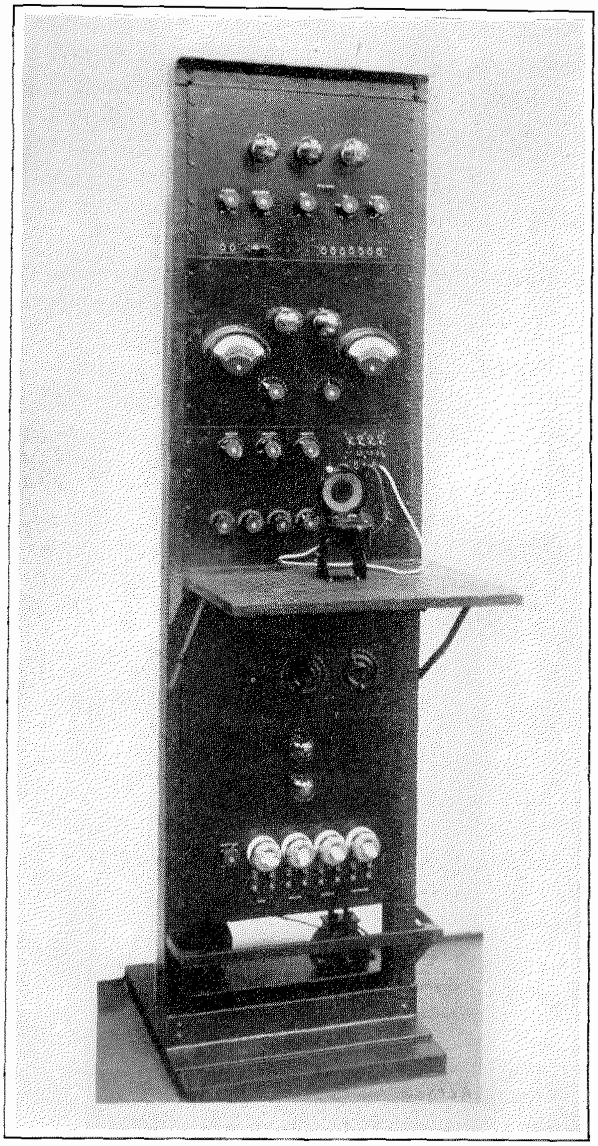


Figure 24—Transmitter Testing Machine.

1. Gravity switch: Check for sufficient operating margins; the contacts for the transmitter should close before those of the receiver to reduce the "click" in the receiver.
2. Dial impulse control: Check for proper short-circuiting of the receiver and transmitter during dialing and for proper operation of impulse springs.

3. Dial "overstep": When "O" is dialed, check to ensure that "kicker" by the reverse movement does not cause an extra impulse.
4. Condenser: Charge and discharge the condenser to check for capacity and possible short-circuit in the condenser.
5. Ringer adjustment: Check for sensitivity of the ringer with a variable resistance in the line.
6. Howling Test: Required for some types of subscriber sets of older design and sets of new design not equipped with the anti-side feature.

To perform these different tests, the testing fixture is directly connected on the line terminals of the subscriber set; and, by simply pressing a button, a new test circuit insulated from the others is connected to these lines, so that each operating requirement is checked separately. A pilot lamp in front of each push button indicates the test circuit connected to the set under test.

A breakdown test completes the sequence of tests applied on each set before being passed to the overhead conveyor for delivery to the transmission test booth. Each set, connected in a standard test circuit, is then submitted to a final voice test by skilled operators in an adequately equipped testing booth.

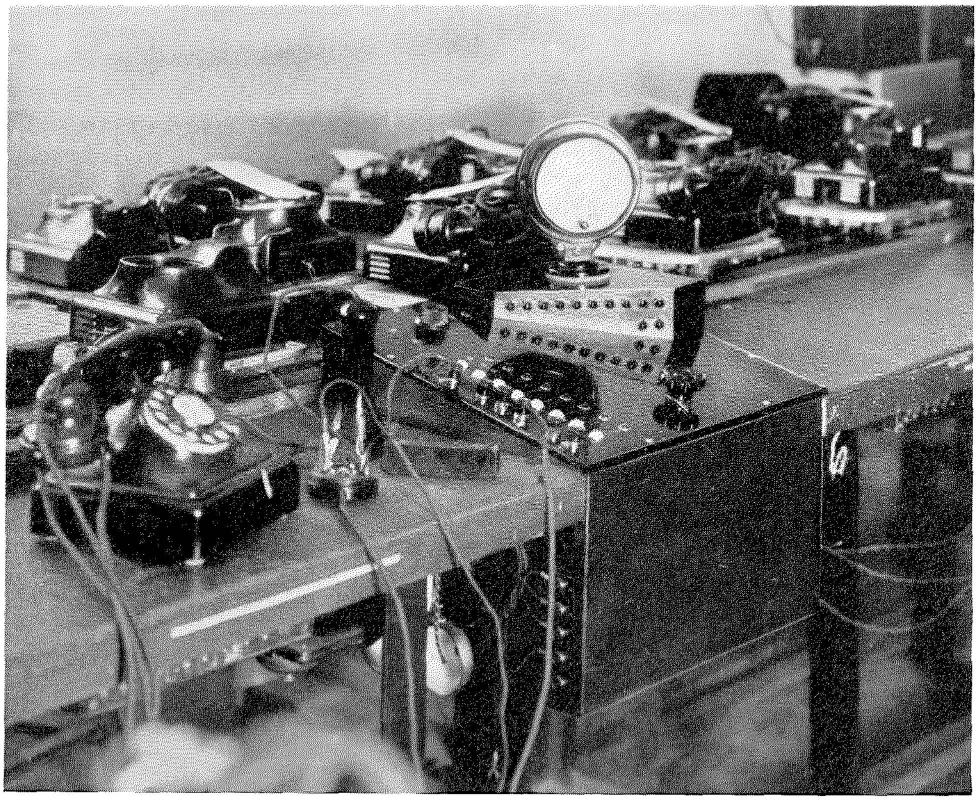


Figure 25—Testing Fixture for Assembled Subscriber Sets.

Inspection of Textiles Used in the Manufacture of Telephone Cords and Cables

By J. VAN LAETHEM and R. VERNIMMEN

TELEPHONE central office wiring, once installed and protected in a suitable way from accidental high voltage, must be in a condition to stand up to all service requirements. This implies the use of wire insulations showing a perfect electrical behaviour under any of the changing conditions of atmospheric temperature and humidity to which they are exposed. It is well known that textile insulating materials, owing to their fibrous nature which permits ready absorption of moisture from the atmosphere, are particularly subject to considerable change in their insulation properties as a result of fluctuations in atmospheric temperature and humidity. The effect of humidity on the resistivity of textiles is governed largely by the structure of the fibres. Another well known factor, which to a great extent determines the relative excellence of the insulation, is the electrolytic salt content of the textile. Fluctuations in the electrical behaviour of the insulation, resulting from changes in the relative humidity of the atmosphere, may be particularly large and sudden with unimpregnated wire.

The requirements generally imposed for textiles used in the manufacture of telephone cords and cables may be divided into three categories, viz., mechanical, chemical, and electrical. Tensile strength, elongation, yardage, absence of acidity to avoid corrosion of the insulated conductor, moisture content, and electrical resistance are the outstanding features as regards the quality of the material, and are generally covered in raw material specifications. It is not the purpose of this article to give a complete analysis of all comparative tests to be carried out in order to examine whether the materials supplied are in accordance with the specified requirements, but merely to describe briefly a test procedure particularly tending to the simplification of the electrical testing of raw material.

Reasons Which Led to the Study of the Test Procedure

The fact that the resistance values obtained with textile materials are largely affected by the relative humidity of the atmosphere, makes it necessary to condition the samples carefully prior to the test by exposing them for several hours in a humidity cabinet to a temperature and a relative humidity kept within narrow limits until complete equilibrium has been obtained. Care should be taken not to handle the thread itself during its winding on the electrodes in order to avoid contamination by perspiration of the hands and the introduction of a possible source of appreciable error in the readings obtained. If the handling and conditioning of the samples be carried out with the necessary precautions, the resistance measurements on the thread will provide consistent results. However, the procedure is long and not very practical when considering the question from the point of view of raw material testing in the factory, since the length of time involved by well controlled preparatory conditioning makes raw material testing, which has to be carried out frequently on all textile lots supplied, very troublesome. With the intention of making the inspection of the insulation properties of textiles more practical, a testing method, which avoids the necessity of conditioning the material before testing and which gives significant indications as to the insulation characteristics of the submitted samples, has been developed and adopted by the Bell Telephone Manufacturing Company, Antwerp.

Fundamental Relation Between Chemical Composition and Insulation Characteristics of Textiles

Experiments have shown that amongst the different factors determining the insulation properties of textiles, the amount and kind of water soluble electrolytic impurities which are present in the material, either naturally or as contaminants, are of cardinal importance. Confirmation thereof is obtained by the great increase in insulation resistance obtained with textiles thoroughly washed with water. In consequence of this fact, it will be obvious that the insulation resistance of a textile material will be in close relation with the electrical resistance of an aqueous extract of the electrolytic matter contained in the material. It is common knowledge that the presence of a too high electrolyte content is to a great extent the cause of low insulation resistance of the fibres. Conversely, a low percentage of conducting saline constituents exerts a favourable influence on the final insulating properties of the material. The simplified electrical test procedure developed by the Bell Telephone Manufacturing Company is based on this relationship.

Experiments were carried out on cotton and silk of different sizes and colours to determine the extent of the relationship for each of the materials examined. For this purpose, several samples of each textile were submitted to two comparative tests, the first consisting in measuring the resistance of an aqueous extract of the material, and the second in determining the insulation resistance of the fibres after carefully conditioning the sample. Quite a fair resemblance, allowing for reasonable experimental errors, was noticed between the quantitative relations found on different samples of the same material. The investigation permitted the adoption, for each kind of textile used, of the minimum resistance required on a given aqueous extract of the material that could be considered as giving a definite guarantee as to the minimum specified insulation resistance of the thread. The electrical test on an aqueous extract was added to the raw material specification, together with minimum resistance requirements. The following is a brief description of the method of testing adopted:

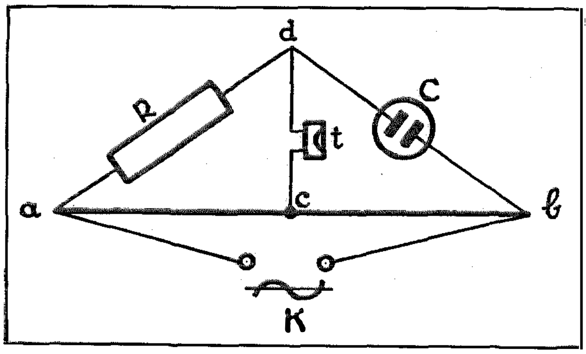


Figure 1—Kohlrausch Bridge Method of Determining the Conductivity of Extract
R = Resistance Box
C = Cell
ab = Platinum Wire of Uniform Thickness Stretched Along a Graduated Board
c = Sliding Contact
K = Rhumkorff Coil
t = Telephone.

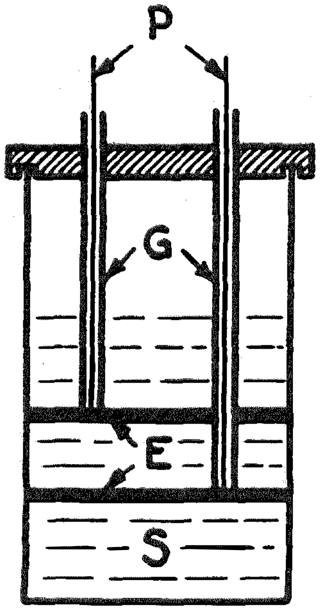


Figure 2—Arrhenius Type Cell
P = Platinum Wires
G = Glass Tubes
E = Electrodes
S = Extract.

Method of Testing

The experimental determination of the conductivity of the extract is done by the Kohlrausch bridge method (Fig. 1). The arrangement which in principle amounts to the measurement of resistance by the Wheatstone bridge method, is too well known to need further explanation.

The cell containing the solution, the resistance of which is to be measured, is of the Arrhenius type (Fig. 2). The electrodes are silver or platinum discs covered with platinum black, approximately 4 cm. in diameter and fixed by welding to platinum wires sealed in glass tubes. These tubes are inserted into the ebonite cover of the cell to keep a constant distance between the electrodes. The distance between the electrodes was determined by experiments carried out on the most frequently used textiles, in order to avoid as much as possible making readings at the ends of the logarithmically graduated scale (ab). The distance of 10.5 mm. was found to be the most convenient for the regular measurements. From the observed electrolyte conductivity, which evidently depends upon the capacity of the cell and thus on the cross section of the electrodes and the distance between them, the specific resistance of the electrolyte specified in raw material specifications must be deduced. First, however, the constant of the cell must be determined. For this purpose a comparison with electrolytic solutions of known conductivity was made and the results shown below were obtained with a cell of 40.5 mm. diameter and a distance of 10.5 mm. between the electrodes, that is, with a capacity of 13.52 cc. The standard solutions used were potassium chloride and potassium nitrate in the following concentration:

N/50 KCl (1.49 gr. KCl dissolved in 1,000 cc. distilled water) having a specific conductivity of 0.00267 mhos. at a temperature of 25° C.

N/50 KNO_3 (2 gr. KNO_3 dissolved in 1,000 cc. distilled water) having a specific conductivity of 0.00248 mhos. at a temperature of 23° C.

Average readings obtained	Temperature	Resistance	Conductivity mhos.
(*a*) With the KCl solution.	25°C	28ω	0.0357
(*b*) With the KNO_3 solution	23°C	30ω	0.0333

Constant of the cell to be used for determination of the specific conductivity:

(*a*) Deduced from readings obtained on KCl solution

$$\frac{0.00267}{0.0357} = 0.0748$$

(*b*) Deduced from readings obtained on KNO_3 solution

$$\frac{0.00248}{0.0333} = 0.0744$$

A mean resistance of 30,000 ohms has been observed for the distilled water used. This has been neglected in the determination of the conductivity of the solutions as it does not affect the value of the cell constant to the four decimal points shown above.

It will be noted that the constants obtained with the two electrolytes were practically the same. The constant of the cell adopted for the determination of the specific resistance of any electrolytic solution and deduced from the specific conductivity of the KCl solution was

$$\frac{1}{0.0748} = 13.36.$$

All resistance measured on aqueous extracts of textiles, with the cell capacity as adopted, are multiplied by this constant to determine the specific resistance of the solution.

The aqueous solution of the water soluble material content of the textile to be inspected is obtained by the extraction of exactly 2 grams of the textile in boiling water. A solution of 80 cc. corresponding to the total capacity of the cell, is used. The external windings of the spool may not be used for the extraction, since the almost certain contamination of the windings, due to handling, is likely to be a source of incorrect readings. The extraction is performed in two stages. In the first extraction, approximately 45 cc. of distilled water, together with the sample, is placed in a 150 cc. Pyrex beaker and heated to the boiling point. Care is taken during heating to have the textile carefully pressed by means of a small glass rod in order to facilitate the extraction of the conductive salts. The solution obtained is poured into a graduated cylinder. Before starting the second extraction, the textile is pressed with the glass rod to eliminate the solution absorbed by it; this eliminated quantity of solution is added to that in the graduated cylinder. A second extraction, similar to the first, is then performed on the same sample by adding to the Pyrex beaker a quantity of distilled water equal to the difference in volume between 80 cc. and the volume already contained in the graduated vessel. Care should be taken to bring the extracted solution up to the mark with cold distilled water in order to obtain a final volume of exactly 80 cc. The resistance of the solution is measured at a temperature of 25° C.

A large number of comparative tests carried out on the different kinds and sizes of textiles used by the Company, made it possible to prescribe the following values of minimum resistance for the aqueous extract, obtained as described above from each of the materials considered. These values were fixed so as to give complete assurance regarding the insulating properties required from the material.

Textile	Min. resistance allowable on aqueous extract (to be obtained with the Arrhenius cell as described)	Corresponding specific resistance of the extract (constant of the cell 13.36)
Soft, glazed, and mercerized cotton, white or coloured........	1,375 ohms.	Appr. 18.400Ω cm/cm²
Natural silk, white	2,000 ohms.	Appr. 26.700Ω cm/cm²
Natural silk, coloured...........	1,200 ohms.	Appr. 16.000Ω cm/cm²
Cellulose acetate silk............	3,000 ohms.	Appr. 40.000Ω cm/cm²

Experiments have shown that textiles meeting the above requirements give at least the following insulation resistances measured on the fibres after conditioning of the samples.

Size and kind of textile	Min. insulation resistance allowable after careful conditioning of the material at a relative humidity of 85% prior to testing
20/1 cotton (woundin multiple ends)..	8,000 megohms per end
36/1 cotton (woundin multiple ends)..	14,400 megohms per end
20/2 cotton.........	4,000 megohmspertwistedthread
30/2 cotton.........	6,000 megohmspertwistedthread
40/2 cotton.........	8,000 megohmspertwistedthread
60/2 cotton.........	12,000 megohmspertwistedthread
200/2 natural silk (white)........	950,000 megohmspertwistedthread
Cellulose acetate silk (wound in multiple ends)...............	7,000 mega-megohms per end and per denier

The insulation resistance is determined on a thread closely wound on a width of 50 mm.

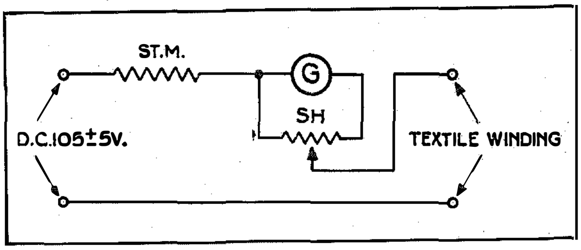


Figure 3—Electrical Circuit Used for the Measurement of Insulation Resistance
ST.M = Standard Megohm
G = Galvanometer
SH = Shunt of Galvanometer.

around two gold plated electrodes distanced so as to obtain threads having a free length of 21 mm. between electrodes. The electrical circuit used is shown in Fig. 3. A direct current tension of 105 V. ± 5 V. is applied. The measuring is done as soon as the galvanometer shows a constant deflection. Care is taken to have the reading noted as quickly as possible (within a time not exceeding one minute). Prior to the test, the samples are carefully conditioned inside a humidity chamber at a relative humidity of 85% and a temperature of 37° C. for a time sufficiently long to obtain complete equilibrium of the material. It may be noted that the testing arrangements adopted with regard to applied voltage, material of electrodes, and measuring time, were taken with a view of reducing to a minimum the effects due to the well known polarization and Evershed phenomena which often lead to anomalous resistance values.

The resistance values specified can only be reached with textiles showing a high degree of purification. Consequently they involve the necessity, on the part of the supplier, for thorough washing of the material. Unwashed textiles often show resistances one-fiftieth of the values indicated in this article.

The East-Jutland Toll Cable

By H. C. PLESSING, B.Sc.

Chief Engineer, Jydsk Telefon-Aktieselskab, Aarhus

Introduction

THE East-Jutland toll cable of the Jutland Telephone Company Ltd., extending from Aalborg over Hobro, Randers, Aarhus, Skanderborg, Horsens, and Vejle to Kolding, was opened for traffic in the latter part of 1933. It is the first long distance cable in Jutland and constitutes the main link in a cable scheme, designed in 1929, for the territory served by this Company (Fig. 1).

The toll circuits formerly consisted of open wire lines, with short lengths of cable, partly of the Krarup type, through the towns and villages on the routes.

The Jutland toll line network differs from those of other Danish operating companies in being more widely extended, but containing comparatively more open wire and less cable. On the islands of Seeland and Funen there are two principal traffic centres, viz., Copenhagen and Odense, whence the toll lines radiate. The network in Jutland consists of a number of towns and villages, the larger towns being situated on a line along the east coast, chiefly at the bottom of the fjords. Table 1 gives the numbers of inhabitants and subscribers in the towns along the cable route and the annual number of conversations between these towns.

The statistics for 1933, issued by the Governmental Supervising Commission for the Concessionaire Telephone Companies in Denmark, show (Fig. 2) that there are 303,332 subscribers and 1,811 exchanges in Denmark. The Jutland Telephone Company's share in these figures is 82,313 and 1,143 respectively (or 27% and 63%).

The curves in Fig. 2 show how the subscribers are distributed on different sizes of exchanges. It will be seen that 80% of the exchanges of the Jutland Telephone Company have less than 50 subscribers, and that 30% of its subscribers are connected to these small exchanges. Of the exchanges of the other companies 30% have less than 50 subscribers, and to these exchanges only 4% of the subscribers are connected.

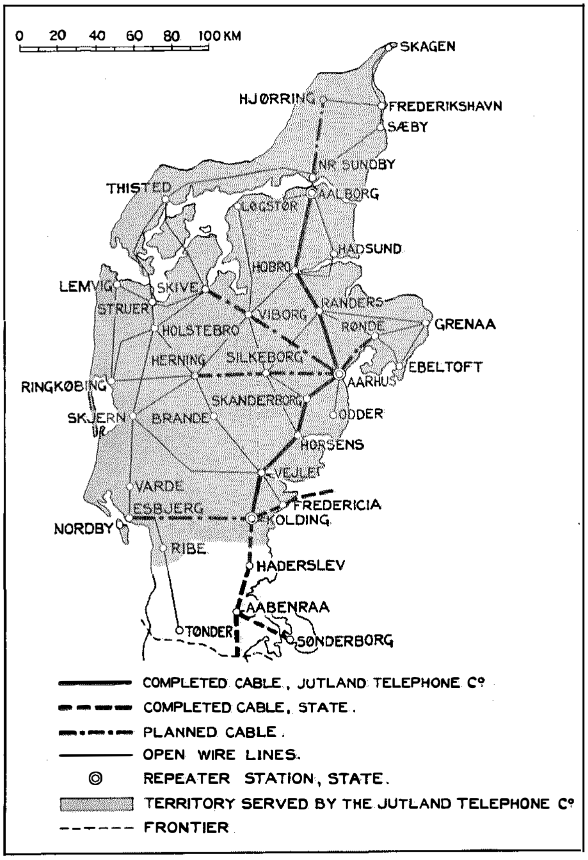


Figure 1—Long Distance Telephone Cables in Jutland.

The foregoing statistics show that the Jutland Company's share in the total length of toll lines is 159,461 km. wire against 198,207 km. wire for the other companies (44.6% and 55.4%, respectively). The statistics also show that the toll line mileage of the Jutland Company is about equally divided between cables and open wire, whereas the other companies, as a whole, have about 78% of their toll plant in underground cables.

The need for cables on the Jutland Telephone Company's routes is illustrated in Figs. 3 and 4, which show how an occasional heavy sleet storm can play havoc with open wire lines. Fig. 5 shows another, but rather less severe disturbance met with in rural districts.

An agreement was reached with the State Telegraph Authorities prior to the planning of the East-Jutland cable, under which the State would lease a considerable number of circuits. The Broadcasting Council of the State also wished to have circuits available in the cable; consequently, it was planned with due regard to the requirements of these two authorities.

The cable forms an important link in the nation wide toll cable system, as it is connected to the cables recently installed by the State from Kolding through Southern Jutland to the German frontier, and from Kolding to Fredericia and the islands of Funen and Seeland, and to Copenhagen. The two last mentioned cables are intended for traffic to the European toll cable network and to the other parts of Denmark.

Economic Considerations

The first question to be decided was the number of circuits to be provided for the traffic of the Telephone Company to meet present and future requirements.

According to an agreement of 1926 the traffic in Jutland is divided between the Jutland Telephone Company and the State in such a way that calls between exchanges with an air line distance of less than 130 km. shall, with a few exceptions, be carried by the Telephone Company within the borders of the grey tinted area in Fig. 1, and by the State in the district south

1ST JAN. 1934	SUBSCRIBERS		EXCHANGES		LENGTH OF TOLL-LINES					
					TOTAL		OPEN-WIRE LINES		CABLE	
	NUMBER	%	NUMBER	%	KM WIRE	%	KM WIRE	%	KM WIRE	%
JUTLAND TELEPHONE Cº	82,313	27·1	1,143	63·2	159,461	44·6	84,036	23·5	75,425	21·1
OTHER COMPANIES	221,019	72·9	668	36·8	198,207	55·4	43,545	12·2	154,662	43·2
THE WHOLE OF DENMARK	303,332	100·0	1,811	100·0	357,668	100·0	127,581	35·7	230,087	64·3

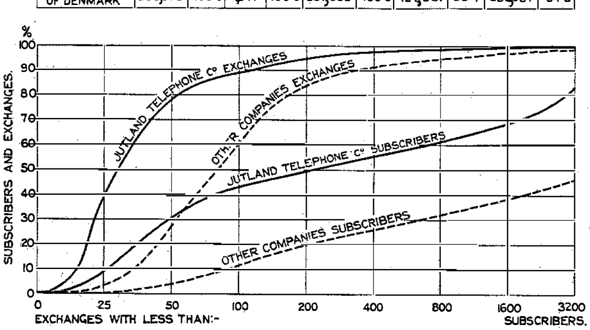
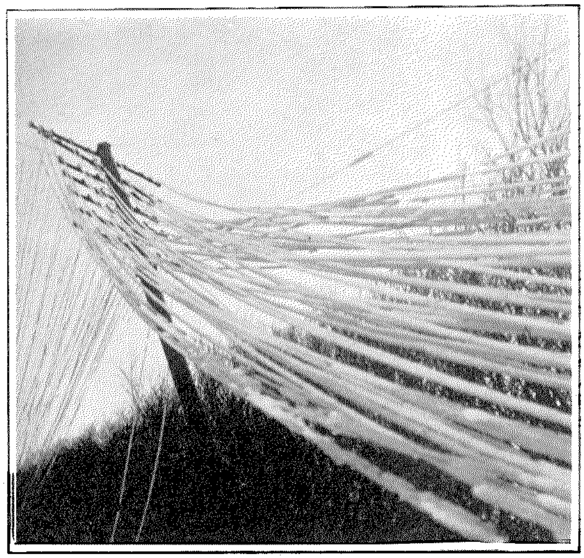


Figure 2—Distribution of Subscribers and Exchanges.



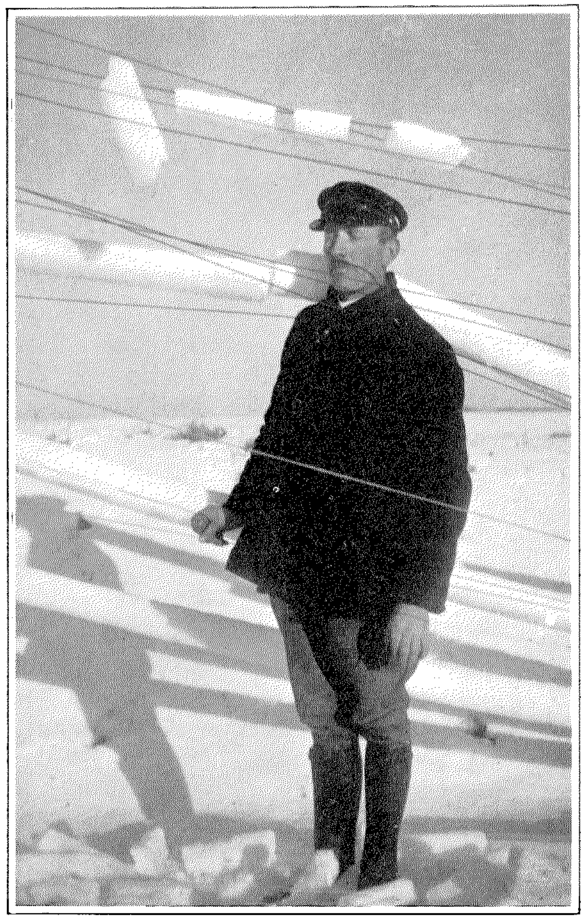


Figure 3 } *Figure 4* } *Effects of Heavy Sleet Storms on Open Wire Lines.*

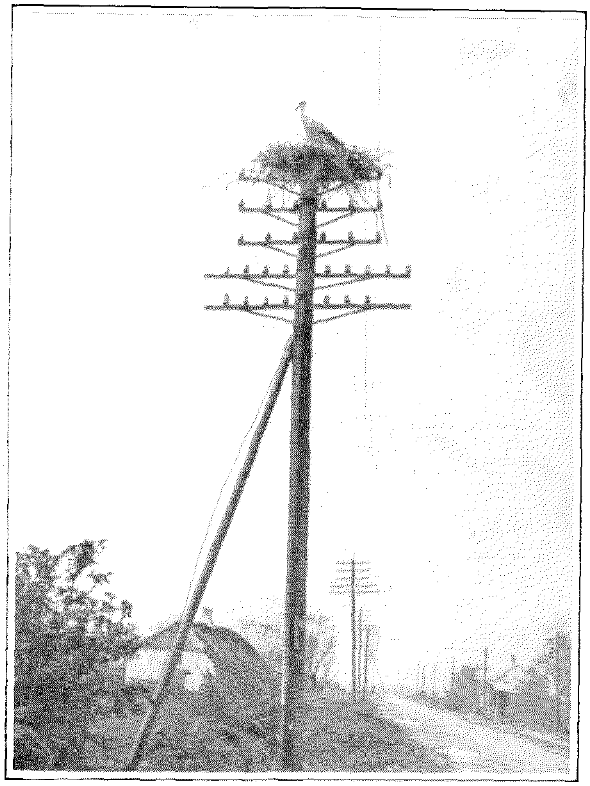


Figure 5—Disturbance Encountered in Rural Districts.

thereof. All calls with air line distance exceeding 130 km. shall be handled exclusively by the State.

This arrangement enables the Telephone Company to discharge its obligations without the use of repeater equipment, and still have reasonable wire sizes in the cables. The State has installed repeater stations in Aalborg, Aarhus, and Kolding.

In determining the number of circuits to be reserved for the Jutland Company's future requirements it was assumed that the rate of increase in traffic would be similar to that of the past five years. Due regard was also given to the assumption that the installation of a cable would tend to increase the traffic owing to the increased facilities and to the reduction in disturbances due to storms, etc.

Fig. 6 shows how the cable is estimated to be filled in the Aalborg-Aarhus section. The initial filling of 40% corresponds to the number of open wire lines in use at the time when this section of the cable was completed, and this filling was at once raised to 50%. This increase would reduce the number of conversations per line per day to sixty or sixty-five, meaning that all calls ought to be completed without any appreciable delay. Under the assumed conditions, it should

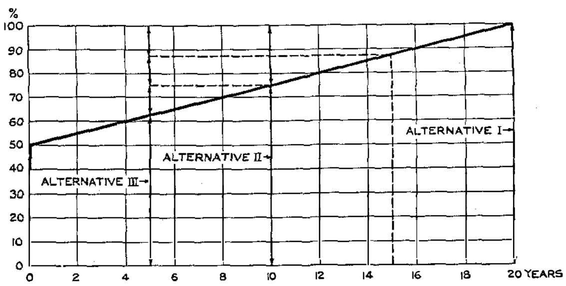


Figure 6—Aarhus-Aalborg Section—Degree of Filling.

TABLE I

Number of Conversations in 1934 between East-Jutland Cities.
(Including calls arrived from and dispatched to other Exchanges through the Cable)

To Exchange	Number of Inhabitants	Number of Subscribers	Number of Conversations in Thousands from Exchange:							
			Aalborg	Hobro	Randers	Aarhus	Skanderborg	Horsens	Vejle	Kolding
*Aalborg	77,000	6,009	——	39.5	63.2	71.8	2.7	1.1	**	**
Hobro	6,682	508	30.0	——	43.6	20.9	1.1	0.09	1.0	0.5
Randers	39,431	3,072	68.7	59.9	——	129.8	3.8	12.4	7.3	4.2
*Aarhus	114,000	10,454	76.5	26.0	141.7	——	89.4	102.0	56.3	45.4
Skanderborg	4,867	444	2.5	2.0	4.6	54.7	——	19.4	3.9	2.6
Horsens	29,611	2,211	1.5	2.0	12.6	87.0	23.2	——	63.7	39.0
Vejle	28,000	2,276	**	0.9	7.9	45.2	3.2	65.7	——	94.6
Kolding	23,600	1,932	**	0.5	5.1	39.7	2.7	34.8	94.1	——

* Inclusive of Suburbs.
** Conversations, which are carried through on the P. & T. Lines.

be possible to maintain this standard of efficiency in the whole filling-up time—20 years.

An example of the actual traffic from Aarhus to the other cities along the cable is shown in Fig. 7.

The size of the Aarhus-Kolding section is based on the same filling-up time, but a slightly faster increase in the degree of filling.

A calculation was made of the initial costs and annual charges, i.e., interest, maintenance, and depreciation, which would result if a cable were installed to cover the requirements for the

TABLE II
Cable Sizes and Distances

Cable Route (Chief Cities Underlined)	Distance from Aalborg m.	Size of Cable				
		1.4 mm. Quads	1.15 mm. Quads	0.9 mm. Pairs	Broadcast Pair	Total Number of Circuits
Aalborg	0					
		23		80		150
Skalborg	5,932					
		19		38		96
Støvring	19,826					
		19		30		88
Hadsundvej	48,080					
		19		38	1 Pair lead-covered 1.4 mm.	96
Hobro	49,468					
		19		38		96
Viborgvej	53,578					
		19		30		88
Randers	76,238					
		23		80		150
Grenaavej	77,714					
		23		43		113
Lisbjerg	104,919					
		23		80		150
Aarhus	113,504					
		18	36	46		209
Skanderborg	136,538					
		18	36	46	1 Pair lead-covered 1.15 mm.	209
Horsens	159,262					
		18	36	46		209
Vejle	186,138					
		18	36	46		209
Kolding	213,838					

TABLE III
Electrical Properties of Typical Circuits

Type of Circuit	Loading Coil Inductance mh. (Spacing: 1,700 m.)	Characteristic Impedance Ohms	Cut-Off Frequency p:s	Attenuation Nepers/km.	
				800 p:s	2,200 p:s
1.4 mm. Broadcast Pair	16	500	10,000	0.0240	0.0250
1.15 mm. Broadcast Pair	16	500	10,000	0.0314	0.0351
1.4 mm. 2-Wire, Side	140	1,520	3,400	0.0095	0.0125
1.4 mm. 2-Wire, Phantom	56	760	4,300	0.0095	0.0115
1.15 mm. 2-Wire, Side	140	1,520	3,400	0.0131	0.0159
1.15 mm. 2-Wire, Phantom	56	760	4,300	0.0130	0.0149
1.15 mm. 4-Wire, Side	140	1,520	3,400	0.0131	0.0159
1.15 mm. 4-Wire, Phantom	56	760	4,300	0.0130	0.0149
1.15 mm. 4-Wire, Side	30	705	7,400	0.0254	0.0258
1.15 mm. 4-Wire, Phantom	12	363	9,900	0.0255	0.0258
0.9 mm. 2 and 4-Wire	140	1,570	3,500	0.0190	0.0210

Between		Number of Lines in Use	Number of Direct Calls Per Line Per Day between the Towns Indicated.	Number of Calls Per Line Per Day between Exchanges beyond the Towns Indicated.	Total
Aarhus	Aalborg	8	39	23	62
	Hobro	3	17	41	58
	Randers	13	36	34	70
	Skanderborg	9	27	29	56
	Horsens	9	39	29	68
	Vejle	5	38	28	66
	Kolding	5	26	33	59

Figure 7—Traffic on the Lines between Aarhus and the Other Towns Along the Cable in 1934.

first 10 years and, subsequently, another cable laid to provide for the last 10 year period. The economics of a division in four equal periods of 5 years each, as well as a division in two unequal periods of respectively 5 and 15, or 15 and 5 years, also were investigated.

On Fig. 6 may further be read on the ordinates the sizes of the single components of the alternatives to be compared in relation to the actual Aalborg-Aarhus plant (alternative I). Only the ordinates representing the actual Aalborg-Aarhus plant and the first two above mentioned alternatives (II and III) are shown in bold lines, since it turned out that the economics of the two last mentioned alternatives would differ but slightly from alternative II (two equal periods of 10 years each). These two alternatives are not included in the following investigation.

Fig. 8 shows the calculated initial cost of components of different size in proportion to the actual Aalborg-Aarhus plant, if the cost of this be fixed to Kr. 100. Costs and sizes of the single components of the above mentioned two alternatives are marked off on the curve and also set up in the table in Fig. 8.

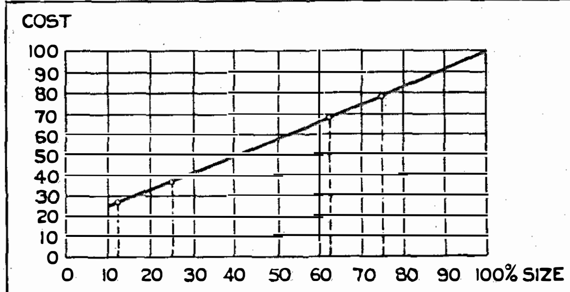
Fig. 9 shows the annual running costs at the 1930 interest level for a cable plant with a life of 50 years, supposing the replacement fund to increase linearly[1] and to be invested in our own plant, or otherwise brought to yield the same rate of interest as this plant.

[1] This is the case with the Danish telephone companies. As to the difference between linear and rational increase, the reader is referred to P. O. Pederson: *On the Depreciation of Public Utilities*. Reprint from: Miscellaneous Papers—Copenhagen, 1934.

It appears from Fig. 9 that the sum of the annual running costs, ΣC, for a plant costing Kr. 100, in, say, the first 10 years, is represented by the shaded area. When the annual charges for interest, maintenance, and depreciation are respectively i, m, and d% of the initial costs, then the size of this area for an initial cost of Kr. 100 is:

$$\sum_{0}^{n} C = (i+m+d)n - \frac{d \cdot i}{200}(n-1)\,n$$

for a period of n years.



ALT.	FILLING-UP TIME YEARS	CABLE SIZE IN PROPORTION TO ALT. I %	RELATIVE INITIAL COST PER KM CABLE
I	0 - 20	100*	100
II	0 - 10 10 - 20	75 25	78 37
III	0 - 5 5 - 10 10 - 15 15 - 20	62·5 12·5 12·5 12·5	68 27 27 27

* COPPER WEIGHT PER KM CABLE :- 1·74 TONS.

Figure 8—Relative Initial Cost (above); Summary of Initial Cost (below) Aarhus-Aalborg Section.

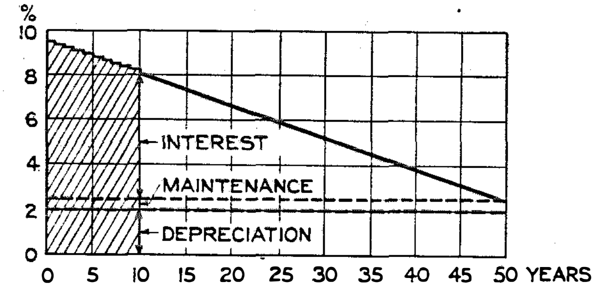


Figure 9—Annual Running Costs of a Cable Plant. Life 50 Years and Initial Cost Taken as 100.

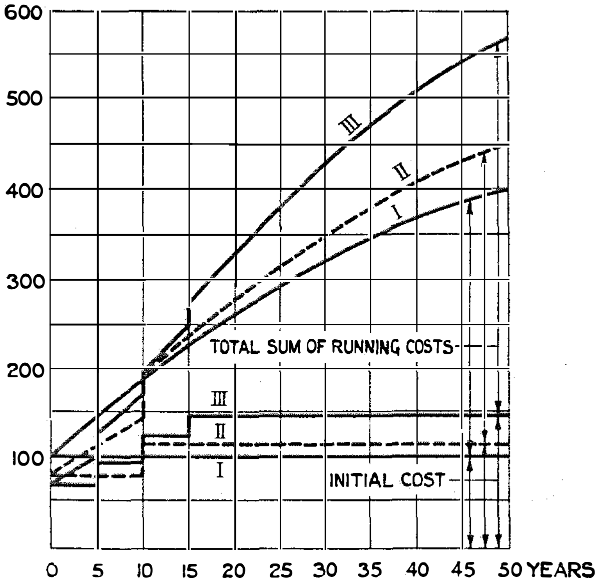


Figure 10—Initial Cost and Total Sum of Running Costs.

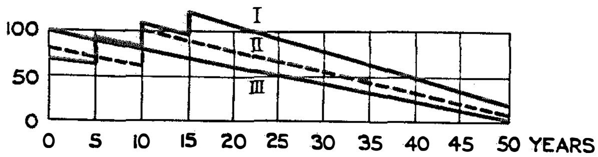


Figure 11—Book Values.

Without any appreciable error this expression may be reduced to:

$$\sum_{0}^{n} C = (i+m+d)n - \frac{d \cdot i}{200} n^2$$

It is assumed that the step-by-step line in the upper part of Fig. 9 is replaced by a straight line.

If $i = 7\%$, $m = 0.5\%$ and $d = 2\%$ in accordance with Fig. 9, the total sum of running costs for n years will be:

$$\sum_{0}^{n} C = 9.5n - 0.07n^2 \ldots\ldots\ldots (1)$$

From the curves in Fig. 10 showing the sum of the running costs according to Fig. 8 and formula (1), it appears that the initial costs as well as the total running costs in 50 years are the smallest for the large plant (plant I) and the largest for the four-period plant (plant III). Fig. 11 shows the variation of the book value, i.e., initial cost of the plant less the corresponding part of the replacement fund, in the same period.

Size and Loading of the Cable

Fig. 12 shows a diagram of the route with all exchanges and cabins (mentioned hereinafter) where circuits are taken out of the cable. The cable sizes and lengths of each size are given in Table II, and target diagrams for three sizes are shown in Fig. 13.

The following circuits are provided in the cable for the use of the State:

Section Aalborg-Randers:	7 quads 1.4 mm. and 6 pairs 0.9 mm.
Section Randers-Aarhus:	7 quads 1.4 mm. and 12 pairs 0.9 mm.
Section Aarhus-Kolding:	36 quads 1.15 mm.

Six pairs 0.9 mm. in the repeater section Aalborg-Aarhus are intended for 4-wire circuits and are divided in two electrostatically screened

TABLE IV

Attentuation. Measured with Standard Electric Transmission Measuring Set. Broadcast Pairs by the Open and Short Impedance Method

Type of Circuit	Mean Attenuation Nepers per km.	
	800 p:s	2,200 p:s
Aalborg-Aarhus Section		
1.4 mm. 140/56 mh. Side.......	0.0089	0.0112
1.4 mm. 140/56 mh. Phantom...	0.0086	0.0102
0.9 mm. 140 mh................	0.0108	0.0198
1.4 mm. Broadcast Pair, mh.....	0.0208	0.0210
Aarhus-Kolding Section		
1.4 mm. 140/56 mh. Side.......	0.0086	0.0108
1.4 mm. 140/56 mh. Phantom...	0.0084	0.0098
1.15 mm. 140/56 mh. Side.......	0.0119	0.0140
1.15 mm. 140/56 mh. Phantom...	0.0117	0.0132
1.15 mm. 30/12 mh. Side.......	0.0235	0.0244
1.15 mm. 30/12 mh. Phantom...	0.0230	0.0240
0.9 mm. 140 mh................	0.0182	0.0199
1.15 mm. Broadcast Pair, 16 mh..	0.0296	0.0317

groups of three pairs each (see target diagrams). In the repeater section Aarhus-Kolding are 12 quads 1.15 mm. intended for 4-wire circuits. These quads are not screened by special screens, but are laid up diametrically opposite in the cable, the intermediate quads acting as screens.

All circuits in the cable are initially loaded with a nominal 1,700 m. spacing. All pairs and side circuits are loaded with 140 mh. coils, and all phantom circuits with 56 mh. coils with the exception of six of the 4-wire 1.15 mm. quads in the repeater section Aarhus-Kolding, which are loaded with 30 mh. in the sides, and 12 mh. in phantoms. The broadcast pair is loaded with 16 mh. coils.

Table III shows the electrical properties of the different typical circuits as guaranteed by the makers of cables and loading coils. Results of transmission tests on the completed plant are given later.

Termination of Circuits

In Aalborg, Aarhus, and Kolding the circuits used by the State are branched off to their exchanges, the branching-off joints being so placed that the circuits of the State as well as those of the Telephone Company terminate with half loading sections at their respective exchanges.

In all other towns circuits are taken out of the cable at the most convenient places without regard to the position in the loading section. The State circuits are then terminated at the Telephone Company's exchanges with transformers and connected to the State exchanges through the ordinary, non-loaded exchange cables.

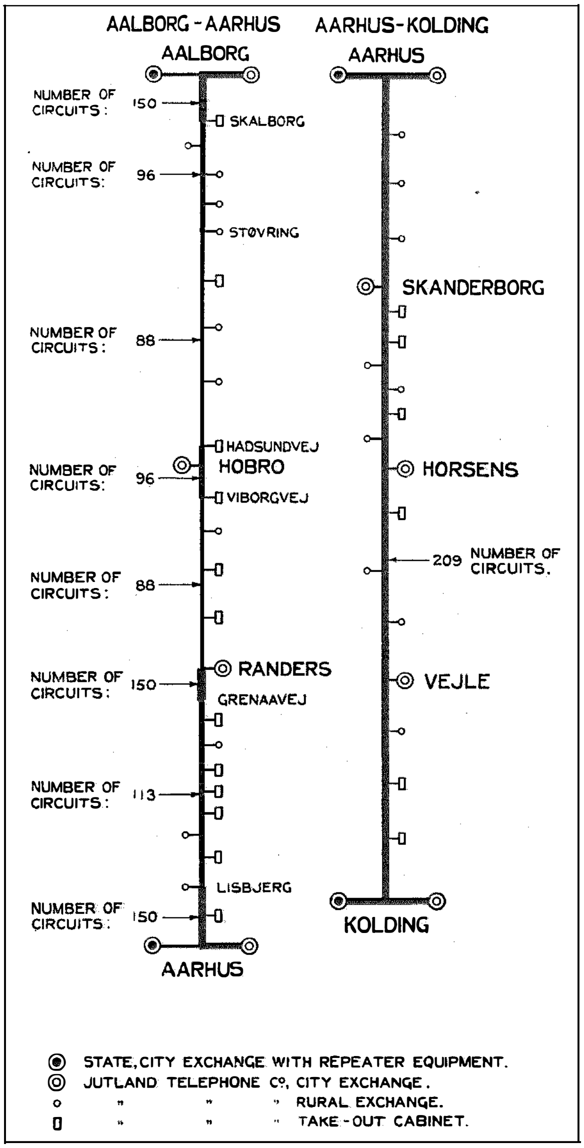


Figure 12—Cable Route Diagram.

TABLE V

Results of Singing Point Tests. Aalborg-Aarhus Section.
Measured with the Standard Electric Singing Point Test Set

Type of Circuit	Singing Point in Nepers					
	Aalborg to Aarhus			Aarhus to Aalborg		
	Max.	Av.	Min.	Max.	Av.	Min.
1.4 mm. 140/56 mh. Side	3.78	3.63	3.46	4.0	3.70	3.39
1.4 mm. 140/56 mh. Phantom	3.76	3.59	3.35	3.99	3.73	3.56
0.9 mm. 140 mh. 4-Wire	4.0	3.85	3.74	4.0	3.88	3.59

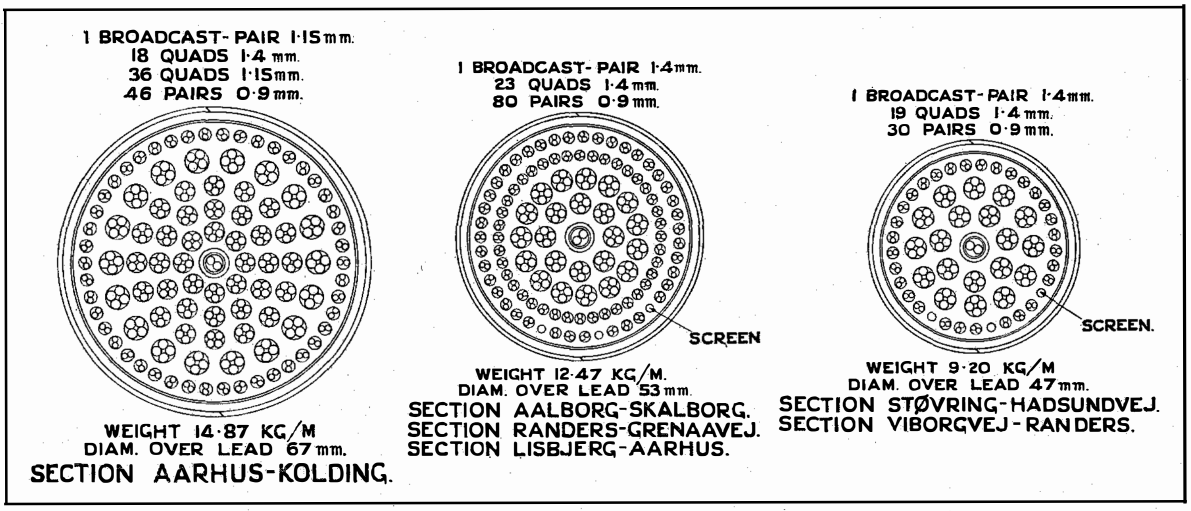


Figure 13—Cable Lay-Ups

1.4 mm. and 1.15 mm. circuits are spliced out only in the towns and are used exclusively for interurban lines.

The 0.9 mm. circuits of the Telephone Company are chiefly used for lines from the towns to rural exchanges and lines between rural exchanges. A certain number are generally looped out by means of branch cables with the same electrical properties as the main cable when the cable passes an exchange.

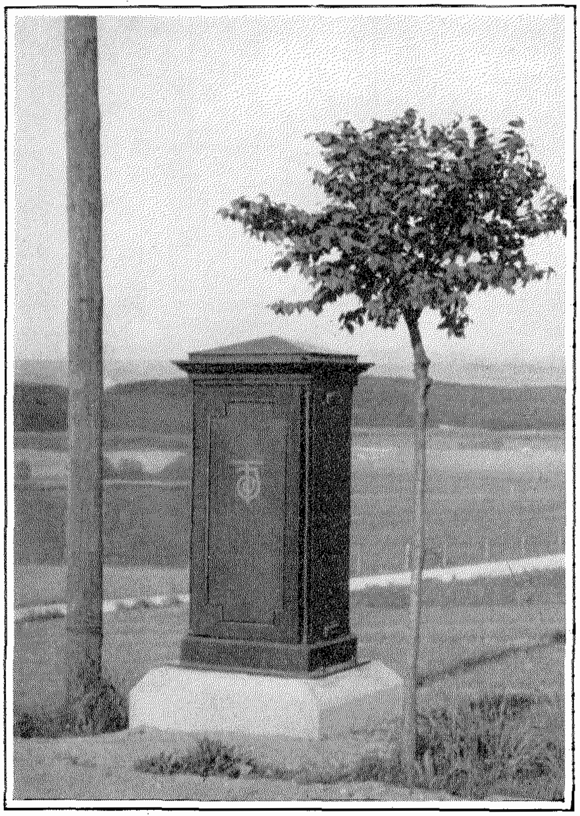


Figure 14—Exterior View of Cabinet.

In places not close to an exchange the branch cable terminates in a small sheet iron cabin (Fig. 14). This cabin encloses another properly ventilated cabin built up of angle iron and celotex panels. The inner cabin is divided in two halves by a vertical wooden wall, one side containing the cable terminal for the branching-off cable and the necessary transformers, while the other side contains vacuum type lightning arresters, fuses, and the cable terminal for the local cable intended to join the lines either directly, or by means of open wire lines to the rural exchange. Fig. 15 shows the interior of the transformer side of the cabin.

The cabins are placed on the roadside and are easily movable should a future widening of the road render it necessary or advisable.

Cable terminals having bakelite moulded front panels and terminals placed on elevated conical studs are used at all cable terminating points. All circuits pass through transformers for impedance matching and protection against accidental direct currents. Fig. 16 shows the terminating panel in Horsens, and Fig. 17 the interior of a rural exchange with cable terminating cupboard open.

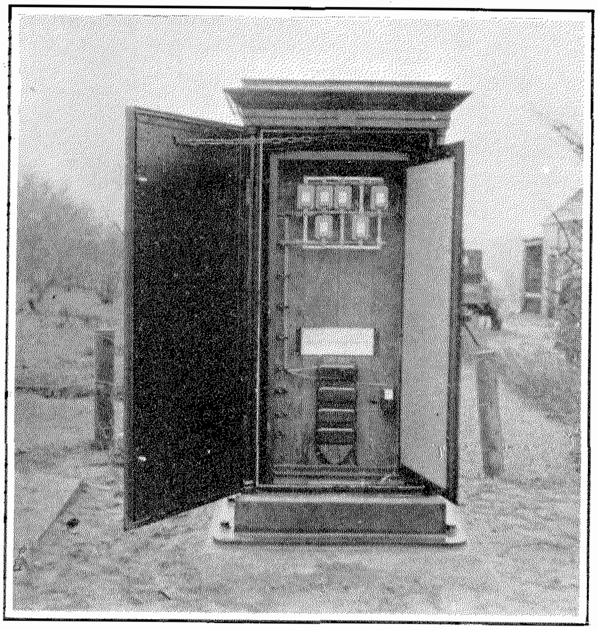


Figure 15—Interior of Cabinet—Transformer Side.

The terminal room of the Jutland Company's exchange at Aarhus is equipped with a special panel with measuring and testing sets (Fig. 18), viz., Wheatstone bridge with mirror galvanometer for measurement of resistance, insulation and capacity, and location of insulation faults, valve-oscillator for frequencies from 300 to 4,000, wave filter, frequency measuring bridge, impedance bridge, attenuation measuring set, crosstalk measuring set, impedance unbalance measuring set, terminating networks, and resistances.

These sets are all designed by the Jutland Telephone Company's technical staff and are of Danish manufacture.

Laying and Jointing of the Cable

The cable, which was manufactured by the Nordiske Kabel-og Traadfabriker, Copenhagen, and armoured with 2 by 1.0 mm. steel tape, is laid along the East-Jutland highroad at a depth of 65 cm. under the road surface (Fig. 19). The trench was dug by hand but a special plough drawn by horses or a motor tractor was used to loosen the surface. The cable drums were transported by means of a cable cart, hauled by tractor (Fig. 20).

The cable was transferred to the trench direct from the cart (Fig. 21) and covered by bricks on the open road, and with lengths of semicircular iron rails or concrete blocks through towns and villages.

In order to obtain a uniform mean mutual capacity in the cable, the individual lengths were placed in a definite order, specified by the maker and based on factory measurements.

TABLE VI

Regular Crosstalk in Nepers Aarhus-Kolding Repeater Section

Type of Circuit	Min.		Average	
	Ph-S	S-S	Ph-S	S-S
Near End				
1.15 mm. 140/56 mh. 2-Wire.	8.83	9.37	9.37	9.86
1.15 mm. 140/56 mh. 4-Wire.	9.02	9.57	9.41	9.96
1.15 mm. 30/12 mh. 4-Wire.	9.80	10.13	10.38	10.70
1.4 mm. 140/56 mh. 2-Wire.	9.07	9.20	9.52	9.81
Far End				
1.15 mm. 140/56 mh. 2-Wire.	9.0	9.5	9.7	10.2
1.15 mm. 140/56 mh. 4-Wire.	9.0	9.5	9.6	10.1
1.15 mm. 30/12 mh. 4-Wire.	9.1	10.9	10.4	11.7
1.4 mm. 140/56 mh. 2-Wire.	8.9	9.1	9.4	9.9

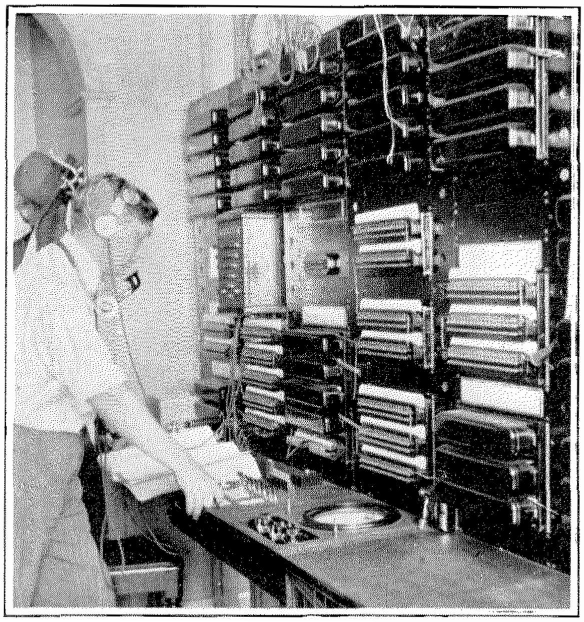


Figure 16—Terminating Panel—Horsens.

The jointing of the cable was carried out by the Telephone Company's staff according to the International Standard Electric system of cross splicing for reducing the capacity and resistance unbalances in the individual loading sections, the work being performed in compliance with instructions provided by the International Standard Electric Corporation.

All measuring sets were mounted in Ford sedan cars where the testers could work comfortably in all sorts of weather, and quickly reach various points along the route. Each loading section was pressure tested before cast iron protecting boxes were fitted around the lead sleeves and filled with compound.

The loading coil equipment was supplied by Standard Electric Aktieselskap. The loading coil cases in the Aalborg-Aarhus section, which was completed first, are of the older type with stub cable, whereas the Aarhus-Kolding section is equipped with the new type stubless cases (Fig. 22). The cases are buried directly in the ground.

The Aalborg-Aarhus repeater section contains sixty-seven cases with an actual spacing of

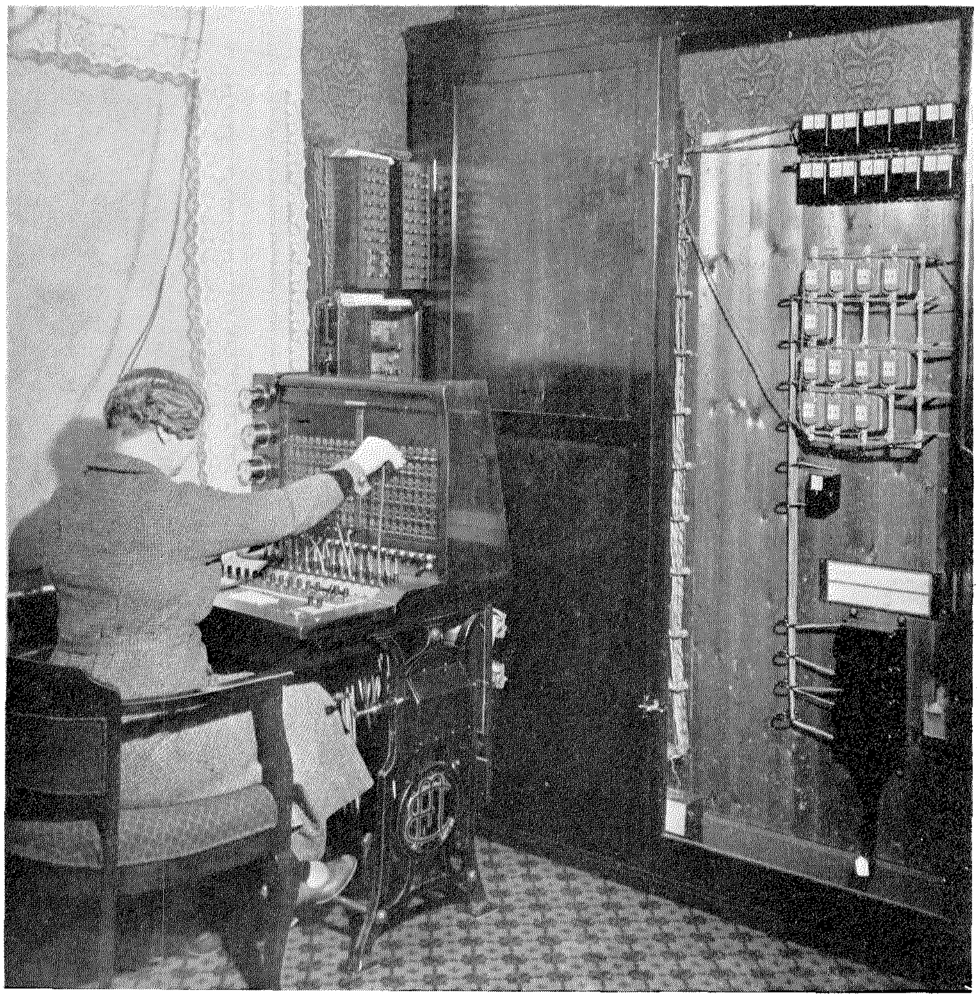


Figure 17—Rural Exchange with Cable Terminating Cupboard Opened.

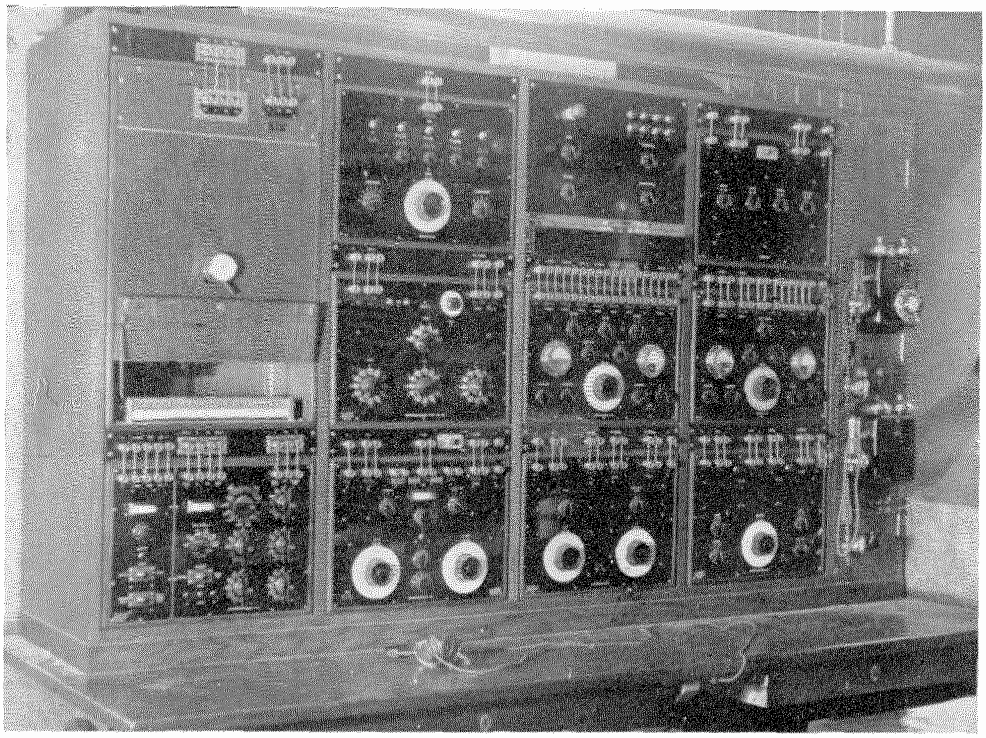


Figure 18—Testing Panel—Aarhus.

Figure 19—Transferring Cable to Trench Directly from Cart.

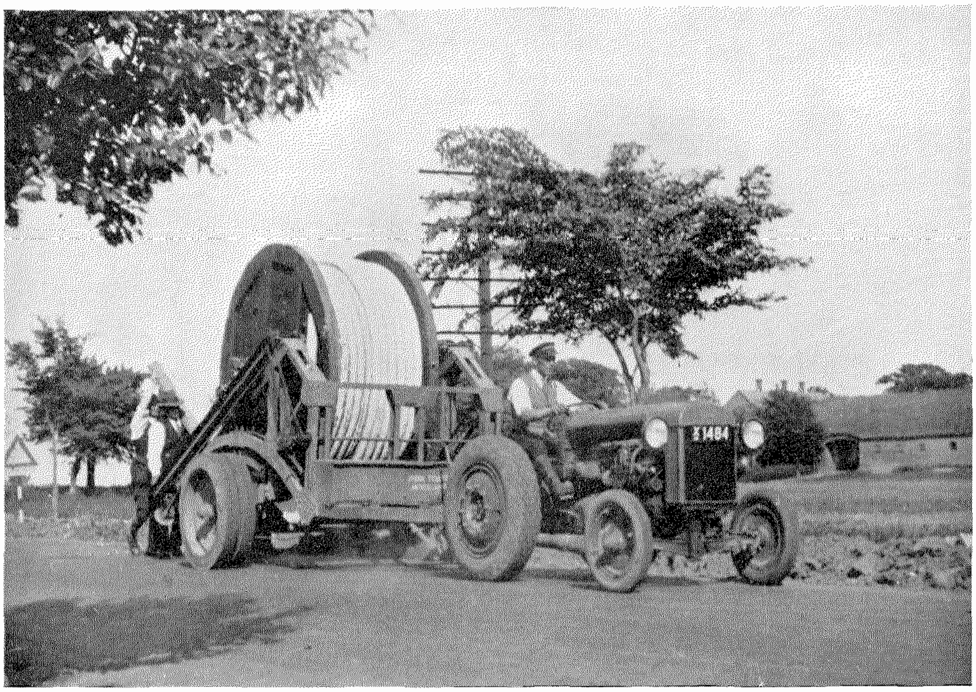


Figure 20—Loaded Cable Cart. The Reel Contains 215 m. Cable of Weight 3.2 Tons (approximately)

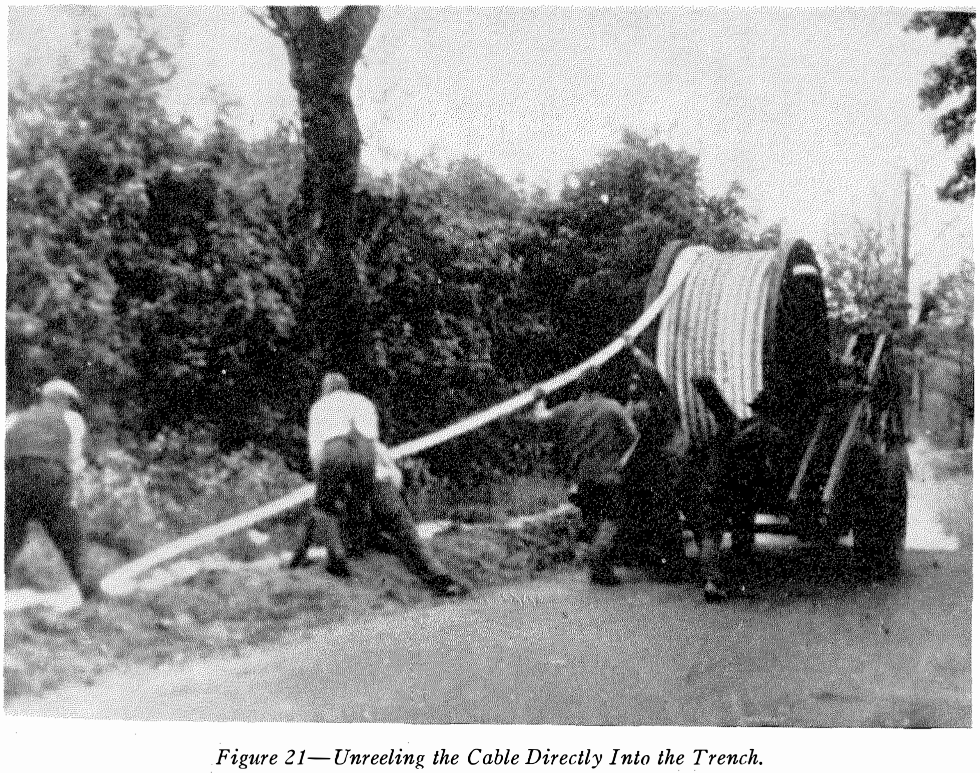


Figure 21—Unreeling the Cable Directly Into the Trench.

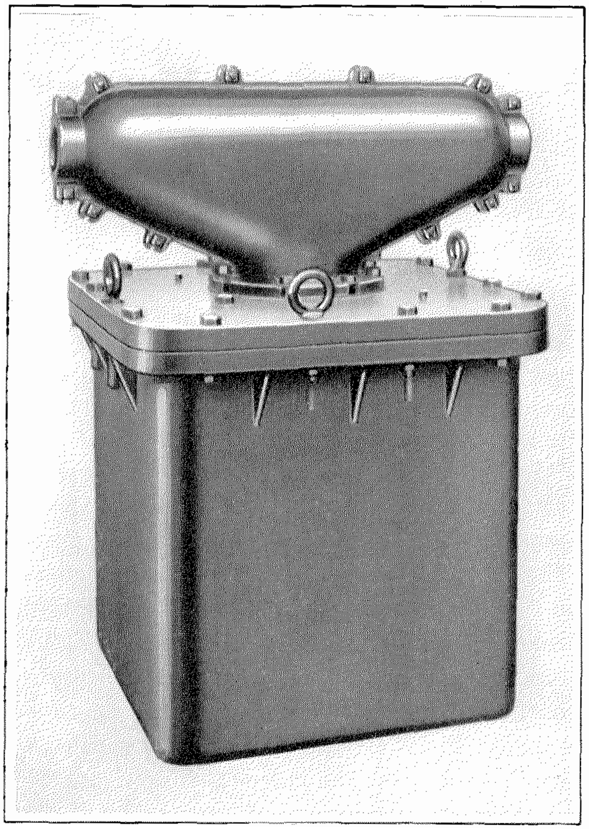


Figure 22—Standard Electric Loading Coil Case.

1,694 m. and the Aarhus-Kolding section, fifty-nine cases with an actual spacing of 1,704 m.

Every joint and loading point along the cable is indicated by small concrete markers, placed at the roadside, each carrying a fixed copper plate on which is marked the distance to Aarhus as well as the distance from the marker to the cable.

Transmission Test Results

After completion of each repeater section the following measured values were obtained:

(1) The maximum resistance unbalance on any circuit was found to be 0.021%.

(2) The minimum insulation (each conductor to earth) was found to be 40,000 megohms per km. in the Aalborg-Aarhus section and 75,000 megohms per km. in the Aarhus-Kolding section, measured from end to end of the section.

(3) The average impedance values for the Aarhus-Kolding section were:

	800 p:s		2,200 p:s	
	Side	Phantom	Side	Phantom
1.15 mm. Broadcast pair............	586		557	
1.15 mm.140/56 mh.	1,549	784	1,954	881
1.15 mm. 30/12 mh.	737	378	749	379
1.4 mm.140/56 mh.	1,547	784	1,971	891
0.9 mm.140 mh....	1,569		1,945	

(4) The attenuation values are given in Table IV.

(5) Singing points in the frequency range 300-2,200 p: s for the Aalborg-Aarhus section only, are given in Table V.

(6) All crosstalk values inside the quads were measured. Crosstalk between circuits in different quads was measured at random on arbitrarily selected circuits. Results of regular crosstalk measurements are given, for the repeater section Aarhus-Kolding only, in Table VI. All tests were made with the "Standard" type crosstalk set and complex tone generator.

Conclusion

The East-Jutland cable, 214 km. in length, is the longest cable in Denmark. It contains 50,137 km. of wire divided 59.7% and 39.5%, respectively, between the Telephone Company and the State. The remaining 0.8% constitutes the broadcast pair. The cost of the whole plant amounted to 5.5 million Kr.

The next move in the execution of the above mentioned cable scheme is a cable from Aarhus to Viborg and Skive, on which work was commenced in 1934.

Teleprogramme in The Hague

By G. DEAKIN

Vice President and General Technical Director, International Telephone and Telegraph Corporation

IN THE article on Rediffusion and Teleprogramme Systems which appeared in the October, 1934 issue of "Electrical Communication" and in articles which have appeared in other publications, due mention has not been made of the pioneer work of Mr. L. Neher, Chief Engineer of The Hague Telephone Administration, and his assistant, Mr. Mak. These engineers were probably the first to take up seriously the equipping of a central office telephone network to give selective multiprogramme service to telephone subscribers on a voice frequency basis. They developed the programme switch.

The Hague Municipal teleprogramme service was planned in 1924 and was put into actual service in November, 1926.

The problem of equipping an automatic system not especially designed for teleprogramme service is not a simple one. Programmes must not only be of good quality but must be given to the subscribers without interference with the normal switching and without crosstalk. These problems were solved by The Hague engineers and the installation became of great value and of guiding interest to those embarking on a similar scheme at a later date.

The Hague Municipal Telephone Administration has always been noted for its enterprise and advanced ideas. The successful operation of its automatic telephone plant attracted the attention of the American Telephone and Telegraph Company. In 1924 that company sent a delegation of engineers to The Hague to investigate the equipment, its operation, and the quality of the service it gave.

The Automatic Rural District of Zurich

By P. SCHILD

Assistant Director of the Zurich District

Translation of a paper from TECHNISCHE MITTEILUNGEN, *1. XII, 1934, No. 6, published in German and French under the titles* DIE VOLLAUTOMATISCHE NETZGRUPPE ZÜRICH *and* LE GROUPE AUTOMATIQUE DE ZURICH, *respectively. Permission granted by the author and the Direction Générale des Postes et des Télégraphes suisses to republish this paper is gratefully acknowledged.*

IN MOST large cities, automatic telephone service is now in operation and, where it is not, the installation of full automatic equipment is in progress. Telephone Administrations for some years have given serious consideration to the use of full automatic equipment in suburban and rural exchanges. Economy, combined with the advantages of uninterrupted twenty-four hour service, secrecy, and reliability, assures that full automatic equipment can be exploited with complete success.

In Switzerland, the various rural networks have been arranged in star formation with but few direct junctions or tie lines between exchanges. Uniform numbering has been adopted since it is considered easier for the subscribers than a non-uniform or prefix system. The subscribers' meters recording the calls are operated a number of times per connection, depending on time and distance. This method is more economical and more certain than the use of tickets, particularly in the case of no-delay toll traffic which, when ticketed, requires that the number of the calling party be checked. The system of time and zone metering has proved practical and flexible, and moreover quite satisfactory for full automatic toll service which is now being developed.

The automatic exchanges forming the rural area of Zurich were built by the Bell Telephone Manufacturing Company during the years 1931-1933. The system installed is known as the number 7-D Rotary System which, in a number of respects, is different from the well-known 7-A Rotary System which is installed in the city exchanges. The principal characteristics will now be described:

Apparatus

All installations consist of three main elements: the 100-point gear driven finder, the flat type relay, and a 10-point marker switch having from three to six brushes (Fig. 1). The finder functions as line finder, group selector, and final selector. When used as final and group selector, the finder has a home position. The marker switch is used to receive the impulses in the register as well as in the group and final selector control circuits.

Exchange Equipments

Three different types of exchanges are used, i.e., center type, subcenter type, and district type.

(*a*) *Center Exchanges* are used to connect subcenter and district exchanges. They may have a capacity from 100 to 2,000 or more lines. Fig. 2 shows the junction diagram of a typical center exchange; it is equipped with first and second line finders, first, second, and third group, as well as final selectors.

The register of a center exchange is utilized to receive and to store incoming impulses, and controls not only the selection of lines within its own area, but also those connected to the subcenter and district offices. The register transmits the impulses to the selectors and, by means of a translator, determines the correct routing of the connection and controls the office selections. Only one register is involved in each connection and it controls the complete selection of the called subscriber (Fig. 3).

Group selectors are associated with control circuits which receive their impulses on marker switches, indicating the desired group of lines. These control circuits are disconnected at the end of the selection. Owing to the fact that the time of occupation of these circuits is very short, one control circuit is considered sufficient for every five or ten selectors. This system of marking of the lines at the selector terminals makes it possible to distribute the outgoing lines in any convenient manner in groups of fifty or more lines per direction. For instance, at Küsnacht, the terminals are distributed as follows: fifty outlets towards the third group selectors, twenty-six outlets towards Zurich, eleven towards Herrliberg, ten towards Zumikon, and three spares.

Single way trunks are used between center exchanges and the Rural Main Exchange in Zurich. On the other hand, the traffic is both way on the trunks to the subcenter and district offices.

Incoming traffic from the city exchanges, inward toll traffic, and incoming rural traffic is handled by common group and final selectors. It should be noted that a connection may be offered from the toll board and that the subscriber may be recalled at the end of the communication.

(*b*) *Subcenter Exchanges* are equipped with line finders, first and third selectors for inward traffic, final selectors, simple three-digit registers and metering control circuits. This type of office is designed for an ultimate capacity of 300 to 1,000 lines and is suitable for interworking with several district offices.

When a call arrives, the first selector seeks a free trunk towards the parent center exchange, a metering control circuit being attached at the same time. Dialling tone is given to the calling subscriber when a register is connected at center. The dial impulses are transmitted directly to the center register and the first three digits are recorded by the metering control circuit.

Should the call remain within the subcenter area, the junction to center is released and the subcenter register controls the last three selections.

(*c*) *The District Type of Exchange* is suitable for capacities from one hundred to three hundred subscribers. These exchanges are equipped with line finders, final selectors and metering control circuits. For capacities above 100 lines, two or three final selectors are connected in parallel. In this case a marker receives the hundreds impulses and connects the group of lines required.

When a district subscriber takes his receiver off the hook, a line finder hunts for a free junction towards the parent subcenter or center exchange.

For a local connection the metering control circuit causes the release of the trunk towards the parent exchange after the third digit, the last three impulses going to the markers of the final selector.

When all the trunks toward the parent exchange are busy, the subscriber is so informed by means of a busy tone. Under these circumstances, however, he may still dial a local connection.

Numbering

All rural offices whether center, subcenter, or district are numbered decimally for the last three digits of the called number.

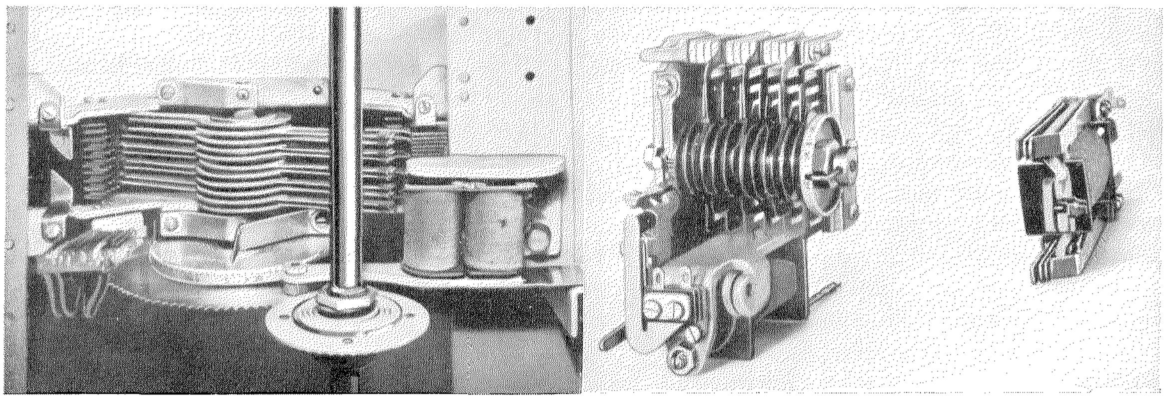


Figure 1—Finder, Marker Switch, and Flat Type Relays.

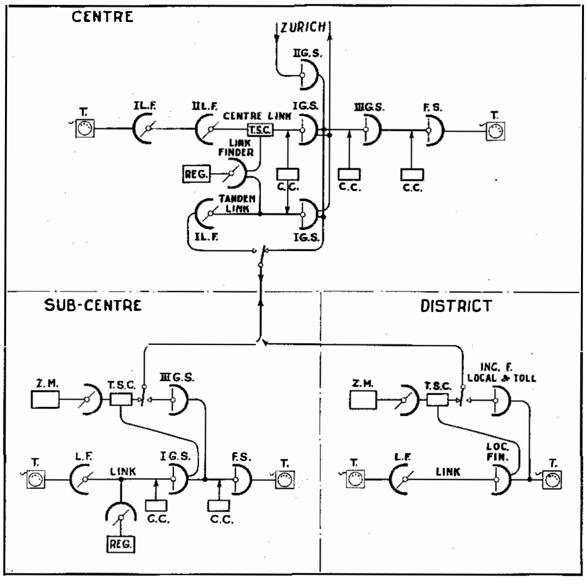


Figure 2—Junction Diagram for Centre, Subcentre, and District Exchanges.

The first three digits are translated at the center office into four series of impulses. The building up of the network and the routing of interoffice connections consequently become independent of the numbering.

At present, Zurich subscribers have five-digit numbers from 20,000 to 79,999, whereas the rural subscribers have six-digit numbers from 910,000 to 989,999. A sixth digit will become necessary in Zurich as soon as the present five-digit numbers are all utilized.

Building Up of a Selection

It has been mentioned that connections are directed by the center office register. The impulse circuit is illustrated in Fig. 4. Selection always takes place over both wires by means of direct current. The system is also developed for a-c. selection, which is not used in the Zurich network notwithstanding the fact that some lines are in close proximity to neighbouring electric railroads. Impulses are repeated twice for every connection from a center exchange to a subcenter or a district office. Distortion is negligible due to the slight self-induction of the impulse circuit. The impulse relays operate with a factor of safety of 2.5 over a loop resistance of 1,000 ohms, equivalent to 14 km. of suburban cable or to 21 km. of regional cable. The traffic may be handled over direct trunks (tie lines) between two center exchanges, necessitating merely a change in the register translator at the center exchanges.

Metering

Metering is effected by means of the subscribers' ordinary message registers which operate on the "repeated metering" principle according to the elapsed time and zone involved. Local connections are metered once (10 ct.) with time unlimited. Connections within the same sector are metered twice per three-minute conversation. Connections between two center sectors and between subcenters and district offices of these sectors are metered in accordance with the tariff applied to the center office (20 ct. per three-minute conversation up to 10 km., 30 ct. for distances from 10 to 20 km., and 50 ct. for a distance exceeding 20 km. in a straight line). The 50 ct. fee is reduced to 30 ct. between 7 P.M. and 8 A.M. Metering takes place at the beginning of each three-minute period.

All rural connections are broken off after a time interval of twelve minutes, the subscribers receiving a warning signal half a minute before the expiration of said interval. This restriction of the time of conversation has given rise to adverse criticism on the part of telephone users and will be abolished during the course of the present year.

The release of the connection is under the control of the calling subscriber. The system, however, has been so designed that, in case only the called subscriber should hang up, the connection is broken down automatically after a certain delay which is usually about one minute, the metering being interrupted at the same time.

The time and zone metering equipment in a center office is associated with the first group selectors. As soon as the register has received the office prefix, the corresponding translator, which is an ordinary six-brush, 100-point finder, is connected to the circuit. By means of its b, c, d, and e brushes, this finder determines the four series of tandem impulses and marks at the same time by means of the f brush the metering relays of the first group selector. The moment the subscriber answers, metering is started by means of the supervisory relay. Two small step-by-step markers associated with the metering control circuit, and actuated by a master clock, register the metering periods and repeat them after each three-minute interval.

In subcenter and district exchanges, the zone metering translator is positioned after the first three digits. The relays and zone markers are placed in the junction circuits. The metering relays are operated from the translator, this being a four-brush, 20-point marker switch, and metering is started as soon as the called subscriber takes the receiver off the hook and the answering signal is received at the outgoing exchange.

From two to four metering control circuits are required in each subcenter or district office, depending on its size and traffic load.

The Zurich Rural Group

The Zurich rural group has an ultimate capacity of sixty-two offices. Fig. 5 shows the Zurich network and gives the capacity of each office, the number of trunks, and the prefixes adopted.

The extension of this network will be performed in four stages. The first stage was completed in 1931 and included thirty-seven offices with 11,250 connected lines.

During the winter of 1932-33 the sectors comprising the Uster, Wetzikon, and Pfäffikon center offices were cut into service, thus adding thirteen new offices and 3,230 lines to the system. This year the Wädenswil, Richterswil, and the Schönenberg offices will be equipped with 1,800 subscribers' lines, and the Bülach-Eglisau district will follow during the next two or three years with nine new offices and a total of about 1,000 subscribers. There are now in service fifteen center, ten subcenter, and twenty-five district offices, the number of connected subscribers being in the neighbourhood of 10,500.

The traffic between two center offices is not very intense and is handled over Zurich. Tie lines have been established only between the Uster, the Wetzikon, and the Pfäffikon offices to take care of the direct traffic between these points. Other similar tie lines will be provided as future demand may require.

The subcenter offices of Männedorf and Stäfa have been connected by means of tie lines to the neighbouring Rapperswil group. These lines permit direct selection by means of a special prefix for inward and outward traffic for the complete sector of the Meilen office towards Rapperswil. In the same way the traffic of the Wetzikon center office towards Rüti and the other offices belonging to that zone is handled by tie lines between Hinwil and Rüti.

PBX Groups. Two or more adjacent subscribers' numbers may be connected in all groups of final selectors to form a group of PBX lines.

Balanced Line Relays. In order to do away with induction and noise troubles due to neighbouring high tension or electric car lines, 20% of the line relays have been equipped with two balanced windings.

Two-Party Lines. In most of the offices it is possible to provide for two-party line service with polarized relay blocking and individual metering. This service is used especially for distant subscribers.

Battery Feeding. The system may be arranged for battery feeding over the subscriber's "a" line for extension sets.

Battery Feeding Bridges may be introduced, but require four additional relays at the central office for each bridge.

Tax Indicators. Alternating current is used to retransmit the metering impulses over the subscribers' lines. The indicators are very favourably regarded in public pay stations and in hotels. To date, no less than 200 rural and 700 city lines are equipped with tax indicators.

Dead Lines. All unused subscribers' lines, such as those kept in reserve or unused during vacation periods or temporary absences of subscribers, are connected in parallel on special terminal strips. The subscriber, when calling one of these lines, receives a special tone indicating that it is "dead" (–..). The same arrangement exists for dead levels, the tone being given to the calling subscriber as soon as the register is released.

Permanent Glow Circuit. In subcenter and district offices, the subscribers' line circuits are equipped with a permanent glow relay. When a false call is made, this relay energizes and holds the line. After a time interval of about one minute, the connecting circuit in the office as well as the junction towards the center office is released. In a center office a false call is connected after about thirty seconds to a lamp and key-ended circuit on the test desk, the register thereupon being released.

To illustrate a few typical equipments: Fig. 6 represents the Küsnacht tandem office. Fig. 7 depicts the finder and final selector bays, as well as the message registers, the line and cut-off relays and the relays associated with the finder and final selectors. Fig. 8 shows a rear view of the register bay. The local cables towards the relays and the six step-by-step selectors of four register circuits are visible on the left-hand side of the picture, while the arcs of the connecting circuit finders appear in the upper right-hand corner. The translators are situated in the middle and the impulse transmitters somewhat lower. A register bay has a capacity of six circuits together with their associated six link finders, translators, and impulse senders.

Rural Main

The equipment required to handle the traffic between the city offices and those of the rural network is installed in the Brandschenkestrasse in Zurich, the toll office as well as the Administration being situated in the same premises. The toll, regional, and suburban cables as well as the cables towards Selnau 1, 2, and 3, Hottingen 1 and 2, and Riedtli are terminated in this building.

The junction diagram of the rural main exchange is shown in Fig. 9.

Calls originated in the city offices and directed towards the rural network are handled over a free level of the first group selector in the local office and a first direction finder of rural main. An interconnecting register receives the impulses of the local register and directs the connection over the first and second direction finders towards the desired center exchange. The register also marks, by means of its translator position, the corresponding tax and operates the metering relay. As soon as the called subscriber answers and, subsequently, at every three-minute interval, the metering impulses are sent over the third wire of the junction towards the local or the satellite office, so as to actuate the calling sub-

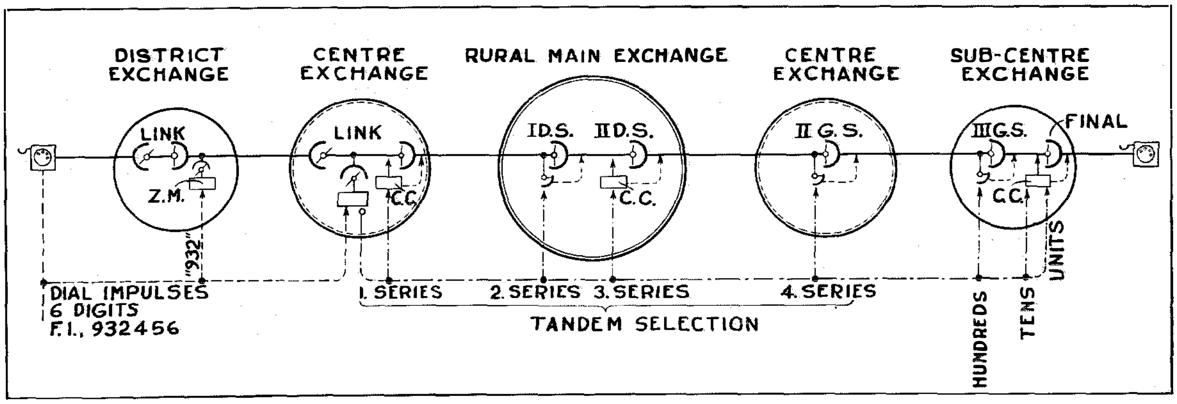


Figure 3—Selection.

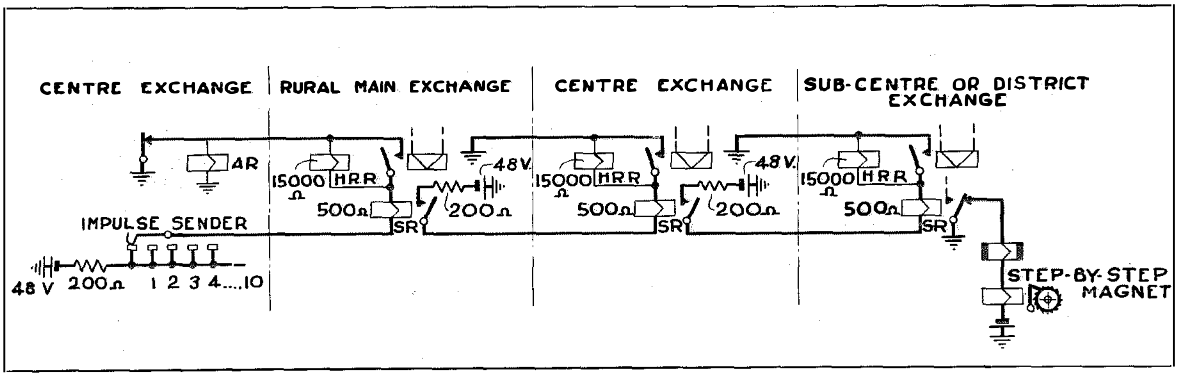


Figure 4—Impulse Circuit.

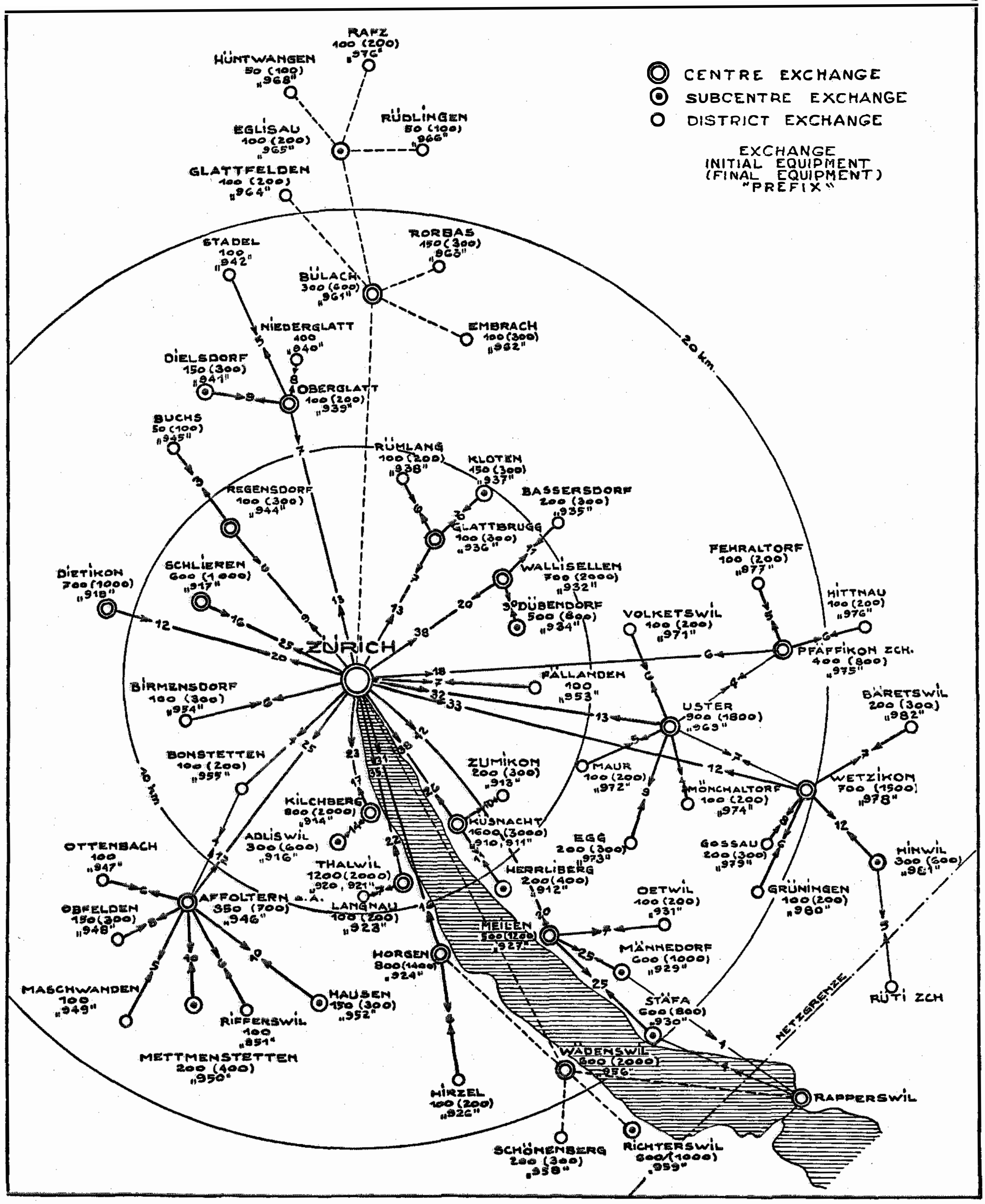


Figure 5—Zurich Rural Network.

scriber's message register. In order to meet this requirement, the outgoing junctions from the satellite offices towards the main offices must be of the 3-wire type.

Inward connections from the rural area towards the local city offices are handled by the center office register, and are routed over the first group selector in the center office and the first direction finder in the rural main and a free connecting circuit. The center register next transmits the called subscriber's number into a main register which routes the call to the desired local office.

The rural connections which are routed over Zurich are handled by the center register which directs them to the first and second direction finders in rural main and then to the center or district office required. At the present time the equipment consists of five second direction finder groups by means of which 500 outgoing lines to the center offices may be connected.

By dialling "14" a rural subscriber is connected over the special service selectors to the toll recording board. The toll operator recalls the subscriber by inserting her plug into a free rural jack and key-sending over the rural register LR. In the no-delay service, which amounts to about 60% of the toll traffic, the subscriber is recalled immediately. Temporarily such calls are being timed by means of tickets, the calling subscriber's number being checked by the operator in connection with the recall feature.

The parent center of the Birmensdorf, Bonstetten, and Fällanden district offices, which are directly connected to Zurich, is situated in the rural main exchange.

Inward traffic routed over automatic toll lines is handled by the toll connecting circuits, and toll registers absorb the impulses sent from the distant toll office. When the communication is intended for a rural subscriber the toll register, by means of the first digit "9," directs a first free direction finder and passes the following five impulses to an interworking register, which

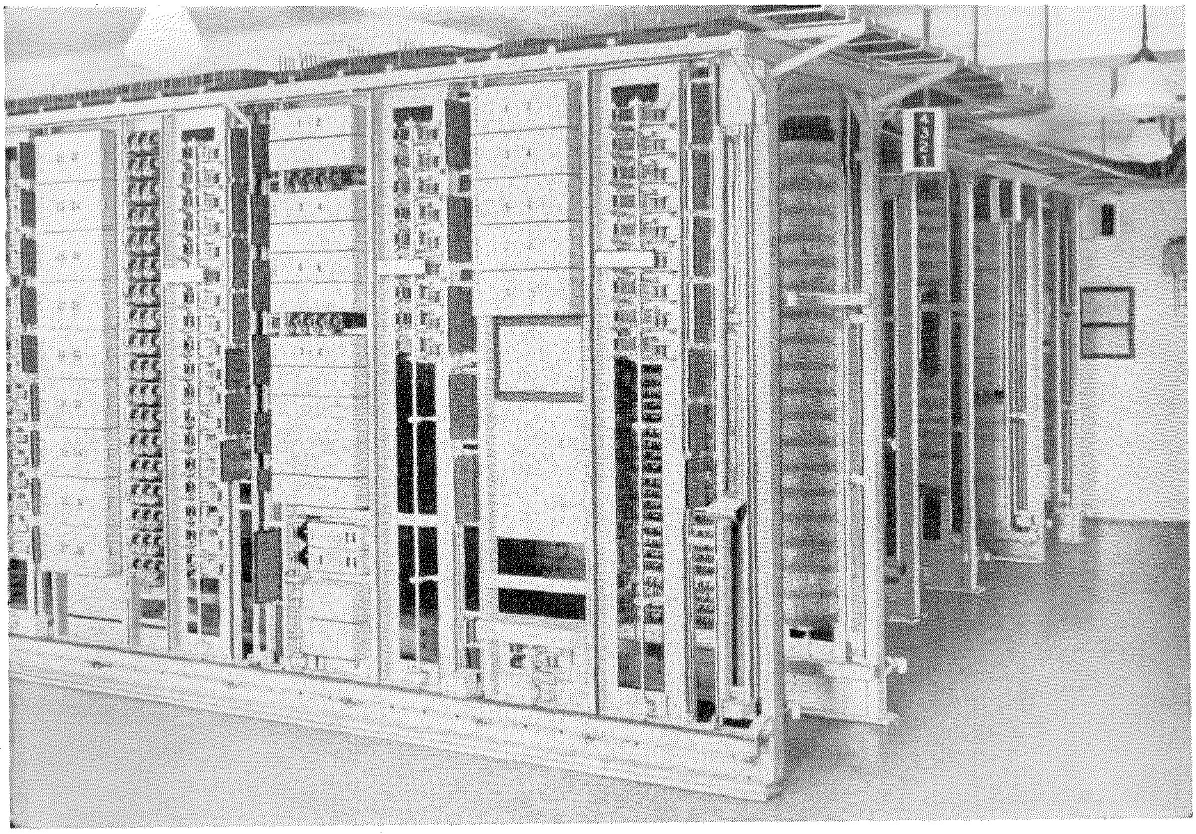


Figure 6—Küsnacht Centre Exchange (Zurich).

directs the selection in exactly the same way as in the case of a local city call towards the rural network.

In Fig. 10 is shown the cable plan of the suburban and regional network. The suburban cables (0.8 mm. and medium heavy loading) are used for distances up to 15 km. from Zurich, and the regional cables (1 mm. and medium heavy loading) are extended as far as 20 to 25 km.

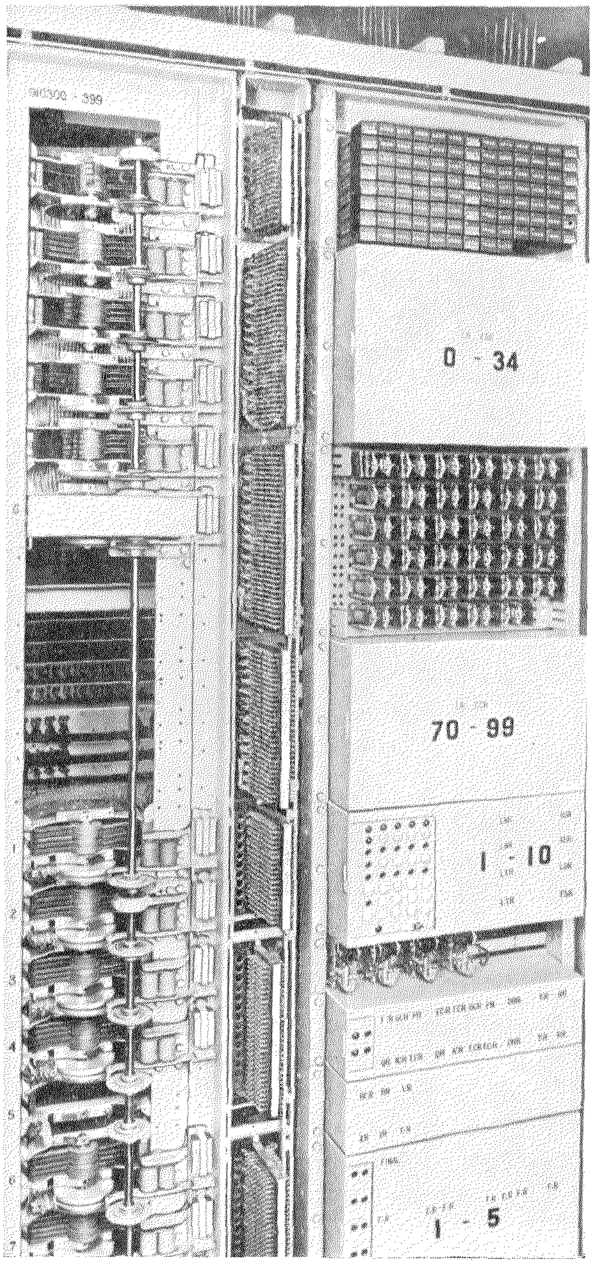


Figure 7—Finder and Final Selector Bays.

The attenuation from the toll office to a district office, including offices and points of reflection, nowhere exceeds 1 neper. Within the network the maximum loss is about 1.8 nepers for a connection between a district office—over a center, subcenter, center to another district office. The loss in this case is also within admissible limits.

Power Plants

Each rural office is equipped with two 48-volt storage batteries, a rectifier, and a power board. The capacity of the battery, which may vary anywhere from 42 to 360 ampere-hours, is chosen to carry the entire load for one or two days. The battery is charged automatically by means of a clock and voltage relays. After a battery has been in operation for twenty-four, thirty-six, or forty-eight hours, it is switched off and re-charged, the reserve battery taking its place. A voltage relay cuts off the charging current as soon as the voltage attains its required value.

Duplex motors are used to drive the finder shafts. These motors operate on alternating current; but, in case of interruption of the a-c. supply, the d-c. windings of the motors are immediately switched on to the battery by means of phase failure relays. A ⅛ HP motor is amply sufficient for driving purposes in a 1,000 line office.

Buildings

No difficulties have been encountered in the installation of the various bays owing to the fact that they are manufactured in two different heights, i.e., 2.05 m. and 2.45 m.

The larger center offices are most commonly located in buildings belonging to the Administration. The medium and small size offices are quite often installed either in schools, in private houses, or in rented former work shops. Only in a few instances has it been necessary to build special premises for these offices. Typical examples of the arrangement of a center, subcenter, or district office are illustrated in Fig. 11.

In order to prevent noises from disturbing the inmates of dwelling places, the floors have been covered by cork linoleum. In some cases the bays have been mounted on antivibration devices.

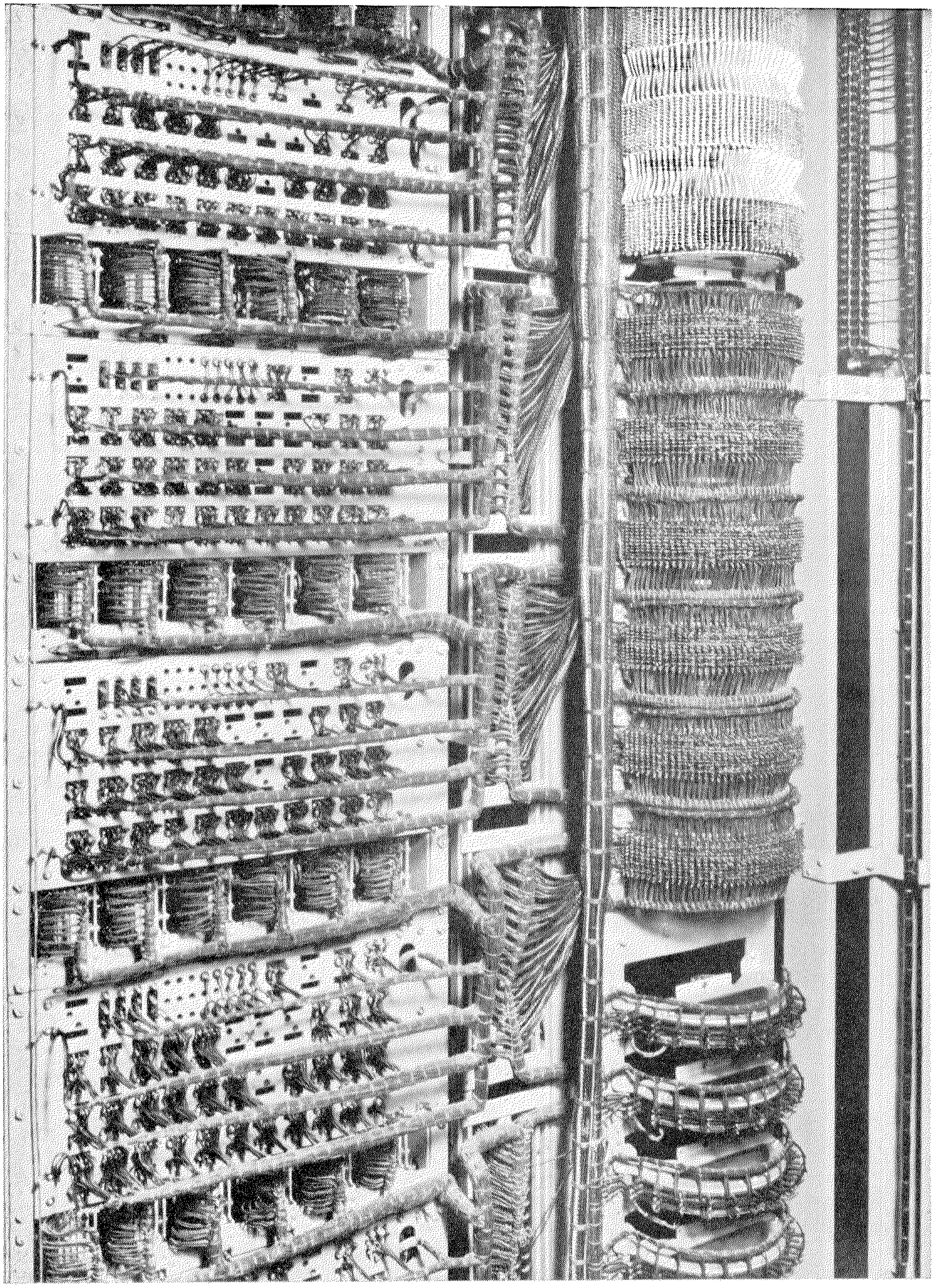


Figure 8—Rear View of Register Bay.

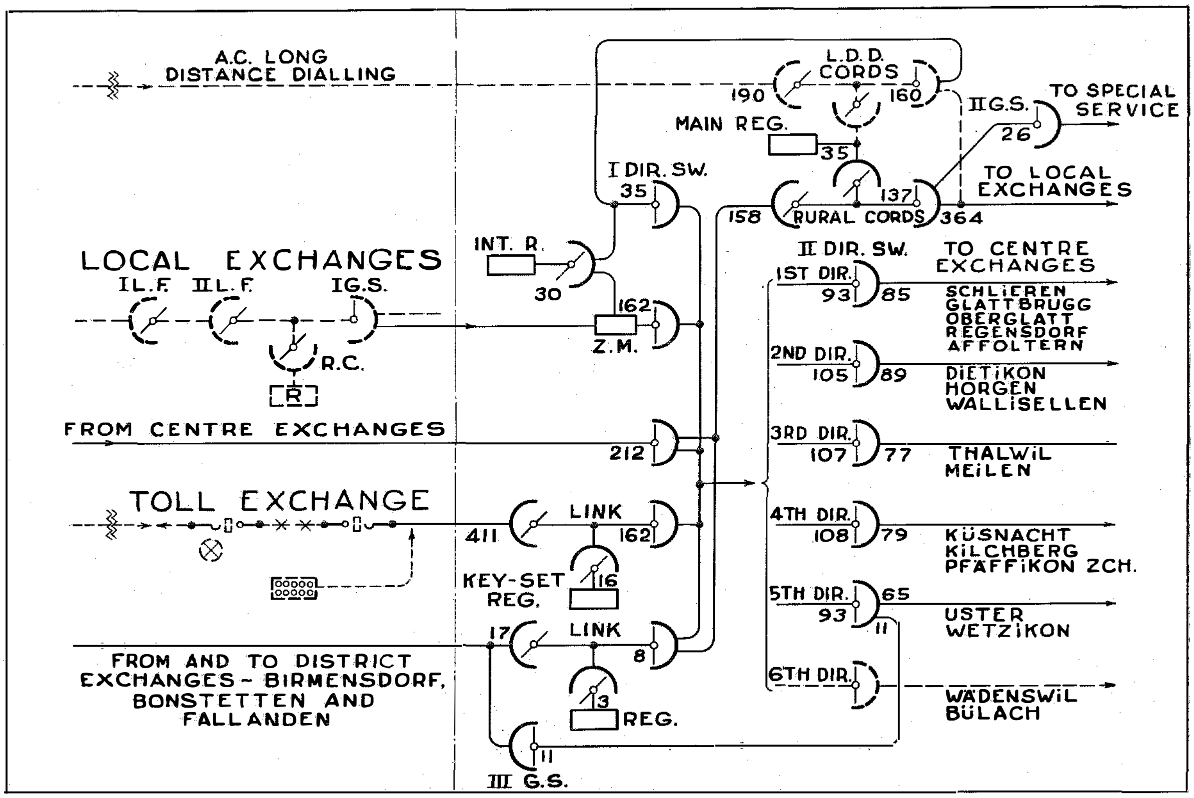


Figure 9—Junction Diagram of Rural Main Exchange.

For heating central office areas, use has been made in so far as practicable of central heating arrangements already in existence in the building. Where central heating is not available in the building, electric heating has been installed. The electric heating elements are connected during the night when current is available at a cheap rate and the heat generated is stored so that the temperature during the day time never drops below the permissible limits. These electric heating units take from 50 to 70 watts per cubic meter of air and they may be regulated for one-third or two-thirds of their full load value.

Temperature variations of 12° to 18° C. are permitted in the larger offices, whereas only 10° to 15° C. are allowed in district offices. At a rate of 3 to 3.5 ct. per KWH., during the winter season the heating charges amount to 1 or 2 francs per cubic meter.

Fault Alarm and Testing Equipment

A test board is equipped in some of the larger offices for the carrying out of tests in connection with troubles occurring on subscribers' lines. A small testing cabinet of the wall type is used in offices which do not exceed 500 lines. A routine test box is to be found in every office, by means of which the operation of finders, connecting circuits, registers, markers, group and line selectors may be checked.

Two test lines are allotted in each office. The first one closes a loop after a call has been received and automatically replies to test calls. The second line is connected to a step-by-step selector with its arc connected to all the outward junctions from a center, subcenter, or district office. This device makes it possible to test all the junctions of the network from one central point. The step-by-step selector advances one step at a time under the influence of impulses received from rural main. Thus the junction network is tested regularly once a week by an operator at rural main.

Certain classes of faults are signalled locally and simultaneously towards Zurich. The alarm is transmitted individually by office over an ordinary junction line; should this junction be found busy, the signal is delayed until it becomes free. The following alarms are signalled as "urgent" (flashing of the alarm lamp of the office under consideration):

Alternating current supply failure.
Main shaft motor stops.
Battery tension either too high or too low.
Ringing current supply failure.
A main circuit-breaker defective.
All first or second finders constantly busy.
All registers constantly busy.
A control circuit permanently busy.
All false call circuits permanently busy.

The alarms enumerated below are signalled as "not urgent" (alarm lamp lights steadily):

Defective heat coil.
Defective line finder, group or final selector fuse.
The charging of the battery is interrupted.
The duplex motor is permanently running on d-c.

Maintenance

As long as an automatic office is under the control of a manual office, and the requirements are not too exacting, it is sufficient to remove the faults as they happen to be reported. The requirements are, however, quite different in a large automatic area; for, while a subscriber's complaint regarding a defective connection may yield helpful information, it is not an easy matter in most cases to locate the circuits that are at

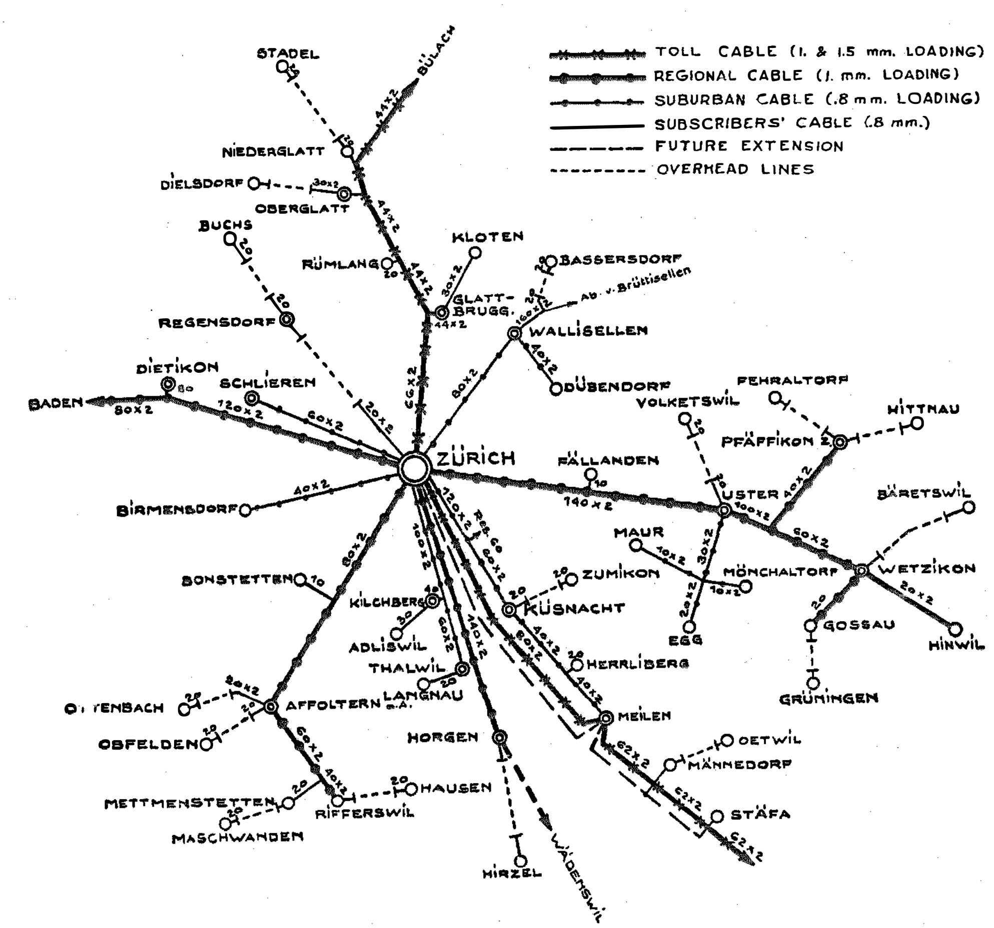


Figure 10—Cable Plan.

fault. In the full automatic system satisfactory results can only be obtained by systematic tests and periodic maintenance. These preventive tests are intended to disclose equipment defects before the service may have become affected and also to reduce undue wear of the parts. While shortening the time interval between periodic tests makes for improved service, cost considerations point in the opposite direction. A compromise, therefore, must be resorted to in practice.

Keeping in mind the above considerations, the following program has been elaborated for the guidance of rural office repairmen:

1. Internal Maintenance

Routine tests	
Registers, starting and alarm circuits:	Once a week.
Connecting circuits and zone markers:	Twice a month.
Line finders, group and final selectors:	Once a month.
Mechanical maintenance	
Finders:	Every two years.
Step-by-step selectors:	Once or twice a year.
Relays:	As required.
Shafts, gears, ball bearings:	Every two years.
Switchrack motors:	Once a year.
Ringing machines:	Twice a year.
Concentration tests for eliminating faults in the multiple:	Once a year.
Balance tests for feeding relays and condensers:	As required.
Tests for determining the quality of the service:	Each repairman should make about 200 calls per month.
Fault removal of any defect occurring in an office.	
Message register tests:	These should be performed upon receipt of customers' claims and as required.
Multiple metering tests:	Every two years.
Meter readings:	At the end of each month.
Battery maintenance	
Full discharge and interrupted charge:	Every two months.
Addition of water and acid density equalization:	As required.
Inspection of fuses:	Once a month.
Cleaning	
Apparatus, bays, and machines:	Once to three times a year.
Cleaning of premises:	As required (work performed by charwomen).

Ventilation: The ventilation of offices should be satisfactory, and means should be devised to protect them from dust and humidity.

Heating: The electric heating devices should be switched in for their one-third, two-thirds, or full load value in accordance with outside temperature conditions.

2. External Maintenance

Determination of faults in subscribers' equipment.

Removal of faults at the subscribers' premises or on the outside lines.

3. Main Distributing Framework

Cross connections for new subscribers, transfers, absences, feeding bridges, tax indicators, telediffusion, and fire alarm.

Cabling changes.

Line changes.

Keeping of subscribers' directories.

4. Installation Work

Installation of relays for tax indicators and prepayment stations.

Extensions to existing relay sets for party line connections.

Installation of new fire alarm groups.

Installation of telediffusion frameworks.

Routine tests should be performed in the following instances: for an ordinary connection, for a busy connection, for a double test, for metering and nonmetering, for multiple metering, release by the called subscriber, false calls, dead lines, dead levels, and the breakdown after the twelve-minute conversation interval.

Mechanical tests relate to wear, bent piece parts, contact pressures, gear operation, cleaning, and greasing. Supplementary electrical tests under normal current conditions are also made as required.

Maintenance men are also obliged to care for the proper operation of apparatus at the subscribers' premises.

Repairmen likewise have to perform considerable work at the main distributing frames, this work being especially heavy in the localities near Zurich. Installation work on an average requires two men for fifty offices.

Offices are inspected periodically in accordance with the magnitude of the work involved, i.e., main frame changes, routine tests fault reports, and monthly meter readings. Small offices are visited on an average of once a week.

For maintenance purposes, the network has been subdivided into ten sectors. Each sector comprises five offices and about 1,050 subscribers or about 1,500 lines. Eight sectors, i.e., Küsnacht, Thalwil, Horgen, Affoltern a/A, Meilen, Wallisellen, Uster, and Wetzikon are in charge of local repairmen; two sectors are taken care of by Zurich mechanics. Each of the ten men is furnished with a small autocar.

Two more mechanics are employed at the present time for the more important maintenance work, such as that involving drives, motors, etc. Two assistant mechanics are constantly busy on installation work, there being two more such men to provide for cases of emergency, sickness, holidays, accidents, or military service.

A chief installer is in charge of the personnel and of all the installations. It is highly probable that, the men gaining in experience as time goes on, it will be possible to use two of them in the new center offices to be installed at

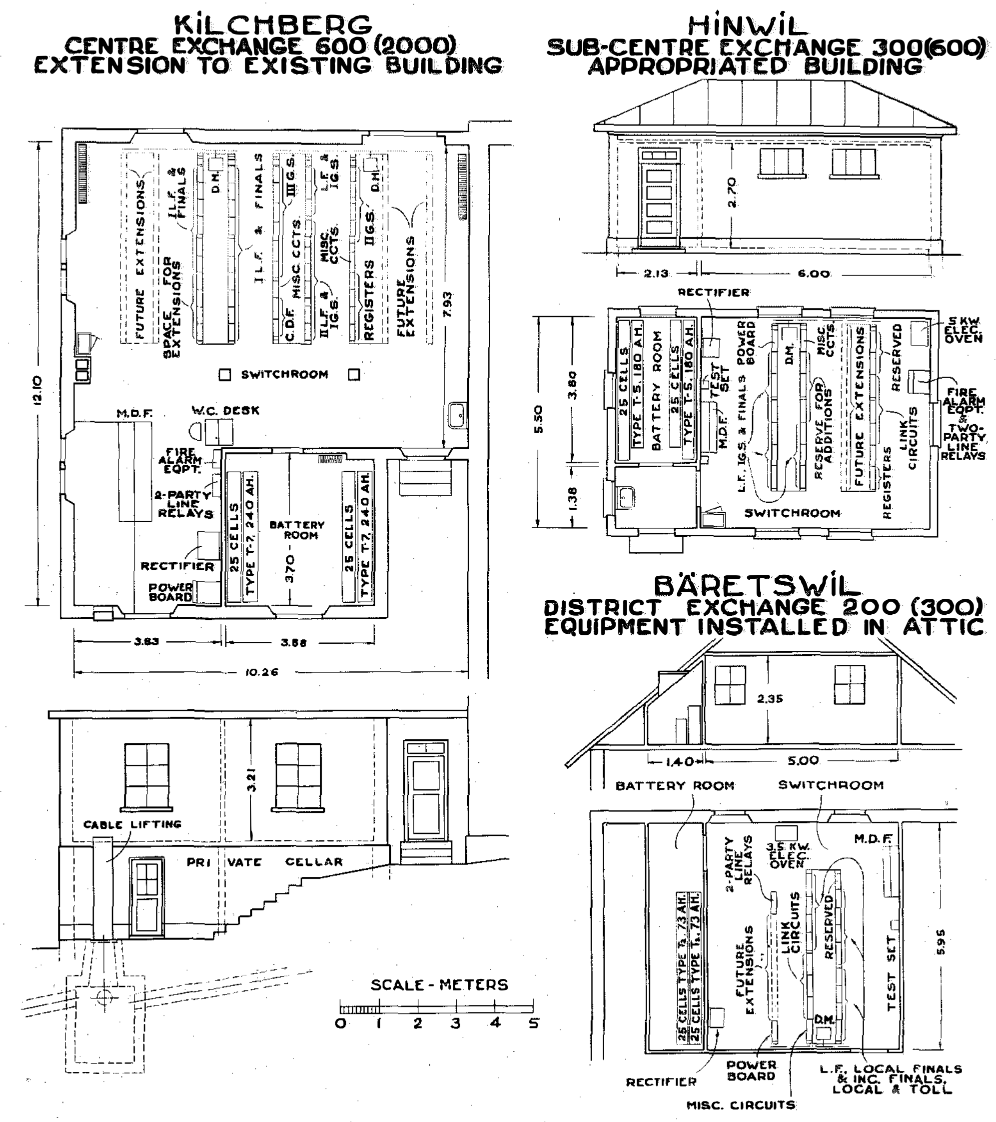


Figure 11—Building Plans.

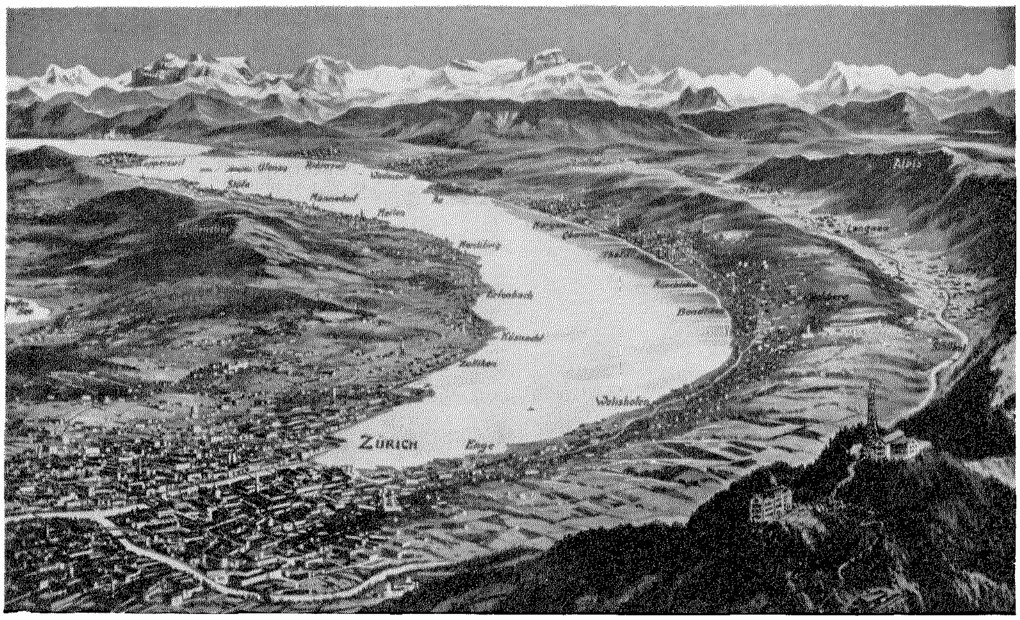


Figure 12—Zurich with Its Lake and the Alps.

Wädenswil and Bülach without increasing the present staff.

The work has been so planned that neither overtime nor night hours are required. Furthermore, none of the inspection work is ever placed in the hands of the supplier of the apparatus.

The staff of seventeen maintenance men (including the foreman and the reserve men) devote 65% of their time to the maintenance of central offices, 10% to subscribers' network troubles, 12% to main framework, and 13% to installation.

Two and one-half hours per subscriber per annum, including sickness, vacations, etc., are required for the maintenance of a rural office. The expenses involved amount to Fr. 6.20 per subscriber per annum. The time required for traveling is about 13%, which figure also applies for substitutions in cases of sickness, vacation, etc.

Three repairmen are kept busy on the outside plant, not including the local man. They take care of inspection work in connection with installations carried out by private concessionaires. All faults are reported to a centralized point at the Selnau main office and handled at the test desk of this office. The removal of a fault is assigned either to the local mechanic or the repairman. About 70% of the troubles occurring on the lines and at subscribers' premises are cleared by the repairmen, and 30% by the local mechanics.

Traffic and Quality of Service

The daily traffic of the rural network amounts to about 40,000 connections, of which

- 11,000 are local connections,
- 1,500 are rural connections within the tandem office sector,
- 9,000 are connections from rural to city,
- 1,500 represent connections from rural in transit over Zurich,
- 10,000 are inward connections from Zurich to rural,
- 3,500 are outward toll connections,
- 2,000 are incoming toll connections originated at the toll office,
- 1,500 are incoming from the automatic toll lines.

The calling time required to complete a connection, from the moment the last digit has been dialled to that at which the subscriber hears the ringing or busy tone, has been measured for different types of connections, with the following results:

Local call in a center, subcenter, or district office:	1–3 seconds.
A call from a center office to a subcenter or district office:	2–3 seconds.
A call from a center, subcenter, or district office to a subcenter or district office:	3–6 seconds.
A call from a center, subcenter, or district office to a city office:	4–7 seconds.
A call from a city office to a center, subcenter, or district office:	5–8 seconds.

Routine calls are put in at frequent intervals to test the quality of the service; the calls being made at different hours and on different days of the week. Care is taken that they are received each time by a different circuit, and the same number is usually not repeated at frequent intervals. In this way it is possible to make tests in a great number of directions. The results obtained are given in the accompanying table.

ROUTINE CALLS IN THE ZURICH RURAL NETWORK

Month: June, 1934 / July, 1934

From Office / To..................	Connections O.K.	Faults.				Total Faults	% of Faults
		Does Not Progress	Wrong Number	Wrong Metering	Misc. Faults		
Selnau to Rural:							
June..................	920	–	2	–	1	9	0.44
July..................	1150	2	1	2	1		
Hottingen to Rural:							
June..................	1300	4	–	3	–	8	0.35
July..................	950	1	–	–	–		
Riedtli to Rural:							
June..................	520	2	–	–	–	4	0.44
July..................	400	–	1	–	1		
Rural—Local:							
June..................	600	–	–	–	–	1	0.08
July..................	600	1	–	–	–		
Rural—Rural:							
June..................	640	–	1	–	2	6	0.46
July..................	600	2	–	–	1		
Rural to City:							
June..................	600	1	–	–	–	5	0.42
July..................	600	3	–	–	1		
Toll to Rural:							
June..................	1050	5	–	–	6	16	0.94
July..................	650	1	1	–	3		
Total..................	10,640	22	6	5	16	49	——
% of Faults..............	——	0.20	0.06	0.05	0.15	—	0.46

Conditioned Air in Telephone Exchanges

By S. FLEMONS, M.I.E.E.

Chief Engineer, Shanghai Telephone Company

THE problem of providing clean dry air for telephone exchanges has been receiving the attention of telephone engineers for a number of years. Circulation of air, and the exclusion from air entering the switchrooms of extraneous matter forming deposits on the apparatus, were given first consideration. More recently, since the art of telephony has become world-wide and telephone equipment consequently must operate satisfactorily in all climates, the control of the moisture content of the air has become an important factor in the operation and maintenance of telephone exchanges in localities where high relative humidity conditions prevail.

The object of this paper is to give briefly the principles of air conditioning, the reasons why air conditioning is necessary, and a short description of the plant installed by the Shanghai Telephone Company for the protection of central office automatic equipment in a climate where high humidity and temperature exist, and where much pollution of the air occurs from the numerous manufactories located in the city.

It is well known to telephone engineers that, when the relative humidity in rooms housing automatic equipment exceeds a certain point for long periods, there is a possible danger to plant. The humidity makes its effects felt in reducing the insulation resistance of cables, wiring, and equipment; and, after long periods of exposure to high humidity, electrolytic action will take place between the various exposed metallic parts which may be carrying different potentials. Trouble also results from the absorption of moisture by insulating material, such as fibre, causing mechanical disturbances in the operation of the plant.

Shanghai is located in a climate where abnormally high humidity exists for many months of the year, and high temperature is experienced during the summer months. Fig. 1 is a chart which was prepared from daily readings taken locally by the Ziccawei Observatory authorities over a three year period and shows the number of observations during the year when relative humidity was over 70% and when it was under 70%. The most extreme conditions that occurred during the period were in July, 1931, when on only four occasions during the month the readings were below 70% relative humidity, while 43.3% of the readings taken ranged between 95 to 100% relative humidity.

Fig. 2 is a chart prepared from local readings taken hourly over a three day period during July, 1933. It is typical of the temperature and humidity conditions existing during the summer months and shows temperature and humidity readings during the period for: (*a*) Outside atmosphere, (*b*) Inside building non-air conditioned rooms, and (*c*) Inside building air conditioned rooms. From these observations it is estimated that the relative humidity in the non-air conditioned rooms remained over 70% for approximately 66 hours during the 72 hour period over which the readings were taken. In other words, during 91.7% of the day, the equipment in the automatic offices would have been exposed to the danger of breakdown from moisture in the atmosphere had no means been taken for its protection.

Fig. 3 is a copy of a chart made from data obtained from the Ziccawei Observatory, showing the monthly mean relative humidities and monthly mean temperatures plotted from observations taken over a period extending from 1873 to 1927. This chart also shows the daily means of temperatures and relative humidities for the year 1927. It is interesting to note that the mean relative humidity over this extended period exceeds 76%, while for eight or nine weeks of the summer months the mean is 84%. From these charts, it will be seen that long periods exist throughout the year, including the cooler months of January, March, etc., when the relative humidity in Shanghai exceeds 70%, and that risks of breakdown are present unless precautions are taken to control the humidity by conditioning the air in the automatic offices.

No data are available concerning soot deposits in Shanghai, but foreign matter normally in the

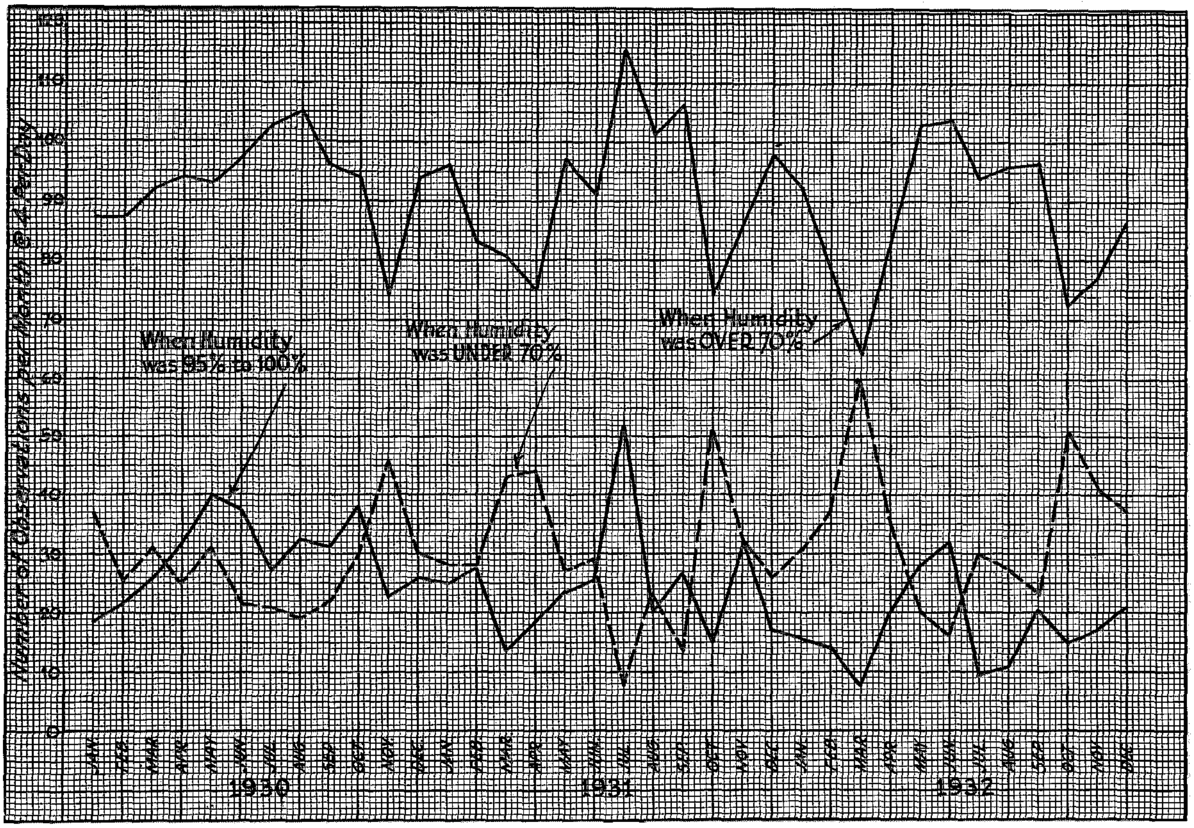


Figure 1—Chart Showing Number of Observations when Relative Humidity was over 70% and when it was under 70%.

air in this city is considerable. At times effects from the sand storms in the Gobi Desert, 800 miles away, are felt in Shanghai and the atmosphere is charged with particles of fine sand, which seeps its way into every nook and corner, leaving a deposit which is difficult to disperse. While such occasions are infrequent, they would be a serious menace to the maintenance of the service of the automatic offices if no provision were made for the protection of the plant.

In order to protect its automatic equipment from humidity and dirt in the air, the Shanghai Telephone Company has taken the precaution to install in all of its automatic offices air conditioning plants which both cleanse the air and control the temperature and percentage of humidity of the air supplied to the equipment rooms. Before describing the plant, a brief outline of the principles of air conditioning will be given.

It is well known to meteorologists, or to those familiar with the characteristics of the atmosphere, that the humidity or moisture content that can be held in the air is dependent on its temperature. At low temperature the moisture content that can be held is small in comparison with the moisture content that can be held at high temperature. Thus air at 32°F. will be saturated when it contains two grains of water per cubic foot, whereas air at 92°F. contains 16 grains per cubic foot when saturated. The saturation point is reached when there is mixed with the air all the water vapour it can hold.

The temperature at which saturation takes place is known as the "dew point" because it is at this temperature that moisture begins to condense and is deposited in the form of dew. The quantity of moisture actually present in a given volume of air, irrespective of temperature, is known as the "absolute humidity."

Since air is generally below the saturation point, it follows that there can be a varying water content in the air at a constant temperature. The moisture content present is expressed in terms of "relative humidity," i.e., the percentage or ratio of the actual amount of moisture contained by a cubic foot of air to the amount

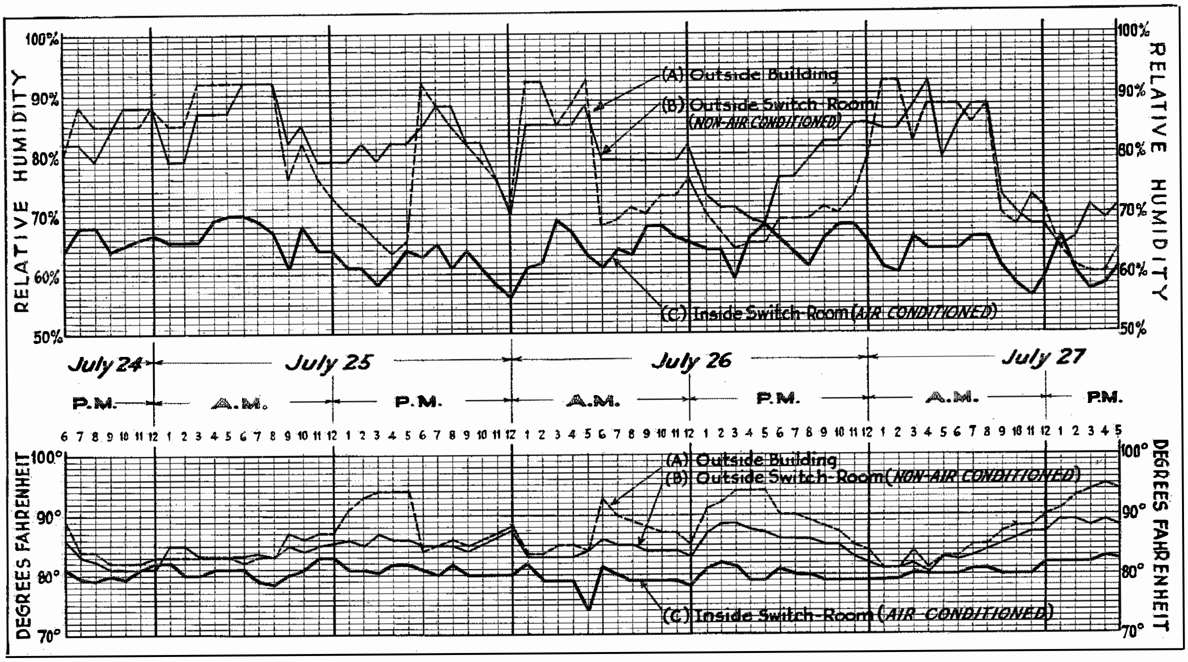


Figure 2—Three Day Record of Observation of Temperature and Relative Humidity—July 25th to 27th, 1933.

which one cubic foot of air would hold at the same temperature if saturated. Thus a relative humidity of 70% means that the air at its given temperature contains 70% of the moisture content required to saturate it at the same given temperature.

Since relative humidity depends upon both the temperature and the moisture content of the air, it becomes an important factor of measurement in the regulation of conditioned air. It is usually read by wet and dry bulb thermometers; the dry bulb temperature is that indicated by an ordinary thermometer, and the wet bulb temperature by a thermometer furnished with a moistened wick wrapped around the bulb. The wet bulb thermometer indicates the temperature of the surrounding atmosphere minus the latent heat absorbed as a result of the evaporation of moisture from the wick. In a dry temperature, evaporation is great and the reading of the wet bulb thermometer falls below that of the dry bulb thermometer. When the air is damp, evaporation is less and the readings of the two thermometers are nearer to each other; but, in saturated air, where there is no evaporation, the readings of both the wet and dry bulb thermometers are identical and thus indicate a relative humidity of 100%.

The above characteristics of air are the basis of air conditioning where dehydration is desired. An easy and reliable means of controlling the temperature and humidity of air is by the use of refrigeration for industrial work and this is the method that has been adopted by the Shanghai Telephone Company for dehumidifying the air in the equipment rooms of its automatic Central Offices. The plant installed is illustrated diagrammatically in Fig. 4 and consists of:

(*a*) Refrigeration machinery for cooling water used in the dehumidification of the air;
(*b*) Air conditioning machinery for dehumidifying and cleansing the air; and
(*c*) Air circulating plant for the distribution of the air.

Description and Operation of Refrigerator

There are several different ways of producing refrigeration, but the method most generally favoured is with the use of ammonia as the refrigerant. Ammonia has the property of vaporising at low pressures, its latent heat of vaporisation being high.

The Refrigerating Plant comprises:

Evaporator and Baudelot Water Cooler:	The object of which is to extract heat from water. It consists of a series of tubular coils arranged in a tank through which the water to be cooled is passed.

Ammonia Compressor: The object of which is to increase the pressure of the refrigerant so that it may be condensed into the condition of a liquid again. It consists of a gas pump driven by an electric motor.

Oil Separator: The object of which is to remove from the refrigerant any particle of oil that may have passed with it from the compressor. It consists of a series of metal baffle plates inside of a container.

Condenser: The object of which is to liquefy the ammonia by means of cooling water and to render possible the use of the same refrigerant continuously. It consists of a series of tubular coils arranged in a steel casing through which the cooling water is passed.

The process of refrigeration is as follows:

The tubes in the evaporator are charged with liquid ammonia. When the compressor is put into operation, this liquid is reduced to low pressure due to suction from the compressor, and so vaporises. In the process of the ammonia passing from the liquid into the gaseous state, heat is absorbed from the water passing through the tank, the cold water thus obtained being collected at the tank and used for dehumidifying the air, as explained later. The gaseous ammonia which, under normal operating conditions, has a pressure at this point of 40 lbs. to the square inch and a temperature of 12°F., is now drawn from the evaporator into the compressor where it is compressed and passed on to the condenser via the oil separator. The high pressure gas passing through the oil separator impinges on the baffle plates, and so removes from the ammonia any particles of oil that may be forced with the ammonia from the compression chamber and permits only clean ammonia gas to pass into the condenser. While the plant is in operation, cooling water is supplied to the condenser. The water circulating around the tubes through which the ammonia gas is passing removes from the ammonia the heat which was generated in the process of vaporation and compression, thus causing the gas to liquefy again. The liquid ammonia is passed on to the expansion valve, reaching this point at a pressure of 200 lbs. and a temperature of 96°F., and then into the

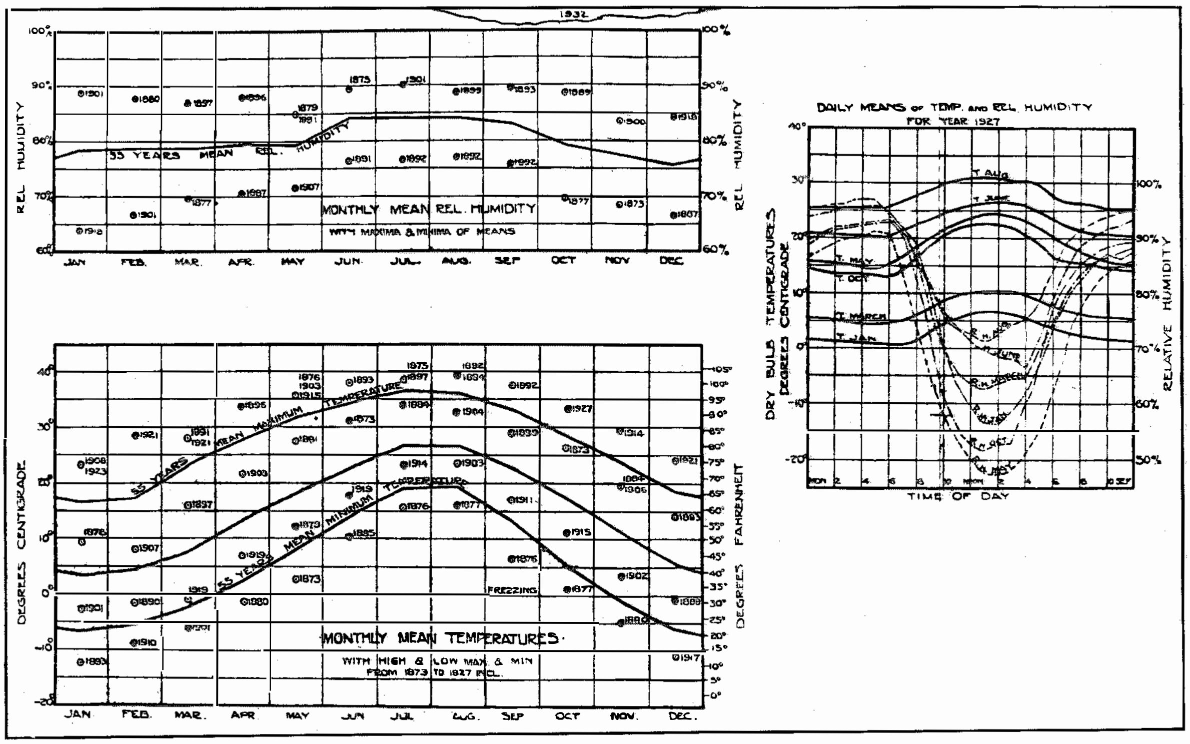


Figure 3—Meteorological Data for Shanghai—Plotted from Bulletin of Ziccawei Observatory, Year Book 1927, from "Air Conditioning" by S. E. Faber, A.F.C., PROCEEDINGS OF ENGINEERING SOCIETY OF CHINA, *1932.*

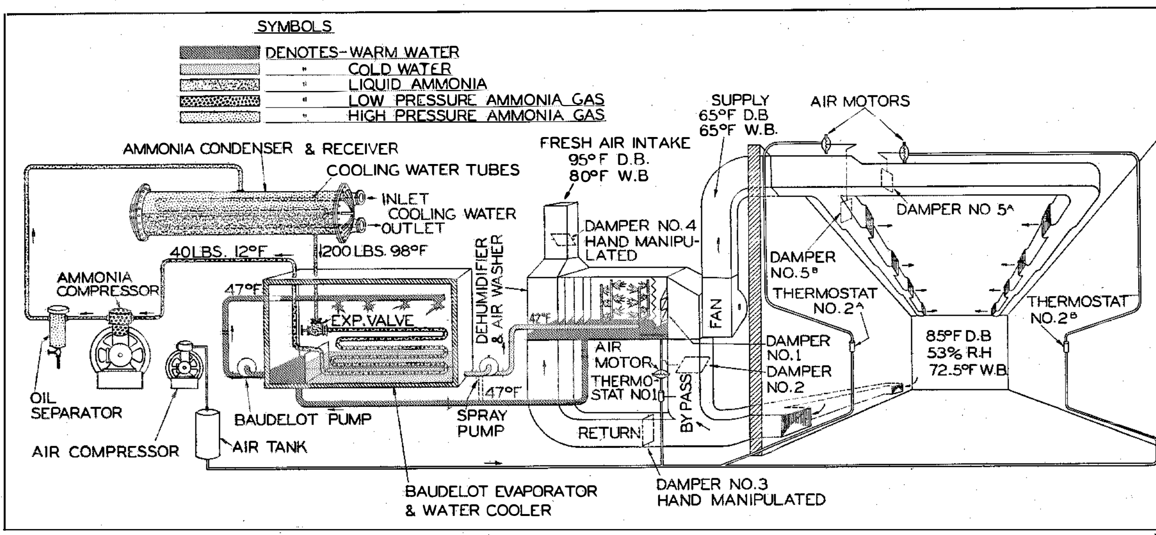


Figure 4—Schematic Plan of Air Conditioning Equipment.

evaporator where heat is again extracted from the water; and the cycle is repeated as long as the apparatus is in motion. The circulation of the refrigerant may be seen at a glance from Fig. 4.

Description and Operation of Air Conditioning Machinery

The dehumidifier, with the associated air washer and fan, is in fact the air conditioning chamber. It is the dehumidifier that sends clean dehumidified air into circulation, and receives back the moist air with its impurities, reconditions it, adds fresh reconditioned air and recirculates it again throughout the system.

The combined dehumidifier and air washer consists of a large chamber fitted with vents for the ingress and egress of the air and forms part of the air circulation system. It contains diffusion plates for providing an even distribution of the air over the water sprays. The water sprayers cool and wash the air; baffle plates also are used for cleansing purposes. The process of dehumidifying and cleansing the air is as follows:

The air is cooled with the supply of cold water available in the evaporator chamber. The water is pumped from the evaporator tank into the air washer chamber, where it is passed through a number of spray nozzles so arranged that the discharge forms a uniformly dense bank of finely divided mist in the body of the chamber.

The air to be conditioned is drawn into the chamber by means of the circulating fans. Diffusion plates are fitted across the chamber in the air inlet channel, so that the entering air strikes the plates and is diffused so that any eddies and stratification in the air stream are eliminated. By this means the air, in uniform volume, is passed through the spray chamber where it impinges on and mixes with the bank of cold mist formed by the spray and thus is reduced in temperature. While the humidity of the air remains at 100%, or at the saturation point, moisture is given up, since the water content is reduced to that governed by its new temperature. The spray both cools and washes the air. As the air leaves the washing chamber it passes through a set of staggered plates which baffle the air from right to left, so that it is scrubbed against the wet surfaces of the plates. This is a further cleansing action, the result being that the air leaving the chamber is practically free from any dirt or solid foreign matter that may have been present prior to its entry into the air washer.

The water used for the cooling spray, which has absorbed heat from the air passing through the spray, is collected in the base of the air washing chamber, whence it is drawn back into the water cooler by means of the Baudelot pump. It is again cooled and then passed on to the air washer by means of the spray pump. This cycle is continuous while the plant is in operation and is clearly indicated in Fig. 4.

Provision is made whereby the supply of water from the cooling chamber can be shut off if desired. Therefore, during the cold season, if refrigeration is not required, the water for the spray nozzles is pumped from the settling tank in the base of the air washer, thus short-circuiting the circulation from the water cooler chamber, as shown in dotted lines in Fig. 4.

Description and Operation of Air Circulating Plant

The air circulating plant comprises the circulating fan, supply ducts, return ducts, fresh air intake, dampers, thermostats, and air compressor. The object of the circulating plant is to supply conditioned air to the rooms where dry clean air is required, and to withdraw moist and impure air from the rooms. The operation of the circulating plant (Fig. 4) is as follows:

The ducts from the fresh air intake and for the return air from the conditioned rooms are connected to the ingress vent of the dehumidifier and air washer. The supply ducts and fan are associated with the egress vent. A duct is provided for short-circuiting the passage of the return air directly to the egress vent and by-passing the dehumidifier and air washer; the by-pass, however, is normally closed and is used only when partial or no dehumidification is required.

Air from the fresh air and return air inlets is drawn into the dehumidifier and air washer by means of the circulating fan, where it is conditioned, passed along the supply ducts, and distributed evenly throughout the rooms via the outlets provided in the ducts. The conditioned air leaves the dehumidifier at a temperature of approximately 65°F., and a relative humidity of 100%. At first glance it may appear strange that air at the saturation point is taken into the rooms where the supply of dry air is the fundamental purpose, but it must be remembered that

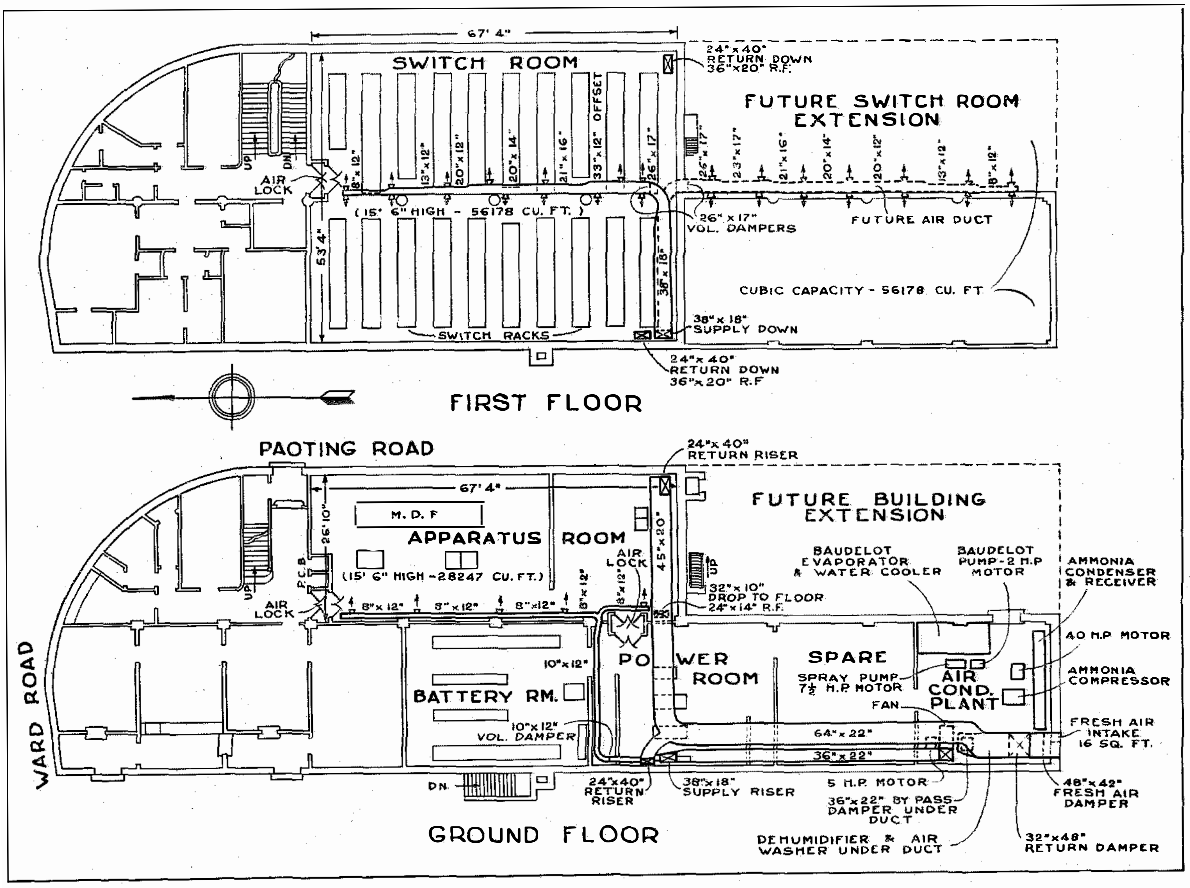


Figure 5—General Arrangement of Air Conditioning Equipment—Wayside Central Office.

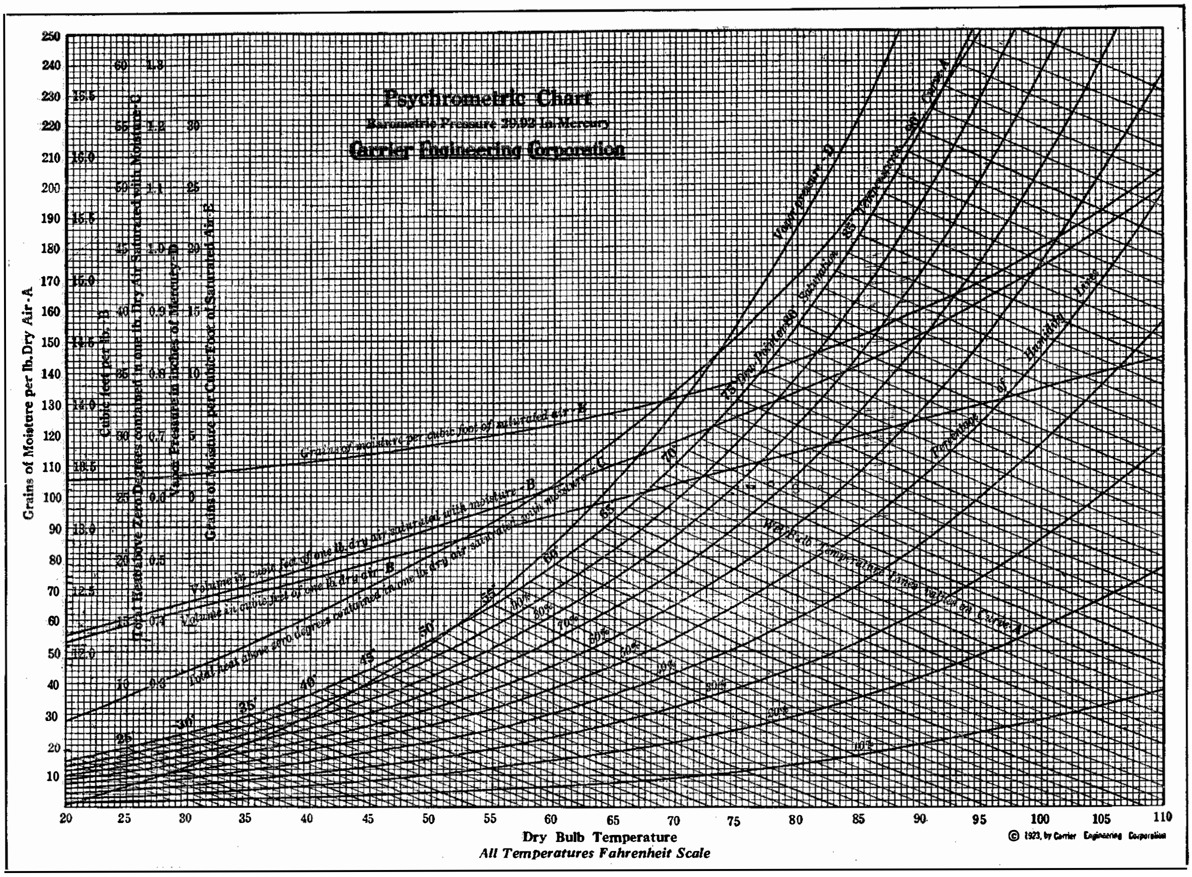


Figure 6—Psychrometric Chart—Barometric Pressure 29.92 Inches Mercury.

the moisture content of air at 65°F., is low in comparison with air having 100% relative humidity at higher temperatures.

Though a certain amount of heat is absorbed in its passage through the ducts, the air enters the room at a comparatively low temperature and high relative humidity. There it meets and diffuses with the room air, which has a higher temperature and a lower relative humidity. The incoming air, absorbing heat from the room, is raised in temperature and absorbs moisture from the air in the room and reduces the relative humidity of the room air, since air at higher temperatures can hold a greater quantity of moisture. At about breathing height complete diffusion may be considered to have taken place, and the room temperature will be approximately 85°F. with a relative humidity of 55%.

Circulation is completed by air being withdrawn from the room via the return duct inlets, whence it is passed back to the dehumidifier for reconditioning.

The above description covers normal circulation usually pertaining to the hot humid months of the year when full dehumidification is necessary for most of the 24 hours of the day. During this period, the volume of fresh air taken in is limited, for more refrigeration is required with the use of fresh air. A supply of fresh air equal to 10% of the volume in circulation provides both economical and efficient operation, this amount being sufficient to maintain the standard of air required for the personnel in the rooms. Control of the air supply is obtained by four dampers fitted in the main ducts adjacent to the dehumidifier. Dampers in the fresh air intake and return ducts are hand controlled and need manipulation only at seasonal atmospheric changes. The dampers in the by-pass and dehumidifier are used at more frequent intervals and are controlled automatically by the use of a thermostat and air motor.

During the hot humid months the fresh air damper is closed to permit entrance of only the limited amount of fresh air to be used, while the return air dampers are opened to allow full circulation of the return air. During cold weather, when the outside air drops below 50°F., and refrigeration is not required, the fresh air damper is opened and the return air damper is closed.

The dampers controlling the by-pass automatically regulate the dehumidification of the air. If the temperature of the air in the rooms is below that desired, the temperature of the air circulating in the return duct on its way back to the dehumidifier brings thermostat No. 1 into action, thus causing the air motor to operate damper No. 1, closing the egress vent of the dehumidifier, at the same time opening damper No. 2 and thereby diverting the circulation of the air via the by-pass duct. The circulation via the dehumidifier being closed, supply of cool air ceases and the air in circulation warms up.

On the other hand, when the temperature of the air in the rooms exceeds the desired point, air returned from the conditioned spaces acting on the thermostat causes the air motor to cease operation. This in turn opens the dehumidifier damper and closes the one in the by-pass, thus allowing the passage of cooler air to the rooms.

A similar control is provided in the main duct supply for sectional regulation of the air in conditioned spaces. Where the duct work splits to supply air to different sections of the building or rooms, dampers operated by air motors are placed to regulate the supply of air, the air motors being controlled by thermostats placed in the rooms. The thermostats can be set at any required temperature so that during the hot summer months when it is the usual practice to maintain a temperature in the rooms of approximately 10°F. less than the temperature of the outside atmosphere, the thermostats provide a means of maintaining this temperature. Should the temperature in any one section drop below the desired point, the thermostat will automatically shut off the air motor and allow the damper in the supply duct to close, thus reducing the amount of conditioned air supplied to the room.

The reduction in the quantity of incoming cold air permits the room to gradually warm up. When the temperature rises to the desired point, the thermostat operates, opening the dampers and admitting the full quantity of cold air, so that an even temperature is automatically maintained in the rooms.

The thermostat and air motor control plant consists of an air compressor, air tank, air motors, and thermostats, each being connected together by conduits as indicated in Fig. 4.

The air compressor is the source of compressed air for the operation of the air motors. It is driven by an electric motor, and is equipped with an automatic pressure switch. When commencing operations, the motor driving the compressor is started manually. As soon as the pressure in the air tank reaches 35 to 38 lbs. per square inch, which is the pressure desired at this point, the pressure switch operates and cuts off the motor which does not operate again until the pressure in the tank has fallen to 23 lbs. when the contacts of the pressure switch are closed and the compressor starts again. This cycle of operations continues until the motor is manually switched out of circuit.

The air, after leaving the air tank, passes through a reducing valve in order to decrease the pressure to 15 lbs., as required to operate the air motors. The thermostats in reality are air valves automatically operated by temperature changes. When the temperature rises beyond the desired point, expansion of a brass cylinder in the thermostat opens a valve to permit air to pass to the motor. When the temperature decreases, due to the cooling of the room, contraction of the brass cylinder again causes the valve to function and diverts the supply of air from the motor through a small air leak, whereby it is discharged into the atmosphere. The air motor is not a rotating machine, but merely produces the necessary motion to set the dampers.

Design of Plant

In all, a total of seven air conditioning plants have been installed in the buildings of the Shanghai Telephone Company. As a specific example, details will be given of the Wayside Central Office installation, which is typical of the equipment in the other six buildings.

The general problem to be met was to supply air free from dust, dirt, or other foreign matter, and to maintain a temperature in the air conditioned rooms 10°F. below outside temperature during the hottest season and, if desired, a relative humidity not exceeding 55% at any time.

An important consideration, also, was the fact that all the Central Office buildings were constructed to meet the requirements for the immediate future, but at the same time were so designed that additions could be made as and when desired to accommodate automatic telephone plant for the estimated ultimate development of the Central Office area. Before any decision could be given as to the capacities of the plant to be installed, it was necessary, therefore, to determine whether the initial installation of the air conditioning plant should be of sufficient capacity to allow for the future extensions, or if it should be designed to meet immediate requirements only. Investigation proved that provision of the main items of the air conditioning plant to meet ultimate requirements would be the most favourable, and the plant was designed accordingly.

A plan of the Wayside Central Office is given in Fig. 5, which shows the layout, both present and future, of plant and ducts. All windows in the air conditioned rooms are sealed, and two sets of doors are provided at each entrance to the rooms (Fig. 5) in order to keep infiltration losses to a minimum. These precautions are important inasmuch as they permit the infiltration losses to be computed on the basis of a complete change of air in the room in 8 hours, whereas normal infiltration loss is usually taken as a complete change in 5 hours, and thus have a bearing on both the operation and first cost of the plant.

In calculating the size of the plant, the main factors are:

1. Cubical contents of space to be conditioned;
2. Amount of heat that must be absorbed by the cooling plant; and
3. Amount of air to be circulated.

Having obtained these data, the size of the evaporator and water cooler or the amount of refrigeration required, also the capacity of the dehumidifier and the air duct distribution system, can be determined.

Details of the various items follow:

For cubical contents of space to be conditioned, see Fig. 5 and Table I.

The size of the cooling plant is based on the amount of heat that must be absorbed by the plant. This heat loss is expressed in B.T.U. (British Thermal Unit) or "Tons of Refrigeration," one ton of refrigeration being equivalent to a cooling rate of 200 B.T.U's. per minute.

The following computations give the heat gain for the Wayside Central Office, and include both present and ultimate requirements of the building.

Heat Gain by Direct Radiation

		B.T.U. Per Minute
Switchroom—Glass from Sunrays	400 sq. ft. × 0.5 B.T.U. =	200
Switchroom—People	10 × 5 B.T.U. =	50
Switchroom—Electrical equipment	5 kw. × 57 B.T.U. =	285
Apparatus Room—People	10 × 5 B.T.U. =	50
		585

The number of square feet in this and the following cases is obtained from the building plans. The number of people and power in kilowatts are based on estimated probabilities.

The value of 0.5 B.T.U. for direct rays through glass is the practical heat gain from direct radiation of the sun through one square foot of glass per minute per degree difference in temperature between the two sides of the glass.

The value 5 B.T.U. for heat gain from people is the sensible heat loss given off from a person per minute when engaged in light duties (sensible

TABLE I
CUBICAL CONTENTS OF SPACE TO BE CONDITIONED (Fig. 5)

Switchroom Present	Apparatus Room Present	Total Present	Switchroom Ultimate Additions	Apparatus Room Ultimate Additions	Total Ultimate Additions	Total Cubical Contents
cu. ft. 56,178	cu. ft. 28,247	cu. ft. 84,425	cu. ft. 56,178	Nil	cu. ft. 56,178	140,600

heat being heat transmission by radiation, convection, and conduction).

The value of 57 B.T.U. for heat dissipation from electrical equipment is based on the heat equivalent for electrical energy:

1 watt = 3.412 B.T.U. per hour, or

$$1 \text{ kw.} = \frac{3.412 \times 1{,}000}{60} = 57 \text{ B.T.U. per min.}$$

Heat gain from illumination is disregarded since, in the equipment rooms, illuminating is mostly limited to the hours after sunset so that the heat gain from illumination is balanced by the drop in heat gain from the sun that occurs after daylight hours.

Heat Gain by Conduction

		Sq. Ft.	Co-efficients	Temp. Difference	B.T.U. Per Hour
Sunny Sides:					
Switchroom—	Wall	1600	× 0.4	× 15	= 9,600
	Roof	7000	× 0.25	× 50	= 87,500
Apparatus Room—Nil					
Shady Sides:					
Switchroom—	Glass	400	× 1.1	× 10	= 4,400
	Wall	2590	× 0.4	× 7.5	= 7,770
	Partition	837	× 0.6	× 5	= 2,511
	Floor	3400	× 0.8	× 5	= 13,600
Apparatus Room—	Glass	200	× 1.1	× 10	= 2,200
	Wall	800	× 0.4	× 7.5	= 2,400
	Partition	1060	× 0.6	× 5	= 3,180
				Total:	133,161

$$\frac{133{,}161}{60} = 2{,}220 \text{ B. T. U. per minute}$$

The coefficients are taken from tables based on practical knowledge of the materials in question.

Temperature difference is an estimate of the maximum temperature difference between inside and outside surfaces of the item in question.

Heat Gain by Infiltration

$$\text{Switchroom: } \frac{112{,}356 \times 10}{60 \times 8 \times 56} = 41 \text{ B.T.U. per minute}$$

$$\text{Testroom: } \frac{28{,}247 \times 10}{60 \times 8 \times 56} = 10.5 \text{ B.T.U. " "}$$

Where 112,356 and 28,247 = cu. ft.
10 = Temperature difference in degrees Fahrenheit between room and outside temperature
60 = Minutes
8 = One complete change due to infiltration in 8 hours
56 = $\left(\frac{1}{56} \text{ B.T.U.}\right)$ specific heat of air per cu. ft.

Amount of Air to Be Circulated

From the sum of the above computations, plus 10% added as a factor of safety, it is seen that the total heat gain in the rooms is 3,142 B.T.U. per minute. Sufficient air must, of course, be circulated from the rooms through the cooling plant to remove this heat.

The volume of air to be circulated depends upon the permissible temperature rise of air in the room, and the specific heat of the air. Specific heat of air is the ratio of its thermal capacity to the thermal capacity of water, and is taken as 0.241 B.T.U's. per lb. of air per degree Fahrenheit.

Referring to Fig. 4, it will be seen that the air leaves the dehumidifier at a temperature of 65°F., and is received into the return air duct at a temperature of 85°F.—a temperature difference of 20°F. Therefore, the amount of air needed, is:

$$\frac{3142}{20 \times 0.241} = 652 \text{ lbs. of air per minute.}$$

Since the air leaving the dehumidifier is saturated, its specific volume will be 13.5 cubic feet per lb. This can be seen from the Psychrometric Chart (Fig. 6) by reading vertically from 65° dry bulb to the intersection of curve "B" and horizontally to scale "B." The volume of air to be circulated, therefore, is:

652 × 13.5 = 8802 cu. ft. per min., the capacity required for the fan.

Amount of Refrigeration

The amount of heat computed above does not represent the total refrigeration required. It has been previously mentioned that a supply of fresh air equal to 10% of the volume in circulation was used during the hot humid months of the year, and it must be cooled.

The heat to be removed from the air is dependent upon the difference between the outside wet bulb reading, and that of the wet bulb reading of the air at the point of entry to the fan when leaving the dehumidifier. From a series of wet bulb readings taken by the local Ziccawei Observatory, it was found that in only a few cases the wet bulb reached 83°F., but that generally a maximum of 80°F. is recorded. This latter figure, therefore, may be taken as a maximum for wet bulb conditions prevailing locally, and be used as one of the factors for computing the amount of refrigeration required for the fresh air, as compared with a wet bulb reading of 72.5°F. for the recirculated air.

As the air is cooled to a temperature of 65°F., both wet and dry bulb, it is from the difference of this reading, and the wet bulb reading of the incoming air, that the total heat to be removed can be obtained.

The total heat contained in 1 lb. of air saturated with moisture when at a temperature of 65°F. can be found on the Psychrometric Chart (Fig. 6) by reading upwards from curve "A" for wet bulb temperature to the intersection of curve "C," and from this point reading horizontally to scale "C," which gives us the total heat.

The total heat of fresh air at 80° W.B. = 42.5 B.T U.
The total heat of air at 65° W.B. = 29.5 B.T.U.

Heat difference = 13 B.T.U.

The amount of air to be circulated being equal to 652 lbs., 10% of which is fresh air, the total heat gain from the fresh air supply equals:

$$13 \times 652 \times 0.10 = 848 \text{ B.T.U.}$$

The total heat of recirculated air 72.5° W.B. = 35.5
The total heat of air at 65° W.B. = 29.5

Heat difference = 6 B.T.U.

The total heat of recirculated air equals:

$$6 \times 652 \times 0.90 = 3521 \text{ B.T.U.}$$

Heat gain from other sources must also be taken into account, including moisture taken into the rooms by infiltration. The moisture when condensed in the dehumidifier adds its additional load to the refrigeration required, also the latent heat from the personnel in the room, heat from the pump motor, radiation from dehumidifier piping, etc. The total heat from these items is:

Infiltration $\frac{140{,}600}{8 \times 60} = 292$ cu. ft. per minute

where 140,600 = cubical contents of space to be conditioned; 8 = complete change of air in 8 hours; and 60 = minutes per hour.

$$\frac{292 \times 11 \times 1080}{7000} = 490 \text{ B.T.U.}$$

where 292 = cu. ft. per minute infiltrating air; 11 = grains of moisture per cu. ft. saturated air at 80°F.; 1080 = B.T.U. per lb. water; and 7000 = grains per lb. water.

Personnel $20 \times 3 = 60$ B.T.U.

where 20 = number of people, and 3 = latent heat per person.

Pump Motor $7.5 \times 42.5 = 319$ B.T.U.

where 7.5 = H.P. of motor, and 42.5 = B.T.U. per H.P.

Radiation from dehumidifier estimated to be 40 B.T.U.

Summary	
Fresh Air	848 B.T.U.
Recirculated Air	3521 B.T.U.
Infiltration	490 B.T.U.
Personnel	60 B.T.U.
Pump Motor	319 B.T.U.
Radiation from Dehumidifier	40 B.T.U.
Total:	5278
Plus 5% Safety	264
Total:	5542 B.T.U.

One ton of refrigeration being equal to 200 B.T.U., the amount of refrigeration $= \frac{5542}{200} = 27.7$ tons.

Water Circulation

Referring to Fig. 4, it will be seen that the water in the dehumidifier is heated from 42 to 47 degrees. The water required will be $\frac{5542}{5 \times 8.3}$ = 134 gallons per minute,

where 5542 = B.T.U.; 5 = Temperature difference of water; and 8.3 = lbs. per gallon of water.

Dehumidifier and Duct Capacities

Having found (*a*) Volume of air to be handled, (*b*) Refrigerating load, and (*c*) Water consumption, it is possible to obtain the size of the dehumidifier and the number of sprays required to provide the necessary cooling, also to find the duct diameter at the different sections of the distribution and return air ducts necessary to provide the correct flow of air throughout the rooms. While these calculations are of importance in the design of the portion of plant in question, they have no specific interest in connection with the general capacity of the plant. Details are therefore not given in this paper.

Details of Plant Installed

The plant installed to meet the requirements of the Wayside Central Office, as based on the preceding calculations, is as follows:

Circulating fan capacity approximately 10,000 cubic feet per minute, driven by a 5 H.P. motor.

Dehumidifier and air washer with capacity for handling 10,000 cubic feet of air per minute.

Centrifugal water pump with capacity of 128 gallons per minute; driven by direct coupling to a 7½ H.P. motor.

Vertical double cylinder ammonia compressor with capacity of 28 tons of refrigeration; driven by a 40 H.P. motor.

Oil separator, size 8 inches × 24 inches.

Condenser, horizontal multipass shell, and tube type and combination ammonia receiver; diameter 2 feet, length 16 feet.

Evaporator cooling chamber with cooling coils arranged in three stands and made of 1200 feet of 1 inch extra heavy ammonia piping.

Automatic air control consisting of: Air compressor driven by ½ H.P. motor, auto-starting switch, air tank, thermostat, and dampers.

Duct work consisting of: galvanized iron ducts for circulation of air.

Installation of Plant

During installation 3-inch layers of cork were placed on the bottom and sides of the machinery foundation to eliminate noise and vibration in the building, due to the operation of the plant.

Ducts conveying conditioned air through non-conditioned rooms were thoroughly insulated with layers of cork, asbestos packing, and canvas wrapping to prevent condensation and dripping of moisture from the ducts.

The placing of air ducts in the rooms requires special study for each individual office. The ducts cover considerable space and must be so placed that they in no way foul the apparatus bays, cable racks, etc. in the room. The supply outlets are placed at ceiling height, and the inlets to the return ducts are generally about 3 feet above floor level. The distribution of the outlets from the supply ducts, and the inlets to the return ducts must be so placed that no dead air pocket can occur in the room.

In the Wayside switchroom the supply duct was placed along the centre of the room with outlets on either side of the duct approximately 12 feet apart. Usually one or two intakes to the return duct are found to be sufficient in a regularly shaped room. Two inlets were found to amply meet the purpose in the Wayside switchroom. Care must be taken to avoid placing return air intakes adjacent to equipment bays, as there is a tendency for dust to be drawn towards the intake.

A very important factor in locating the outlets of the supply ducts is the permissible distance between the outlet and the equipment in the rooms, for it must be remembered that the reconditioned air when entering the room is around the saturation point. Tests were made for the purpose of determining the minimum permissible distance between the supply air duct outlets and equipment or cable in the room. The results proved that the minimum distance at which equipment should be placed away from the duct outlet decreases as the distance from the entrance line to the outlet increases, the entrance line being the point of entry of the main duct into the room. This is due to the effect of the room temperature on the air in the duct over that section of the duct exposed to the room. The variation of minimum distance permissible at which equipment may be placed, taking 70% relative humidity as the margin of safety, is given in Fig. 7. It will be seen that where the outlet is 2 feet away from the entrance line, the minimum distance to the equipment must be 32 inches, or again, where the outlet is 50 feet away from the entrance line, the minimum distance from the face of the duct outlet is 8½ inches.

In cases where it is not possible to provide the necessary clearance, the incoming air flow should be diverted from direct contact with the plant by means of deflectors fitted on the mouth of the outlets.

As a precaution against possible ammonia leakage from the refrigerating plant, the rooms housing the refrigerator plant in the different buildings are so arranged that they can be closed to other parts of the buildings; also, exhaust fans with control accessible outside the room, and a gas mask are provided for use should an emergency arise. A humidistat with an alarm is installed in the telephone equipment rooms, whereby the attention of a responsible member of the staff is obtained should the relative humidity rise above a predetermined point.

To insure protection in the ammonia compressor against excessive pressure, which may occur from lack of water entering the condenser, an automatic cut-off switch is provided. This switch comes into operation and shuts down the motor driving the condenser before the pressure rises to a point dangerous to the operation of the plant.

In offices where the water is obtained from public supply sources, control valves are installed. These valves automatically control the water supply so that the water passing from the condenser does not exceed the requisite amount needed for the efficient operation of the plant.

A general view of the plant installed in the Wayside Central Office is shown in Fig. 8.

Water Supply and Operating Economics

Referring to Fig. 4, it will be seen that water is used as an agent for cooling the high pressure ammonia gas passing through the condenser. The water supply for the condenser has a considerable bearing on the efficiency of the ammonia compressor, since the compression required is dependent on the quantity and temperature of the water used. Cold water lowers the pressure, while with warm water higher pressures result; similarly, a large amount of circulating water will effect a lower pressure than will a smaller flow. As less energy needs to be expended when the compressor is running at low pressure, it is naturally desirable to operate under these conditions if possible.

There are generally two sources available for water supply, i.e., the public town supply and an Artesian well. Thus there is available the choice of the following methods:

(*a*) Town supply with its relatively high temperature using a smaller or a larger quantity of water.

(*b*) Artesian well with its relatively low temperature using a smaller or a larger quantity of water.

Water from an Artesian well with large quantities available at a low temperature, is usually found to be the most satisfactory source of supply. Table II shows the approximate saving in power for varying quantity and temperature of the water supply.

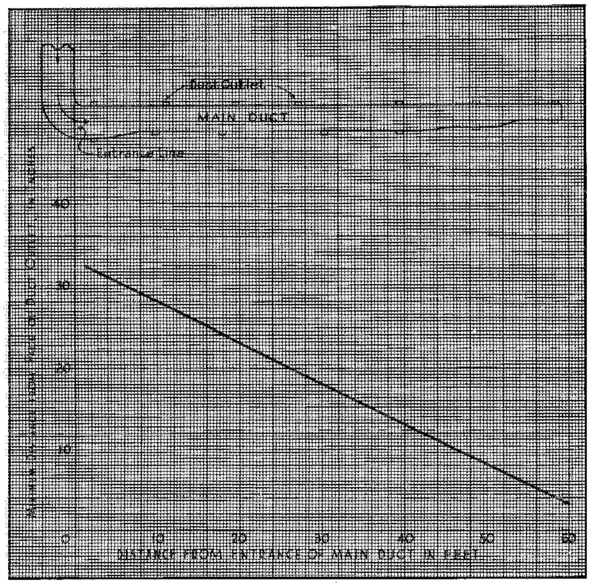


Figure 7—Variation of Permissible Minimum Distance from Duct Outlet Versus Length of Main Duct Run in Air Conditioned Room (On Basis of 70% Relative Humidity as Safe Working Limit).

The maximum temperature of the public town supply water during the summer months ranges about 85°F. The temperature of Artesian well water remains constantly around 70°F. throughout the year.

The Wayside plant having a capacity of 28 tons of refrigeration, the minimum amount of water required, using town water with a temperature of 85°F., would be 1.5 × 28 = 42 U.S. gallons per minute, which per day would equal 42 × 60 × 24 = 60,480 U.S. gallons or say 48,250 Imperial gallons.

Since the water consumption is large, it constitutes a considerable portion of the operating

TABLE II

Water Temperature °F.	Water Rate in U.S. Gallons Per Minute, Per Ton of Refrigeration	Pump Motor B.H.P.	Ammonia Condenser Pressure Lbs. Per Sq. In.	Compressor B.H.P.
70	2	3.55	160	24.78
70	1.5	3.3	175	26.2
80	2	3.9	191	27.8
80	1.5	3.5	207	29.6
85	2	4	207	29.6
85	1.5	3.5	225	31.75

costs of the plant. For this reason much thought has been given by refrigerating engineers to the conservation of the water circulated through the condenser. Atmospheric condensers and cooling towers for cooling and recirculating the water have been developed for this purpose. Manufacturers claim a saving of 70% or over of the water supply by these methods, and where water is obtained from public supply sources a considerable saving in operating costs is effected. Atmospheric condensers and cooling towers cover a considerable area and must be erected in exposed situations. Buildings erected in large cities usually have very little, if any, exposed area, excepting the roof; therefore, when atmospheric condensers or water towers are used, they are usually erected on the roof of the building. This invariably calls for special construction work in order that the building will stand the additional weight and stresses involved while pipe connections must be made from the roof to the plant. The exposure of the condenser tubing and water connection in a climate where temperature during the winter months may fall below the freezing point creates a hazard of damage to pipes and subsequent flooding. For these reasons, atmospheric condenser and water cooling towers were not favoured for use in the Central Office buildings, where no risk of damage to the equipment from flooding could be entertained. In each case, the enclosed shell and tube type condenser, which also has the advantage of being installed in the same room as the rest of the air conditioning equipment, has been adopted.

Having ruled out any saving by the use of the atmospheric condenser or cooling tower, a study was made to obtain comparative costs for obtaining water from public services or by means of an Artesian well.

While the investigations covered the plant for all of the Central Office buildings, some of which are in the International Settlement and some in the French Concession, the Wayside office, where the public supply is controlled by a public utility company in the International Settlement, is here being dealt with specifically.

Cost of Artesian Well

The well under consideration has a capacity of 100 U.S. gallons per minute. Details of costs are:

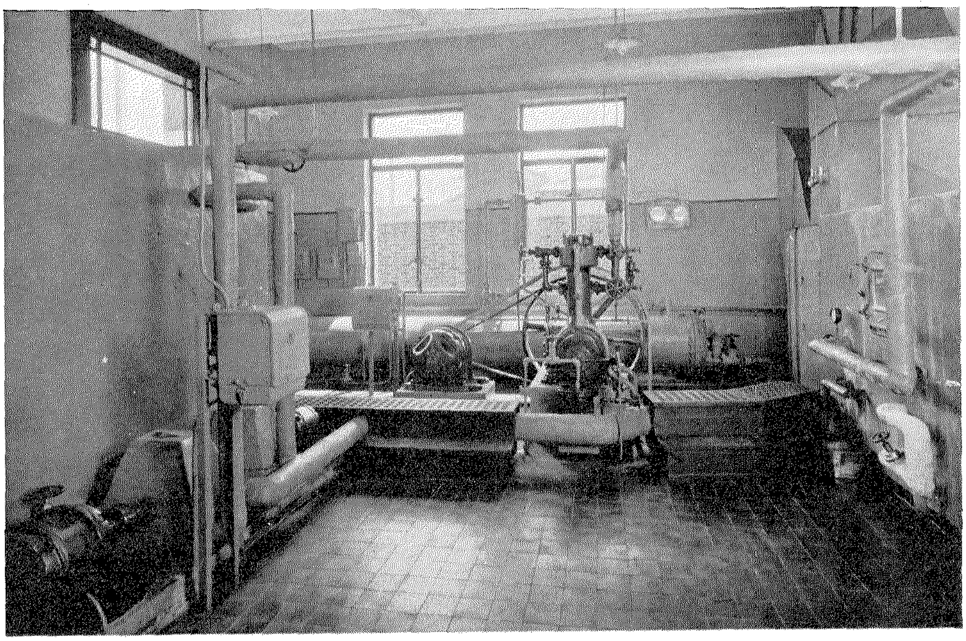


Figure 8—General View of Plant Installed in Wayside Central Office.

The capital cost of well pumps and pump house is approximately C.S. $10,000.*

Annual charges, based on an estimated life of ten years with a net recovery value of 3% at the end of the period, including maintenance, interest, and insurance, total C.S. $2,494. While the estimated life may be considered rather short and maintenance has been taken on the high side, these figures were assumed due to the fact that little information is available as to the behavior of Artesian wells in Shanghai.

Operating Charges

Operating charges are dependent on the quantity of water to be pumped. To obtain water consumption, the use over varying periods of the year was estimated in accordance with information supplied by the contractors, i.e.,

Plant in operation 7 months per year on the following basis:

- 2 months 18 hrs. per day @ normal water consumption with water @ 70°F.
- 2 months 24 hrs. per day @ normal water consumption with water @ 70°F.
- 2 months 24 hrs. per day 1½ times normal water consumption with water @ 70°F. to 80°F.
- 1 month 24 hrs. per day 2 times normal water consumption with water @ 80°F. to 85°F.

where normal consumption is equal to 0.8 Imperial gallons per minute per ton of refrigeration.

On this basis and 28 tons of refrigeration, the estimated annual water consumption is equal to 8,225,280 Imperial gallons.

To provide ample reserve in the event of larger amounts of water being required, the estimated consumption was placed at 17,000,000 Imperial gallons per year. Estimated power required to pump this supply of water, taking running hours to be approximately 4680 and B.H.P. 4½ = approximately 3.357 K.W. × 4680 = 15,711 K.W.H. Allowing for motor losses, this figure may be taken as 19,000 K.W.H.

19,000 K.W.H. @ C.S.$0.063 per K.W.H = C.S.$1,197.

Cost of Public Town Supply Water

Amount of water 17,000,000 Imperial gallons per year @ C.S. $0.41 per 1,000 gallons = C.S. $6,970.

Operating Costs for Compressor

(*a*) Using Well Water, see Table III.

Taking the power consumption at 117,000 K.W.H. to provide for electric motor losses,

117,000 K.W.H. @ C.S.$0.063 per K.W.H. = C.S.$7,371.

(*b*) Using Town Supply Water, see Table IV.

Increasing the figure to 140,000 to provide for electric motor losses,

140,000 K.W.H. @ C.S.$0.063 per K.W.H. = C.S.$8,820.

Note: Above costs are based on power supply for the Compressor only.

Comparative Annual and Operating Charges

	Artesian Well C.S.$		*Town Supply* C.S.$
Annual Plant Charges	2,494	Cost of Water	6,970
Annual Oper. Charges (for well)	1,197	Annual Oper. Charges (for compressor)	8,820
Annual Oper. Charges (for compressor)	7,371		
	11,062		15,790

The difference in favour of an Artesian well, therefore, is approximately C.S. $4,728 or 30%.

Power Consumption

(*a*) The refrigerating plant is in operation for

* C.S.$ = Chinese Silver Dollar.

TABLE III

Water Temperature	Condenser Pressure	Compressor B.H.P.	K.W.	Approximate Running Hours	Power Consumption K.W.H.
70°F.	160	27	20.142	4680	94,265

TABLE IV

Water Temperature	Condenser Pressure	Compressor B.H.P.	K.W.	Approximate Running Hours	Power Consumption K.W.H.
85°F.	225	32.2	24.021	4680	112,418

approximately 7 months in the year as follows:

2 months @ 18 hrs. per day = 1080 hrs. approximately
5 months @ 24 hrs. per day = 3600 hrs. approximately

Total hrs. in oper. per annum = 4680 hrs. approximately

(*b*) The air conditioning plant is in operation continuously. Total hours in operation per annum = 8760 hours.

The electric motors associated with (*a*) consist of:

1. Compressor motor	27 B.H.P.
2. Baudelot pump motor	2 B.H.P.
Total B.H.P. =	29 B.H.P.

Power consumed $= 29 \times \frac{746}{1,000} \times 4,680 = 101,247$ K.W.H. (approximately).

Adding 25% for electric motor losses, this figure becomes 126,559 K.W.H.

The electric motors associated with (*b*) consist of:

1. Air washer pump motor	3.9 B.H.P.
2. Fan motor	2.9 B.H.P.
Total B.H.P. =	6.8 B.H.P.

Power consumed $= 6.8 \times \frac{746}{1,000} \times 8,760 = 44,438$ K.W.H. (approximately).

Adding 25% for electric motor losses, this figure becomes 55,548 K.W.H.

Total power consumption = 182,000 K.W.H. per annum.

Total cost per annum for power at C.S. $0.063 per K.W.H. = 182,000 × 0.063 = C.S. $11,466.

Cost of Air Conditioning Plant

Capital cost including:

(*a*) All air conditioning machinery, ducts, and auxiliary apparatus.
(*b*) Artesian well and associated apparatus.
(*c*) Charges of contractors, installers and architects.

Present cost equals approximately	C.S.$58,880
Estimated ultimate additional cost	7,000
Total:	C.S.$65,880

Annual Plant and Operating Charges

Annual plant charges, assuming a life of 15 years with a net recovery value of 5% at the end of the period, total C.S. $9,862 for the present and C.S. $11,034 for the ultimate plant. Annual and operating costs (including an Artesian well) total C.S. $23,438 for the present, and C.S. $26,269 for the ultimate plant.

Unit Costs

The cost of the air conditioning plant for various units, both for the present and ultimate capacity of the office, is given below:

(a) *Cost per Switch*

	Present	*Ultimate*
Estimated number of switches	2008	6528
Estimated first cost per switch	C.S.$29	C.S.$10
Estimated annual and operating costs per switch	C.S.$11.68	C.S.$ 4.02

(b) *Cost per Equipped Line*

Number of equipped lines	3400	10000
Estimated first cost per line	C.S.$17.29	C.S.$ 6.58
Estimated annual and operating costs per line	C.S.$ 6.89	C.S.$ 2.63

(c) *Cost per Cubic Foot*

Number of cubic feet	84425	140604
Estimated first cost per cu. ft.	C.S.$ 0.696	C.S.$ 0.47
Estimated annual and operating costs per cu. ft.	C.S.$ 0.278	C.S.$ 0.187

Personnel

When running at full load fairly constant attention is necessary, but on the average one attendant per 24 hours will be sufficient for the efficient operation of the plant.

Operating Records or Plant Log:

Records are kept on daily log sheets, readings being taken periodically, of

High and low ammonia pressures
Condensing water temperatures
Humidity and temperatures
Also a record of running time in hours is kept for the
(*a*) Ammonia Compressor
(*b*) Water Cooling Pump
(*c*) Air Washer Pump
(*d*) Air Fan
(*e*) Artesian Well Pump
(*f*) Air Compressor

A recording hygrometer is kept in the automatic equipment switchrooms whereby a weekly record is obtained of the relative humidity obtaining in the rooms.

All the above data are summarised and reviewed to enable the engineers to ascertain that the plant is fulfilling its functions and is being operated under the most economical conditions.

Conclusion

While it is difficult to give cost comparisons for the provision of air conditioning against possible saving in maintenance and breakdown costs, air conditioning undoubtedly has a definite economy value. It can also be regarded as an asset in the reduction of fire risk, since a very considerable fire hazard is present when wiring and equipment carrying electric potentials are exposed for long periods to atmospheres containing high relative humidity.

While the use of air conditioning equipment entails a not inconsiderable first and annual cost, it can be shown that a similar increase in first and annual cost, in any case, must be incurred in tropical climates. This, for the reason that with air conditioned rooms ordinary equipment may be used, but in non-air conditioned rooms all parts of the equipment must be given a special tropical finish, the cost of which may be taken, for the exchange in question, at approximately U.S. $3 per line or, at recent rates of exchange, approximately C.S. $7.14 per line, and the annual cost roughly at C.S. $1.57 per line, assuming that the ratio of annual cost to first cost remains the same whether the equipment is installed in a temperate climate or in a tropical climate. The indications are that equipments installed in a tropical climate without being in air conditioned rooms, have a shorter life and higher annual cost for a given first cost than equipment installed under more favorable conditions.

It is the author's opinion that air conditioning is a very necessary precaution for protection against humidity troubles in automatic telephone plant under protracted adverse atmospheric conditions. Whether the progress of science and developments in the communication art will make available a product which will prove more resistant to such conditions and which will tend to eliminate the use of air conditioning, is a question which the future only can answer.

The development of catopa yarn and non-hygroscopic materials may reduce the value of air conditioning. While they would meet a real need in installations such as private branch exchanges and building cable, where the provision of air conditioning is not economically possible, materials of this character might have very little bearing on the automatic central office problem where many other factors, such as the presence of dirt in the atmosphere, add their quota to the call for ideal operating conditions.

In the preparation of the present paper, refrence has been made to the "Handbook of Mechanical Refrigeration" by H. J. MacIntyre, and a paper on "Air Conditioning" by S. E. Faber contained in the *Proceedings of the Engineering Society of China, 1932.* Data have also been supplied by Messrs. Hugo Reiss and Company, Shanghai. The psychrometric chart was obtained from the Carrier-Brunswick International, Inc., and the meteorological data for Shanghai were prepared by the Ziccawei Observatory. The author, in conclusion, wishes to express his thanks for the assistance obtained from these sources.

Recent Telecommunication Developments of Interest

AXLE counting apparatus has been developed by the Standard Telephones and Cables, Limited, London, which provides a simple and relatively inexpensive system of automatic control for signals, track diagrams, point locks, etc. It performs the same function as a track circuit in that it detects the presence of trains, but overcomes the difficulties experienced in the use of track circuits on steel-sleepered roads, heavily sanded gradients, in tunnels, and on long block sections.

The equipment required to provide control on one section of track, e.g., between two adjacent signals, comprises two depression treadles (Fig. 1) mounted on the track, one at each end of the section, each equipped with a pair of contacts normally closed. These contacts are arranged to hold energised an in-counting and out-counting impulse relay, respectively. These two impulse relays are mounted in a small control unit which also contains a special form of stepping switch provided with two rotating cans (Fig. 2). This switch is arranged to step under the control of the two impulse relays—the impulse relay associated with the first signal causing the in-counting cam to step, and the impulse relay associated with the second signal causing the out-counting cam to step. Mounted on the switch are two contact springs, one associated with each cam. In the normal or home position of the switch each spring is arranged to make contact with its cam and a local series

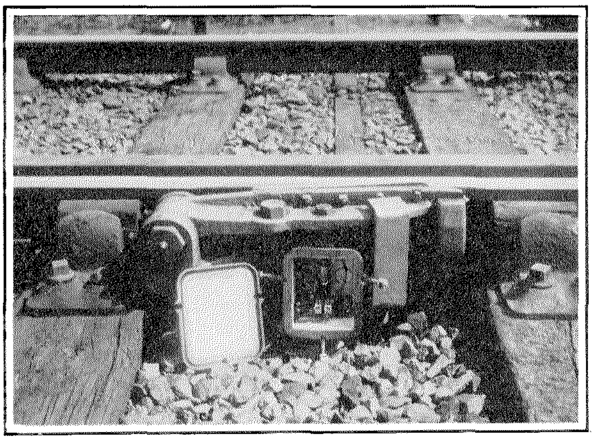


Figure 1

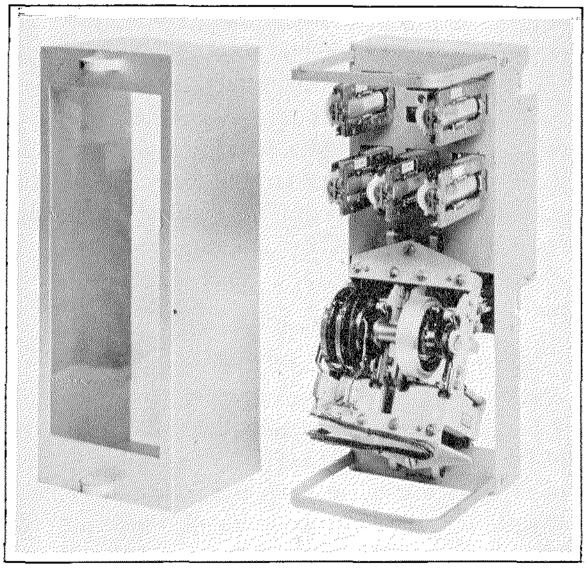


Figure 2

circuit is closed to energise a lock relay. Contacts on this lock relay are used to control the lock associated with the first signal in the same way as contacts on a track relay. This relay may also be used to control a track diagram, etc.

The counting treadle is so designed that each wheel depresses the treadle lever and causes the contacts to open once. Each wheel of the train as it passes over the first treadle will cause the in-counting cam to make one step and thus the total number of axles on the train are automatically stored. As the train passes over the second treadle at the other end of the section, each axle causes the counting switch to make one step in an out-counting direction. Only when the complete train has left the section will the out-counting axle storage agree with the in-counting storage and the switch return to a normal home position. In this position the lock relay is once more energised, giving the track clear indication.

The system is so designed electrically and mechanically that no failure of the apparatus, broken wire, or imperfect contact can cause the equipment to indicate conditions more favourable than the state of the track permits.

Field trials have shown that speeds of 80 miles per hour can be handled quite successfully, and laboratory tests indicate that the equipment operates correctly at speeds of 150 miles per hour.

A COMBINED coin box and telephone with many advantageous features has been developed recently by Standard Electric Company, Ujpest. Instead of having separate units for the telephone itself, the coin box, and the backboard, the new design combines them in one unit. The combined apparatus is covered by a sturdy metal box which is locked in place and makes the mounting screws inaccessible from the outside. The overall dimensions are 37 by 17 by 17 cm. and the weight is approximately 6 kg.

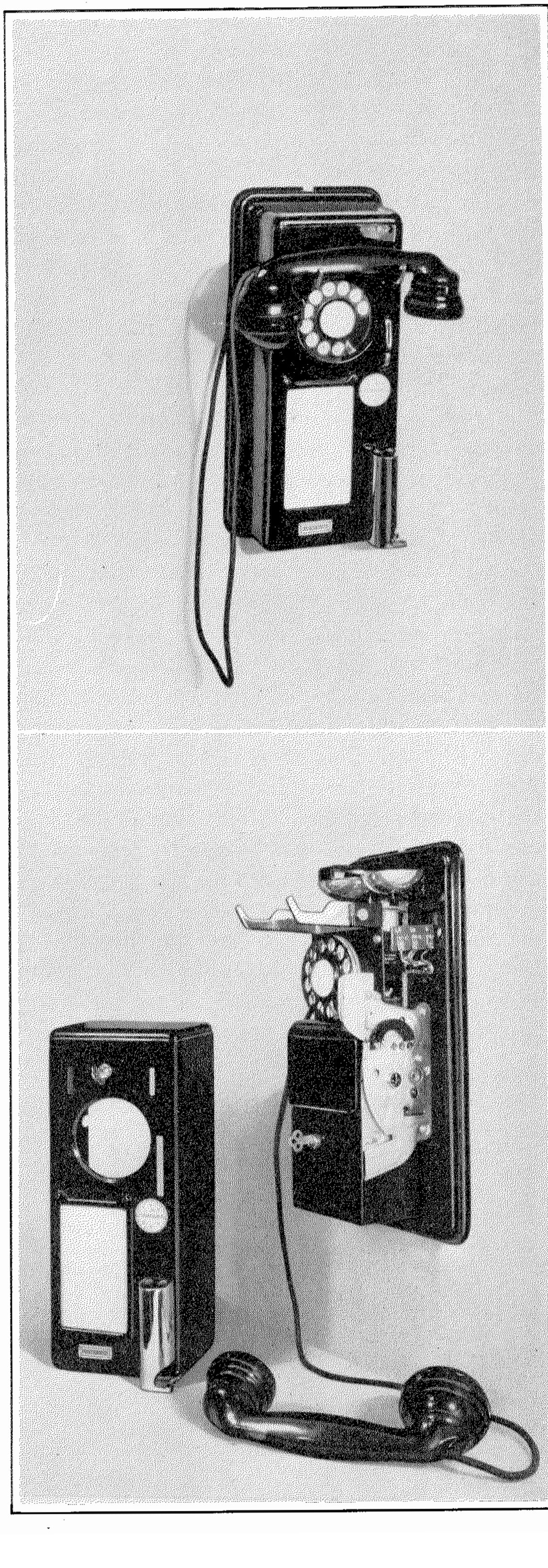
Since the coin box and the telephone are in a single case, there are no external interconnecting wires to give an opportunity for fraudulent interference. Simple to install, because of the absence of interconnecting wiring, the set is also easy to maintain as all components of both the telephone set and the coin box are accessible and easy to replace.

The set is of the single coin prepayment type. The coin when deposited closes the coin switch, completing the circuit from one side of the line through the magnet coils to ground. The magnet is of the double coil polarised type. When operated, it directs the coin to the cash box or refund channel, according to whether +110 or −110 volts direct current is applied to the line at the exchange. Fraudulent operation cannot take place even if an attempt is made to put through a call by grounding the line.

The apparatus may be used in connection either with automatic or with manual central battery exchanges. As the telephone set has an anti-side tone circuit, there is no trouble from local noise.

While the combined set is a single unit, the telephone set itself is mounted on a separate frame and can be removed easily by the repairman after loosening the terminals of three connections.

The lock of the housing is opened by a flat type key, while that of the coin box requires a fluted key. There are five hundred and sixty different combinations for the lock of the coin box. If desired, a separate sealed coin container may be incorporated in the coin box proper.



THE International Marine Radio Company's type M. 100.D. radio transmitter provides facilities for C.W. and I.C.W. telegraphy on the medium and short wave ship-to-shore bands.

The installation possesses several features which have not hitherto been incorporated in a ship's radio equipment. The short wave transmitter, for example, has been specially designed to meet the high standard of frequency stability now called for by the Regulations of the International Radio Telegraph Convention. In addition to its wide range it is notable for two special features, viz., master oscillator control over the whole wave band and crystal control on any two selected spot waves. These features not only ensure that its operation meets international requirements but also that communication is maintained at maximum efficiency on the medium wave band.

Particular attention has been given to the requirements of safety to life at sea, an automatic sending key being supplied with the equipment which, in the event of distress, enables the operator to send out the alarm signal without hand manipulation, thereby leaving him free to attend to other important matters at such a critical moment. At the same time the mechanical accuracy of this transmission ensures the reception of the alarm signal by the auto alarm apparatus installed on other ships in the vicinity.

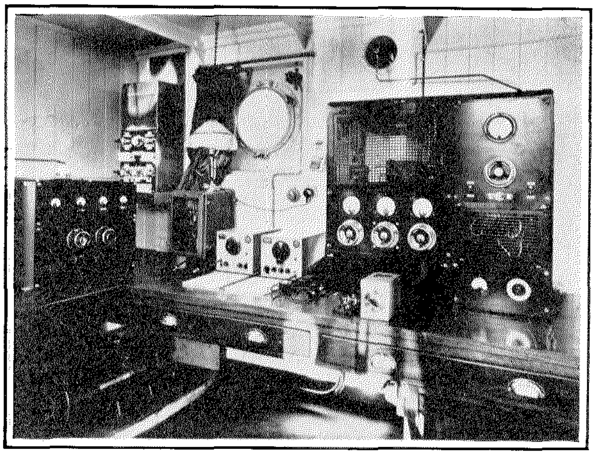
The wavelength range and power consumption of this equipment are:

Wavelength Range: 22.4—24.4 and 33.7—36.6 metres, 550 to 850 metres.
Power Consumption from Mains: 1.9 kw.
Power Consumption from Batteries (Emergency): 300 watts.

The equipment has been approved by the British Board of Trade and the British Post Office as meeting all the requirements of the Safety of Life at Sea and International Radiotelegraph Regulations.

The following is an extract* from the *Nautical Magazine,* describing the excellent results obtained by the Anglo-Saxon Petroleum Company with this type of equipment, which has been installed as part of the radio equipment on their most recently commissioned tankers.

"THE four 12,000-ton tankers built in Great Britain for the Anglo-Saxon Petroleum Co. have



all passed into commission after very successful trials. All these vessels had a speed of 13 knots in loaded trim. They are fitted with all the latest appliances including the new short and medium wave wireless equipment supplied by the International Marine Radio Co. of London. The first ship *Ancylus* while on trials off the Tyne called up an American station which reported the reception was excellent. The second vessel *Acavus,* while on trials in Belfast Lough, called up and spoke to her sister ship the *Ancylus* which was then over 3,000 miles away and nearing the West Indies. Again the sending and reception from both ships were excellent. *Acavus* communicated with the short wave station at Portishead every other day during her voyage to Curacao and was then ordered through the Panama Canal to San Pedro. It then became a real test, for while in the Pacific, and right up to the day before arrival at San Pedro, she was in direct communication with Portishead, a distance of 5,400 miles. The direct line to ship's position was across the Atlantic and right across the United States. The last two ships, *Anadara* and *Amastra,* while on trials at the entrance to the Firth of Clyde, were both in communication with the *Ancylus* which was then 2,000 miles out on her voyage to the West Indies. These results will astonish the average shipowner and seafaring man because we have imagined up to the present that the range of an ordinary wireless as fitted in our ships was 500 to 700 miles at the utmost. But what has been a dream has now come true, and this new direct service with Portishead as the receiving station for Great Britain is in full

* Quoted paragraph reprinted by permission from the *Nautical Magazine,* April, 1935.

operation. What has been the privilege of the big liners up to the present is now open to the Mercantile Marine as a whole. This new development has only been made possible by the introduction by the International Marine Radio Co. of their new crystal control short wave. It was introduced for the first time on a cargo boat or tanker on the *Ancylus*, this crystal control having hitherto been exclusively confined to large passenger vessels. Instead of waiting days for a reply to a message sent, while it was being relayed by other vessels, the direct communication now offered enables a reply to be received the same night or the next day. Then again these ships are acting as wireless transmitting stations sending messages from other vessels which have only medium wave equipment. This is indeed a great stride ahead and shipowners will be quick to see its advantages."

• • •

THE R.M.10 Radio Receiver is a nine valve superheterodyne general purpose receiver designed for telegraphy and telephony. The range of 13.5 to 550 metres is covered by five sets of plug-in coils. The high frequency coils for each band are ganged on a single triangular unit and changed simultaneously. The large drum dial is calibrated directly in kilocycles for each of the five wave ranges.

The appropriate calibration track is automatically illuminated by insertion of a coil unit.

Rapid adjustment of tuning can be done by turning the knurled rim of the drum dial, and fine adjustment by means of an anti-back lash worm drive. The reduction of the worm drive is sufficient to make band spread coils unnecessary.

A local beat-oscillator is provided for reception of C.W. telegraphy and a control for adjusting the pitch of the received note is also provided.

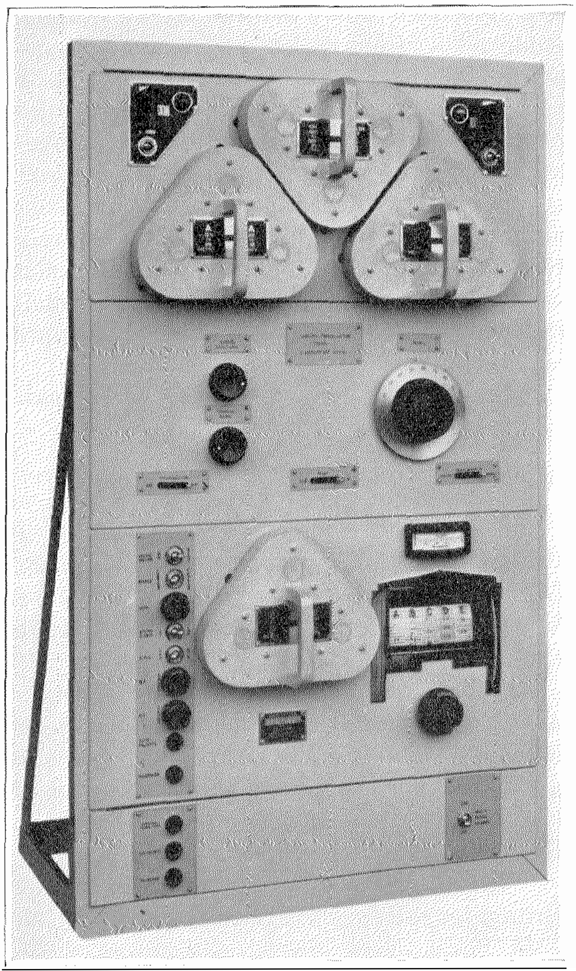
For conditions of extreme selectivity, an audio frequency filter panel passing a band of 900 to 1,100 p:s is available. To match the receiver to all types of antenna systems, an antenna impedance matching panel is provided. This supplementary panel adds an extra balanced tuned circuit which improves second channel selectivity and assists in duplex operation in addition to providing the correct matching impedance for all types of antennae. This device also considerably attenuates noise pick-up on the transmission line from a doublet antenna.

Further refinements are provided in a time lag control for the automatic voltage control permitting the choice of a long time lag in low speed telegraphy, or a short time lag in telephony or high speed telegraphy. The resonance meter is provided with a switch and multiplier to check high tension voltages. A crash limiting circuit is provided for headphone or loudspeaker operation.

The receiver can be supplied either with four sets of coils to cover 13.5—200 metres or with five sets to cover 13.5—550 metres.

The receiver illustrated, the first model of which was manufactured by Kolster-Brandes Limited, Sidcup, covers the wave range of 13.5—200 metres. The units from top to bottom are:

(1) Combined spare coil rack and power supply unit
(2) Antenna matching panel.
(3) Receiver unit.
(4) 1,000 p:s note filter.



Telephone and Telegraph Statistics of the World

Compiled by Chief Statistician's Division, American Telephone and Telegraph Company

Telephone Development of the World, by Countries
January 1, 1934

Countries	Number of Telephones: Government Systems	Private Companies	Total	Per Cent of Total World	Telephones Per 100 Population
NORTH AMERICA:					
United States	—	16,710,858	16,710,858	51.42%	13.29
Canada	193,641	998,689	1,192,330	3.67%	11.15
Central America	12,137	14,020	26,157	.08%	0.39
Mexico	1,337	99,871	101,208	.31%	0.59
West Indies:					
Cuba	485	32,355	32,840	.10%	0.81
Porto Rico	537	11,209	11,746	.04%	0.71
Other W. I. Places	7,044	14,135	21,179	.07%	0.32
Other No. Am. Places	—	11,032	11,032	.03%	3.02
Total	215,181	17,892,169	18,107,350	55.72%	10.38
SOUTH AMERICA:					
Argentina	—	312,086	312,086	.96%	2.64
Bolivia	—	2,000	2,000	.01%	0.06
Brazil	1,041	169,764	170,805	.53%	0.38
Chile	—	46,159	46,159	.14%	1.04
Colombia	2,500	27,425	29,925	.09%	0.32
Ecuador	3,010	2,730	5,740	.02%	0.23
Paraguay	—	2,499	2,499	.01%	0.28
Peru	—	17,200	17,200	.05%	0.27
Uruguay	—	42,707	42,707	.13%	2.14
Venezuela	600	19,390	19,990	.06%	0.61
Other So. Am. Places	2,808	—	2,808	.01%	0.52
Total	9,959	641,960	651,919	2.01%	0.71
EUROPE:					
Austria	239,870	—	239,870	.74%	3.55
Belgium**	317,217	—	317,217	.98%	3.86
Bulgaria	20,276	—	20,276	.06%	0.33
Czechoslovakia	149,296	19,878	169,174	.52%	1.12
Denmark#	16,289	348,438	364,727	1.12%	9.99
Finland	1,658	138,000	139,658	.43%	3.74
France	1,349,520	—	1,349,520	4.15%	3.19
Germany#	2,953,614	—	2,953,614	9.09%	4.48
Great Britain and No. Ireland	2,226,329	—	2,226,329	6.85%	4.78
Greece	—	20,356	20,356	.06%	0.31
Hungary	110,430	727	111,157	.34%	1.25
Irish Free State#	33,450	—	33,450	.10%	1.11
Italy*	—	482,507	482,507	1.48%	1.13
Jugo-Slavia	46,006	1,209	47,215	.15%	0.33
Latvia#	62,174	—	62,174	.19%	3.19
Netherlands	343,177	—	343,177	1.06%	4.14
Norway*	121,376	78,400	199,776	.61%	7.00
Poland	100,839	88,366	189,205	.58%	0.57
Portugal	11,500	35,706	47,206	.15%	0.68
Roumania	—	51,613	51,613	.16%	0.28
Russia¶	576,332	—	576,332	1.77%	0.35
Spain	—	290,829	290,829	.90%	1.24
Sweden	589,394	1,520	590,914	1.82%	9.51
Switzerland	363,655	—	363,655	1.12%	8.81
Other Places in Europe	104,308	12,696	117,004	.36%	1.41
Total	9,736,710	1,570,245	11,306,955	34.79%	2.02
ASIA:					
British India#	22,804	35,437	58,241	.18%	0.02
China	72,000	82,000	154,000	.47%	0.03
Japan#	1,015,372	—	1,015,372	3.13%	1.50
Other Places in Asia	132,669	60,257	192,926	.59%	0.12
Total	1,242,845	177,694	1,420,539	4.37%	0.14
AFRICA:					
Egypt	46,888	—	46,888	.15%	0.22
Union of South Africa#	126,608	—	126,608	.39%	1.50
Other Places in Africa	96,317	1,813	98,130	.30%	0.09
Total	269,813	1,813	271,626	.84%	0.18
OCEANIA:					
Australia*	487,662	—	487,662	1.50%	7.35
Dutch East Indies	38,267	3,663	41,930	.13%	0.06
Hawaii	—	23,111	23,111	.07%	5.78
New Zealand#	155,059	—	155,059	.48%	10.01
Philippine Islands	6,000	20,182	26,182	.08%	0.19
Other Places in Oceania	3,294	228	3,522	.01%	0.15
Total	690,282	47,184	737,466	2.27%	0.81
TOTAL WORLD	12,164,790	20,331,065	32,495,855§	100.00%	1.54

*June 30, 1933. **February 28, 1934. #March 31, 1934.
¶U.S.S.R., including Siberia and Associated Republics.
§Includes approximately 14,300,000 automatic or "Dial" telephones, of which about 46% are in the United States.

Telephone and Telegraph Wire of the World, by Countries
January 1, 1934

Countries	Service Operated By (See Note)	Miles of Telephone Wire: Number of Miles	Miles of Telephone Wire: Per Cent of Total World	Miles of Telephone Wire: Per 100 Population	Miles of Telegraph Wire: Number of Miles	Miles of Telegraph Wire: Per Cent of Total World	Miles of Telegraph Wire: Per 100 Population
NORTH AMERICA:							
United States	P.	87.000,000	56.92%	69.21	2,265,000	33.50%	1.80
Canada	P.G.	5,135,000	3.36%	48.04	365,000	5.40%	3.41
Central America	P.G.	61,000	.04%	0.92	20,000	.30%	0.30
Mexico	P.	550,000	.36%	3.02	88,000	1.30%	0.51
West Indies:							
Cuba	P.	298,000	.19%	7.38	14,000	.21%	0.35
Porto Rico	P.	33,000	.02%	2.01	1,000	.01%	0.06
Other W. I. Places	P.G.	104,000	.07%	1.55	8,500	.12%	0.13
Other No. Am. Places	P.	19,000	.01%	5.21	11,000	.16%	3.02
Total		93.200,000	60.97%	53.44	2,772,500	41.00%	1.59
SOUTH AMERICA:							
Argentina	P.	1,200,000	.78%	10.17	200,000	2.95%	1.70
Bolivia	P.	5,500	.004%	0.17	5,000	.07%	0.16
Brazil	P.	644,000	.42%	1.42	106,000	1.57%	0.23
Chile	P.	200,000	.13%	4.51	54,000	.80%	1.22
Colombia	P.	85,000	.06%	0.91	20,000	.30%	0.21
Ecuador	P.G.	8,000	.01%	0.32	4,500	.07%	0.18
Paraguay	P.	7,000	.005%	0.79	2,500	.04%	0.28
Peru	P.	46,000	.03%	0.71	12,000	.18%	0.19
Uruguay	P.	75,000	.05%	3.77	7,500	.11%	0.38
Venezuela	P.	78,000	.05%	2.37	7,000	.10%	0.22
Other So. Am. Places	G.	5,500	.004%	1.02	500	.01%	0.09
Total		2,354,000	1.54%	2.57	419,000	6.20%	0.46
EUROPE:							
Austria	G.	732,000	.48%	10.85	49,000	.72%	0.73
Belgium**	G.	1,794,000	1.17%	21.83	35,000	.52%	0.43
Bulgaria	G.	65,000	.04%	1.07	6,500	.10%	0.11
Czechoslovakia	P.G.	580,000	.38%	3.84	82,000	1 21%	0.54
Denmark#	P.	1,192,000	.78%	32.66	11,000	.16%	0.30
Finland	P.	342,000	.22%	9.16	12,000	.18%	0.32
France	G.	4.823,000	3.16%	11.41	523,000	7.74%	1.24
Germany#	G.	15.500,000	10.14%	23.49	132,000	1.95%	0.20
Great Britain and No. Ireland#	G.	11.123,000	7.28%	23.88	327,000	4.84%	0.70
Greece	P.	67,000	.04%	1.01	34,000	.50%	0.51
Hungary	G.	398,000	.26%	4.47	49,000	.72%	0.55
Irish Free State#	G.	121,000	.08%	4.03	21,000	.31%	0.70
Italy	P.	1,700.000	1.11%	3.98	250,000	3.70%	0.59
Jugo-Slavia	G.	145,000	.10%	1.00	57,000	.84%	0.39
Latvia#	G.	267,000	.18%	13.71	4,500	.07%	0.23
Netherlands	G.	1,070.000	.70%	12.91	27,000	.40%	0.33
Norway*	P.G.	615,000	.40%	21.53	28,000	.41%	0.98
Poland	P.G.	943,000	.62%	2.86	51,000	.75%	0.16
Portugal	P.G.	114,000	.07%	1.64	15,000	.22%	0.22
Roumania	P.	209,000	.14%	1.15	45,000	.67%	0.25
Russia¶	G.	730,000	.48%	0.44	300,000	4.44%	0.18
Spain	P.	1.180,000	.77%	5.05	91,000	1.35%	0.39
Sweden	G.	2.140,000	1.40%	34.45	33,000	.49%	0.53
Switzerland	G.	1,266,000	.83%	30.68	10,000	.15%	0.24
Other Places in Europe	P.G.	326,000	.21%	3.92	26,000	.38%	0.31
Total		47,442,000	31.04%	8.48	2,219,000	32.82%	0.40
ASIA:							
British India#	P.G.	397,000	.26%	0.11	431,000	6.37%	0.12
China	P.G.	485,000	.32%	0.11	135,000	2.00%	0.04
Japan#	G	3,756,000	2.46%	5.55	232,000	3.43%	0.34
Other Places in Asia	P.G.	573,000	.37%	0.36	180,000	2.66%	0.11
Total		5,211,000	3.41%	0.50	978,000	14.46%	0.09
AFRICA:							
Egypt	G.	305,000	.20%	1.44	35,000	.52%	0.16
Union of South Africa#	G.	511,000	.33%	6.05	32,000	.47%	0.38
Other Places in Africa	P.G.	269,000	.18%	0.23	145,000	2.15%	0.13
Total		1,085,000	.71%	0.74	212,000	3.14%	0.14
OCEANIA:							
Australia*	G.	2,553,000	1.67%	38.50	98,000	1.45%	1.48
Dutch East Indies	G.	235,000	.15%	0.36	25,000	.37%	0.04
Hawaii	P.	89,000	.06%	22.25	0	.00%	0.00
New Zealand#	G.	618,000	.40%	39.90	23,000	.34%	1.48
Philippine Islands	P.G.	65,000	.04%	0.48	11,000	.16%	0.08
Other Places in Oceania	P.G.	7,500	.01%	0.33	4,000	.06%	0.18
Total		3,567,500	2.33%	3.92	161,000	2.38%	0.18
TOTAL WORLD		152.859,500	100.00%	7.24	6,761,500	100.00%	0.32

NOTE: Telegraph service is operated by Governments, except in the United States and Canada. In connection with telephone wire, P. indicates that the telephone service is wholly or predominantly operated by private companies, G. wholly or predominantly by the Government, and P.G. by both private companies and the Government. See preceding table.

* June 30, 1933. ** February 28, 1934. #March 31, 1934.

¶ U.S.S.R. including Siberia and Associated Republics.

Telephone Development of Large and Small Communities—January 1, 1934

Country	Service Operated By (See Note)	Number of Telephones: In Communities of 50,000 Population and Over	Number of Telephones: In Communities of less than 50,000 Population	Telephones per 100 Population: In Communities of 50,000 Population and Over	Telephones per 100 Population: In Communities of less than 50,000 Population
Australia*	G.	279,700	207,962	8.71	6.08
Austria	G.	178,802	61,068	8.13	1.34
Belgium**	G.	221,621	95,596	6.33	2.03
Canada	P.G.	647,000	545,330	19.33	7.43
Czechoslovakia	P.G.	69,133	100,041	4.04	0.75
Denmark	P.	181,822	180,778	19.24	6.72
Finland†	P.	50,151	84,500	10.49	2.61
France	G.	734,401	615,119	8.31	1.84
Germany#	G.	1,897,458	1,056,156	7.12	2.69
Great Britain and No. Ireland#	G.	1,618,500	646,700	6.17	3.18
Hungary	G.	84,636	26,521	4.14	0.39
Japan#	G.	656,752	358,620	3.41	0.74
Netherlands	G.	224,604	118,573	6.65	2.41
New Zealand#	G.	61,486	93,573	11.34	9.29
Norway*	P.G.	76,461	123,315	18.88	5.03
Poland	P.G.	111,102	78,103	2.29	0.28
Spain	P.	177,601	113,228	3.54	0.62
Sweden	G.	231,996	358,918	22.59	6.92
Switzerland	G.	163,961	199,694	18.82	6.13
Union of South Africa	G.	69,451	57,157	6.77	0.77
United States	P.	9,386,321	7,324,537	18.54	9.76

NOTE: P. indicates that the telephone service is wholly or predominantly operated by private companies, G. wholly or predominantly by the Government, and P.G. by both private companies and the Government. See first table.

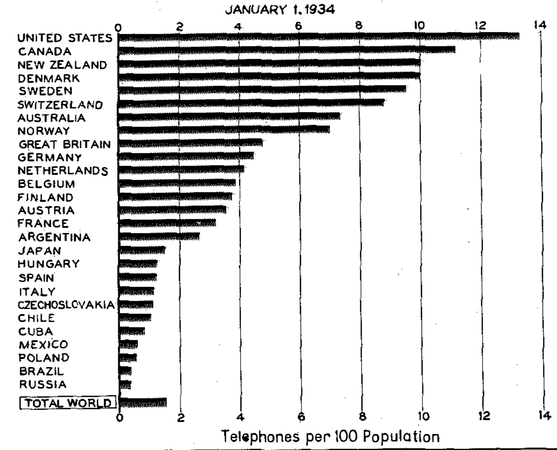
† January 1, 1933. * June 30, 1933. ** February 28, 1934. # March 31, 1934.

Telephone Conversations and Telegrams—Year 1933

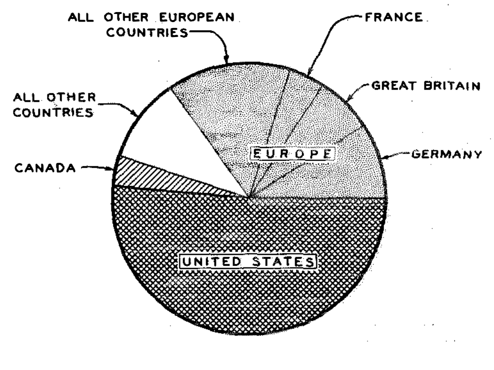
Country	Number of Telephone Conversations	Number of Telegrams	Total Number of Wire Communications	Per Cent of Total Wire Communications: Telephone Conversations	Per Cent of Total Wire Communications: Telegrams	Wire Communications per Capita: Telephone Conversations	Wire Communications per Capita: Telegrams	Wire Communications per Capita: Total
Australia	408,732,000	13,417,000	422,149,000	96.8	3.2	61.9	2.0	63.9
Austria	557,000,000	1,609,000	558,609,000	99.7	0.3	82.6	0.2	82.8
Belgium	239,671,000	5,703,000	245,374,000	97.7	2.3	29.2	0.7	29.9
Canada	2,271,581,000	9,409,000	2,280,990,000	99.6	0.4	214.1	0.9	215.0
Czechoslovakia	274,000,000	3,887,000	277,887,000	98.6	1.4	18.2	0.3	18.5
Denmark	576,000,000	1,745,000	577,745,000	99.7	0.3	158.7	0.5	159.2
Finland	180,000,000	522,000	180,522,000	99.7	0.3	48.4	0.1	48.5
France	857,572,000	29,981,000	887,553,000	96.6	3.4	20.3	0.7	21.0
Germany	2,175,640,000	18,238,000	2,193,878,000	99.2	0.8	33.0	0.3	33.3
Great Britain and No. Ireland	1,620,000,000	45,355,000	1,665,355,000	97.3	2.7	34.8	1.0	35.8
Hungary	131,000,000	1,894,000	132,894,000	98.6	1.4	14.8	0.2	15.0
Japan	3,813,000,000	52,331,000	3,865,331,000	98.6	1.4	56.7	0.8	57.5
Netherlands	411,000,000	3,385,000	414,385,000	99.2	0.8	49.9	0.4	50.3
Norway	223,521,000	2,945,000	226,466,000	98.7	1.3	78.5	1.0	79.5
Poland	687,000,000	3,102,000	690,102,000	99.6	0.4	21.0	0.1	21.1
Spain	670,000,000	20,257,000	690,257,000	97.1	2.9	28.7	0.9	29.6
Sweden	852,000,000	3,522,000	855,522,000	99.6	0.4	137.4	0.6	138.0
Switzerland	270,800,000	2,054,000	272,854,000	99.2	0.8	65.8	0.5	66.3
Union of South Africa	213,000,000	4,759,000	217,759,000	97.8	2.2	25.4	0.6	26.0
United States	24,000,000,000	145,000,000	24,145,000,000	99.4	0.6	191.4	1.2	192.6

NOTE: Telephone conversations represent completed local and toll or long distance messages. Telegrams include inland and outgoing international messages.

TELEPHONES PER 100 POPULATION
JANUARY 1, 1934



DISTRIBUTION OF THE WORLD'S TELEPHONES
JANUARY 1, 1934



Telephone Development of Large Cities
January 1, 1934

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones Per 100 Population
ARGENTINA:			
Buenos Aires	2,970,000	179,154	6.03
AUSTRALIA:			
Adelaide	313,000	27,692	8.85
Brisbane	301,000	25,107	8.34
Melbourne	996,000	94,779	9.52
Sydney	1,240,000	108,679	8.77
AUSTRIA:			
Graz	160,000	8,019	5.01
Vienna	1,900,000	159,478	8.39
BELGIUM:**			
Antwerp	530,000	38,993	7.36
Brussels	966,000	103,580	10.72
Liege	427,000	23,001	5.39
BRAZIL:			
Rio de Janeiro	1,717,000	55,460	3.23
CANADA:			
Montreal	1,017,000	164,184	16.14
Ottawa	186,700	35,256	18.88
Toronto	757,000	184,982	24.44
Vancouver	189,000	51,888	27.51
CHINA:			
Canton	1,050,000	7,300	0.70
Hong Kong	850,000	14,871	1.75
Peiping	1,520,000	12,390	0.82
Shanghai††	1,500,000	49,401	3.29
CUBA:			
Havana	780,000	26,801	3.44
CZECHOSLOVAKIA:			
Prague	910,000	45,451	4.99
DANZIG:			
Free City of Danzig	263,000	16,725	6.36
DENMARK:			
Copenhagen	813,000	165,518	20.36
FINLAND:			
Helsingfors	265,000	36,962	13.95
FRANCE:			
Bordeaux	267,000	19,551	7.32
Lille	202,000	16,954	8.39
Lyons	667,000	35,345	5.30
Marseilles	895,000	32,428	3.62
Paris	2,900,000	411,249	14.18
GERMANY:#			
Berlin	4,205,000	456,304	10.85
Breslau	625,000	40,192	6.42
Cologne	758,000	62,254	8.21
Dresden	726,000	58,560	8.07
Dortmund	582,000	22,826	3.92
Essen	660,000	28,748	4.35
Frankfort-on-Main	648,000	59,752	9.22
Hamburg-Altona	1,643,000	150,292	9.15
Leipzig	766,000	63,369	8.27
Munich	738,000	74,152	10.05
GREAT BRITAIN AND NO. IRELAND:#			
Belfast	415,000	17,945	4.32
Birmingham	1,200,000	59,248	4.94
Bristol	415,000	21,015	5.06
Edinburgh	442,000	31,873	7.21
Glasgow	1,190,000	58,806	4.94
Leeds	512,000	24,135	4.71
Liverpool	1,196,000	57,993	4.85
London	9,170,000	831,800	9.07
Manchester	1,100,000	64,402	5.85
Newcastle	470,000	19,527	4.16
Sheffield	518,000	19,829	3.83
HAWAII:			
Honolulu	138,000	15,446	11.19
HUNGARY:			
Budapest	1,350,000	74,743	5.54
Szeged	140,000	1,898	1.36
IRISH FREE STATE:#			
Dublin	424,000	18,972	4.47

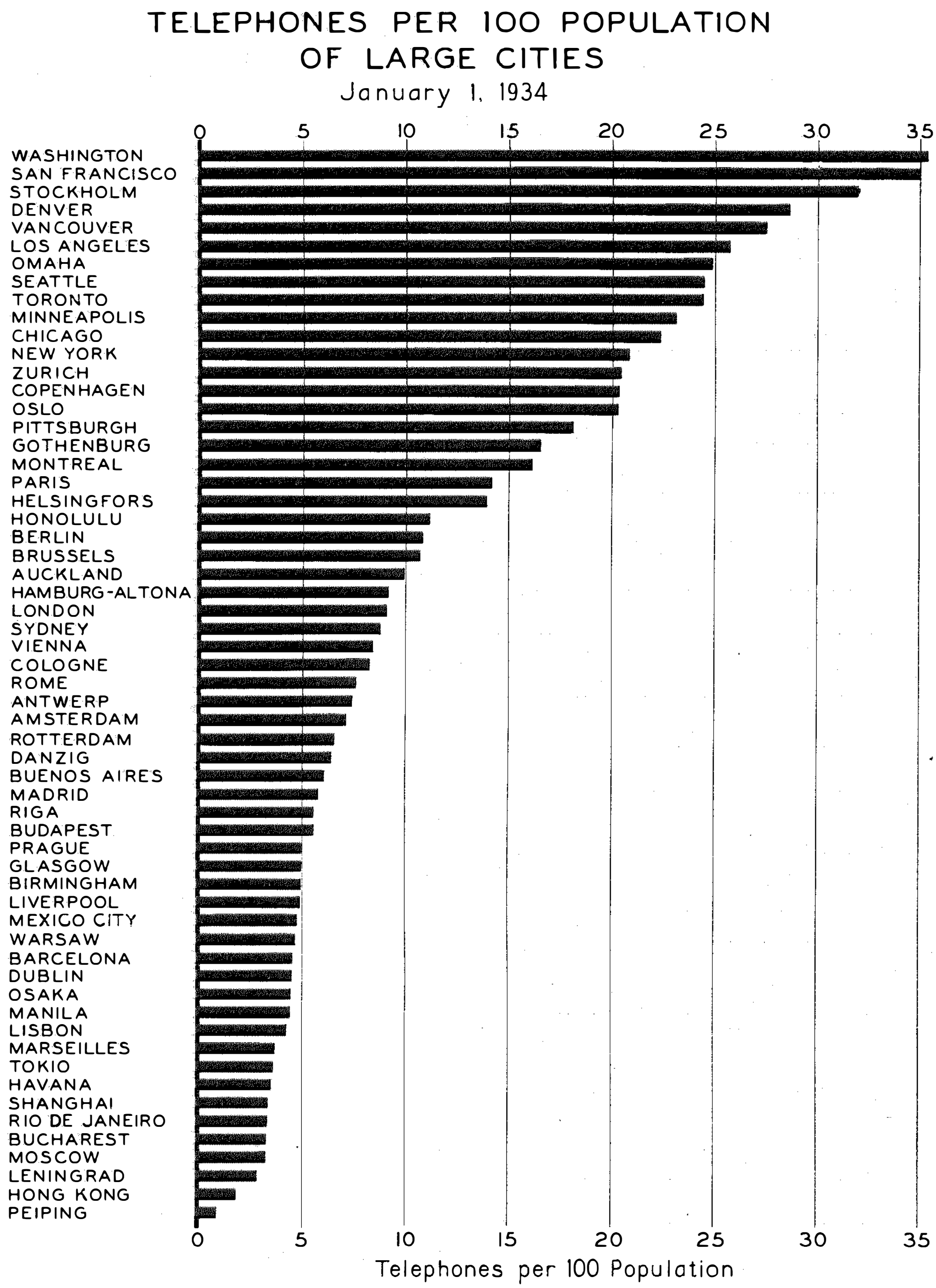
Telephone Development of Large Cities—(Concluded)

January 1, 1934

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones Per 100 Population
ITALY:			
Milan	1,025,000	84,956	8.29
Naples	1,000,000	26,135	2.61
Rome	1,045,000	79,247	7.58
JAPAN:#			
Kobe	837,000	32,482	3.88
Kyoto	1,027,000	40,695	3.96
Nagoya	990,000	33,243	3.36
Osaka	2,654,000	117,104	4.41
Tokio	5,486,000	195,225	3.56
LATVIA:#			
Riga	417,000	23,134	5.55
MEXICO:†			
Mexico City	1,100,000	51,492	4.68
NETHERLANDS:			
Amsterdam	778,000	54,952	7.06
Haarlem	159,000	11,975	7.53
Rotterdam	608,000	39,677	6.53
The Hague	508,000	48,262	9.50
NEW ZEALAND:#			
Auckland	214,000	21,262	9.94
NORWAY:*			
Oslo	250,000	50,763	20.31
PHILIPPINE ISLANDS:			
Manila	390,000	17,136	4.39
POLAND:			
Lodz	875,000	13,360	1.53
Warsaw	1,230,000	56,839	4.62
PORTUGAL:			
Lisbon	630,000	26,455	4.20
ROUMANIA:			
Bucharest	670,000	21,450	3.20
RUSSIA:			
Leningrad	2,800,000	76,933	2.75
Moscow	3,700,000	117,619	3.18
SPAIN:			
Barcelona	1,050,000	47,212	4.50
Madrid	980,000	56,558	5.77
SWEDEN:			
Gothenburg	253,000	41,965	16.59
Malmö	132,000	20,329	15.40
Stockholm	438,000	139,933	31.95
SWITZERLAND:			
Basel	150,000	30,208	20.14
Berne	113,000	23,250	20.58
Geneva	146,000	26,589	18.21
Zurich	263,000	53,799	20.45
UNITED STATES: (See Note)			
New York	7,180,000	1,495,922	20.83
Chicago	3,575,000	799,122	22.35
Los Angeles	1,364,000	351,174	25.75
Pittsburgh	1,007,900	182,483	18.11
Total 10 cities over 1,000,000 Population	22,020,600	4,393,541	19.95
Milwaukee	754,900	132,991	17.62
San Francisco	681,000	238,384	35.00
Washington	506,300	178,761	35.31
Minneapolis	502,000	116,145	23.14
Total 10 cities with 500,000 to 1,000,000 Population	6,445,300	1,289,569	20.01
Seattle	414,000	101,398	24.49
Denver	298,000	85,215	28.60
Omaha	236,300	58,780	24.88
Hartford	234,300	51,640	22.04
Total 33 cities with 200,000 to 500,000 Population	9,832,900	1,723,484	17.53
Total 53 cities with more than 200,000 Population	38,298,800	7,406,594	19.34

NOTE: There are shown, for purposes of comparison with cities in other countries, the total development of all cities in the United States in certain population groups, and the development of certain representative cities within each of such groups.

† January 1, 1933. * June 30, 1933. ** February 28, 1934. #March 31, 1934. †† International Settlement and French Concession.


TELEPHONES PER 100 POPULATION
OF LARGE CITIES
January 1, 1934
0 5 10 15 20 25 30 35
WASHINGTON
SAN FRANCISCO
STOCKHOLM
DENVER
VANCOUVER
LOS ANGELES
OMAHA
SEATTLE
TORONTO
MINNEAPOLIS
CHICAGO
NEW YORK
ZURICH
COPENHAGEN
OSLO
PITTSBURGH
GOTHENBURG
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