ELECTRICAL COMMUNICATION

JANUARY 1933 No. 3 VOL. 11

ELECTRICAL COMMUNICATION

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

H. T. KOHLHAAS, Editor

Published Quarterly by the

International Standard Electric Corporation

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

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

G. E. Pingree, President S. G. Ordway, Secretary James E. Fullam, Treasurer

Subscription $3.00 per year; single copies 75 cents

Volume XI JANUARY, 1933 Number 3

CONTENTS

PAGE

ELECTRICAL COMMUNICATION IN 1932 113

SPECIAL NOISE TESTING EQUIPMENT 128
By D. H. Macnee, B. Sc., A. M. I. E. E.

THE INFLUENCE OF SIDE TONE UPON THE INTELLIGIBILITY OF TELEPHONE COMMUNICATION 135
By L. C. Pocock, A. M. I. E. E., M. Sc.

TOLL PLANT ENGINEERING 140
By Bruce H. McCurdy

INTERNATIONAL INSTRUCTION IN COMMUNICATION 155
By F. Gill

IN MEMORIAM—*Richard Becker Hungerford* 159

THE STOCKHOLM-MALMÖ RAILWAY CABLE EQUIPPED WITH TELEPHONE REPEATERS 160
By Ivar Billing

HENDON LABORATORIES

LONDON ENGLAND

Electrical Communication in 1932

IN general, the lull in business activity has not prevented the telephone, telegraph, and radio organizations of the world from perfecting their plans for extending service to new places, for offering new kinds of service, and for giving existing service more efficiently. The result of these activities and the readjustments in operating cost is that today communication administrations and companies probably are in an excellent position to take advantage promptly of the increased volume of business that inevitably should accompany the clearing of the business skies.

International Radio Telephone Services

No attempt can be made to enumerate in detail the international telephone services inaugurated in 1932 but even when indicated partially and in sketchy form as in this review, they make an imposing array. These new services of course include not only point-to-point communication but also radio with land line extensions. Thus, when one end of a new radio link is referred to as terminating in Great Britain, the probabilities are that additional services are available such as to many countries of Europe through land line extensions. Similarly, radio connections terminating in the United States probably include Canada, Cuba, Mexico, the Hawaiian Islands, and other countries or territories.

In 1932, for the first time direct telephone calls were put through between Europe and Japan through the League of Nations' wireless station and Kamikawa station, Tokyo. By means of this service the Japanese delegates at Geneva were able to keep in direct touch with their foreign office at home. The Japanese are reported also to have decided to establish an international radio telephone service to promote international telephonic communication to include America, England, Formosa, and other territories as well as vessels at sea.

Arrangements have been announced for the establishment of radio telephone service between China and Great Britain, and also between China and the United States. Through these countries others doubtless will be brought into the world telephone network with China.

Radio telephone service between Belgium and the Belgian Congo was authorized in September by Royal Decree.

Radio telephone services opened during the year include Egypt and South Africa on the one hand and Great Britain, United States and Latin America on the other. Service also was established between Germany and the Union of South Africa, and between Belgium and the Union of South Africa.

South American services were extended by the opening of service between Great Britain and Venezuela, the United States and Venezuela, Spain and Venezuela, the United States and Colombia, Spain and Brazil, Portugal and Brazil by way of Madrid, Peru and the United States, and Peru and Chile with land line and radio extensions including Argentina, Uruguay, and Brazil. Extension of the Peruvian service to Europe is also in early prospect. The service between the United States and Brazil now includes the States of Minas Geraes and Sao Paulo.

In September, radio telephone service was inaugurated between the Balearic Islands and the United States, and in December between Portugal and the United States.

Too late to appear in the communication review for 1931, international radio telephone service was opened from the United States to Bermuda and to the Hawaiian Islands; late in 1932, to the Bahama Islands. In 1932, also, radio telephone service was opened from Great Britain and Argentina to Hawaii, and from Great Britain to Canada.

In June, a highly successful test call was made between Buenos Aires and Batavia, Java, by way of London and Amsterdam.

The Bell System has announced plans for linking the United States to half a dozen Central and South American Republics bordering on the

Caribbean Sea. Service will be established through a new radio station at Hialeah, Florida, near Miami. Among the countries to be reached are Panama, the Canal Zone, Honduras, Nicaragua, Costa Rica, and the Bahama Islands.

Point-to-Point and Mobile

Experiments have been made with superimposed telegraphy on the Madrid-Buenos Aires radio link. The tests were made to determine what arrangements would be necessary if speech and telegraphy were to be transmitted simultaneously over one radio link. The experiments proved successful, as by the use of inverters and spreaders in the telephone channel and by appropriate allocation of frequencies, telegraphy at 125 words per minute was possible at the same time as speech. Telegraphy, in fact, proved possible at periods when radio conditions were extremely severe.

Radio Transmission Cable

Following upon the supply to the Hungarian Administration of a special design of radio transmission cable intended for use as an interconnecting link between the receiving antenna and the short wave receiving station, two further orders have been completed for the Norwegian and Danish Administrations respectively. These transmission cables consist of a single copper conductor surrounded by an "air space" insulation consisting of alternate layers of paper tape and paper string, over which may be applied one or more metallised papers and finally the lead sheath and wire armour. In this type of cable, the transmission loss is expected to be reduced to a very low order at short wavelengths.

Grinding of Tourmaline Crystals

In trying to grind quartz crystals for very high frequency crystal controlled oscillators, say above 20,000 kc., it becomes more and more difficult not only to obtain crystals producing one frequency only, but also to make the crystals oscillate. At frequencies higher than 40,000 kc. it is impossible to obtain oscillations. On the other hand, with tourmaline crystals, it is easily possible to obtain pure oscillations up to frequencies of 100,000 kc. This, however, can only be obtained by grinding these crystals to geometrically correct proportions. It is now possible commercially to make crystals to oscillate at wavelengths as low as 5 metres.

Radio for the Police

Considerable success has attended the development by Standard Telephones & Cables, Ltd., of a system for radio communication with patrol cars and motor-cycle combinations for the police force. A system has been developed which is practically automatic in operation, the transmitter being arranged to function without attention and to start automatically when the telephone handset is lifted from its stand. Immediately the transmitter goes into operation, the attention of the driver of the police vehicle is called by the lighting of a lamp on the radio receiver. The equipment operates on a fixed wavelength and requires no tuning or other skilled attention. Close contact has been established with the various police forces in the United Kingdom and much interest has been shown in the Standard system. Four highly successful demonstrations have been given—to the Scotland Yard authorities and to the police forces of Bradford, Newcastle and Edinburgh, respectively.

Micro-ray System for British Air Ministry

An order has been received from the British Air Ministry for a Micro-ray equipment which will be erected at Lympne, and will operate on a wavelength of 15 centimetres in conjunction with a similar equipment to be situated at St. Inglevert aerodrome, near Calais. It will be used for announcing the arrival and departure of airplanes and for routine service messages and will be the first commercial application of the Micro-ray system which was recently demonstrated by the International Telephone and Telegraph Laboratories. An extremely interesting feature of this new service will be the use of teleprinters for transmitting and receiving messages. In this way typewritten messages will actually be sent across the Channel by radio, thus providing a permanent record at each end. It is expected that the station will be in operation early this spring.

Marine Communication

Radio telegraph service between the United States and Haiti was initiated in 1932 by the

Radio Corporation of America, and between the United States and Hungary by Mackay Radio. To the latter company the Federal Radio Commission granted construction permits for ten new transmitters for oceanic radio telegraph communication, thus presaging the advent of that company to a larger rôle in radio communication. Engineers of the Commission estimated that the installation of these additional transmitters will cost about one million dollars.

The International Telephone and Telegraph Corporation on July 22nd announced that there had been concluded an agreement between the Minister of Communications of China and the Mackay Radio and Telegraph Company for the exchange of radio telegraph traffic between China and the United States, Hawaii and the Philippines. This agreement, together with the existing services to Honolulu and the Philippines, gives Mackay Radio a complete transpacific service in addition to its services to South America and Europe.

The growing importance of ship-to-shore telephony and telegraphy is attested by the recent opening, by Mackay Radio and Telegraph Company, of its fifth ship-to-shore radio telegraph transmitting station on the Atlantic Coast. The new station near Montauk Point, Long Island, operates in the intermediate wave band and is part of the program of wide expansion being carried on by the Company which has greatly extended its point-to-point world-wide radio telegraph network as well as its marine services.

On January 1, 1932, the Mackay Radio and Telegraph Company operated the radio service on 170 American merchant vessels. On December 1, 1932, this figure had increased to 215 ships, and includes the United States liner "Manhattan." Mackay Radio also will operate the radio services on the United States liner "Washington" when it is placed in commission in 1933. Incidentally also, the Kolster Radio Direction Finder forms part of the radio equipment of both of these vessels.

The International Marine Radio Company had a year of very satisfactory progress in the marine field. In addition to obtaining a contract for the operation of the wireless services of the transatlantic fleet of the Cunard Steamship Company and the equipment of five of the Anchor Line fleet with short wave radio telegraphy and telephony, the company is now responsible for the radio maintenance and operation of about 160 ships installed with radio apparatus of various types, included in which is the British Post Office cable ship "ALERT." Amongst the equipments which the Company has placed on the market are several of special interest to shipowners, including a master oscillator controlled equipment of medium power for use on passenger vessels, a rotating loop direction finder of very simple design, and an improved and much simplified form of auto alarm apparatus for the automatic registration of a ship's call of distress, designed to meet the requirements of the Convention for Safety of Life at Sea.

As a pioneer company of practical radio telephony on board ship, the International Marine Radio Company continues to keep the possibilities of this form of communication well to the fore in the design of its equipments and confidently anticipates that, with the return of prosperity, radio telephony will play an increasingly important part in the business transactions of the travelling public.

Mobile Transmitters and Receivers

Among the developments of the International Telephone and Telegraph Laboratories of equipment for marine work, the M. 6 transmitter is an outstanding example of what can be done to make a radio transmitter simple to operate and cheap in first cost. This transmitter is primarily intended for ship use, and provides operation on the short, medium and long-wave mobile bands. The combined transmitter is mounted in a single framework. It is made up on the unit principle so that the separate units may be supplied as required if operation is not wanted on all three wave bands. A special feature of the transmitter is that it is really "foolproof" in operation. That is to say, any control on the transmitter may be operated whether the power is on or off the transmitter without any damage to the equipment.

Two other transmitters, the M. 7 and M. 8 are small transmitters developed to replace the emergency spark transmitter which has been used hitherto on ships. The M. 7 is of twice the power of the M. 8. The M. 8 is self contained with power plant, whereas the M. 7 has an external motor alternator set.

To provide the diverse reception facilities required by the development of mobile services, etc., three new receivers have been added to the range of standard receivers, the R. M. 3, R. M. 4 and R. M. 5, which are simple receivers covering all requirements, from the lowest to the highest wavelengths in use for radio communication purposes, and embodying the latest developments in receiver technique, including variable mu tubes.

On many ships where the traffic to be handled does not justify the continuous watch of operators, it is often economical to provide an auto-alarm equipment. This type of equipment rings an alarm on the reception of an internationally used signal comprising a certain sequence of timed dashes, thereby warning the operator off duty.

The Federal Telegraph Company Laboratories, under specifications of Mackay Radio and Telegraph Company, has developed a series of marine transmitters for installation on American ships. These are available in four sizes, 100, 250, 500, and 1,000 watts. Short, intermediate, and long wave equipment can be secured, and some of the models have been designed as combination sets, so that both short and intermediate wave operation may be secured from a single transmitter.

In addition, two other types of transmitters have been developed, one for emergency use which may be installed on vessels where such equipment is compulsory, and the other for life boats.

Special receivers also have been developed for ship use in three types, a combination intermediate and long wave, a short wave, and a lifeboat unit.

The Federal Telegraph Company has designed and supply to the Mackay Radio and Telegraph Company, radio transmitters, rectifiers and receivers for fixed, point-to-point communication service, and for coastal stations communicating with ships. The transmitters range in size from 5 kW to 20 kW, with different types for the different wave bands. This Company also designs and manufactures transmitting vacuum tubes, to operate in all of their transmitters and rectifiers.

Radio Direction Finders

The International Telephone and Telegraph Laboratories have designed three types of direction finder, one incorporating a unique feature in that it has an automatic indicator showing the bearings of the station at any time.

The Direct Reading Direction Finder indicates without need of calculation or ambiguity the exact bearing of a source of radiation simply by tuning the receiver to the desired source. It has the unique advantage of giving accurate bearings of a transmitter even if the signals are only of a few seconds duration, also, of obtaining accurate and continuous bearings between points in motion; for instance, during fleet manoeuvres, bearings can be kept of a leading vessel and the accompanying ships can each be allotted individual positions relative to the leader.

Hand-operated direction finders are much simpler in conception, and were designed for use when cost considerations, as well as space available, are of importance. With hand-operated direction finders, more operations are usually required to obtain the desired bearing, but these are comparatively simple in the equipments designed by the Laboratories, due to elimination of the 180° ambiguity without requiring any supplementary operation. These direction finders need no correction as the quadrantal error is permanently eliminated by suitable design of the loop and antenna systems.

Aircraft Radio

A complete series of radio transmitting and receiving equipment has been developed for use on aircraft. These range from a simple receiver designed for private light aircraft to combined long and short wave transmitting and receiving equipment for the largest commercial air liners. Of special interest is the short wave transmitting and receiving equipment which was designed for high speed single seater fighting aircraft and which achieved an air-to-ground range of 100 km. when operated in conjunction with a 120 watt transmitter. This is remote controlled so that the apparatus can be located in any part of the fuselage and operated by the pilot from the cockpit. All of the equipments are designed for telephony as well as telegraphy.

After stringent tests on the actual route Imperial Airways have ordered "Standard" equipments for their new service of "Atalanta" type air liners flying between Cairo and Cape Town. Successful demonstrations were given in Belgium and other countries and a large number of these equipments have been ordered.

Experimental work on radio beacons for aircraft has been carried out by C. Lorenz in conjunction with the German air authorities and the Deutsche-Lufthansa A. G. A system has been installed on one of the Deutsche-Lufthansa A. G. routes and has proved satisfactory.

Long Distance Telephony

Most of the European Administrations have decided to carry on with their long distance network programmes, although in many cases the work accomplished during the year has suffered some curtailment. In spite of this, it is interesting to note that the average maintained between the years 1924 and 1929 has been well upheld in 1932. This is indicated by the loading coil deliveries made by the associated Standard Companies. In 1924 over 150,000 coils were delivered, whilst the average for this and the succeeding five years was a little over 130,000 coils. That 1932 will maintain this average is indicated by the fact that for the first nine months of 1932, the number of loading coils delivered was 108,152. There is evidence, therefore, that long distance systems are progressing at a rate consistent with that obtaining immediately preceding the abnormally high years of 1930 and 1931, when the loading coil output for the two years totalled half a million loading coils from the associated Standard factories alone.

Among the outstanding events of the year is the completion and successful inauguration of the Italy-Sardinia submarine cable, the longest submarine telephone cable in the world. This continuously loaded cable was manufactured and laid by Messrs. Pirelli, with the assistance of Standard engineers, between Fiumicino (Italy) and Terranova (Sardinia). It provides a single two-way circuit on which are operated one composited duplex telegraph channel and one telephone channel, and is designed for the addition of a two-way carrier telegraph channel. A special feature is the long length of the cable resulting in a high attenuation and necessitating the achievement of high singing points in order that the circuit might be operated two-wire at a net loss not greater than 1.0 néper. The attenuation was 4.35 népers at 2,500 p: s, and the singing points achieved were at least equal to the attenuation up to this frequency.

Other features are the employment of the impulse method of transmission for the composite telegraph channel over which teleprinters are to operate, and the connection of the telephone channel to the main Italian toll cable network at Rome via a cord circuit repeater equipped with a two-wire echo suppressor. The terminal equipment was supplied by Standard Telephones and Cables, Ltd., of London.

The extensive State underground network in Italy is growing year by year, and it was expected that the extension to Bari would be ready for service by the end of 1932. Progress has also been made in Southern Italy towards Sicily. An interesting feature in connection with the Italian network is the fact that extensions of the repeater equipment have been necessary between Rome and Milan to provide for the rapidly growing traffic. This work has been completed in twelve repeater stations during the year.

The Italian Administration has studied the possibilities of providing a large number of telegraph channels over the State telephone network using both super-phantom and voice frequency telegraph systems, and it is expected that the work will be put in hand very shortly. The underground networks of the Italian concessionaire companies have also been increased, the completion of the Genoa-Lucca-Florence and Genoa-Savona cables being the most important additions. All the long distance underground construction work in Italy is undertaken by the Standard affiliated company, the Societa Italiana Reti Telefoniche Interurbane.

In Poland the underground network from Warsaw to the Czechoslovakian border has been completed, and circuits have been put into service between Warsaw and neighbouring European capitals.

The underground system in Czechoslovakia has been further extended during the year, and attention has been given to the provision of telegraph circuits over the telephone network by means of super-phantoms, a number of such circuits having been put into service. In both Poland and Czechoslovakia the underground constructional work is undertaken by long distance cable companies affiliated with Standard.

In Hungary additional circuits on the Budapest-Vienna cable are now necessary, involving the completion of loading throughout the route and additional repeaters. This work is now in hand.

Much progress has been made in the extension of the telephone network in Sweden, and an important railway cable between Stockholm and Malmö has been completed. Very considerable further extensions to the Swedish Railway cables are being planned for installation in the immediate future.

In Norway considerable study has been given to the planning of an underground telephone network which would bring this country into line with other European countries.

Considerable progress has been made in France, particularly in connection with the Paris-Le Mans-Rennes, and Le Mans-Angers cables, and also with second cables over the two routes from Paris to Lille and Lyons respectively. Various cables establishing connections with Spain and transversal cables Toulouse-Dax-Avignon-Narbonne-Perpignan; and Narbonne-Toulouse have been installed, whilst the Bordeaux-Hendaye cable has been placed in service.

In Denmark, Belgium, Holland, Switzerland and England much progress has been made and many new cables have been completed, whilst, in the last named country, important innovations have been made in inaugurating and extending a no-delay service for long distance traffic, the British Post Office thus giving the lead to European Administrations, rapidly following upon the pioneer work of the United States. Much ingenuity has been displayed in providing for the circuit facilities necessitated by a no-delay service and a particularly interesting achievement was the re-loading and balancing of an early 100 lb. conductor telegraph cable on the west coast of England to provide telephone circuits suitable for modern conditions. This work was entrusted to Standard Telephones and Cables, Ltd., of London, and proved a marked success.

A development in Great Britain of the 4-wire repeater working has been the utilisation of two pairs of the same star quad for the "Go" and "Return" circuits in the cable. Successful operation of this scheme has been achieved over 100 miles of cable. It is necessary, however, that the capacity unbalances between the pairs of adjacent quads should be small and special precautions are taken to achieve this result.

The British Post Office were supplied with a number of welded sheet steel loading coil cases of novel design specially adapted for the loading of aerial cables.

There is an increasing tendency towards the use of toll cables for telegraph circuits simultaneously with their normal use as telephone circuits, and considerable improvements have been effected in composite telegraph systems; notably an increased range of telegraph transmission between telegraph repeaters with considerably less distortion of the signals. The importance of this development lies in the fact that long international telegraph circuits can be set up on the existing telephone cable networks, a practice which was not possible with the same degree of reliability over the older type of open wire circuits.

An interesting order was completed for New Zealand, covering the first loaded cable to be installed in that country, between Wellington and Paekakariki, a distance of about 40 km.

Mention should also be made of the special high grade broadcast repeaters which have been installed in many countries to cater for the transmission of broadcast programmes over the long distance network.

A new broadcasting repeater has been developed, consisting of a two-stage main amplifier and a push-pull output stage with a distortionless power handling capacity of 400 milliwatts instead of the 50 milliwatts provided by the existing broadcasting repeater. Any required number of output stages may be bridged in parallel for branching purposes. It is equipped with a low impedance ball-type slide wire potentiometer, and special circuits are introduced enabling a particularly flat gain frequency characteristic to be obtained.

Three values of output impedance are provided: 500 ohms, 75 ohms and 30 ohms; the corresponding distortionless powers delivered to a 500 ohm circuit are 400, 120 and 60 milliwatts. The low impedance outputs are for use with the C. C. I. constant voltage method of lining up circuits. The 500 ohm output is intended for use with a new method of lining up circuits which the International Telephone and Telegraph Laboratories have just developed and in which the circuit level is determined by an interstage measurement of voltage across a resistance in the output of the main amplifier. This new method of measurement has the advantage that the full power output of the repeater (400 milliwatts) is delivered to the line, and at the same time all difficulties at branching points are avoided.

To enable individual equalisers to be used for each direction of transmission on repeater sections on broadcast circuits without switching complications, and so to enable closer equalisation limits to be met, the equalisers for standard broadcast circuits have been redesigned to permit all equalisers to be located at the receiving end of each section.

Overall characteristics of circuits containing several repeater sections can now be equalised within closer limits than has hitherto been possible, e.g., to within ± 1 db by means of a group of three complementary infinitely variable equalisers covering the whole frequency range.

Toll Signalling

Ideas on operating methods have been considerably modified during the last few years owing to the development of improved signalling means. The development of the four frequency system has enabled full automatic working to be obtained over any kind of long distance circuit. This results in large economies in operators and improvements in the traffic carrying capacity of lines.

Trial circuits were installed both in Italy and England, and permanent installations have since been decided on for the whole of the London area and on the Milan-Florence cable. In addition, eleven circuits are being installed between Leeds and London, giving full automatic operation on a voice frequency basis. These will be put into service in the early part of 1933.

The British Post Office will operate four frequency keysending between manual and automatic exchanges in 60 manual exchanges in the London area, and the whole of the voice frequency keysending equipment for these 60 exchanges will be supplied by Standard Telephones and Cables, Limited. Two new voice frequency schemes have been developed to carry the traffic originated at manual exchanges:

(1) 4-digit voice frequency keysending from the manual exchange to the terminating automatic exchange, where direct junctions between the two exchanges exist.
(2) 7-digit voice frequency keysending from the manual exchange to the nearest automatic exchange, which acts as a tandem exchange to carry the traffic where no direct junctions exist between the originating and terminating exchanges.

Equipments for twenty-four exchanges for scheme (1) are already in service out of a total of thirty-five on order, and orders have been received for the first section of the scheme (2) conversion.

A ringer panel using four voice frequency relays and operating on two steady frequencies has been developed. It permits conversion to full automatic working at any subsequent date. Seventy-four of these panels have been installed in Italy on the Milan-Genoa-Lucca-Florence cable route.

Interest has also been shown in the four frequency system in France and Switzerland. A trial installation of four frequency keysending has been installed on a circuit between Paris and Marseilles, and a trial of four frequency dialling has been made on two circuits from Genoa to Zurich, and three circuits from Rome to Zurich.

Studies are now being made in many countries which will undoubtedly lead to the general adoption of automatic long distance switching methods by means of voice frequency switching.

Carrier Telephony

The year has been remarkable for the number of new countries in the world which have introduced carrier telephony for the first time, and for the number of new systems and uses which have been introduced in countries already using carrier current working. The area in which carrier development has been particularly rapid is the Balkans where Sofia is now linked to

Rumania and Turkey, Stamboul to Angora, and Belgrade to Szeged by recently installed Standard Carrier systems. There have also been several outstanding developments in the carrier current art.

For telephone public services Austria, the Irish Free State, Northern Ireland, Russia, Turkey in Europe, Turkey in Asia, Bulgaria and Yugo Slavia have installed carrier systems for the first time, while Finland, Morocco, France, Rumania, Hungary, New Zealand, Rhodesia and South Africa have added to their existing carrier telephone equipment.

The British railways, in particular the London Midland & Scottish and the Great Western, have installed carrier telephone systems for traffic control and private telephone services, and such is the economic success of these systems that it is probable that other railway companies will follow their example in the near future.

A single channel carrier telephone repeater, considerably simpler than the repeater previously in use, has been developed. It consists of a single amplifier which is used in either direction as required. Since different frequencies are used in the two directions, it has been possible, by means of filters, to use the valves in the amplifier in push-pull arrangement in one direction, and in parallel in the opposite direction. The gain obtainable from this repeater is about 37 decibels, it is completely mains-operated and will mount on one 7 foot rack.

A notable achievement was the placing in service of the Calcutta-Bombay high frequency carrier telegraph system with four repeater stations.

A very interesting development which was partly completed in 1931 and finished in 1932 was the new 18-channel voice frequency carrier telegraph system. This system was fully described in *Electrical Communication* of April, 1932, and it is of interest to note that three systems have been installed in England. One of these terminals was in successful operation between Paris and Geneva during the Disarmament Conference and worked perfectly in conjunction with a Siemens & Halske equipment located in Geneva.

The Swedish Administration installed a 6-channel voice frequency carrier telegraph system between Göteborg and Malmö during 1932. This system is on the 170 cycle spacing (which is a special requirement of the Swedish Administration) to cater for existing telegraph equipment which is already in Sweden. The new 18-channel equipment of course meets the C. C. I. requirements as regards 120 cycle spacing and operating conditions.

A 2-channel voice frequency telegraph equipment has recently been supplied to the Allied Newspapers for private service working on a circuit equipped with the Belin picture transmission system and it is probable that other newspaper organisations will follow this lead.

A very interesting development has been that of the carrier broadcast channel which has been developed in order to provide a broadcast quality channel on open-wire lines where it is not possible to allocate a separate circuit for the purpose of the voice frequency band. This channel has several outstanding features which may be summarised as follows:

(a) A single sideband system, Carrier suppressed.

(b) On the V. F. side,
Band width 30—8,000 cycles.
Volume range catered for: about 40 db.
The system will accept and deliver 50 mW.

(c) On the Carrier side,
The frequency range required is approximately 34—42.5 kc., the carrier frequency being 42.5 kc. A pilot current, 34 kc. in frequency, is used not only to give indication of the state of the line but also to keep in synchronism the modulator and demodulator oscillators.

(d) It is possible to switch this channel for use in either direction on the line.

(e) With regard to equipment features, it is designed to be similar in general appearance to the 3-channel system. A combined transmitting and receiving terminal occupies two 10 ft. 6 in. racks and a repeater, one 10 ft. 6 in. rack.

An order has been secured in Australia for a one-way broadcast channel, and this development will undoubtedly provide Administrations a facility for which they are looking, particularly in view of the growth of the broadcasting network and the increasing desire for the interchange of programmes.

Printing Telegraphs

The remarkable progress of the teleprinter and similar start-stop systems in replacing hand Morse and other operating methods involving special telegraphic skill was continued throughout 1932.

The British Post Office have now 2,400 tape model teleprinters in actual service for dealing with public telegraph traffic, and 1,000 page model teleprinters have been ordered for person-to-person and private wire services. It was anticipated that all these page machines would be in service by the end of the year. It is significant of the revolutionary progress which the telegraphs have made during recent years that 82% of the telegraph traffic over the Post Office lines is now being handled by Creed teleprinters, and that the Morse code is no longer being taught in its operating school.

The ease of operation and the striking operating economies made possible by these simple typewriter keyboard machines have led the Railways, County Police and Scotland Yard to make extensive use of them, while numerous other fields for written communication have been opened up in commerce and industry.

Several European Administrations have reviewed their line tariffs and have made considerable reductions in order to stimulate the demand for private telegraph communication and thereby derive additional revenue from idle facilities in their telephone cables.

During the early months of the year the British Post Office launched a campaign to popularise their private point-to-point teleprinter services and public demonstrations on an imposing scale were made in London and Birmingham. These demonstrations were followed up by intensive canvassing throughout the year, and resulted in a big demand for private telegraph communication. Where there are no idle physical lines available this demand is being met by super-phantom methods and by the introduction of multi-channel voice frequency telegraph systems.

An epoch-making event took place in August when the British Post Office introduced person-to-person written communication service. This is called "Telex" Service, and from the subscriber's standpoint it is a combination of the telephone and the typewriter, as he may talk or typewrite at will over the same connection, though not simultaneously. A charge of £65 per annum is made for the subscriber's apparatus, which includes a Creed No. 7A Teleprinter and a single-channel voice frequency unit.

Ordinary Telex calls are connected like telephone calls and the charges are similar, but a special cheap rate service, restricted to written communication, has been introduced between London, Liverpool, Manchester and Birmingham; this will gradually be extended to other provincial towns.

The new teleprinter,* developed for Telex and similar services, incorporates many novel features and represents a big advance in the design and construction of printing telegraph apparatus During 1932 the efforts of the Creed Company were directed towards perfecting the design and manufacture of this machine, and in providing additional operating facilities. The typehead clutch has been improved considerably and a new motor governor has been developed. The tape attachment, which replaces the paper carriage where printing on a paper tape is required, has been fitted with an "end of line" warning device in order that tape teleprinters in telegraph offices may be used for sending telegrams to subscribers equipped with page teleprinters. A sprocket feed paper platen has also been developed to meet the need for strict paper registration where printed forms are used in the printer.

The use of teleprinters on the Railways was considerably extended during 1932, and one interesting project was the modernising of the telegraph system of the London "Underground." The centre of this extensive network of electric railways is at Leicester Square, where the movements of every train are recorded and controlled by telephone, telegraph and traffic control equipment. This centre is now equipped with No. 7A teleprinters communicating with seventeen No. 8A teleprinters (receiving only), grouped on four lines.

Of technical interest is an automatic switching system introduced by the Great Western Railway, in which a novel selector is used. This selector comprises a Creed teleprinter modified by replacing the typehead and clutch with a bank of contacts controlled by the printer selecting bell-cranks. Merely by transmitting a predetermined sequence of upper case characters

*"Developments in Start-stop Telegraphy—the New Creed Printer," *Electrical Communication*, October, 1931.

to the teleprinter selector, any one of three stations can establish connection with one or both of the other stations.

During the year there were important teleprinter developments in the police field. Scotland Yard, the headquarters of the London Metropolitan Police, introduced a network of thirty-four teleprinters connecting Divisional stations with headquarters, and it is planned to use a further one hundred and three machines for extensions to sub-divisional stations.

The Lancashire County Police also have introduced teleprinter intercommunication between their headquarters in Preston and seventeen divisional stations, with special switching facilities including group selection and broadcasting. Headquarters is equipped for both direct keyboard and automatic tape transmission. Teleprinter receiving reperforators are also used.

In the press field Creed Teleprinters are handling the heavy news traffic of the Tidningarnas Telegrambyra over voice frequency channels between Stockholm, Malmö and Gothenburg, with extensions to local newspapers in these towns. The Exchange Telegraph Company in London has ordered an additional 250 page machines for replacing obsolete apparatus and extending its services, and Agence Havas, the big French news agency, is introducing teleprinter communication between its offices in Paris and London.

It is also of interest that teleprinters are being used for transmitting the results of the Irish Sweepstakes from Dublin to London, and for redistributing the results direct from the Central News to the newspapers.

In the Federated Malay States five important telegraph lines between Penang, Singapore, Kuala-Lumpur and Ipoh have been equipped with Creed Teleprinters.

The usefulness of this machine is not confined to communication over long distances. It is finding numerous applications in business offices and factories, where its speed, accuracy and dependability are effecting considerable savings and improving service efficiency. Teleprinters are being used for transmitting important control orders between the main generating station and sub-stations of the Birmingham Electric Supply Corporation. An internal installation of outstanding interest is in the factory of the well-known Austin Motor Company where, in addition to speeding up service between various offices and stores, Creed Teleprinters are playing an important part in the production control, being used for transmitting vital information between the Body Shop and the Chassis-erecting Shop. Such excellent results have been obtained that further extensions are being planned.

Special Telegraphic Services

In line with the efforts of American telegraph companies to offset the falling off in volume of messages by procuring by-product business, arrangements were completed for the inauguration on August 1st of a nation-wide interline Air Express System with connections to Canada, Mexico and South America. Special door-to-door pick-up and delivery service is performed at all points by Postal Telegraph which was appointed commercial agent.

In January, Postal Telegraph pioneered in the simultaneous delivery of a million or more messages by Postal Telegraph messengers throughout the United States at comparatively low cost through a new service. Use of the service involves a master telegram sent to key cities where duplicate copies are made for messenger delivery. The service was first utilised by the Hudson Motor Car Company, Detroit, Michigan, which sent personal invitations to 1,207,500 automobile owners to visit local show rooms and inspect the new 1932 Hudson and Essex cars. This type of service has been developed by both the Postal Telegraph and Western Union Companies.

During the year the campaign for the telephonic pick-up and delivery of Postal Telegraph business was actively pushed, especially among the Independent Telephone Companies. These Companies have taken enthusiastically to this pick-up and delivery service inasmuch as it is a by-product with them and establishes them firmly as the communication utility of their territories and, moreover is beneficial in public relations. On the other hand, in many cases it enables the telegraph companies to furnish their customers with an improved telegraph service.

Automatic Telephony

During the year the "International" European Laboratories completed the redesign of the Rotary system, the first typical exchange of the new type being under manufacture in the Antwerp factory of the Bell Telephone Manufacturing Company, for operation in Bucharest (Rumania).

Each process in the building and operation of automatic equipment has been studied, and in the redesign the aim has been to simplify, improve the operation, the life and the appearance of the equipment, reduce weight, floor space, and cost.

Manufacturing processes have been improved by the introduction of die-cast switch frameworks and arc terminal blocks of insulating material mounted in one block of 300 terminals. Selector and sequence switch bays have been combined, and use the same vertical shaft.

The amount of installation work required on site has been reduced and simplified, and is practically confined to the running of interbay cabling and its connection to terminal strips which are provided on the top of each type of bay. The equipment has been designed so that circuit units can be built and mounted in bays of 20, and completely wired and tested before leaving the factory.

The method of installing common leads, such as battery, ground, various tone leads and ringing current leads has been greatly simplified. In addition, accessibility to and identification of these main wires have been greatly improved, thus facilitating maintenance.

The use of the 200 point line finder has made it possible to eliminate second finders for the normal traffic, with a consequent simplification of maintenance. Tracing of connections becomes much easier, and permanent loops can easily be identified by means of a permanent loop finder for each group of 200 lines, which after a convenient delay indicates on the wire chief's desk the number of the subscriber's line on which a permanent loop appears. This indication is made on a lamp display panel of the call indicator type. Restricted service can easily be arranged without transferring the subscriber's line from one group to another, which again simplifies maintenance and records.

In each group of 200 lines, sufficient finders for carrying the normal traffic are connected direct to first group selectors; the remainder, i.e., those carrying peak traffic, are connected over second finders to common first group selectors. The peak traffic finders are brought into service only when all the normal traffic finders are engaged. The net result of this arrangement is increased efficiency of the first group selectors, with a consequent reduction in the total number of switches.

The register chooser of the 7-A.1 switching scheme has been eliminated, and intermediate register link circuits provided, having access on one side to 100 first group selectors, and on the other to 100 registers. The total number of switches is therefore reduced, and since the registers are in such large groups, they operate at high efficiency.

Controlled Single Motion Switch Systems

The 7-D Rotary system, which includes a number of units operating with single motion switches, with and without control circuits, has been improved and simplified. Important changes in the layout have been made, and the small type gear-driven line finder incorporated. Cabling has been greatly simplified, and the floor space has been considerably reduced. The power plant has also been improved and simplified. The smaller units covering capacities from 25 to 300 lines have been redesigned, and the amount of equipment involved reduced by about 40%. This system is also designed for national dialling.

P.B.X. Developments

A complete line of the P.A.B.X.'s has been produced ranging from a 4-line all-relay unit for residential or small business house traffic to a 400-line unit employing gear-driven line finders and suitable for large factories, government buildings, hospitals and so on. All units are designed to permit city calls, both inward and outward, to be transferred from subscriber to subscriber, and from subscriber to attendant, by means of a simple push button which is included in the standard subscriber's set. A very simple and attractive cordless attendant's unit has been designed, which is easily accommodated on the average office desk or table, and which reduces the attendant's work to the minimum. Tie line, conference line, preference line, code calling and fire alarm circuits have also been designed to be included when desired.

For the smaller capacity P.B.X.'s power units using dry rectifiers have been developed. These can be installed instead of the usual battery supply arrangement. In case of failure of the mains, one of the junctions is automatically switched to one of the stations.

Bypath Equipment

The installation of the experimental Bypath Exchange in London has been completed, and 3,400 lines will be cut into service in February. The experimental Bypath Exchanges in the Burton Area are nearing completion and will be cut into service next April. These consist of three exchanges serving 2,400 lines.

Considerable interest is being shown by the British Post Office and other Administrations in these exchanges, particularly from the point of view of the improved maintenance features, the new operating facilities, and the reduction in capital cost and annual charges.

Vacuum Tubes

The continuous increase in the power of radio transmitters during the last few years is one of the most striking characteristics of the tremendous development of the radio industry. This increase in power would have been greater still had it been possible to employ an unlimited number of vacuum tubes in parallel working. The output energy obtainable by means of tubes connected in parallel and operating at high plate voltages is limited by well-known difficulties. In practice, the various manufacturers have limited the number of tubes which can be used in parallel in the high power stage, to about 12. The broadcasting station in Prague employs twelve 40 kW tubes in parallel which produce a peak energy in the antenna of 480 kW with 100% modulation. In order to reduce the number of tubes in transmitting stations of so high a power (200 kW, C.C.I.R.) and also in order to enable the construction of still higher power transmitters, a 120 kW tube has been developed by the European Laboratories. Only four tubes of this new type are required in the Budapest broadcasting station in order to produce the same power as the Prague transmitter. The development of this tube has been carried out with the aim of obtaining a factor of safety very much greater than with any other existing water-cooled tube.

With a plate voltage of 25,000 volts this tube gives for test a continuous output of 200 kW; it resists double the normal anode dissipation, i.e., 160 kW, and is only half the size of the 120 kW tubes already on the market. The technique developed by the Laboratories allows the use of a normal operating plate voltage, of 20,000 volts. This is probably the highest plate voltage used at present on any standardised water-cooled tube, and is one very valuable feature of the Laboratories' 120 kW tube.

The increase in power and the corresponding increase in the supply voltages has led to the demand for more powerful rectifiers.

The cost of primary energy in high power stations necessitated an improvement of the efficiency of the rectifying system; an increase of only 1% in efficiency decreases the annual running cost of a transmitter such as the one in Budapest by as much as $400. With this in view, a complete line of hot cathode mercury vapour rectifier tubes has been developed, permitting the construction of rectifiers for voltages from 500 volts to 20,000 volts and currents up to 50 amperes; this with an efficiency of between 95 and 99.6%, depending on the rectified voltage. The development of these tubes, the working principles of which are not new, has been carried out with the same aim in view as in the case of the 120 kW tube, i.e., to obtain tubes with an exceedingly high factor of safety. These tubes contain an oxide coated cathode for direct or indirect heating, according to the power to be produced and, further, an anode located at the opposite end of the tube. The presence of the mercury vapour in the tube neutralises the space charge and maintains the voltage drop within the tube constant at 15 volts. These tubes normally support an inversed voltage of 10,000 volts, and they are tested for double this voltage.

The same elements as at present in these tubes, also served for the construction of a line of low voltage rectifier tubes which may be employed in the place of other types of rectifiers now used for charging accumulators as well as for the filament supply of ordinary D.C. radio tubes, for the current supply for D.C. motors of variable speed, and even for the construction of small lighting power substations for voltages of up to 500 volts and a current of 120 amps. The voltage drop in these tubes is of the order of 5 volts. This small value made it possible to obtain an efficiency of 80% for charging accumulator batteries of 48 volts generally used in telephony, and an efficiency of up to 98% for voltages of 500 volts.

The applications of the new quarter ampere range of tubes have been extended and their use in the voice frequency teleprinter unit and the 18 channel voice frequency telegraph system adds materially to the efficiency of these equipments.

Measurements and Measuring Instruments

Articulation

As the result of a comprehensive study of articulation testing, a new technique for the measurement of articulation and the calibration of articulation crews has been developed. This technique gives considerably greater accuracy than that obtainable by older methods, and has proved so successful that it has been adopted by the C. C. I. as the official testing method.

Interference

A series of field and laboratory tests has been carried out, and these have resulted in the development of improved methods of estimating the effect of inductive interference produced in communication circuits by neighbouring power systems.

A new method of balancing a telephone cable has been developed which makes the cable much less susceptible to the effect of induced noise. This method thus makes it possible to operate cables under conditions of severe interference which would make the use of an ordinary cable impossible.

Direct Reading Transmission Measuring Sets

The demand for simplicity and for direct and rapid operation of measuring and testing apparatus, especially that used for routine installations and maintenance measurements, has resulted in the production of direct reading transmission measuring sets in which a meter is incorporated reading directly in decibels or nêpers the level, gain or loss being measured. The meter used in these sets incorporates a metal oxide rectifier, and has specially shaped pole pieces and coil core to give an approximately even decibel scale. Examples of such sets developed in 1932 are a direct reading level measuring set (having facilities also for gain and loss measurement) for repeater stations, also embodying the new type repeater construction, and a similar instrument in portable form for measuring levels at junctions in automatic areas. A direct reading gain measuring set, with a range of 0 to 35 db, and requiring no power supplies for its operation, has also been produced for measurements on junction line repeaters.

All these sets have the advantage of considerably reduced size and lower production cost due to the elimination of a number of components and of greater speed and simplicity of operation, leading to reduced maintenance costs.

Heterodyne Oscillators

For similar reasons, the heterodyne type of oscillator having a single dial only for control of frequency is being adopted for transmission maintenance tests and for measurements where a range of frequencies is required, the extreme simplicity and speed of operation of this type of oscillator being an important factor leading to increased efficiency and reduced maintenance cost. A high quality heterodyne oscillator is now available in both rack mounted and portable form, covering the frequency range 20 to 11,000 p: s, and incorporating a frequency standard enabling constant check of the calibration to be kept.

Telegraph Distortion Measuring Set

Until recently the performance of a telegraph channel has been described in terms of the maximum speed in words per minute at which accurate operation has been obtained. Such information giving the limit of speed, whilst of some practical interest, gives no reliable indication of the margin of safety available for any given speed at which the channel is actually required to work. A measuring set has, therefore, been introduced to determine this margin in a more scientific manner by measuring the imperfections or distortion introduced into a telegraph message during transmission. This telegraph distortion measuring set consists of three units: a transmitter unit which produces accurate signals for transmission through terminal apparatus and line; a receiver unit which, by means of a cathode ray oscillograph, gives a visual and direct reading of the percentage distortion incurred by these signals during transmission; an oscillator unit which drives both the transmitter and the receiver.

With this set, it is now possible rapidly to determine the transmission condition of lines and apparatus, and to rectify faulty conditions before they become sufficiently serious to interrupt traffic. Especially in connection with such systems as the 12 or 18 channel voice frequency telegraph systems, maintenance is simplified and operating efficiency increased.

Rediffusion System

In cities, high quality reception of radio broadcasting is not an easy matter as the great density of population makes it difficult to allow the erection of individual antennae, while a considerable amount of interference is caused by elevators, tramways, and domestic electrical equipment. These difficulties can be overcome by the distribution of entertainment and information over a separate wire network from which leads are branched off to loudspeakers installed in the homes. All the subscriber needs is a loudspeaker and a simple switch by means of which he selects the programme he desires from a number available.

Programmes obtained from radio receivers or other sources are amplified at a central station, and from there distributed to secondary stations where they are again amplified for connection to the subscriber's feeders. Standard Telephones & Cables, Ltd., London, have developed central station control equipment and amplifiers giving 200 watts undistorted voice frequency power for this service.

Teleprogramme System

The telephone network can be used for the distribution of music, entertainment and information to the subscribers by means of the teleprogramme system. The subscribers obtain a programme box and an amplifier loudspeaker unit. The telephone line, the telephone set and the amplifier are all connected to the programme box. This box contains a knob by means of which the subscriber can connect to the programme service and a relay which automatically disconnects the amplifier loudspeaker should the subscriber make or answer a telephone call. The subscriber can select one of the programmes supplied by operating a button on the amplifier unit. This unit has the appearance of a radio set from which the tuning dial has been omitted. It operates from power mains.

In the telephone exchange, each subscriber's line is provided with a programme selector which can be stepped to four positions by operating the programme selection button at the subscriber's home. Each position corresponds to a programme. The selectors of subscriber groups are connected to the programme busbars that are fed by power amplifiers. The power amplifiers in the various exchanges of an area are connected over special pairs in the junction cables to the preamplifiers in the control room of the main exchange.

In the control room the operator adjusts the levels to the outgoing junctions, and he composes the programme by connecting the inputs of the preamplifiers to sources of information and entertainment such as radio receivers, gramophone pick-ups, pick-up microphones in concert halls or in meetings, and long distance lines.

Broadcasting

The year brought the number of broadcasting stations manufactured by companies in the International Telephone and Telegraph Group to 104 representing a total carrier power of nearly one million watts. Broadcasters were ordered or put into service during the year in the Argentine, Portugal, Australia, Sweden, Great Britain, Germany, Hungary, and Denmark.

An example of the latest type of Standard broadcaster to be put into operation is the Magyarovar station in Hungary, with a power of 125 kW. This transmitter embodies the latest design features. No moving machinery is used.

A special external high stability quartz-controlled master oscillator ensures a frequency stability of better than five parts in a million.

A 60 kW broadcaster of the same type is being manufactured to replace the present Standard 7 kW equipment at Kalundborg. The new station is scheduled to go into service in April, 1933. This station is of interest because it represents a completely new departure in the design of the high power radio frequency equipment. According to the new principle, the apparatus will be lined up in accordance with high tension power engineering practice instead of in the manner previously followed in radio frequency engineering. The radio frequency components will be assembled in a series of brick-built cubicles.

In pursuance of their broadcasting plans the Hungarian Administration have ordered one transmitter with a carrier power of 120 kW together with one relay station of 6.25 kW and three of 1¼ kW. As noted above, one of these relay stations is already in operation, and manufacture and installation of the remaining stations is progressing. All these stations are being manufactured by the Standard Electric Co., Ujpest.

C. Lorenz A. G. have constructed three new broadcasters: the Leipzig 125–150 kW, and the Munich 60–75 kW high power broadcasters, and the Frankfurt-on-Main 15–25 kW broadcaster. All are of new design and particular attention has been paid to good modulation and constancy of carrier frequency. In the new high power transmitters, water cooled valves with a new porcelain cooling jacket and outputs of 40–140 kW are used in the last stages.

In co-operation with the Reichspost, C. Lorenz have carried out a series of experiments on antenna design with a view to increasing the fading-free area round a broadcaster. A series of antennae are arranged in a circle around a central antenna, and by correct design of the phases and powers in the different antennae a very considerable reduction of the skywave can be obtained and the fading-free area considerably increased.

A new tuning fork control system for common wavelength working has been installed to control the wavelengths of the Frankfurt-on-Main, Trier, Kassel and Freiburg stations. By means of special circuits interference in the control channels has been eliminated, and several more networks of the same type will be introduced in Germany next year.

Standard Telephones & Cables, Ltd., were awarded the order for the complete equipment of the British Empire Broadcasting Station of the B. B. C. at Daventry. This station is designed to give service to the British Colonies and Dominions throughout the world. Two Type IV (15–20 kW) short wave transmitters were supplied. As compared with the commercial Type IV transmitter, these equipments have been somewhat modified so as to give transmission quality equal to the highest standard required for broadcasting. A special frequency control equipment has been incorporated. Seventeen different antennae are used to give service to the various colonies. The whole scheme was engineered by the Standard Company in collaboration with the B. B. C., including the determination of the wavelengths and erection of the antenna system required to give service to the various colonies at each particular time of the day. The station was placed in service on December 19th.

Special Noise Testing Equipment

By D. H. MACNEE, B.Sc., A.M.I.E.E.

RAPID progress during recent years in the development of communication and heavy current systems and the consequent increase in the numbers of both types has resulted in the question of interference between power and communication circuits becoming a factor of major importance to the communication engineer. The International Telephone and Telegraph Laboratories have found it desirable, therefore, to devote special attention to the various problems which arise in this branch of communication engineering, and in general have studied them under two main headings:

(1) General study of interference and the means of its reduction.

(2) Application of the knowledge thus gained to the solution of interference problems arising in practice.

Both of these functions entail large numbers of tests, the greater proportion of which must be carried out in the field. Their varied nature may be gathered from the list given below:

Noise Measurement.
- Measurement of Line Noise.
- Measurement of Radio Noise.
- Measurement of Room Noise.
- Measurement of Valve and Johnson Noise.

Determination of the Noise Characteristics of Power Systems.
- Measurement of Noise Field Strength.
- Analysis of wave-form in inducing and induced systems.

Determination of the Fundamental Noise Constants of Communication Systems.
- Measurements of the Mutual Impedances of Grounded Circuits.
- Measurement of the Shielding effect of Cable Sheath and Armouring.
- Measurements in connection with Series and Shunt Unbalances.

Instead of designing a series of separate instruments for each of the above types of measurement, which would have necessitated the transportation of a large amount of apparatus when testing in the field, and entailed a lack of flexibility, it was decided to develop a set of apparatus comprising a number of individual, easily portable, units which could be connected together in various ways so as to serve for any of the different measurements.

In the design and construction of this apparatus, the following features were taken as the guiding principles:

(a) *Portability.*—Since the apparatus was required very largely for field tests it was obviously necessary to make it as compact and portable as possible.

(b) *Flexibility.*—In view of the many uses to which the apparatus might be put it was essential that its application be made as general as possible and it was considered therefore that a large number of small units would meet this requirement better than a few relatively large units.

(c) *Reliability.*—This apparatus might, at any time, be required for use in some locality in which considerable difficulty might be experienced in obtaining replacements of faulty or damaged components, and in which atmospheric and electrical conditions might be such as to impose a severe strain on any equipment. It was therefore essential that the apparatus be made as reliable as possible from the mechanical as well as the electrical standpoint, in order that it could be depended on to function satisfactorily under conditions of excessive humidity or in the presence of strong stray magnetic fields.

Apparatus

The noise-set apparatus includes high gain amplifiers, resonant wave analysers, variable or fixed frequency oscillators, thermomilliammeter sets, attenuators, search coils, and a large quantity of subsidiary equipment such as battery boxes, resistance boxes, and receivers.

The principal items of one set of apparatus connected up for a test are shown in Figure 1. The precise method of connection, in practice, would be governed by the field conditions, and the illustration indicates only one of the many possible arrangements. Each piece of apparatus is mounted in a fumed oak box fitted with a

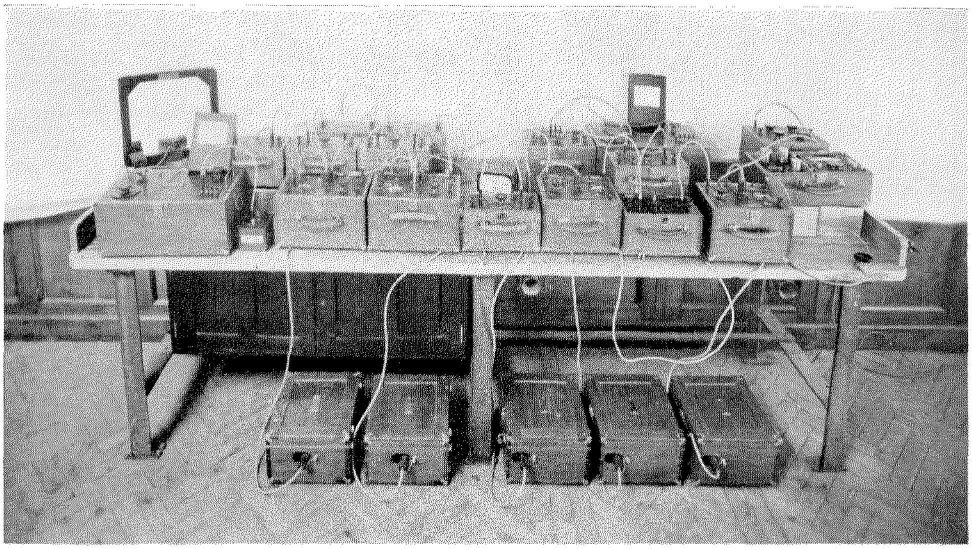


Figure 1—Principal Items of One Set of Apparatus Connected up for Noise Measurement.

hinged and detachable lid, and is provided with a carrying handle. Certain instruments, notably those containing valves, are fitted with hinged metal panels in order to facilitate interior adjustments. All connections are made by means of plug-ended cords. These cords are of the triple concentric type, containing three concentric flexible conductors covered by cab-tyre sheathing. The two innermost conductors are used to make circuit connections and the third or outermost to pick up the common earth circuit through the sleeves of the jacks. Each box is provided with a metallic lining, which is connected to the screens of all component apparatus, such as repeating coils, and to the sleeves of all jacks. When the apparatus is in use, this earth circuit is effectively earthed at one or more points, by means of the earth terminals provided on the panels of all units.

The apparatus, as a whole, has been designed as unbalanced, that is to say, that of the two wires of a pair used to make a connection between two units, one is relatively at earth potential as compared with the other. The jacks on each unit have been so wired that the high potential lead is, in all cases, connected to the tip, while the low potential side of the circuit is connected to the ring. Tip to tip connections are made by means of the innermost conductor of the connecting cords in all cases, so that poling of the circuit connections is avoided.

A figure of 200 ohms has been selected as the most suitable value for the general coupling impedance of this apparatus. One of the chief reasons for the selection of this value of impedance is that the type of receiver normally used for measurement of noise has an 800 cycle impedance of approximately 200 ohms. A further advantage gained by the use of this relatively low value of terminating impedance is that it tends to reduce the possibility of any "singing" which may occur due to back coupling between adjacent stages of the amplifier. Certain networks which may be used with this apparatus operate considerably more satisfactorily between impedances somewhat lower than 200 ohms; for this reason certain units have been provided with an alternative terminating impedance of 25 ohms.

In all units considerable care has been expended on getting as complete a shielding as possible, consistent with reasonable weight and portability.

Amplifier

In order to obtain the utmost flexibility the amplifier has been constructed as four individual units. Each unit is boxed separately and is provided with its own accessories in the way of batteries, filament current meter, filament rheostat, B battery jack, etc., so that each unit forms a complete amplifier in itself.

The first two of these units each contains two stages of amplification and the last two one stage each. In the two stage units, the input and output of each stage is transformer coupled and terminated in jacks, so that each of the four stages can be used independently making for the whole amplifier, six available stages of amplification, any one of which may be used separately.

The first four stages comprise the high gain stages, each stage giving a gain of 25 db, between 200 p.p.s. and 3000 p.p.s. when operated between 200-ohm impedances; the last two stages form power stages, each giving a gain of 20 db, between 200 p.p.s. and 3000 p.p.s. The complete amplifier with all stages connected in series has an overall gain of 138 db and a gain frequency characteristic flat to within 4 db over the frequency range given above.

Figure 2 shows the average gain-frequency characteristic for one stage of the high gain unit and also for a power stage. These curves have actually been obtained by averaging the results from 12 stages in the case of the high gain stage, and from 6 stages in the case of the power stage. The characteristic of any individual stage, however, was found to agree with the average curve to within ± 2 db over the whole frequency range. All valves are mounted antimicrophonically, the mounting consisting of a block of Sorbo rubber cut in half and hollowed out to receive the valve and its socket, the two halves being clamped together and to the bottom of the box by a metal bracket. These valve mountings have proved quite satisfactory in practice, microphonic noise originating from the normal vibration of benches and such causes being in most cases audible only in the case of an overall gain exceeding about 70 db.

Dry cell batteries are used to energise the valves and are contained in separate battery boxes, each unit being supplied with its associated box. Each battery box, in addition to carrying the necessary batteries, fuses, etc., also carries spare valves. Connection between a battery box and its associated amplifier unit is established by means of a shielded four conductor cord, cab-tyre sheathed and terminated in plugs which fit into sockets provided on the panels of the amplifier and the sides of the battery boxes.

Resonant Wave Analyser

The noise tones most commonly met with in practice are complex in character, and it is often desirable to have some means of separating out the various components of the incoming wave in order that some form of analysis may be made.

The Resonant Wave Analyser has been designed primarily for this purpose, although there are obviously many other uses to which it may be put. It consists essentially of a simple series resonant circuit comprising a variable condenser and tapped inductance coil.

Keys are provided on the panel for the purpose of selecting the various tappings on the coil and

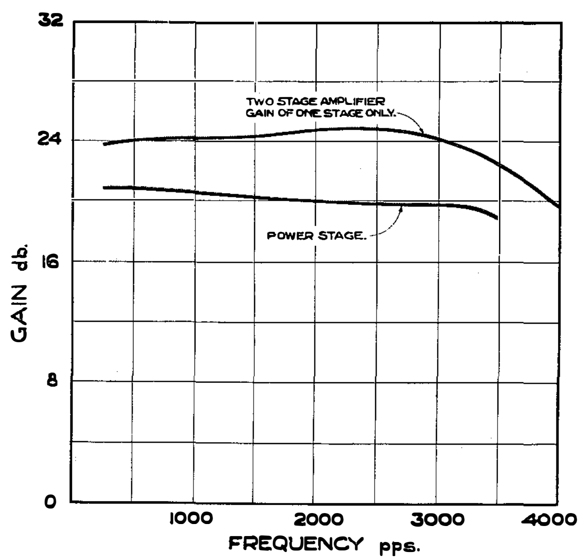


Figure 2—Average Gain-frequency Characteristic of Amplifier Stages.

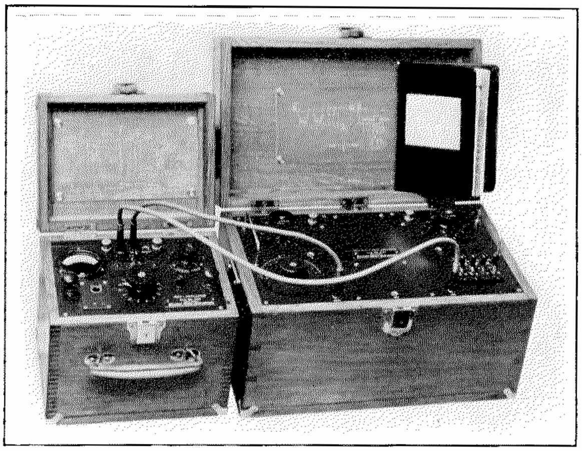


Figure 3—Resonant Wave Analyser and Oscillator.

for short-circuiting or open-circuiting the resonant circuit. Facility is also provided by means of break jacks for picking up the variable condenser or coil when it is necessary to make use of them separately.

When operating between, say, two consecutive stages of the amplifier, the resonant wave analyser, of course, acts in the manner of an acceptor circuit. It is sometimes desirable to widen the band of accepted frequencies which can most conveniently be accomplished by inserting resistance in series with the tuned circuit, thereby broadening the tuning; a break-jack is provided for this purpose.

A Resonant Wave Analyser may be seen in Figure 3, which shows this instrument coupled to an oscillator. The frequency range covered is from 100 p.p.s. to 4000 p.p.s. This range can, however, be increased to about 5000 p.p.s. should it be desired, by a slight modification in the wiring of the key controlling the coil tappings.

An idea of the selectivity of this instrument can be obtained from Figure 4 which shows a typical resonance curve at 1400 p.p.s. It will be noted from this curve that the loss introduced into the circuit is greater than 10 db at any frequency below 1360 p.p.s. or above 1440 p.p.s., that is, a frequency band of 40 p.p.s. on either side of the frequency at which resonance occurs.

This particular curve was taken with the Resonant Wave Analyser operating between 200-ohm impedances. Since, from the nature of the circuit used, the terminal impedances must add to the total effective resistance of the resonant circuit and hence must decrease the selectivity, it is obvious that a greater degree of selectivity than that shown could be obtained by the use of terminal impedances smaller than 200 ohms.

Oscillator

The oscillator, which can be seen in Figure 3, in conjunction with a Resonant Wave Analyser, was designed primarily as a source of standard 800 p.p.s. or 1000 p.p.s. tone. The oscillating circuit is of the standard feed-back type and consists essentially of an oscillating valve, oscillatory circuit and output transformer. The oscillatory circuit is constructed so that either 800 p.p.s. or 1000 p.p.s. can be selected by means of a key provided on the panel.

The feed-back resistance is variable in 15 steps and has been adjusted, as far as is possible with this somewhat limited range, so that the output

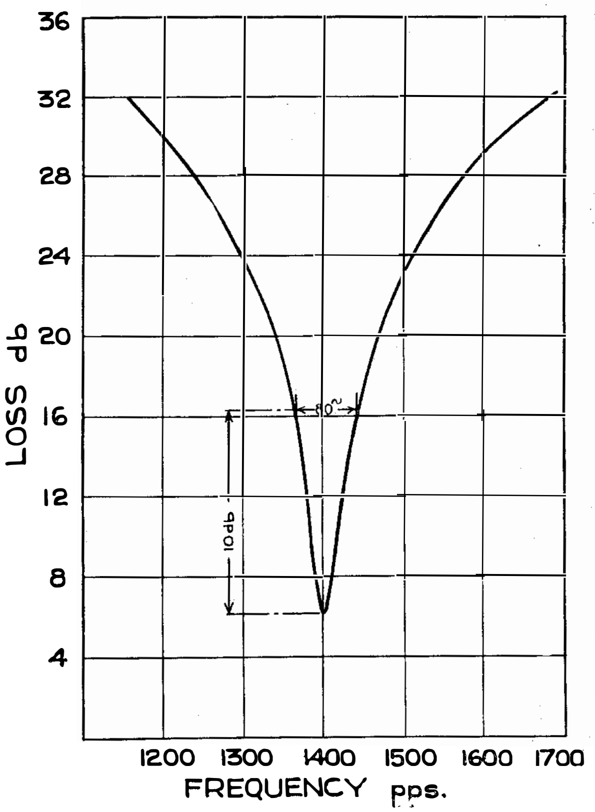


Figure 4—Typical Resonance Curve of Resonant Wave Analyser.

is kept constant at 5 milliamperes into 666 ohms at all frequencies.

In addition to the two fixed frequencies previously mentioned, facility has been provided on this instrument for replacing the fixed tuning circuit of the oscillator by the variable tuning circuit of a Resonant Wave Analyser. The tuning circuits of both instruments have been connected through break jacks, and it is only necessary to couple the two instruments together by means of two cords in order to convert the oscillator from a fixed frequency to a multi-frequency instrument. Figure 3 shows an oscillator and Resonant Wave Analyser coupled up in this manner. When used in conjunction with the Resonant Wave Analyser, the oscillator will provide tone at any frequency between 140 p.p.s. and 4000 p.p.s.

A filament current milliammeter is mounted on the panel of the oscillator and a jack is provided into which a voltmeter may be plugged for the purpose of measuring the plate voltage.

Thermomilliammeter Set

Since a knowledge of the magnitude of the standard tone must form the basis of any method of noise measurement, the Thermomilliammeter Set, which may be seen in Figure 5, has been provided for this purpose.

This instrument may be used to measure any alternating current between 0 and 50 milliamperes, and any direct current between 0 and 60 milliamperes.

The instrument consists essentially of a Galvanometer, together with the necessary thermocouples and D.C. shunts. Four thermocouple cases are provided with each set, two containing thermocouples but the remaining two containing two D.C. shunts a piece, each case being so arranged that either of the two shunts available or a short circuit may be connected between two adjacent contacts on the valve socket marked "Meter Shunt." The value of the shunt may be altered by rotating the case in the valve socket through 90°, 180° or 270°, the corresponding current range appearing in a slot cut for this purpose in the front of the valve socket.

A key is provided on the panel by means of which the galvanometer may be switched either to one of these shunts or to the couple side of the thermocouple, thus providing facilities for the calibration of the latter. In addition to the input jack, two break jacks are mounted on the panel, one in series with the heater of the thermocouple, and the other in shunt across it. Unless the jack placed in shunt is open circuited by means of a plug, it effectively short-circuits the heater of the thermocouple, thus safeguarding the latter against damage when measuring direct current. Two jacks are provided in order that the heater of the thermocouple may be built out to any desired resistance, or may be shunted to reduce its sensitivity.

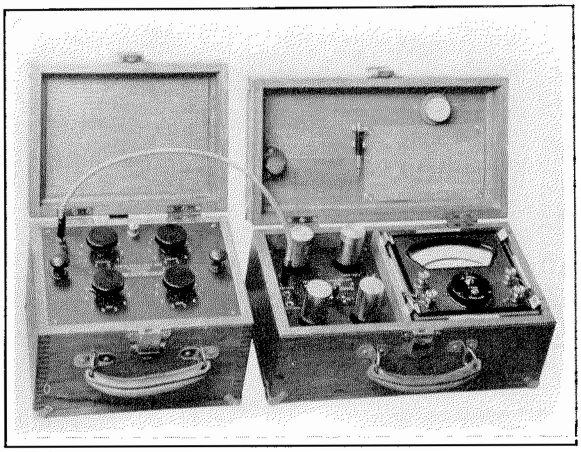


Figure 5—Thermomilliammeter Set and Resistance Box.

The Thermomilliammeter Set is not screened, but the continuity of the earth circuit is maintained through the sleeves of the jack. The shunts and thermocouples not in use are carried in spare valve sockets mounted on the panel.

Resistance Boxes

Two types of resistance box are incorporated in this equipment. Both are four-dial boxes, metal lined and fitted for plug and jack connections with all resistances non-reactively wound. The first type has a range of from 0—1,111 ohms in steps of 0.1 ohm, and the second a range of from 0—11,110 ohms in steps of 1 ohm. The latter type may be seen in Figure 5 connected to the Thermomilliammeter Set.

Switch Box

The Switch Box contains all the switching arrangements necessary for any of the methods of noise measurement detailed previously. By means of the keys provided, the receiver-ear combination can be switched either to the standard tone or to the source of unknown tone or, for measurement by masking, the standard tone can be injected into the circuit containing the unknown tone and both tones heard in the receiver simultaneously.

Facility is also provided in the Switch Box for measuring the overall gain of any combination of amplifiers and networks inserted in the circuit between it and the source of unknown tone. This is done by the comparison method of measurement. The standard tone is arranged so that it either passes direct to the receiver, or through a bank of attenuators to the input of the amplifier and thence, through the switch box, to the receiver. By suitably adjusting the attenuators, the tone from the amplifier can be arranged to have the same volume as the tone heard direct from the standard. The readings of the attenuators then afford a measure of the overall gain of the amplifier.

Attenuators

The attenuators incorporated in this set of apparatus cover three ranges, 0—90 db in steps of 1 db, 0—50 db in steps of 5 db, and 0—10 db in steps of 1 db. These attenuators are all of the unbalanced or "L" type and are composed of non-inductively wound resistances, the required values of attenuation being selected by means of 11-position switches, or, in a few cases, by keys. All attenuators have been designed to have a constant input impedance of 200 ohms when terminated by 200 ohms.

For high values of attenuation, with this type of attenuator, the shunt arm becomes of very low impedance, and the resistance of switch or key contacts introduced into the arm is apt to produce considerable error. The switches and keys used in these attenuators have been so designed that all contact resistances are introduced into the series arms of the networks, where, being in series with a resistance of the order of 200 ohms, they introduce no appreciable error.

The 90 db attenuator is primarily intended to perform the functions of the shunt on the 3-A Noise Shunt, an instrument widely used in the measurement of noise on toll telephone systems. For this reason, and in order that it may be used in conjunction with the 74001-A Noise Measuring Set and the Oscillator, a second input jack, built out to 666 ohms, is provided on the panel.

On test none of these attenuators showed any appreciable frequency error for frequencies in the voice range. When arranged in cascade to give large values of attenuation, their accuracy is of the order of 1.5% for attenuations between 100 and 150 db at 2400 p.p.s.

Search Coil

The search coil may be seen on the extreme left of the apparatus shown in Figure 1. It consists of two separate windings of 150 turns each mounted in brass channel in the form of a square of 35 cm. side. A terminal strip is mounted in the centre of one side and the metal case is discontinuous at the terminal strip, thus avoiding short-circuited turn effects. The brass casing has been made watertight so that, if suitable precautions are taken to protect the terminal strip, the search coil will operate satisfactorily even when standing in water. One winding only is found to provide sufficient "pick-up" for the majority of cases met with in practice. The relatively low impedance obtained by utilising only one winding, as compared with the unshunted input impedance of the amplifier, is of advantage in that the voltage obtained under these circumstances simulates closely the open circuit voltage that would be obtained at the terminals of the coil.

In cases in which the magnetic field through the coil is extremely weak, it is sometimes necessary to increase the number of turns in order that the noise induced in the search coil may be audible above the valve noise of the amplifier, and it is to meet the demands of such cases that the additional winding has been incorporated.

A series resistance of 300 ohms is connected to one end of this second winding in order to flatten out, as far as is possible, any resonance effects between the impedance of the coil and input impedance of the amplifier.

Miscellaneous Apparatus

In addition to the items already enumerated, several miscellaneous pieces of apparatus are included in each set.

Although the majority of this apparatus is unbalanced, it is sometimes necessary to use certain items in conjunction with balanced apparatus. On such occasions, it is usually desirable to avoid metallic connections between the balanced and unbalanced apparatus, and to couple the two set-ups together by means of some form of repeating coil.

For this purpose the coil boxes have been provided. They consist of a 1:1 ratio screened repeating coil having one highly balanced winding, mounted in a similar type of box to the remainder of the apparatus and provided with plug and jack connections to all windings.

While extremely convenient and serviceable from a great many standpoints, the plug and jack method of connection raises a difficulty when it is desired to connect apparatus in series with one arm of the circuit but not with the other. To overcome this, terminal boxes have been provided, consisting of two jacks brought out to terminals, thus enabling subsidiary apparatus to be connected in either arm of the circuit or in parallel across it.

In addition, each set of apparatus includes a box for the housing of the rather large quantity of cords required, and another containing a supply of tools usually required in the field.

Two 200-ohm head receivers fitted with plug terminated cords are also provided with each complete set of apparatus.

Summary

The three main principles of general reliability of construction, flexibility and portability previously mentioned have been kept well to the fore in the construction of this apparatus, as may be seen from the few examples cited below.

Reliability

The shielding of the various instruments and their connecting cords has proved in practice to be sufficiently effective to enable tests to be carried out in the presence of stray electrical and magnetic fields, while the fact that the search coil, connecting cords and other items are practically water-tight, has enabled this apparatus to be used in the open, even under extremely adverse weather conditions.

Flexibility

The large number of small units available greatly increases the number of possible uses to which this apparatus may be put. In addition, each item has been designed to fulfil as many different functions as possible. As instances of this may be cited: (1) The Resonant Wave Analyser, which may be used to analyse noise tones, to act as the tuning circuit of the oscillator or merely as an acceptor or rejector filter; (2) The Attenuators, which in addition to their more obvious functions may be used in the capacity of a noise shunt; (3) The Switch Box, by means of which noise may be measured either by the "comparison" or "masking" method; or by which, in conjunction with the attenuators, the amplifier gain may be measured under any desired condition.

The ease with which circuit connections can be made by means of the plug and jack system of connection has resulted in an immense saving of time and labour in the field. It is estimated that a set-up of the apparatus, such as that shown in Figure 1, can be completely connected up within ten minutes by this method, whereas, if terminals had been provided and shielded wire used, a period of about an hour would be required.

This apparatus has been in continual use for three years, both in the field and in the laboratory. In the field its portability and efficient weather protection have enabled it to be used under conditions which would preclude the use of ordinary testing equipment, and in the laboratory its flexibility has enabled it to be adapted to an extremely wide range of measurements. In the International Telephone and Telegraph Laboratories it has thus proved of exceptional use in its very varied work which ranges from the measurement of the noise field of a 100,000-volt power line to the determination of amounts of valve or Johnson noise so small as to be audible only after amplification of the order of 100 db, or from measurements carried out under the carefully controlled conditions of the laboratory to field tests carried out under weather conditions of extreme severity.

The Influence of Side Tone Upon the Intelligibility of Telephone Communication

By L. C. POCOCK, A. M. I. E. E., M. Sc.
International Telephone and Telegraph Laboratories, Incorporated

THE function of the telephone is to provide a means of communication, and the measure of its success is the ease with which the parties at the two ends can converse, without repetitions or misunderstandings and without consciousness of the distance between them. The measure of the facility for communication is called the intelligibility[1] of a system and may be expressed as the percentage of phrases correctly understood without repetition when using the system under consideration.

There are many factors in intelligibility; some have long been appreciated, others are not so widely recognised. It has been obvious from the first that no one could understand sounds that were inaudible, and so it was natural that loudness was the first standard of communication. It was not quite so obvious that sounds might be loud and yet incomprehensible because a certain resemblance to the correct reproduction of speech had to be possible before telephony could exist. For this reason, and because in pre-repeater days the loudness problem was a formidable one, recognition of the importance of improving telephone articulation has been slow. It was good enough at first to make distant communication of any sort possible; for easy conversational purposes the subscribers could guess and divine from the context what was said and if figures, letters or names were to be transmitted, the subscriber might exercise his ingenuity in paraphrases or indulge in alliterative spelling.

The extension of telephony to long distance and relatively high priced communications, emphasised enormously the need of more efficacious communication with less waste of time in misunderstanding and repetition. Today, therefore, enlightened transmission technique recognises the value of good speech quality.

It is of interest to examine what influence this "recognition" of good speech quality has or might have on telephony. In the first place, it stimulated careful transmission engineering of the long lines or trunks until these reached a pitch of perfection far in advance of the actual talking and listening instruments; this enabled long distance communications to be as intelligible as local calls and for several years this standard of attainment remained unchanged. Meanwhile, the telephone apparatus engineer was acutely conscious of the imperfections of his microphones and receivers, but the problem of improvement presented much difficulty; the systematic study of articulation brought into the light of a wider circle the need of improvement if a subscriber were to acquire such confidence in the facility of telephone communication as would encourage him to make long distance calls freely and so substantially increase the revenue of telephone concerns.

Within recent years several microphones, which are markedly better in articulation than those formerly in use, have made their appearance. The commercial value of improved articulation is, however, even now not fully appreciated and much work remains to be done.

Apart from improvements in microphones and receivers, the general ease and intelligibility of communication can be advanced by consideration of the subscriber himself as part of the system. Foremost in this direction comes the now universally acknowledged advantage of handsets over fixed transmitters, giving the subscriber greater physical comfort. Next comes the reaction of the talking apparatus on the subscriber, that is, the automatic adjustment of the subscriber's voice level in accordance with the level of sound he receives from the far end and the level at which side tone reproduces his own speech. Within the limits of automatic (i. e., unconscious) adjustment the subscriber is to be encouraged to talk reasonably loudly; this enables the expenditure on copper in the local lines to be kept down—a very important consideration from the point of view of capital expenditure

[1] Intelligibility throughout this paper may be regarded as "intelligibility of phrases." (*C. C. I. Red Book*, page 35.)

Figure 1—Short Handset with Effective Anti-Side Tone Circuit and Efficient But Not Microphonic Transmitter.

especially when it is considered how small a part of the time the local lines are in actual use earning money.

The presence of relatively high side tone prevents the subscriber speaking loudly; he finds loud speech unpleasant to himself and also thinks he is talking more loudly than is really the case. When it is considered that the side tone is several times louder than the speech heard at the far end, it is evident that the reaction of side tone on the subscriber is unfavourable and tends to neutralise the advantage to be gained by the use of more efficient instruments. There is a further disadvantage when, as often happens, the telephone has to be used in a more or less noisy office or other location. Articulation studies have established that room noise picked up by the microphone and introduced into the telephone ear through the side tone channel masks certain elements of the sound received and thereby reduces the intelligibility. This fact is doubtless well known, but few who have not tried the experiment can appreciate the enormous loss in intelligibility which may result from room noise. It is the main object of this paper to furnish illustrations of this loss and its avoidance by correct design of the subscriber's set circuit.

Interference from room noise is controllable in two ways. First, through the design of a good anti-side tone subscriber set whereby the sounds impinging on the transmitter are heard at a minimum level in the receiver. This problem, to be satisfactorily solved, must take into consideration the dependence of side tone upon line impedance and the feed current through the transmitter. It should preferably be resolved so as to give the best compromise between the following conditions, the local line being in each case supposed extended to a trunk for a long distance call:

1. On short local lines the transmitter receives a greater current and therefore under the influence of a given noise gives rise to a greater E. M. F.; the circuit should, therefore, be designed so that, when the impedance at the line terminals is such as is found upon short local lines, the side tone is low.
2. On long local lines the received speech is necessarily fainter, and therefore there is an argument for achieving minimum side tone on long local lines.
3. The masking effect of low frequency sounds is greater than the masking effect of higher frequency sounds; this, in combination with the characteristics of present day receivers causes the interfering effect of noise to be a maximum for noise frequencies in the region of 1100 p: s. The side tone should, therefore, be a minimum at this frequency.

In general, condition (1) is of controlling importance as the reduction of microphone current on long lines usually reduces the side tone more than the variation in line impedance increases it; in telephone systems with high resistance cord circuits for battery supply, however, the variation of feed current with line resistance is small, and condition (2) then becomes important.

The second way in which noise interference is controllable is by the design of the transmitter capsule and the handset. If the handset is designed so that the mouthpiece is brought close to the mouth (say 1 cm.), the incident speech to noise ratio will evidently be as high as is practicable. If, on the other hand, the handset is designed with a long handle so that the mouthpiece is at the best 3 or 4 cms. from the mouth, a more sensitive transmitter must be used to obtain the same transmitting efficiency and therefore the noise pick-up is increased and the speech to noise ratio is reduced. The experiments which will be described illustrate how wrong in principle is the use of an increased talking distance and a highly microphonic or sensitive transmitter.

In the *C. C. I. Proceedings*, 1931, page 90 et seq., and in the *Bell System Technical Journal*, January, 1931,[2] the subject of rating subscribers' apparatus is fully discussed. The measure of the grade of service is based on the direct observation of the subscriber's telephonic difficulties when he

[2] W. H. Martin, "Rating the Transmission Performance of Telephone Circuits."

is using different kinds of equipment under different conditions; in judging the telephone plant, therefore, the final appeal should be to the subscribers themselves. There is no denying that this democratic treatment of the problem is right and gives effect to the recognised principle that, for a continuing business, customers must be satisfied.

It is impossible to set up in the laboratory conditions which are completely representative of complex service conditions but, recognising actual service experience as the true basis of rating equipment, experiments may be made in a laboratory which lead to results that may be expected to correlate with service results.

The experiments which follow were made primarily with the object of gaining information on the effect of noise and the extent of the disadvantage attending very sensitive transmitters; the factors were, therefore, so chosen as to give ample weight to the conditions to be examined. Inasmuch as a very poor telephone will be quite serviceable over a short line with high level of received speech and quite useless over a long line with faint speech, the experiments do serve as a classification of the instruments tested since the conditions were chosen to agree approximately with the maximum permissible reference equivalent laid down by the C. C. I. for international telephone calls, with the addition of representative amounts of room noise and line noise.

The circuits were furnished with identical subscribers' sets at the two ends; lists of questions published in the *Journal of the Acoustical Society of America*, January, 1930, were read over the system in a uniform manner, pausing after each question for a reply from the listener. The percentage of questions to which the listener could give a satisfactory reply was recorded as the phrase intelligibility of the system.

The results are exhibited in Figures 2 and 3. In both sets of results, the new set illustrated in Figure 1 shows higher intelligibility than any other set; the care taken in the design of the anti-side tone circuit combined with the avoidance of undue microphonicity in the transmitter capsule are the explanations of its supremacy.

It is seen that there are unmistakable differences between the sets compared; analysis of the characteristics of the sets showed that, although

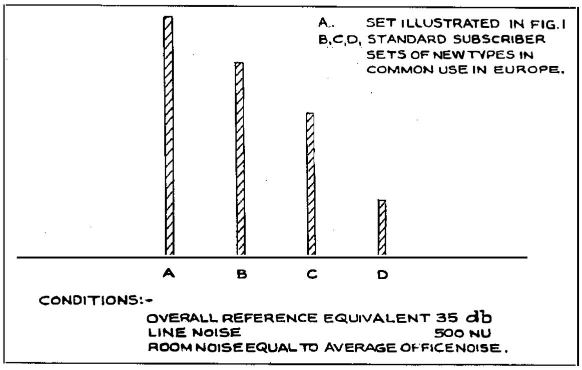


Figure 2—Relative Intelligibility of Subscribers' Sets of Four Types.

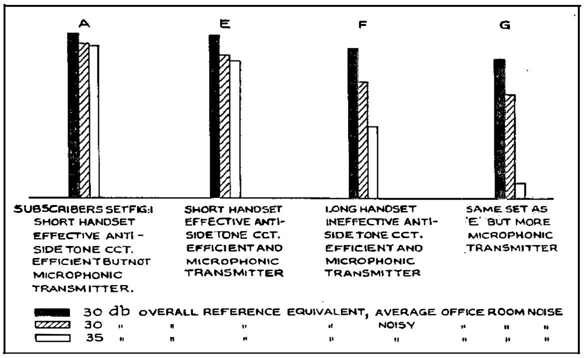


Figure 3—Relative Intelligibility of Subscribers' Sets Under Noisy Conditions.

all the sets were of anti-side tone types, set A (illustrated in Figure 1) was good in articulation, far lower in noise pick-up and more effective as an anti-side tone set than the other three. Set B owed its position next to set A to its good anti-side tone circuit which considerably counteracted the bad effect of an efficient and highly microphonic transmitter capsule used in a long handle; in articulation it was below set A. Set C was less microphonic but also less effective as an anti-side tone circuit; the resultant noise pick-up was equal to that of set B but the efficiency was lower; the result is particularly interesting because this set was good in articulation efficiency but judged on the whole inferior to Set A when the newer concepts of side tone influence are taken into account. Set D was of poor efficiency and articulation and liable to introduce interference with speech through burning noises originating in the transmitter capsule; this set is typical of the cheaper type of set exhibiting no appreciation of modern tendencies except in external form.

In Figure 3, sets E, F, G, all use very sensitive transmitters of the carbon diaphragm type designed for use in long handsets; all these sets are capable of good practical service under good transmission conditions, but the rapidly increasing loss in intelligibility as transmission conditions become more difficult is very noticeable in comparison with set A. G is of particular interest, illustrating a decided loss in intelligibility when set E is used with a more sensitive transmitter. Such a transmitter is driven to its maximum output by the voice and therefore a voice transmission test underestimates its sensitivity to sounds of lower intensity than speech; in service, the increase in noise pick-up at the listening end is considerably greater than the increase in intensity of speech transmission. The final result of using a very sensitive transmitter is a loss in intelligibility under noisy conditions and a very harsh unpleasant speech quality which causes an appreciable articulation loss even under good speech conditions.

Reviewing the results as a whole the damaging effect of side tone is evident; when articulation and efficiency are approximately equal (sets A and C) the side tone of set C produces a considerable loss; when the anti-side tone circuit is a good one, the advantage is considerably destroyed by undue microphonicity (set B), lower articulation being a smaller but contributory factor in this instance. When the set is of poor design without up-to-date instruments (set D), it may be useless under conditions such as those of the test although apparently satisfactory by an ordinary acceptance specification covering efficiency only. It is also evident from E, F, and G (Figure 3) that sensitive microphones designed for use in long handle type handsets are at a great disadvantage which becomes greater when the efficiency of the microphone is increased.

In an earlier paper,[3] the writer discussed the arguments for and against the tolerance of a certain amount of side tone in subscribers' apparatus. The results now disclosed are judged to outweigh considerably the advantage of allowing side tone to exist as a check upon unnecessarily loud talking; indeed, under difficult noisy conversation conditions the absence of side tone may compare in importance with improvements in speech quality. For example, under given conditions, poor commercial speech may be reasonably intelligible in the absence of side tone, while better quality speech of the same volume may be inaudible and therefore unintelligible in the presence of loud side tone.

The use of an anti-side tone set cannot completely eliminate side tone unless the subscriber's line has a particular impedance-frequency characteristic under all conditions of line length and exchange impedance; this equalisation of local line impedances is one of the possible future improvements and may perhaps be ultimately attained in conjunction with equalisation of the resistance of local lines. Looking to the future and bearing in mind the growing appreciation of the reaction of the telephone upon the subscriber, there must be real advantage in bringing the received speech to a constant and adequate loudness level; under present conditions the tendency to adjust one's voice level in accordance with the impression of distance produced by the sounds heard leads, when the transmission equivalents are unequal in the two directions, to louder speech in the direction for which the transmission equivalent is lower and quieter speech in the

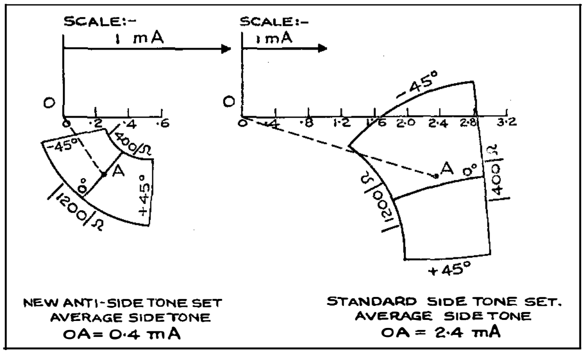


Figure 4—Side Tone Current for Various Line Impedances.

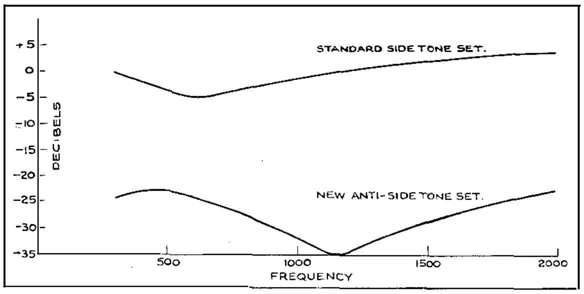


Figure 5—Relative Side Tone Voltage Across Receiver with Representative Line.

[3] "Progress in Subscribers' Transmission Apparatus," *Electrical Communication*, April, 1930.

contrary direction, thus accentuating the transmission differences in the system. This unsatisfactory state of things might be dealt with by automatic level adjustment in the terminating cord circuits or by equalisation of the local line resistances where differences in battery supply are the principal cause of transmission inequality.

This is, however, a digression from the consideration of the effect of line impedance on side tone. The design of an anti-side tone circuit involves the choice of conditions for which the side tone shall be zero; in the design work done by the International Telephone and Telegraph Laboratories (set A) a number of representative connections were considered and the impedances averaged with different weighting, maximum weight being given to the impedances typical of long distance communications in order that the lowest side tone might be secured with the calls to which both the subscriber and the telephone administration attach most importance.

It is of some interest to compare the side tone characteristics of the anti-side tone set illustrated (Figure 1) with the characteristics of the most widely used standard type of side tone circuit.

In Figure 4* two diagrams are shown which have been prepared to show the magnitude of the side tone current in the receiver for 1 volt E. M. F. (800 p : s) in the transmitter, and for various subscriber line impedances. For all impedances lying between 400 and 1200 ohms at an angle between $+45°$ and $-45°$ the side tone current is determined by the length of a line from the origin to some point within the area marked out by the system of curvi-linear coordinates. It will be observed that the anti-side tone set has from about one-tenth (minimum) to one-sixth (average) as much side tone current as the side tone set.

Figure 5 shows the variation of side tone current with frequency when the two types of set are connected to a particular line impedance and it will be observed that the standard side tone set at 1100 p : s has side tone about 5 db. above its minimum, while the new anti-side tone set has minimum side tone at this frequency of maximum interference.

---

*Since this article was written the impedance characteristics of a number of actual working lines have been published in the British *Post Office Electrical Engineers' Journal* (October, 1932). It is interesting to note that the 800 p: s impedance of the lines measured is in the sector 0° to $-45°$, and generally quite close to the $-45°$ line.

Toll Plant Engineering

A Discussion of the Development and Application of a Toll Fundamental Plan to the Rumanian Toll Network

By BRUCE H. McCURDY

Engineer of Toll Lines and Transmission for Rumania

1. Introduction

THE rapidly increasing demand for nation-wide—and, today, even world-wide—telephone service from *any telephone to any other telephone* is bringing into a position of major importance the subject of toll plant engineering. The technical problems involved in providing a connection between any two points are being solved in rapid succession and equipment capable of performing almost any required function is being placed at the disposal of the operating engineer. For the operating engineer, however, this is but the beginning of the problem; there still remains for him the problem of so utilizing these discoveries and inventions that universal service may be given *at reasonable costs* from any telephone to any other telephone. It is by no means a simple problem. It requires the utmost care in the design of an over-all system which will permit combining:

a) Maximum efficiency in circuit and equipment usage
b) Maximum economy in plant construction and operating costs.

To put it in a slightly different way, the economic realization of "universal" service requires that for the interconnecting network the following ideals be realized as far as is practicably possible:

1) Minimum facilities for the service given
2) Minimum grade of facilities throughout the system consistent with the demands of satisfactory service
3) Minimum plant costs (both from the standpoint of initial investment and annual charges) for the facilities provided.

It has been said that two infinitely simple problems when superimposed on each other result in a problem of infinite complexity. This is most certainly true of the toll systems problem. Given two specific points to be interconnected, the transmission engineer has at his disposal a fund of information both as to over-all standards of volume and quality which must be met and as to the type of facilities which can be used to obtain these standards. With this information as a basis the toll line engineers can plan the given connection, select the most economical type of facility, select the most practicable route, etc. Unfortunately, however, the number of "given connections" involved in any large operating unit is so large that a direct study of each individual case is an almost impossible task. In Rumania for instance, with its 1,380 exchanges connected to the toll network there are 951,510 possible exchange-to-exchange connections. Any attempt to analyze each and every one of these possibilities and to combine the whole in one over-all analysis into an economically engineered system is obviously a problem beyond the range of practical solution. The Fundamental Plan is an attempt to break down this complex problem into its more simple parts, each part of which may be attacked separately but, at the same time through the medium of the Fundamental Plan it is fully correlated with the other and the fundamental demands of efficient and economical universal service. The preparation of such a plan involves a considerable amount of "cut-and-try" investigations in which certain temporary assumptions have to be made while other dependent variables are being investigated. As the study progresses, however, there will be brought to the surface a large number of practical considerations which will very definitely fix certain factors in the toll network and by so fixing them bring the whole problem to the point where it is subject to a very definite and specific solution.

The Rumanian toll network as taken over by the Societatea Anonima Romana de Telefoane, one of the International Telephone and Telegraph group of operating companies, consisted of approximately 56,000 circuit kilometers of toll and toll-tributary circuits interconnecting some 1,380 exchanges scattered over an area of 316,700 sq. kilometers. Except for a few short toll entrance cables the toll plant consisted entirely of open wire of various gauges, mostly of copper. In general, the condition of the copper circuits was good and a reasonable grade of service was being given between *main centers.*

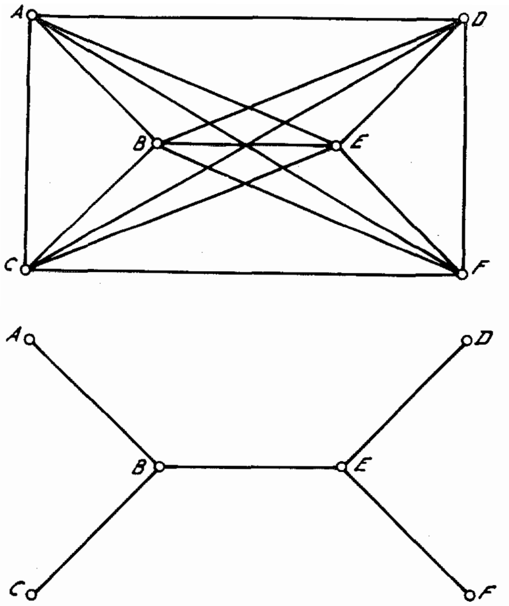


Figure 1—Theoretical Layouts.

Universal service, however, was far from being realized even within the limits of the country itself. Two main hindrances in the way of such service were found to exist:

a) Such circuits as existed, for the most part, had been engineered on the basis of terminal business and any attempt to extend service beyond these terminal points usually resulted in such high transmission losses that commercial service was impossible.
b) The majority of circuit groups, especially the main groups between important centers, were heavily over-loaded with the result that the waiting time even on terminating business was excessive, while that on switched calls beyond these points was such as practically to prohibit business.

The immediate problem faced by the toll engineers was of course that of rearranging and adding to the toll plant in such a way that both of the above difficulties could be overcome. Certain rearrangements and additions were sufficiently apparent to permit taking immediate steps toward their realization. Such changes and additions, however, were merely a means of ameliorating specific local conditions. Any large scale development had to wait for the preparation of a general Toll Fundamental Plan; otherwise there was danger that such additions as were made would be very inefficiently used and would not meet the needs of the future layout. Since the inherent life of most telephone plant and equipment is anywhere from 10 to 20 years while buildings for housing items such as repeater and carrier stations may have even higher inherent periods of service, it is extremely important that every item of expense incurred for new plant or for changes in existing plant be viewed in the light of the ultimate plan.

The preparation of such a Fundamental Plan was therefore immediately undertaken. It is the purpose of this paper to discuss briefly the various steps involved in its preparation, using the Rumanian toll network as an illustration.

II. Toll Centering or "Minimum Facilities for a Given Service"

The first step in the preparation of the general plan was to investigate the question of the facilities (i.e., the paths of communication) required in the light of the first of the prerequisites of an efficient system: "minimum facilities for the service given." The service given was, of course, the interconnection of any two telephones within the country and later the interconnection of any telephone within the country with any other point with which the Rumanian system has commercial service. This investigation led immediately to the consideration of what has been termed "toll centering."

A number of articles on "Toll Centering" has appeared during the past few years covering the various phases of the subject and there is little need here to enter fully into a discussion of the various factors leading to the concentration method of handling traffic as against a 100% direct trunking plan.

For the sake of completeness, however, and to illustrate the traffic features involved, a very simple theoretical case of 6 centers located as indicated in Figure 1-a and 1-b will be taken. To provide direct trunking between all six points will require $\frac{6\,(6-1)}{2} = 15$ trunk groups, as shown in Figure 1-a. If, on the other hand, we

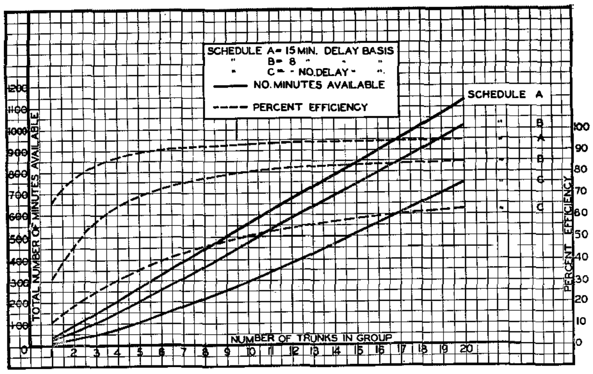


Figure 2—Long Distance Circuit Efficiency.

should concentrate A and C at B and D and F at E, providing only the groups shown in Figure 1-b, the total number of groups is reduced from 15 to 5. More circuits per group will be required in this second case than in the first and the choice between direct trunking and such a centering plan will depend, of course, on the relative total lengths of circuit required in the two cases. Under normal traffic flows the total number of circuits and the total length of circuit required under a switching plan such as that of Figure 1-b will be much less than for the direct trunking plan of Figure 1-a since the factor of the efficiency of large trunk groups as compared to small groups enters in. This factor, although known to traffic and toll line engineers and fully considered in exchange-area layouts, has not always been taken into full account in the design of the various toll networks.

This factor of efficiency of trunk group comes into play as a result of the introduction of a minimum delay requirement. It is based on the fact that calls are not placed at regular intervals but usually come in groups, especially during the busy hours. If we insist, as we usually must in order to satisfy the public, that no call be delayed beyond a certain interval we must, in calculating the number of circuits, take into account the probability that a certain number of calls will be placed simultaneously. The usual method of taking this into account is by using for traffic design, curves of the form shown in Figure 2 which for a given delay and average hourly load give the efficiency of the trunk groups or conversely the total number of minutes available for a given group. This latter figure is always less than 60 N, where N equals the number of circuits per group.

A simple quantative case, still based on a theoretical layout as shown in Figure 1, may serve to clarify application to the design of the toll system and show the possible efficiency resulting from a centering plan as compared with a direct trunking plan.

Assume for the sake of simplicity that the distances between the various exchanges are as shown in Figure 1-b (AB, BE, etc., each being considered to have unit length) and that all through groups such as AD will follow the route via BE. This is a fair assumption since, in a layout of the form shown, such a routing would permit concentrating all wires on a single pole lead or in a single cable, a very desirable feature from the standpoint both of line maintenance and total plant investment.

Let n equal the equivalent "Busy Hour Mins." between each two centers. Calculating the number of trunks required in each group for the two plans of Figure 1-a and 1-b on schedule A and for the range from 10 BH Min. to 300 BH Min. and plotting the total circuit length for the whole network under both plans we have the relation shown in Figure 3. As will be seen, the total circuit kilometers in each case is always less by from 10% to 40% in the case of plan b than for plan a.

In actual practice of course, the flow of traffic between centers is never uniform as was assumed in this illustrative case. The variation, however, is such as to make even more striking the advantages of concentrating traffic at certain centers. Thus in a layout of the form shown it will usually be the case, if centers B and E have been properly

Figure 3—Relative Circuit Lengths to Handle Traffic Under (A) Direct Trunking, (B) Toll Centering Plan. (See Figure 1.)

selected, that the natural flow over links AB, CB, DE, etc., will be very much heavier than that over such groups as AD, CF, etc. The latter will often in the larger toll networks be less than a single circuit load. The increase in circuit-use efficiency is thus greatly increased by the concentration plan.

There is, of course, one major source of inefficiency in such a plan, namely, the increased operating time necessary for setting up a switched connection as against that required for a direct connection. Furthermore, this operating time increases rapidly as the number of switches increases. This factor must be given full weight in any specific study and will tend to decrease the number of switches allowable in any connection.

The first stage of the Fundamental Plan for Rumania was an attempt to take these factors into full account and to design a switching system which, from the traffic standpoint, would result in "minimum facilities for a given service." To do this an answer was sought on the basis of both present and future traffic demands to such questions as the following:

1) What is the general flow of traffic between centers?
2) Are there natural centering points which could be used economically for concentrating and redistributing such traffic?
3) How are these natural concentration centers located geographically with respect to each other and to their secondary dependent centers?
4) What interchange of traffic do these concentration centers have with other similar centers?
5) What form of network will combine maximum efficiency in the circuit time usage within the local area with the least lost circuit time in the long-haul groups?

In the first place three major groupings of centers and of traffic were immediately recognized which gave a hint toward a possible centering plan:

1) *Small Local Offices and Little or no Demand for Long-Haul Service.*

Of the 1,380 exchanges connected to the

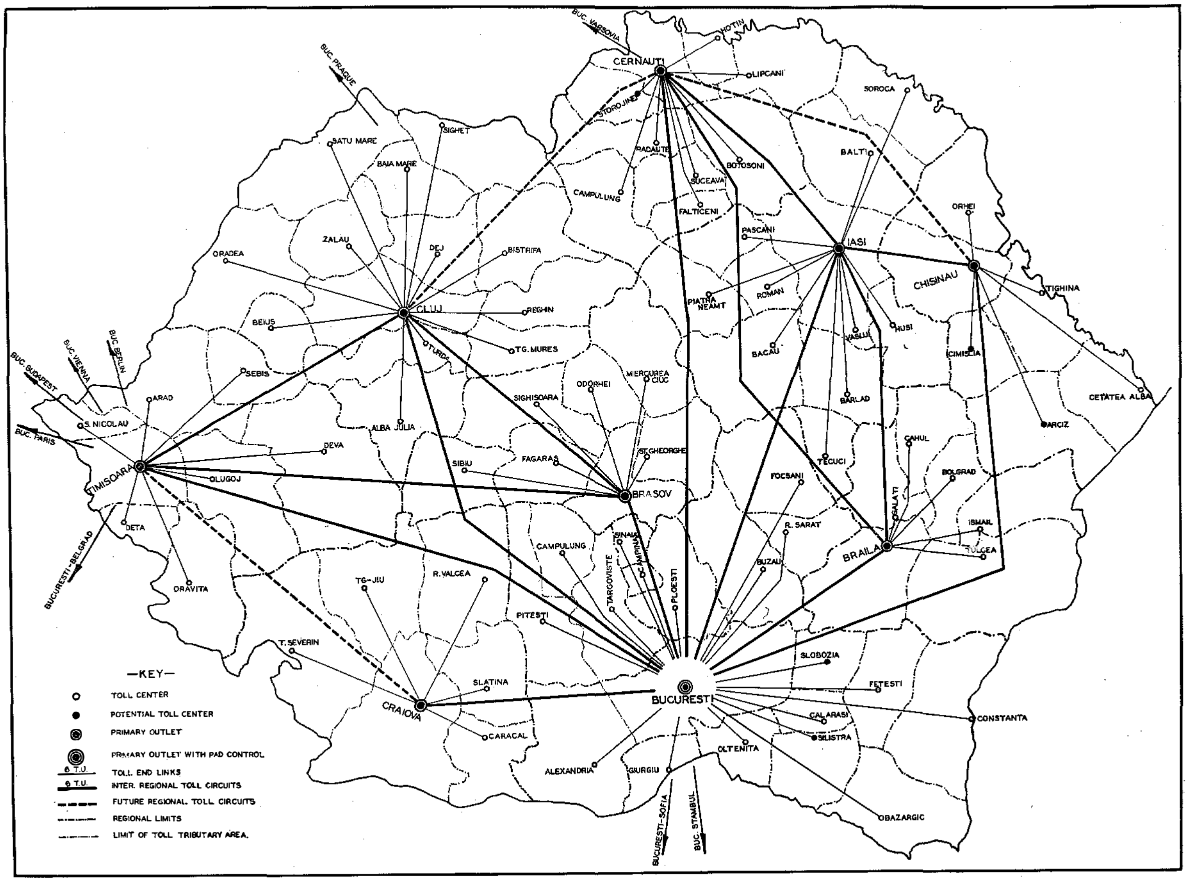


Figure 4—Tentative Toll Centering Plan for Rumania.

Rumanian toll network it was found that all but approximately 85 could be considered as of purely local importance from the standpoint of long-haul traffic. Not that there was no long-haul demand from these centers. There was such a demand and although it was extremely light and scattered, it represented not only a service requirement which the telephone company was desirous of meeting but also, a possibility of revenue which taken as a whole was by no means negligible. It appeared probable from the first analysis that such service could from a traffic standpoint be provided more or less on a by-product basis through the 85 centers which appeared to have an appreciable amount of long-haul service, especially since in every case these secondary centers are or must eventually be connected directly to one of the 85 concentration centers. These 85 centers have been termed "toll" centers, as contrasted with the term "tributary" office which was used to denote the small local offices.

2) *Primary Concentration Centers or "Toll Centers."*

A number of considerations such as the question of ticketing and billing for calls, etc., entered into the differentiation between "tributary" and "toll" centers. From the standpoint of the Fundamental Plan, however, the main difference to be considered was that each of the 85 "toll centers" selected had a considerable amount of long-haul toll traffic to the remaining 84. The meeting of this demand was therefore a very definite and specific matter warranting detailed study. It cannot be considered as a "by-product."

3) *Major Concentration Centers or Primary Outlets.*

Although the traffic from the various "Toll Centers" involves connections to all parts of the country, by far the major portion of it is to points within certain fairly restricted areas with a general tendency to concentrate at the principal city within these major areas. These latter areas follow roughly the main industrial or commercial divisions of the country. This pointed strongly to the possibility of carrying the concentration process one step farther by selecting a certain few major concentration centers. This selection was further indicated by the fact that in the majority of cases these principal cities all had a relatively high demand for a fast grade of service among themselves and an even more marked demand for direct fast service to Bucarest. A number of trial plans were therefore set up and analyzed purely from the traffic standpoint. One was a complete concentration plan in three steps:

1) All tributary centers concentrated at their main "toll center."
2) All "toll centers" concentrated at their major concentration center or "primary outlet."
3) All primary outlets concentrated at Bucarest.

The final analysis after all factors were taken into account showed roughly that, except for minor exceptions where direct interconnection would prove more economical, steps 1 and 2 were economical but that step 3 was not. The factors tending toward the abandonment of a complete concentration at Bucarest were:

a) Excessive back-haul.
b) An excessive number of switches.
c) Relatively large volumes of traffic between contiguous "primary outlets" and consequently a relatively small increase in theoretical circuit efficiency by concentrating such traffic at Bucarest.

The tentative centering plan arrived at from the standpoint of "minimum facility" after all factors had been taken into account is indicated in Figure 4.

III. Transmission Considerations: "Minimum Grade of Facilities"

Whether or not such a plan will result in maximum toll plant efficiency when the other two requirements are met, i.e., "minimum grade of facilities" and "minimum plant investment" still remains to be seen. Theoretically the concentration procedure introduces a certain penalty from the standpoint of the grade of facilities required unless we assume that at every concentration point a certain transmission gain can be introduced. To illustrate, let us take again a very simple case.

X and Y, having provided themselves with telephone subsets, wish to have these sets interconnected so that conversation may be exchanged between the two. There remains only the problem of examining the characteristics of set X and set Y and of designing a transmission line between the two which, as economically as possible, will meet the standard decided upon by X and Y. A third subscriber Z wishes to be connected to X and Y. X and Z therefore decide between them what standard of transmission they are to work to and design line X-Z. Likewise Y and Z agree; *no single decision* affecting in any way the other two connections. *Each line is a unit unto itself and may be designed wholly in accord with the conditions at its own terminals.* In other words we always have here the transmission engineering problem in its most simple form—that of providing economically a *given physical unit.* The problem will remain in this simple form for any number of points such as, for instance, the six points of Figure 1, as long as we keep to the 100% direct interconnection method of providing the connections.

Once we depart from this method, however, and adopt a concentration plan, the transmission problem becomes more complex. Thus, if we design such links as AB, BE and EF of Figure 1-b on the basis of purely terminal connections, the over-all connections such as A-B-E-F will be entirely beyond commercial limits. On the other hand, if we design AB, BE and EF on the basis of the over-all connection A-B-E-F, it will mean that for a large portion of the use to which the individual circuits are put, a considerably higher grade of service than that required will be given. Such a condition may be a source of considerable inefficiency from the standpoint of cost vs. average service given; that is, for the majority of service given the plant will be of a much higher grade and therefore probably much more expensive than necessary. In other words the requirement "minimum grade of circuit for a given service" will not be met. The development of the cord circuit repeater was the earliest attempt to meet this difficulty. Under such a plan each link is designed on the basis of purely terminal requirements. When switched connections are set up a cord repeater is inserted at one or more of the switching points. The general application of cord repeaters, however, in addition to involving a very material expense, is accompanied by a number of operating difficulties. These operating difficulties can conceivably be eliminated by making the insertion of these repeaters and the adjustment of gains entirely automatic, but not without adding to the cost. Whether or not such a procedure should be adopted is purely one of relative economics.

Theoretically, for a specific layout such as that illustrated, there is a determinable loss for each individual link which, with or perhaps without cord repeaters as indicated by the economic studies should result in a minimum over-all investment for a given transmission standard between the centers. The determination of such a point of minimum costs, however, involves the joint consideration of every possible combination and, when considering a toll system as a whole, is an almost impossible problem. In fact, so nearly impossible was such a determination in the case of the Rumanian network that an attempt was made to attack the problem from an entirely different angle. This analysis resulted in bringing to light some interesting and useful factors which have provided a very powerful method of simplifying the problem.

This study was essentially of the following form: Assuming that the various radiating networks arrived at from the consideration of "minimum facilities" are engineered wholly on the basis of local requirements, what inherent electrical characteristics do these networks present when viewed from the standpoint of the problem of inter-network or inter-area connections? With these inherent characteristics as a basis, the question of universal interconnection can then be studied with a view to arriving at the most economical method of providing the additional gain, if any, required for the over-all connections.

As a preliminary to this discussion, however, it will be necessary to consider for a moment the over-all transmission standards which any given connection must meet to be considered a satisfactory connection.

The basis for the determination of transmission standards is an engineering judgment of the value of transmission in terms of expense. In general, an improvement in transmission, through the two factors of

a) Increased demand when good service is given and
b) Less repetition and hence more efficient operation on the part of the forces handling the call,

will result in an increase in revenue, but will involve increased expense. There will be a certain standard which will result in satisfactory service

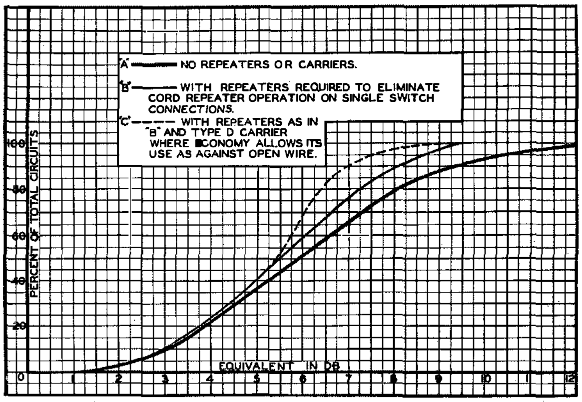


Figure 5—Toll Fundamental Plan for Rumania—Inherent Equivalent of Toll Circuits.

at minimum cost. The exact determination of this point of maximum efficiency is difficult of accomplishment since it depends upon a number of somewhat intangible factors such as the type of service the public has been accustomed to, the type or nature of the demand, influence of operating methods, etc. The standards to which the plant in Rumania has been engineered are as follows:

	Maximum Loss
1) *Local Calls*	
Business area-to-business area.........	18 db.*
Business area-to-residential area.......	20 " *
Residential area-to-residential area....	22 " *
2) *Toll Calls*	
Principal Toll Center-to-Principal Toll Center—Subscriber-to-subscriber......	26–28 db.*
Maximum subscriber-to-subscriber connection within an operating company	31 db.*

Theoretically, for any particular transmission standard and distribution of plant there will, as just mentioned, be some allocation of losses to the various parts of the toll plant such as will result in maximum economy, especially if we assume a sufficient variety of facilities so that each line can be engineered closely to a given equivalent. Actually of course this last assumption is not valid.

The problem of standardization of facilities to keep construction and maintenance costs at a minimum has resulted in a reduction in the types of facilities available, so that for a given case even though we could theoretically use a certain grade of facility, other considerations will force the use of a considerably better grade. Thus, whereas there are large areas in the case of the local plant in which a subscriber's loop of smaller than 26 gauge (0.41 mm.) could conceivably be used, construction difficulties in connection with using a smaller gauge are such as to make it impossible. Likewise, in an open wire plant, there is a lower limit to the size of wire which can be used. As a result of these considerations the toll engineer finds at his disposal only a certain limited number of types from which to choose. In Rumania these standard facilities are as follows:

a) Toll

Open-wire

1) 109 iron wire (2.75 mm.) for short tributary lines
2) 2.0 mm. copper for short secondary lines
3) 2.5 mm. copper for long-haul circuits in light and medium storm load areas
4) 3.0 mm. copper in heavy load storm areas.

Cable

Any of the standard cable facilities now accepted throughout Europe.

b) Exchange

1) 26 ga. (.41 mm.); 24 ga. (.51 mm.); 22 ga. (.64 mm.); 19 ga. (.91 mm.) non-loaded-cable
2) 109 iron (2.75 mm.) open wire.

Studies of probable toll line loads and the relative economies involved between cable and open-wire have indicated that in but extremely few cases will cable be placed, at least for a considerable time, and for the present study it may therefore be neglected. Hence, the majority of the toll circuits will be made up of open-wire facilities of the type above enumerated.

Inherent Toll Plant Losses for Rumania

1) *Inherent Toll Terminal Losses*

Because of the preponderance of the number of units, one factor in the design of the telephone system can in general be considered as being fixed by purely local considerations: The design of the local subscriber's plant and equipment. Assuming that each and every exchange will be engineered to meet most economically the 18–22 db. standard for local connections, the following

*All of the above are total losses including battery supply losses and the relative efficiency of the subscriber's equipment.

probable inherent toll terminal losses* were found to obtain in Rumania:

a) *Analysis of all 85 Toll Centers.*
  Maximum T. T. Loss..................7.25 db.
  Average..............................3.95 "
b) *Analysis of all 85 Toll Centers Excepting the 9 Major Concentration Centers.*
  Maximum............................ 5.9 db.
  Average.............................. 3.65 "
c) *Analysis of the 9 "Major Concentration" Centers.*
  Maximum............................ 7.25 db.
  Average............................. 5.33 "
d) Bucarest..............................10.7 "
e) *Small Tributary Toll Centers.*
  No full data is available. In general these centers consist of toll stations only and the toll terminal loss is therefore that resulting from the type of subset available on a zero loop. The equivalents for the toll-switching trunk for such centers is now under investigation and it appears probable that the total toll terminal loss from these centers to the toll center will not be greater than that for the toll center proper.

2) *Inherent Toll Line Losses in the Secondary Radiating Toll Networks*

Taking the toll lines which connect the 85 "toll centers" selected as a result of the traffic considerations and engineering them in the most economical manner to provide intercommunication through their main concentration centers, we find that inherent losses will be obtained as shown in the curves of Figure 5. As will be noted, less than 10% are over 7 db.

3) *Inherent Toll Line Losses for Main Long-Haul Inter-area or Major Toll Groups*

The analysis of the inherent toll line losses in the case of the longer-haul inter-area groups is not so clear-cut as in the case of the two groupings of plant noted above. It was found that because of the distances involved repeaters would be required on almost every group; also because of the fact that carrier with its accompanying possibility of obtaining low equivalent circuits at practically no additional cost can usually be proved in on these groups, it appears probable that for these long-haul circuit groups a 5–6 db. equivalent can be considered as possible at practically no additional cost over that required if the circuits were designed for purely terminal traffic. Whether or not this is desirable and whether the slight additional cost involved is economically justifiable is still under consideration and cannot be fully determined until more detailed and comprehensive studies can be made.

For the purpose of the 1931 toll plant extension studies, no attempt was made to carry the analysis beyond this point. It was assumed that both the local subscribers' plant and the primary radiating toll networks could be designed entirely on the basis of the most economical layout from the local standpoint of inter-area single-switch traffic and that the transmission requirements for long-haul multi-switch connections would be provided for either by introducing cord repeater operation at the 10 major centers or by working the major toll links at sufficiently low equivalents to provide a 30 db. connection or the maximum subscriber-to-subscriber connection, whichever proved more economical. Since then, however, specific quantitative data have been found to prove:

a) That, even neglecting the question of circuit time saving by eliminating cord repeaters it will be more economical to reduce all secondary toll circuit equivalents to 7 db. and the major inter-area connections (except at Bucarest) to 6 db. than to provide the cord circuit repeaters necessary for use on multi-switch connections.
b) That the most economical method of obtaining a 6 db. equivalent from every major toll center to every other major center is to set up a major toll network of the form shown by the heavy lines of Figure 4. Each of the circuit groups will operate normally at 6 db. At Bucarest a 6 db. gain will be provided for such major center-to-center connections as are not obtained direct, either by means of cord repeater operation or by pad-control. Present indications are that pad-control will be more economical and the new Bucarest toll board has therefore been wired to provide this facility when and if desired.
c) That toll terminal losses can economically be kept to the following:
  1) Toll Centers (including tributaries)....... 5 db.
  2) Primary Outlets........................ 7 "
  3) Bucarest..............................10 "

As a result of the establishment of the above standards the following *maximum* subscriber-to-

*It is customary within the International Telephone and Telegraph System to take the average of the transmitting and receiving losses of the circuit from and including the subscriber's station to the toll line jacks at the toll switchboard and call this the "toll terminal loss." Accordingly, the over-all subscriber-to-subscriber loss is the sum of the two "toll terminal losses" plus the toll line loss. The error involved in this procedure is negligible when dealing with *maximum* or *average* limits and when the two subscribers' networks are engineered to the same limit.

subscriber transmission limits will be met within the Rumanian network:

Tributary Center-to-Tributary Center	30 db.
Secondary Toll Center-to-Secondary Toll Center	30 "
Primary Outlet-to-Primary Outlet	20 "
Primary Outlet-to-Secondary Toll Center	25 "
Bucarest-to-Tributary Center	28 "
Bucarest-to-Secondary Toll Center	28 "
Bucarest-to-Primary Outlet	23 "

IV. Specific Application of Fundamental Plans to Plant Design Problems:

"Minimum Plant Investment for a Given Facility"

The meeting of the third requirement of efficiency and economy, that is, the requirement of Minimum Plant investment for a Given Service, comes more in the field of specific plant engineering than in that of Fundamental Plans. There are, however, in connection with these engineering studies certain factors of advance planning which require an analysis of the over-all plant layout and can best be grouped under the heading of Fundamental Plans.

Reduced to bare essentials, the requirement of economy in plant design may be said to demand that for the over-all period for which the service is given the annual charges of giving this service be kept at a minimum. Actually, of course, there are numerous considerations which cannot be specifically equated in terms of expense and which will influence to some extent the execution of specific projects. The essential factor, however, is always that of the over-all costs and it is this factor which must be controlled by the toll plant engineers. Such costs may be broken down into two main divisions:*

a) Costs dependent solely upon the inital investment involved, i.e., interest, taxes and insurance.
b) Costs dependent on the choice of the specific type of facility, i.e., maintenance and depreciation.†

The control of the first of these is obviously to be made by so choosing materials and methods of construction and by so planning the execution of the work that the over-all investment will be kept as low as possible. Control of the second is accomplished by choosing routes and types of facilities which will result in the lowest possible maintenance costs and by so laying out new plant that its inherent period of service will be most fully utilized. In fact, it is with this latter problem that advance planning deals most directly. Most telephone plant and equipment has an inherent life of from 10 to 20 or 30 years while buildings, such as used to house repeater stations, etc., may be said to have an inherent life of at least 50 years. To place such plant and then because of insufficient capacity or other similar reasons supplant it before its useful period of service has passed is obviously uneconomical. Over-building in the initial period is likewise uneconomical.

Before expending funds for new plant, therefore, an attempt should be made to determine the type of plant dictated by future requirements and to see how the proposed additions will fit in with this future demand. The chief considerations involved are:

a) Actual location of future routes and probable circuit loads
b) The possibility of cable being required, together with the probable time
c) Location of present and future repeater stations.

As in the case of most phases of advance planning, the determination of such factors can be arrived at only by means of trial-and-error analyses of possible layouts. In the case of the Rumanian study the procedure has been:

a) On the basis of the toll centering plan arrived at in section I, and II, to determine the probable circuit requirements over a period of years.
b) To design and route these circuits under a number of assumed plans, keeping in mind that economy in maintenance and pole line plant usually will result (until the maximum pole line load is exceeded) when as many circuits as possible are routed over a single lead rather than over two or more parallel leads.

*The reader should not confuse this classification with the classifications usually made for accounting or rate base purposes. It is a classification made solely from the standpoint of analyses for Fundamental Plan or program study purposes.

†The term depreciation has been used here, for want of a more comprehensive term, to indicate not only that factor of depreciation usually understood from the accounting standpoint which is dependent on the theoretical average life of a given type of plant but also that factor resulting from the retirement of plant before its theoretically economical period of service has been utilized. It may be argued, of course, that this is the factor of obsolescence which will show up finally in the average life of the given class of plant. If such a shortening of life is due to poor engineering, however, it is a factor under the control of the engineer and should be distinguished for the purposes of this discussion from the usual obsolescence factor due to advancement in the telephone art.

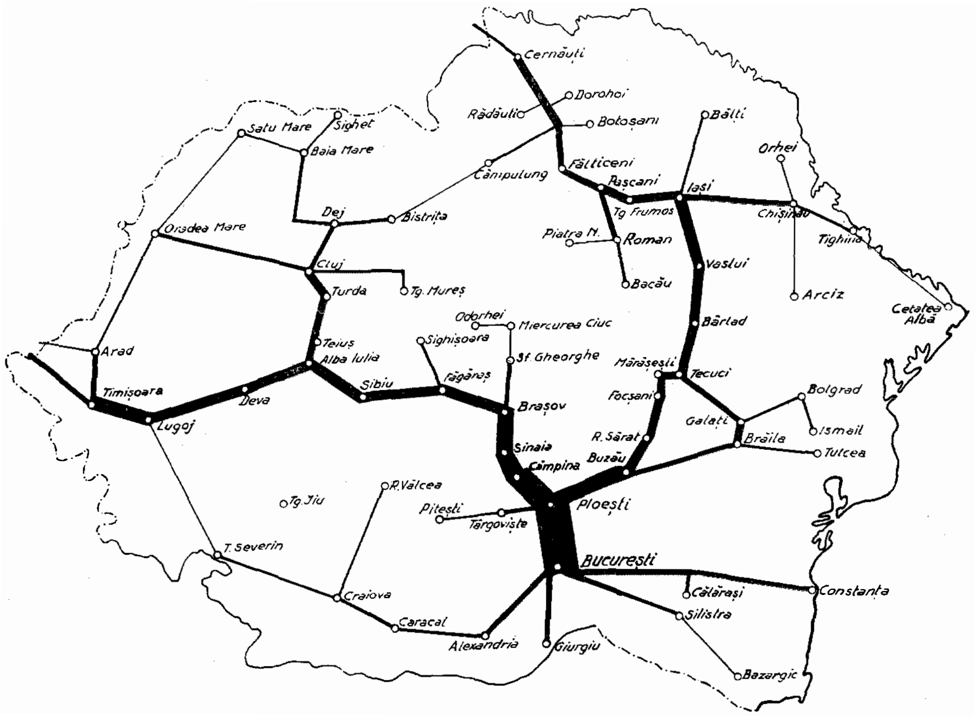


Figure 6-a—Toll Fundamental Plan for Rumania, 1940—Probable Toll Circuit Loads on Main Toll Lines. (Thickness of Line Indicates Number of Circuits.)

c) To determine under the various possible plans the present and future location of toll cables, voice frequency repeater stations and carrier repeater and terminal stations.

Under each possible plan the initial investment and annual charges, reduced to a present worth basis, were calculated, compared and analysed with a view to meeting for the over-all system the requirement of maximum economy.

Such analyses, of course, had to be on rather a broad "high-spot" basis, especially since the fundamental data upon which they were based, that is, the traffic projections, are highly problematical. These analyses, however, do not involve definite commitment to do work but are an attempt to obtain as clear a picture as possible of *probable* lines of development. This picture will be used as a starting point for specific short-time studies and the inexactness of the data for which it is drawn need not detract from its value. That the results of such studies must be used with caution and re-examined constantly in the light of all new data as they come to hand, is obvious.

In the case of the Rumanian network it has been possible to fix with a fair degree of probability certain essential features of the future network toward which the company is working. These may be summarized, for the main toll network as follows:

a) *Toll Routes and Pole Line Loads.*

The future main toll leads can be fixed very definitely as following directions shown in Figure 6-a and 6-b. The general procedure followed in arriving at such charts is to plot by varying widths of lines the number of circuits required from each toll center to every other toll center on an air-line basis. Such an arrangement if followed out in actual practice would result, of course, in a minimum circuit in kilometers but would be extremely uneconomical as regards pole

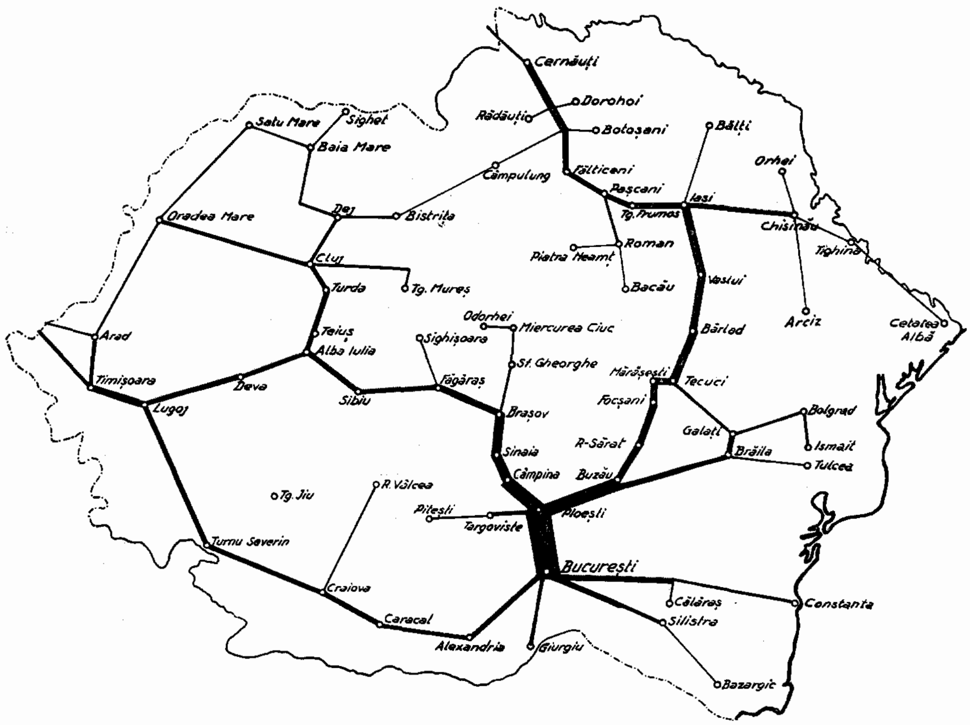


Figure 6-b—Toll Fundamental Plan for Rumania, 1935—Probable Toll Circuit Loads on Main Toll Lines. (Thickness of Line Indicates Number of Circuits.)

lines, the cost of the latter as compared with the saving in circuit length being excessive. Such a map, however, will indicate general directions of traffic flow, and will serve the very practical purpose of suggesting a number of possible plans of route concentration. These in turn can be analysed in terms of pole line costs vs. circuit kilometer costs and a final plan arrived at as shown in Figure 6-a and 6-b. Whether the ultimate routes will follow the road, the railway or private property are questions of specific engineering to be settled when any major addition is made in a given region. In arriving at the final determinations, the engineer will have as the starting point of his studies the fact that a main line must ultimately be provided here and that it must be engineered to carry ultimately a load of general proportions as indicated by such charts as Figure 6-a and 6-b.

b) *Cable vs. Open Wire.*

The advantages of cable are of course numerous, the chief ones being dependability of service, freedom from outside interference, and low maintenance costs. Unless, however, there are a comparatively large number of circuits to be provided, the cost of cable will be greater than open-wire circuits. The rapid advances made in the past few years with carrier have tended to accentuate this difference and at the same time it has raised both the quality and dependability of open-wire circuits.

A series of studies has been carried out to determine the possibility of proving in cable over the main Rumanian toll routes. Even assuming a considerable variation in traffic loads from those arrived at in the present traffic projections the studies indicate that cable cannot be proved in from the purely economic standpoint except possibly over one or two short heavily loaded routes.

In planning open-wire construction on all routes where cable is definitely out of the picture, the engineer should proceed on the basis of such construction being of as permanent a nature as possible. Conversely, in planning open-wire additions for any of the lines where there is some possibility of employing cable, the engineer must use extreme caution that he does not commit himself to making expenditures for open-wire which in a few years must be taken down and replaced by cable. Every possible method of postponing relief over these routes should be resorted to such as:

1) Rerouting over other parallel routes which it is definitely known will be maintained as open-wire.
2) Maximum use of carrier which, when cable is placed, can be installed over other routes with practically no loss, etc.

c) *Repeater Station Layout.*

Coupled with the toll routing study and the cable study was the question of the most economical layout of repeater and carrier stations to meet the transmission requirements already set forth. Three main factors were kept in mind in this study:

a) Circuit quality and stability
b) Location of future automatic or common battery offices
c) Reduction in power and maintenance costs possible by keeping number of repeater and carrier stations at a minimum.

V. Summary—Rumanian Network

That the Rumanian plant will be quickly brought into the form indicated by the general toll plan outlined is obviously beyond the range of practical accomplishment, the main objection to such a move being the existance of some 56,000 kilometers of toll circuit and over 10,000 kilometers of toll pole line which have not as yet lived out their full period of usefullness. Nor, in all probability, will the complete plan ever be accomplished exactly in the form in which it is outlined at the present time. With each change in the telephone art, with each unforseen change in economic conditions, etc., the plan must be revised correspondingly.

On the other hand, it is quite probable that the development of the Rumanian system will follow more closely the form foreseen in the general Toll Plan than have other systems because of the relatively small ratio of existing plant to future requirements. Within the first eighteen months of operation it has been necessary to increase by approximately 35% the number of circuit kilometers in the toll plant. Both because of the economic factors involved and because it was desired to postpone any major plant rebuilding until the general Toll Plan was available, these additional facilities were obtained for the most part by carrier. This possibility of adding circuits is, however, nearly exhausted until more copper is strung. The latter will require extensive pole line construction. Natural deterioration is bringing certain lines into a condition where they must be replaced; storm damages have weakened other lines; leads such as the Bucarest Ploeşti lead are approaching the point where no additional circuits can be added without the construction of completely new leads.

In planning this work the toll and transmission engineers now have as a basis for these more specific studies the following information (in addition, of course, to the specific data as to costs and annual charges of all types of plant and equipment):

a) The exact transmission characteristics to which every individual circuit required by traffic conditions must be engineered, making the design problem a simple, straightforward case of transmission engineering.
b) The probable ultimate route over which each circuit should be built and the probable loads over each pole route involved, thus enabling them to analyse specifically all factors of construction costs and to determine the most economical procedure to be followed with each specific item of plant placed.
c) The probable location of permanent carrier and repeater points, thus permitting them to so plan power plants and buildings that temporary installations, costly moves, etc., may be eliminated.

With such basic data available the otherwise unwieldy problem of providing economically a truly universal service becomes merely a series of straightforward analyses of reasonable proportions.

Improvement in the Rumanian network has resulted in a constantly increasing amount of toll business being handled during a period of almost universal business decline. Certain of this increase is due directly to new circuits provided between points where there was a large over-load on existing circuits. The remainder is due to the gradual extension of the range of toll service

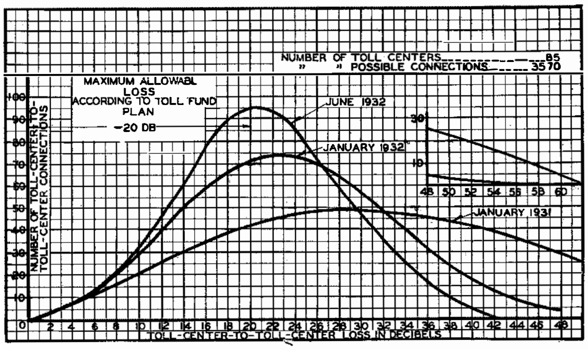


Figure 7—Toll Transmission Performance, Rumania. Number of Toll Center-to-Toll Center Connections Having a Given Loss (Intervals of 0.5 db).

obtained by toll centering. This is illustrated in Figure 7, in which there has been plotted the distribution of toll center-to-toll center connections against transmission equivalents. That progress has been made is very evident.

VI. The Rumanian Fundamental Plan in Relation to International Service

In all of the previous discussions no mention has been made of the problem of international service. The requirements of this service have been considered, but not from the standpoint of modifying the design of the internal network. The preponderance of internal toll traffic as compared with international traffic is such that it would not be economical to increase the grade of the general toll network used for internal traffic to care for it.

Theoretically a full solution of the problem of rapid and efficient "universal" international service would require the study and preparation of a general International Fundamental Plan following some such general lines as are already outlined for the Rumanian internal network. With the existing separate control of individual intra-national systems and the resulting necessity for specific internal efficiency and economy, such a plan would of course have to start with the assumption that a more economic over-all layout might conceivably be arrived at by increasing the grade of certain intra-national networks to permit a greater saving in other intra-national networks or in the general international network, but this cannot be done. In other words, each intra-national system must be considered as an independent unit with form and characteristics dependent upon internal economies. This of course reduces the International Fundamental Plan to a study of:

a) The inherent terminal characteristics of the intra-national network as seen from the terminals of the international links;
b) The design of an efficient and economical network interconnecting these independent intra-national networks.

Such a study is not as limited in scope and possibilities as might be assumed at first thought. The fundamental features to be dealt with in each country are very similar, and there is every probability that the various networks while varying in specific details will be much alike when viewed from the standpoint of the characteristics which they present at the international switching centers. For instance, it will be found that both the Spanish and the Rumanian toll networks, although independently arrived at and differing in the specific allocation of losses in the

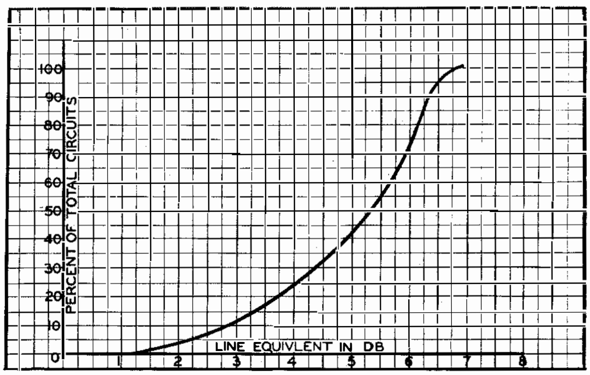


Figure 8-a—Probable Toll Line Equivalents for Secondary Toll Circuits in Rumania.

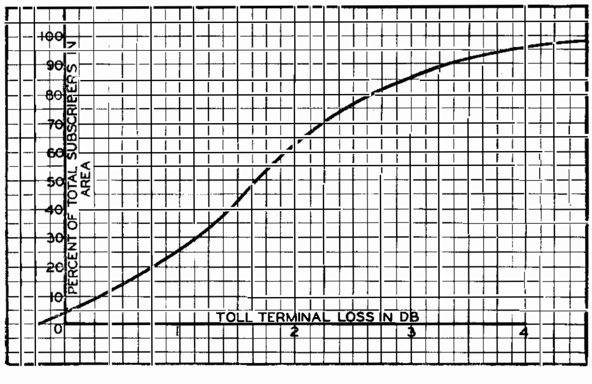


Figure 8-b—Probable Toll Terminal Loss for Subscribers in Secondary Toll Centers.

individual links present very similar characteristics when considered from the international standpoint. Likewise, both of these networks present very close parallels to the networks found within the eight major regional centers of the American switching plan.

Furthermore, when viewed from the standpoint of national interconnection, it is an encouraging fact that the characteristics which these networks present vary but little from the latest recommendation of the C. C. I. An example is the case of Bucarest, which is the main switching point for international service between all points in Rumania and the rest of Europe. If we break down the "toll terminal losses" standardized for Rumania into the corresponding sending and receiving losses and take the probable maximum value which will be encountered in each case, we find:

1) *Sending Losses to Terminals of International Circuits**

Bucarest Subscribers	13.8 db.
Subscribers in Buc. Tribs	11.3 "
Subscribers in Primary Outlets	13.7 "
Subscribers in Tribs. to Primary Outlets	11.5 "
Subscribers in Sec. Toll Centers	15.3 "
Subscribers in Tribs. to Sec. Toll Centers	16.8 "
C. C. I. STANDARD	17.0 " †

2) *Receiving Losses from Terminals of International Circuits**

Bucarest Subscribers	6.2 db.
Subscribers in Buc. Tribs	8.7 "
Subscribers in Primary Outlets	6.3 "
Subscribers in Tribs. to Primary Outlets	8.5 "
Subscribers in Sec. Toll Centers	12.7 "
Subscribers in Tribs. to Sec. Toll Centers	13.2 "
C. C. I. STANDARD	11.0 " †

As will be noted from the above comparisons, the only connections which are over the C. C. I. standard are those to secondary toll centers and their tributaries, in which cases a maximum excess of from 1 to 3 db. may be expected *for limiting subscribers.*

Up to the present time no study has been made as to the possibilities of reducing the standard losses to these centers for the following reasons:

a) *Possible inherent margin in international links.* The recommendations of the C. C. I. provide for an international link working at 0.7 népers (6.1 db.) equivalent, but does not specify the "minimum net equivalent" of such links. Under the Rumanian plan any connection put up at Bucarest between two "inter-regional" circuits will result in there being introduced at Bucarest (either by means of pad control or by means of a cord repeater) a gain of 6 db. In other words, the "inter-regional" circuits although working at 6 db. on terminal connections will have an inherent margin on through connections of from 2 to 4 db. each, the inherent margin at Bucarest for each combination being 6 db. It has been tentatively assumed that the same inherent margin would be available at Bucarest when an inter-regional circuit was switched to an international circuit. If this is so and if we continue to assign 0.7 népers to the international link as far as the terminals of the Bucarest cord repeater (or its equivalent in the case of pad control), we may reduce each of the losses in the table above by 3 db. in which case all connections come within the recommended limits of the C. C. I.

b) *Probable Percentage of Total Calls Reaching Maximum Limits.* Even assuming, however, that the 3 db. margin is not available in the international link, there is another factor which tends toward leaving the standard limits as they are and treating any particular subscriber in the limiting range of the secondary areas as a special case. This factor is the relatively small proportion of subscribers who will be found in the limiting range. In Figure 8-a, there is plotted the probable distribution of secondary toll circuits with respect to transmission losses while Figure 8-b shows the probable distribution of subscribers in secondary toll centers and tributaries with respect to toll terminal losses to the secondary toll center. Whether or not this will result in more than 90% of such subscribers being 3 db. better than the maximum standard is difficult to determine at the present time. When the relatively small amount of international calls coming from such secondary centers is considered, however, it will be seen that the number for which special measures must be taken is so small as to warrant the assumption that such special measures will be more economical than a straight reduction of 3 db. in the toll losses from the terminals of the international circuits to all secondary centers.

If we assume that as a result of one or the other of these factors the transmission provided to all points in Rumania will ultimately be brought within standard limits, it is obvious that the international problem beyond the provision of the main international links reduces itself purely to one of traffic loads, no special facilities within

*Note: These are probable maximum values. The exact value for a given Toll Terminal Loss Limit depends upon the makeup of gauges in the subscriber's loop, the type of switchboard, etc.

†The C. C. I. recommendations call for 90% of the subscribers meeting this value.

the country being required in the general internal network. The elimination of such special internal links to care for international service has numerous distinct advantages, chief among which is the question of circuit time efficiency. Thus in the case of the Rumanian system any circuit of any group terminating at Bucarest is available for use in connection with the various international circuits, there being no necessity for waiting for any special high-grade circuit to be free. Traffic routings are exactly the same as for all internal calls. No special high-grade maintenance other than that normally involved in the regular internal network is required.

Whether or not this condition can be made to obtain throughout Europe depends, of course, upon the degree of similarity which the terminal characteristics for the various intra-national operating units are found to present, and to the technical limitations which these terminal characteristics impose on the international links. This can be determined only by a joint study by all operating units concerned, and it is probable that some such idea actuated Question 5 of the Third Sub-commission of the C. C. I. for 1932. The joint consideration of a general interconnecting network for international service is of extreme importance as well as of extreme complexity. Before a workable scheme can be adopted there will undoubtedly be required numerous joint meetings of the various delegates followed by detailed study and consideration by all administrations concerned. The preparation of such an International Fundamental Plan acceptable to all is, however, the key to the successful provision of "universal" international service at reasonable costs.

Bibliography

F. Gill, "Economics of Engineering," *Electrical Communication*, July, 1923.

J. N. Chamberlin, "Advance Planning of the Toll Telephone Plant," *A. I. E. E. Transactions*, 1928, page 1.

Burke Smith and G. B. West, "Telephone Toll Plant in the Chicago Region," *A. I. E. E. Journal*, January, 1928.

J. G. Hines, "The Anticipation of Demand and the Economic Selection, Provision and Layout of Plant," *Journal of I. E. E.*, May, 1929.

J. N. Hill, "Critical Methods of Investigation as Applied to the Study of Telephone Areas and Plant Layout," *Institute of Post Office Electrical Engineers*, 1931, Paper No. 128.

C. C. McFarland, "Advance Planning of Long Distance Telephone Facilities," *A. I. E. E. Journal*, 1931, page 902.

W. C. Lallier, "Toll Switching Plan for Wisconsin," *A. I. E. E. Transactions*, 1932, page 628.

International Instruction in Communication

By F. GILL

EDITOR'S NOTE: *The paper discussed by Mr. Gill may not be conveniently accessible to readers of Electrical Communication. A brief outline is therefore included in this issue of Electrical Communication as an Appendix to Mr. Gill's paper.*

IN the paper by Craemer, Ebeling & Küpfmüller on "International Courses of Instruction for the Electrical Communication Service in Connection with the C. C. I." published in the journal "Europäischer Fernsprechdienst," No. 28, April, 1932, the question is asked:

> "Whether the manner and extent of international cooperation so far achieved in this domain" (electrical communication) "has been adequate to keep pace with technical development and to ensure that the traffic needs of the communication service have benefited therefrom to the fullest possible extent."

In what follows the writer refers especially to telephony.

This question is not to be understood as a criticism of the C. C. I., for the C. C. I. has indeed done an outstanding work, and it is certainly not an overstatement to say that the advance in European long distance telephony, since 1923, is due to the action of the C. C. I. and to the devotion of its members and those cooperating with them.

But admiration for the work of the past ought not to prevent us from examining the present and future needs; the very progress which has been made has also shown where these needs lie and what are some of the things which are necessary before we shall be in a position to act up to our knowledge.

The proposal put forward by the authors is for an international school of Communication Engineering; and they point to the good work this kind of education has done in the Bell System in the United States. But are they not putting the cart before the horse? Are they not confusing effect with cause?

It is true that there is great educational activity among the engineers of the Bell System, and that the activity is along a common line of thought, and is built up both by numbers and by finance into a strong position. But that educational activity is by no means confined to engineering. It covers also many plant, traffic, commercial and other practices. And behind it the real motivating cause is the desire of a unified control to do the best it can with its common service. This unified control is the real cause; the education is merely one (although an important one), of its many effects.

While much education is not governed by commercial decisions, yet much of the special education necessary in this kind of training is, and always must be, governed by decisions to do things in a certain manner and to certain standards. And it would be difficult to produce the results of the Bell System of education were all the commercial and other decisions first expunged from the basis of the curriculum.

Let us look at some examples: In the study of transmission unless great wastage of time and money is to be encouraged, attenuation must be dealt with in terms of one kind of unit—decibels or népers; it is of course easy to refer from one to the other and to deal with the difference between them, but in the practical work of transmission one must select one or the other for tables, charts, instruments, etc., or lose quite a lot of time in always stating the same thing in both ways.

Echo suppressors may be taken as another case; if everything is to be taught regarding the different kinds much time will be occupied; if one type is selected for any particular work it involves a decision—and who is to make that decision?

The different kinds of cable, twisted-pair quad or star quad may be taken as a third example. But each engineer will from his own knowledge recognize that in different organizations very similar results are achieved by different means, and while much of the education is of a theoretical nature, yet a great deal is also concerned with the efficient handling of the apparatus or plant which has been selected.

The Bell System education is effective because it knows what it is trying to do; a school without that directive policy could not achieve the same results.

What then is to be done? It seems to the writer that so long as the European Long Distance system is made up of so many authorities, some of which cannot possibly be expected to support expensive schools of their own, the better present course lies not in the establishing of a central common school, but rather in the opening of the existing schools to each other.

Certain Telephone Administrations are strong enough to have efficient schools covering different subjects. If these schools are thrown open to engineers (and of course to others also) of the various administrations, (whether Government or Company), small and inefficient schools need not exist, and a student from any country can select the school he wishes to attend, being guided by his choice of teachers, language, the primary decisions, etc., of the country in which he wishes to study—and those so inclined can take courses in more than one country. This would be following the University plan and would seem to be much more promising than the Central School idea. But of course it will not produce a corps of technicians, well drilled in the use of the same practices; that can only come after there is unity of control.

It is interesting to note the growth of the idea that perhaps after all there may be something in the simple idea of Unity of Control. In his Presidential Address* to the Institution of Electrical Engineers, October, 1929, commenting on the author's suggestion in 1923 of entrusting international telephony in Europe to a single company or, in default of that, to a single organization set up by the existing administrations to carry on the business as a separate entity, Col. Purves says:

> "No doubt either of these plans would, from the standpoint of efficient working have been superior to the present system since, even with the best will in the world, co-operation is *but a poor substitute for unified control*."

**Journal of the Institution of Electrical Engineers*, Vol. 68, No. 396, December, 1929.

The italics are the writer's. Here is the judgment of one well situated to judge as to the effect of the various plans, and recognition that the efficiency of European Long Distance Telephony has been sacrificed to something else. His statement a little later in the same address as to skimming of the cream of Europe's telephone service will not bear examination, since in one of the proposals to which he there refers, the cream was to be divided among "existing telephone administrations" so that they would not have been called upon to "give it away." This confirms the belief that this particular proposal was not in fact ever given any serious consideration.

Another instance of the gradual admission of the idea is given by the paper under review. In it the authors say:

> "The object which must be aimed at, is to create, by combined efforts, a superstate communication system embracing the whole earth and to keep it always in proper working condition. This superstate world network cannot be brought into being merely by combining the national networks which are designed for internal traffic and are relatively simple from the standpoints of organization, engineering and operation, but it represents a new structure for which special requirements must be fulfilled in these three respects."

While on this subject, it may be worth while in these times of economy, to point out the terribly heavy and rather costly machinery which is involved in the settlement of decisions, ideas and specifications by international conference and compromise. Each year a number of Commissions meet to consider questions which have been put to them; a great deal of thought, time and study is given; they issue their reports and these reports are taken up to the annual Plenary meeting.

In 1930, the Plenary Meeting at Brussels was composed of the members of twenty-four countries with their attendant experts, altogether 106 persons. They met in conference for eight days, and the cost was possibly in the order of 100,000 gold francs for this Plenary Meeting alone, apart from the cost of the meeting of the Commissions and of the annual expenditure of the C. C. I. itself, the last about 150,000 gold francs.

If any new device or method or practice is perfected it is not brought into general use in the European network without going through the above process, and it is difficult to see how it can be otherwise so long as the primary decisions on which so much depend must be made by so many people.

It is not the writer's desire to suggest for one moment that the C. C. I. is not efficient; he yields to no one in his admiration of the work it has done or of the manner in which it has been carried out. But the fact remains, the primary decision of 1923—that it was not possible to have unity of control of the Long Distance service in Europe—imposed upon the service the great handicap of having to set up complicated and expensive machinery to effect what, given a different decision, could well have been done by a simpler and less expensive organization.

The competitive era has not been strikingly successful, and there is now being envisaged a system under which needs are studied and construction is organized. In this matter of International Telephony may it not be better to allow the competition (not a material competition but all the same, a competition of minds), to give place to the more rational idea of unified planning and control over areas of considerable extent, not the whole world—that seems unnecessary—but considerably larger than the present system of areas in use in Europe?

APPENDIX

Outline of the Paper[1] by Craemer, Ebeling and Küpfmüller on "International Courses of Instruction for the Electrical Communication Service in Connection with the C. C. I."

In addition to the question quoted in the opening paragraph of the foregoing paper, Messrs. Craemer, Ebeling and Küpfmüller's paper includes the following:

Development to date of international co-operation including mention of the loaded and repeatered cable and the need for a more unified system throughout Europe. The authors state that the problem broadly is not merely a matter of interconnecting existing telecommunication networks but rather of co-ordinating organization, technique, and operation in such a manner that the desired world network can be efficiently established.

They advocate as the first step the provision of staffs of competent technicians in every country to deal intelligently with the common problem. Mention is made of the Berne Bureau comprising the International Telegraph Union and the International Radio Union, the International Consultative Committees on telephony, telegraphy, and radio, (C. C. I., C. C. I. T., and C. C. I. R.), and the International Broadcasting Union. As regards the International Telegraph Union, the authors point out that it is not an independent and creative body for the benefit of international operation nor was it organized for that purpose; they add that it is not capable of undertaking such a task since it is almost entirely out of touch with the practical side.

The above mentioned Consultative Committees were formed after the War to bring about a better understanding between the Government officials of various countries as regards telecommunication problems. All three have permanent Commissions working on technical, operative, and tariff questions of common interest. Once a year, as a rule, their findings are submitted to Plenary Assemblies which are called upon to approve the Committees' recommendations. These are generally followed by the Administrations and Operating Companies but are not mandatory.

Present means for educating tele-technicians are reviewed including C. C. I., C. C. I. T., C. C. I. R. publications, periodicals and books, as well as special instruction and lecture courses arranged for by some Telephone Administrations.

In connection with the need for and means of systematic courses, the authors state that the success of the telephone in the United States, where it is under unified control, is in large measure due to the training of all ranks of employees. In Europe, where unity of control is lacking, the problem is all the more difficult and is constantly getting more complex.

The suggestion is made that one method of educating telephone men would be to establish a permanent central institution, including a modern and well-equipped laboratory in one of the European capitals. Apart from cost and the necessarily large technical staff for covering subjects as highly specialized as telephony and telegraphy, it is pointed out among other considerations that it would be difficult to procure qualified teachers representing an international viewpoint. The only practicable solution, according to the authors, would be to associate such an educational plan with the work of the C. C. I.

The authors suggest that the educational scheme follow the lines of the C. C. I. organization and line up somewhat as follows:

I. Organization and Administration.
II. Operating practices.
III. Transmission technique.
IV. Interference problems.

[1]Published in the Journal, "Europäischer Fernsprechdienst," No. 28, April, 1932.

Specimen Curriculum

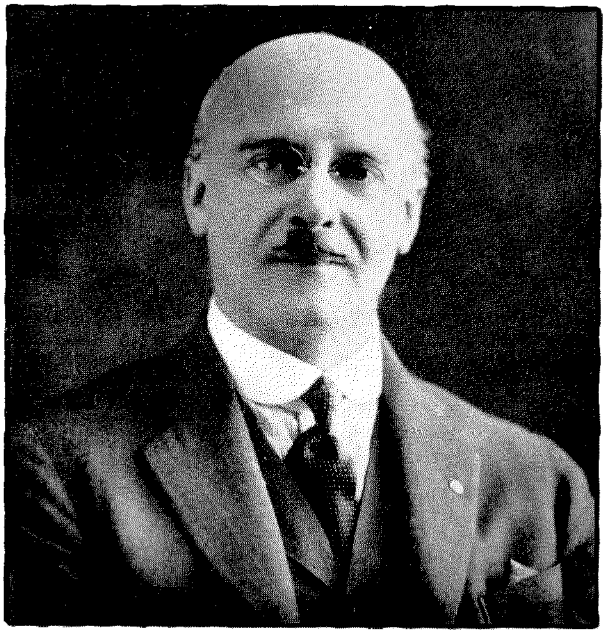
Course I. Organization and Administration.
1. History and object of the C. C. I. 4 hours
2. Organization of telecommunication in various countries......5 "
3. Rates as affecting international service......................4 "
4. Operating statistics in relation to plant requirements...........5 "

Course II. Operating practices.
1. Common with I: 1 above.......4 hours
2. Operating requirements in international telecommunication as affected by C. C. I. rules.....5 "
3. Maintenance and supervision...5 "
4. Operating international radio circuits.....................5 "

Course III. Transmission technique.
1. Electrical requirements of long lines (Specifications)..........5 hours
2. Transmission Reference Circuit and its use..................5 hours
3. Common II: 3. above..........5 "
4. Common with II: 4. above......5 "

Course IV. Interference problems.
1. The "Guiding Principles" of the C. C. I......................5 hours
2. Means of protection against high tension interference..........5 "
3. Co-operation with Power Companies.......................4 "
4. Theoretical and experimental data and their use...........5 "

The paper concludes with comments on the cost of the courses, number of lecturers required, selection of lecturers and their emoluments, raising of funds, attendance fees, and the expression of the hope that the C. C. I. will take this suggestion under consideration.



IN MEMORIAM

IT is with sincere regret that *Electrical Communication* records the death, on November 3, 1932, of Mr. Richard Becker Hungerford, Managing Director of Standard Telephones and Cables (Australasia), Limited. ¶ Born on June 21, 1879, at Clontarf, Dublin, Ireland, Mr. Hungerford received his education at the Colchester Grammar School and later at the Polytechnic School of Engineering in London. After graduation he was apprenticed as a mechanical engineer at the Crewe Works of the London and Northwestern Railway, and on October 15, 1900, he joined the Western Electric Company, Limited, in the Installation Department, being appointed supervisor in charge of installation of common battery exchanges in 1901. In 1902, he was appointed chief of testing and installation of all common battery exchanges supplied to the British Post Office by the Company in the London area. ¶ Due to his untiring energy and his outstanding ability in mastering the problems of the business, Mr. Hungerford was selected as a man for rapid advancement and, in 1903, was sent to Australia as representative of the Company in charge of engineering and sales work. In 1912, on the incorporation of the Company's activities in Australia into the Western Electric Company (Australia), Limited, now Standard Telephones and Cables (Australasia), Limited, he was appointed Managing Director. ¶ Mr. Hungerford was always alive to introducing the new products of the Company and it was through his initiative that the Australian Government was one of the first outside of the United States to install carrier telephone equipment.

His death is a great loss not only to the Company which he directed, but to his colleagues in the field of electrical communication throughout the world. He leaves a host of friends who were particularly devoted to him because of his many sterling qualities.

The Stockholm-Malmö Railway Cable Equipped with Telephone Repeaters

By IVAR BILLING
Byrådirektör, Swedish State Railways

General

IN connection with the electrification of the Swedish State Railways it became necessary to take certain protective measures with the power lines as well as with the telephone communication circuits along the railway in order to avoid interference.

On the first electrified railway between Luleå-Kiruna-Norwegian border (435 km.), which was opened for service in 1923, the telegraph and telephone circuits were retained as open wire lines, but the pole route was moved to a distance of 50 meters away from the track. No repeater stations were required for these circuits.

When later the line from Stockholm to Gothenburg (457 km.) was electrified (1924-26), the local conditions in these densely populated and cultivated parts of the country made it impossible to move the existing open wire lines away from the railway and an underground cable was therefore installed.[1]

When the electrification of the Stockholm-Malmö route was started in 1931, it was also necessary to install a telephone cable along the railway. This cable was completed and ready for service in September, 1932.[2]

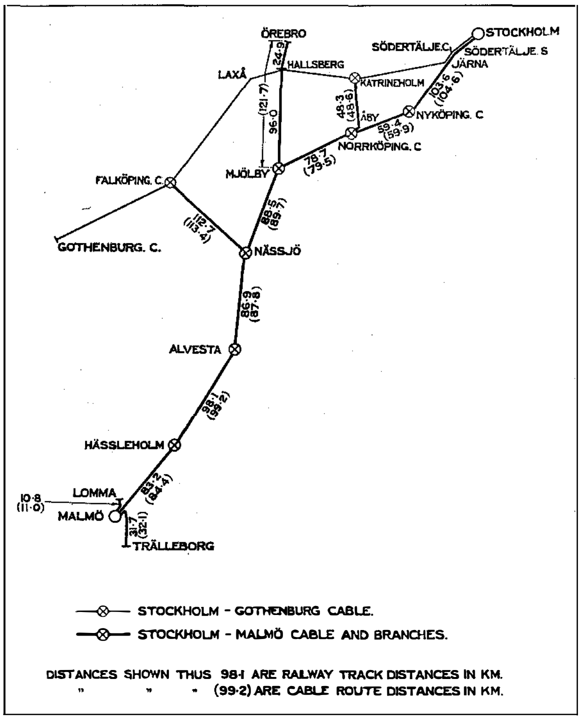


Figure 1—Cable Route Diagram.

Cable Routes

Figure 1 shows in diagrammatic form the cable routes which, in addition to the main route Stockholm-Malmö, comprise branch cables: Norrköping-Katrineholm, Mjölby-Örebro, Nässjö-Falköping, Malmö-Trelleborg and Malmö-Lomma. The aggregate length of these cables amounts to 932 km.

Three types of cable (Figure 2) were used on the sections indicated below:

Type I	3 quads 1.4 mm. 2 pairs 1.4 " 10 quads 0.9 "	Stockholm-Malmö	(605 km.)
Type II	3 quads 1.4 mm. 16 pairs 0.9 "	Örebro-Mjölby Nässjö-Falköping Malmö-Lomma	(246 km.)
Type III	3 pairs 1.4 mm. 12 pairs 0.9 "	Norrköping-Katrineholm Malmö-Trelleborg	(81 km.)

The conductors are paper insulated and laid up partly as pairs and partly as quads for phantom working. The lead sheath, 2 mm. thick, contains 2% tin and was tested with an internal pressure of two atmospheres. The armouring consists of two layers of 1 mm. iron tape, augmented by an extra armouring of 5 mm. iron wires on the sub-fluvial sections.

The cables were manufactured by Sieverts Kabelverk in Stockholm and delivered in lengths of 553 meters.

[1] I. Billing, "Stockholm-Göteborg Railway Cable," *Electrical Communication*, April, 1926.
[2] "Stockholm-Malmö Railway Cable," *Electrical Communication*, October, 1931.

The specified and tested values of the electrical characteristics are given in Table I. In addition, the cable was tested with 2,000 volts (50 p:s) between conductors and sheath for 30 minutes and with 1,000 volts between conductors for 1 minute.

The cables were laid by the Railway's own staff at a distance of about 1.9 meters from the centre of the track and at a depth of 0.7 meters. The trench on a part of the route was cut by a plough of the type used in 1924 for the Stockholm-Gothenburg cable (Figure 3). This plough necessitates manual removal of falling ballast gravel and stones before the cable can be laid from the conveying train. In order to save this work an improved plough was used, so constructed that the cable, running over a wheel inside the plough, is deposited in the trench before any gravel falls into the trench (Figure 4). This latest type of plough is connected in the train, ahead of the cable trucks and is operated with compressed air from the locomotive.

The laying of the cable took place between May 4–November 13, 1931 and March 31–July 7, 1932, at an average rate of 22.7 km. per week and a maximum of 43 km. per week.

At all railway stations the cables are terminated in boxes of the types shown in Figures 5 and 6, while certain circuits are led into guard houses and signal posts, etc. The average distance between the branch points is 1.6 km.

Loading and Repeaters

In the Stockholm-Gothenburg cable, containing 21 pairs, a number of circuits was reserved for telegraphs and only 10 pairs were loaded and 6 pairs of 1.4 mm. conductors were equipped with repeaters for long-distance telephone circuits.[3]

[3] *Electrical Communication*, April, 1926, loc. cit.

TABLE I

Electrical Characteristics, Factory Cable Lengths

	Guaranteed Values	Average Measured Values: Cable Type I	Cable Type II	Cable Type III
Wire resistance per km. at 15° C.				
1.4 mm. conductors, ohms	max. 11.4	10.86	10.92	10.78
0.9 " " "	" 27.5	26.3	26.4	26.27
Resistance Unbalance between the wires of a pair expressed as a percentage of the average resistance	max. 3	0.5	0.6	0.4
Insulation Resistance with 100 volts D.C. (megohms per km.)	min. 10,000	25,600	26,200	29,000
Mutual Capacity μF per km. measured at 800 p:s				
Side Circuit 1.4 mm. max. μF	max. 0.042	0.0330	0.0329	0.0328
" " 1.4 " average μF	" 0.038	0.0325	0.0324	0.0322
" " 0.9 " max. μF	" 0.039	0.0296	0.0303	0.0305
" " 0.9 " average μF	" 0.036	0.0290	0.0296	0.0296
Ratio between Side and Phantom Capacities	max. 1.05 x 1.62	1.02 x 1.62	1.03 x 1.62	—
Capacity Unbalance per 550 meter length:				
Pairs:				
Average unbalance between adjacent pairs μμF	max. 100	—	18	14
Unbalance between any two pairs μμF	" 200	—	53	47
Quads:				
Side-to-Side in same quad μμF	max. 350	51	43	—
Side-to-Phantom in same quad μμF	" 900	175	116	—
Pair-to-Pair, Pair-to-Phantom, Phantom-to-Phantom in adjacent quads μμF	" 600	52	72	—
Side-to-Earth μμF	" 1000	200	271	188
$\frac{G}{C}$ at 800 p:s	25	17	19.5	19.5

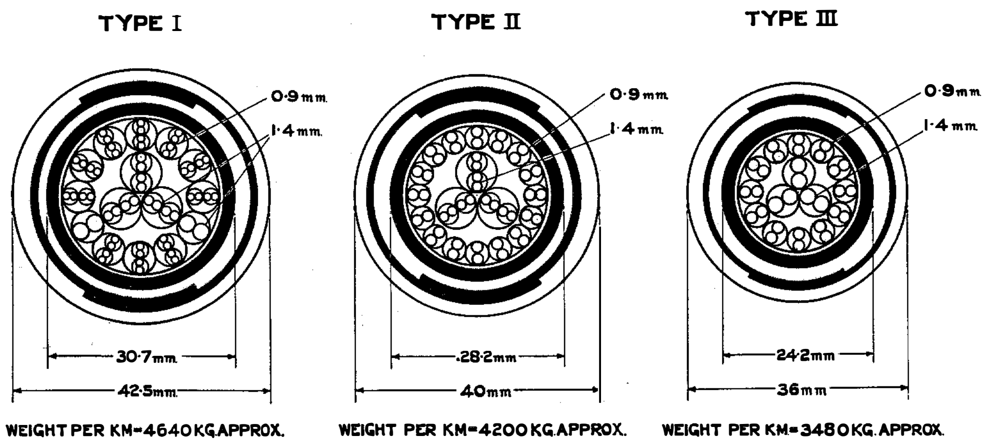


Figure 2—Types of Cable.

When plans were drawn up in 1930 for the Stockholm-Malmö cable it was assumed that telegraph operation would be confined to international traffic and that other communications would be handled by telephone. This requirement made it necessary to increase the number of loaded circuits to cater for this telephone traffic with a resulting increase in the number of repeaters.

The loading of the present cable, which has a somewhat lower mutual capacity than ordinarily used for telephone cables, was carried out according to the plan tabulated below, the distance between coils having been fixed at 2,200 meters ± 1%. The loading coil characteristics are shown in Table II.

		Grade of Loading		Coils per Case
		Side (mH)	Phantom (mH)	
Cable Type I:	3 quads 1.4 mm.	160	63	27
	4 " 0.9 "	177	63	
	2 pairs 1.4 "	177		
	4 " 0.9 "	177		
Cable Type II:	3 quads 1.4 mm.	160	63	17
	8 pairs 0.9 "	177		
Cable Type III:	3 pairs 1.4 mm.	160		7
	4 " 0.9 "	177		

In Figure 7 is shown a loading coil case, containing 27 coils, the weight of the case being about 250 kg.

In order to provide satisfactory transmission over the long-distance circuits involved, six repeater stations are provided between Stockholm and Malmö at the points indicated in Figure 1. Repeaters are used on the longest 1.4 mm. circuits as well as on 0.9 mm. circuits of 200–300 km. lengths. For through connection, Stockholm-Malmö, only three repeaters are required, namely, at Norrköping, Nässjö and Hässleholm.

The specified transmission characteristics of the repeater sections and those obtained are given in Table III.

Typical curves, showing impedance-frequency and attenuation-frequency characteristics are shown in Figures 8 and 9.

Repeater Stations

The repeater equipment was manufactured by the Standard Telephones and Cables, Ltd., London, and was delivered and installed by the Standard Electric, Oslo.

In order to make the fullest possible use of the facilities available, all repeater stations are accommodated in existing railway stations so that no extra building has been required. The motor generators for direct supply of 130 volt for the plate voltage and for the 16–2/3 p:s ringing have been installed in the stations, together with the necessary 24-volt filament supply.

The stations are generally equipped with through type repeaters and only at one station, Nässjö, have cord circuit repeaters been provided. The stations Nyköping, Norrköping and Mjölby have each been equipped with 10 through repeaters, Nässjö with 10 through and 5 cord circuit repeaters, Alvesta with 12 through repeaters and Hässleholm with 15 through repeaters, making a total of 72 repeaters.

The cable is led into the repeater station and terminated in cable terminating boxes and from these terminal boxes, textile insulated cables are used to connect the cable to the terminal blocks at the top of the repeater bays. All jumpering is carried out on these terminal blocks and in this way the use of intermediate distributing frames has been avoided.

The repeaters are of the two-way, two-wire type equipped with 16–2/3 p:s signalling arrangements. The repeaters are mounted on iron bays on the unit type principle, and in order to facilitate the installation work each bay was completely equipped and wired in the factory.

In each repeater station three types of unit

TABLE II
Loading Coil Characteristics

	Guaranteed Value	Measured Average Value
Insulation measured with 150 volt D.C. (megohms)	min. 10,000	min. 80,000
Inductance with 1 m.a. at 800 p:s (in mH)		
Side Circuit Coils	177	175.6
" " "	160	159.4
Phantom Circuit Coils	63	63.0
Deviation in %	max. ± 2	max. ± 0.8 1.6
Magnetic Stability with 0–2 amps. D.C. in one winding		
before magnetisation—mH	—	180.1
5 mins. after magnetisation—mH	—	180.3
26.5 hours after magnetisation—mH	—	180.05
Change in inductance after 5 mins. in %	max. 2.5	+ 0.113
Direct Current Resistance		
Unit 177/63 ohm	max. 10.5	about 8.7
" 160/63 "	" 10.2	" 8.1
Coil 177 "	" 7.5	" 5.1
" 160 "	" 7.2	" 4.4
Effective Resistance at 800 p:s and 1 m.a.		
Unit 177/63 Side ohms	max. 12.5	about 10.9
" " Phantom ohms	" 6.0	" 5.0
" 160/63 Side "	" 12.2	" 10.01
" " Phantom "	" 6.0	" 4.8
Coil 177 "	" 9.0	" 7.3
" 160 "	" 8.7	" 6.6
Effective Resistance at 2000 p:s and 1 m.a.		
Unit 177/63 Side ohms	max. 18.5	about 15.7
" " Phantom "	" 9.5	" 6.8
" 160/63 Side "	" 18.2	" 14.8
" " Phantom "	" 9.2	" 6.7
Coil 177 "	" 15.0	" 12.2
" 160 "	" 14.5	" 11.5
Resistance Unbalance between windings		
Side Circuit ohm	max. 0.1	about 0.012
Phantom Circuit "	" 0.15	" 0.014
Inductance Unbalance between windings		
Side Circuit in %	max. 0.1	about 0.025
Phantom Circuit in %	" 0.15	" 0.026
Crosstalk between any two circuits in a loading coil case, at 10 m.a. 800 p:s néper	min. 10	min. 11

Figure 3—Cable Plough Used in 1924 for the Stockholm-Gothenburg Cable.

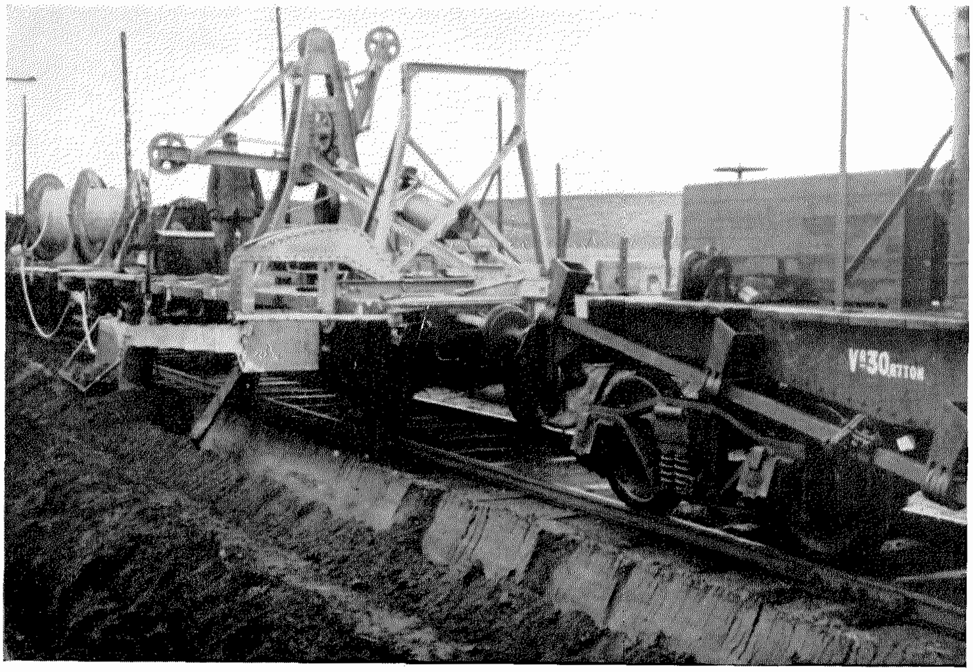


Figure 4—New Type of Cable Plough.

TABLE III
Installed Cable Characteristics

	Guaranteed Values	Measured Values: Cable Type I Norrköping-Nyköping	Type II Nässjö-Falköping	Type III Norrköping-Katrineholm
Insulation in megohms per km	min. 10000	min. 28000	41500	35000
Resistance Unbalance between wires in same pair in ohms				
0.9 mm. non-loaded	—	max. 0.6	1.2	0.4
0.9 " loaded	—	" 0.8	0.6	0.5
1.4 " "	—	" 0.35	0.25	0.2
Impedance at 800 p:s (ohms)				
1.4 mm. Side 160 mH	about 1480	about 1530	1560	1530
1.4 " " 177 "	" 1560	" 1610	—	—
0.9 " " 177 "	" 1640	" 1700	1710	1690
1.4 " Phantom 63 "	" 715	" 750	750	—
0.9 " " 63 "	" 750	" 780	—	—
Attenuation at 800 p:s in néper				
1.4 mm. Side 160 mH	max. 0.0110	max. 0.0094	0.0092	0.0086
1.4 " " 177 "	" 0.0097	" 0.0085	—	—
0.9 " " 177 "	" 0.0200	" 0.0177	0.0170	0.0172
1.4 " Phantom 63 "	" 0.0110	" 0.00934	0.0091	—
0.9 " " 63 "	" 0.0215	" 0.0188	—	—
Cut-off Frequency p:s				
1.4 mm. Side 160 mH	min. 2950	2950	2950	2950
1.4 " " 177 "	" 2800	2800	—	—
0.9 " " 177 "	" 2950	2950	2950	2950
1.4 " Phantom 63 "	" 3530	3530	3530	—
0.9 " " 63 "	" 3690	3690	—	—
Crosstalk between any two circuits in népers	min. 8.0	min. 9.1	9.3	9.7
Singing Point per Repeater Section 300–2000 p:s	min. 2.7	min. 4.0	4.0	3.3

type bay are installed. These bays can be referred to as the repeater bay, testing equipment bay and repeating coil and network bay.

Figures 10, 11, and 12 show typical photographs of these bays.

On the repeater bay are mounted the repeater units, 16–2/3 p:s ringers and ringer test panels and the associated battery supply circuits. In the jack field on this bay appear jacks associated with the repeater and ringing equipment for the purpose of patching and testing.

The centre bay shown in Figure 10 indicates the lay-out of the repeater apparatus.

On the test panel bay are mounted the voltmeter panel, telephone and trunk panel, oscillator and transmission testing equipment and associated battery supply equipment. A jack field is also provided on which appear the jacks associated with the various pieces of testing apparatus.

The left hand bay shown in Figure 10 indicates the lay-out of the testing equipment.

The third type of bay carries all the repeating coils and repeater balancing networks, the repeating coils being associated either with the repeaters or for terminating circuits.

A typical lay-out is shown in Figure 11, while Figure 13 shows the type of repeating coil which is associated with the repeater.

The two-wire repeaters are of the well-known type which have been described in previous issues of this journal, but were provided with the latest type of low consumption vacuum tubes. These new tubes[4] are a recent development in the repeater art and are designed to use only 0.25 ampere for the heating of the filament.

[4] W. E. Benham, J. S. Lyall and A. R. A. Rendall, "The New Quarter Ampere Repeater Tube and its Applications," *Electrical Communication,* October, 1932.

A further feature of these repeaters is the new type of slide wire potentiometer which enables infinitely variable adjustment of the repeater gain.

In the case of the cord circuit repeater the actual repeater is identical with the through line repeater. An additional relay panel is, however, provided by means of which the correct gain is automatically selected when the operator sets up the circuit.

The cord circuit repeater equipment is connected to cords in the switchboard (Figure 14), enabling the operator to insert these repeaters when required. The repeater is given an initial gain setting and three other gain settings are obtained by adding attenuation networks in series with the repeater. The values of these networks are: 0.22, 0.44 and 0.60 néper. In order to conserve filament current, arrangements are provided on the switchboard whereby the filament supply to the cord circuit repeater can be switched on or off.

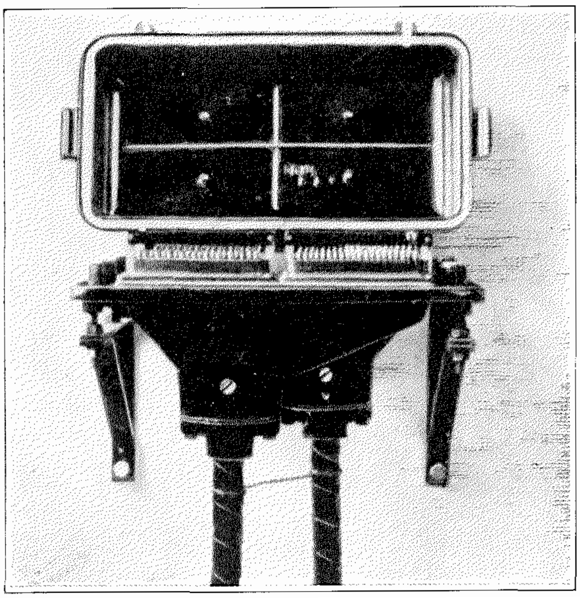


Figure 5—Cable Terminal Box.

A photograph of the repeater unit is shown in Figure 15 and a schematic drawing in Figure 16.

A photograph of a ringer panel used for relaying the 16–2/3 p:s ringing current around the repeater is shown in Figure 17. This panel is required on account of the fact that the repeater is not designed to amplify and transmit frequencies below approximately 200 p:s. The incoming signalling current operates a sensitive A.C. relay circuit which, in turn, operates a sending relay, whereby a fresh supply of signalling current is transmitted to the line.

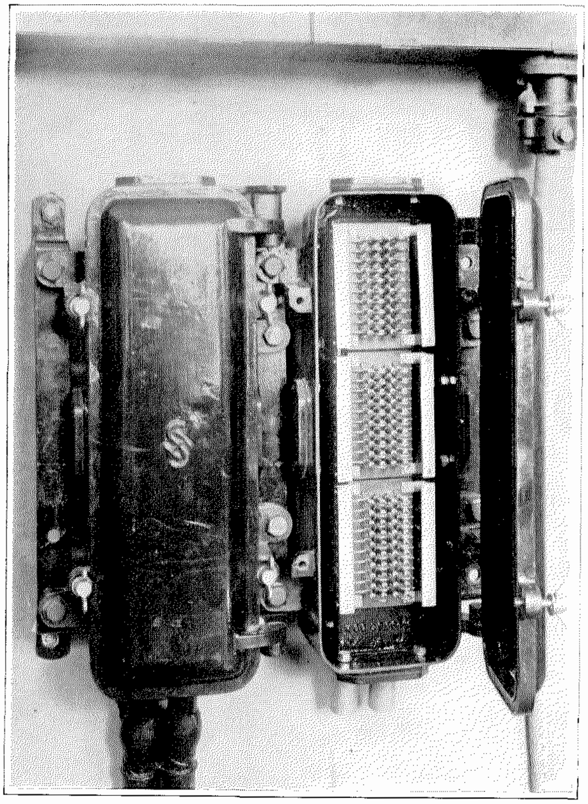


Figure 6—Cable Terminal Box.

Associated Equipment

In addition to the repeaters and their associated equipment such as repeating coils, bal-

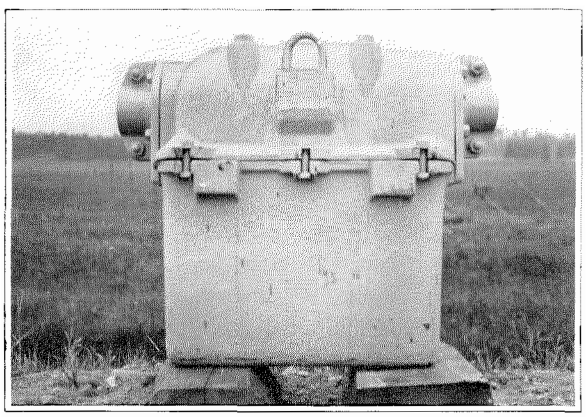


Figure 7—Loading Coil Case.

ancing networks and ringing panels, each station has been equipped with full facilities for transmission and maintenance testing. A two tube oscillator, giving seven frequencies of 300, 500, 800, 1,000, 1,400, 2,000 and 2,400 p:s, together with transmission measuring apparatus, enable repeater gains and circuit losses to be measured. The transmission measuring apparatus consists of two panels, the detector amplifier panel and a special test panel equipped with the necessary keys and attenuation networks.

With this measuring set, gains up to 4.0 népers, losses up to 2.3 népers, as well as levels between -2.3 and $+2.3$ népers can be measured. Routine gain measurements can be easily carried out with this equipment as well as direct or looped transmission loss measurements. The testing equipment utilises the same battery supply equipment as the normal repeaters.

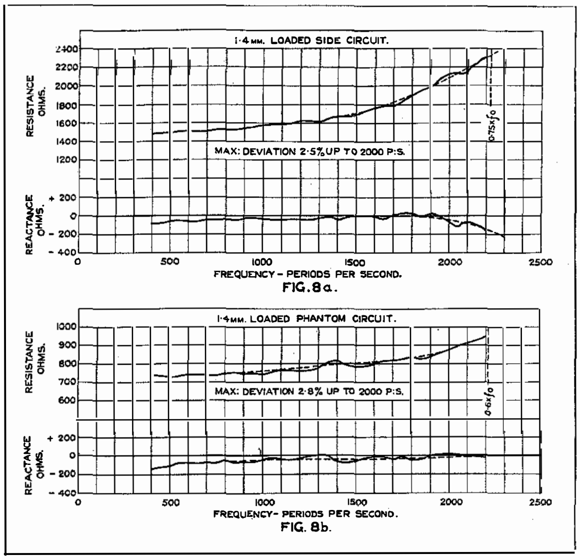


Figure 8—Impedance-Frequency Curves.

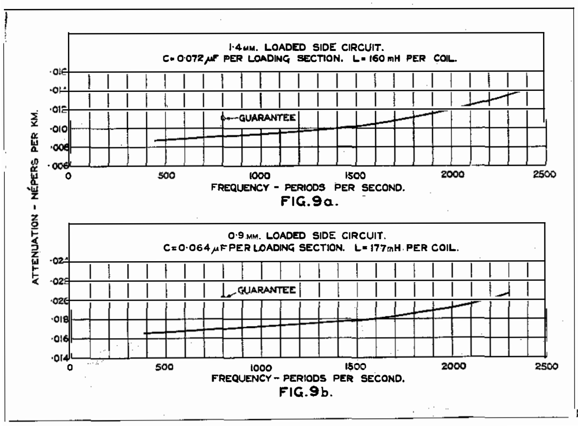


Figure 9—Attenuation-Frequency Curves.

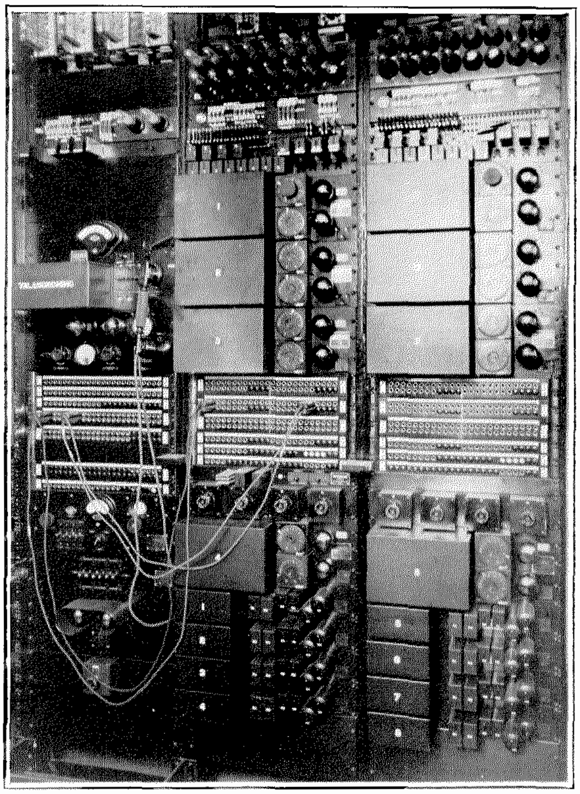


Figure 10—Repeater Bays.

Monitoring on the circuits is carried out by the attendant by means of a telephone and trunk panel. By the use of keys on this panel the attendant can listen and talk on both or either side of the repeater through the monitoring winding associated with each repeater. The set may also be used for signalling or talking direct on any line. Facilities are provided for ringing up a repeater station attendant over one of the cable circuits or from the switchboard.

For the purpose of checking the battery supply voltages at the repeater bay bus-bars, a voltmeter panel is provided. This panel is equipped with a double scale voltmeter for measuring the filament and plate voltages, a two-way key being provided to connect the voltmeter and the necessary shunt across the desired supply.

Finally, a test panel is provided for testing the 16–2/3 p:s ringer panels, and is equipped

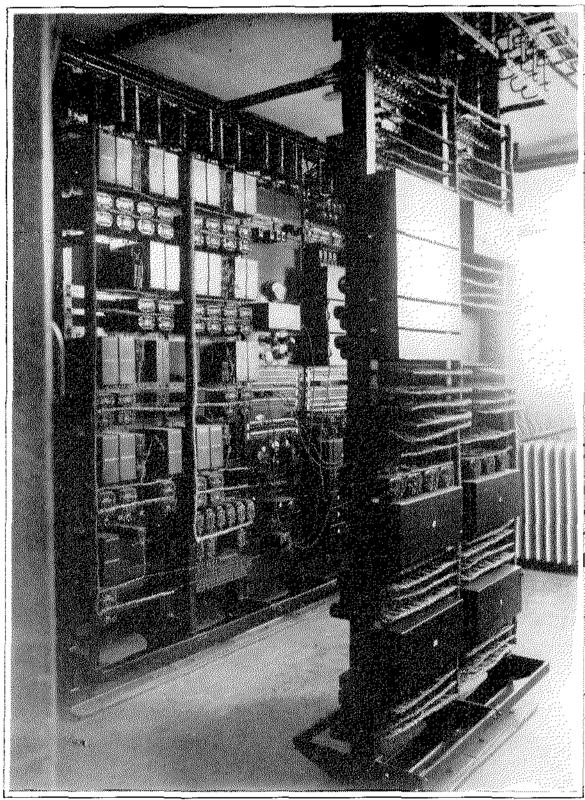


Figure 11—Repeater Bays.

with two resistance networks which are brought into operation by means of a key. This panel is used after the relays on a 16–2/3 p:s ringer panel have been cleaned and adjusted and enables the attendant to test the ringers by giving an operating and non-operating limit.

Power Supply

The necessary power for the repeater station is obtained from the normal lighting supply of the railway. The Railway Administration have a 10 kilovolt circuit running along the track which is transformed down to 220 volt at each railway station, and from this the power supply for the repeater stations is obtained.

The 24-volt filament supply is normally provided by a dry plate rectifier. In the case of failure of the A.C. supply, a 24-volt battery of 100 ampere hours capacity is automatically switched in. This battery is kept fully charged by means of a tube rectifier. When the A.C. supply is re-established the battery is automatically cut out and the filament current obtained from the rectifier as before.

The 130-volt plate and 75 volt, 16–2/3 p:s ringing supply is obtained from a generator driven by a 220-volt single phase motor. As reserve, another generator driven by a 24-volt D.C. motor is supplied from the battery. The switching over from one supply to the other is also performed automatically in this case. The time interval from the failing of the 220-volt outside supply to the re-establishing of the plate supply from the reserve motor-generator is approximately 3 seconds, a period which does not cause inconvenience in carrying on conversations over the cable. The motor generators and their associated switchboard are shown in Figure 18.

On account of the filament supply being obtained from a dry plate rectifier it is necessary for the battery supply circuits to contain rheostats individual to each repeater for the regulation of the filament current. Alarm relays to indicate failure of either filament or plate voltage

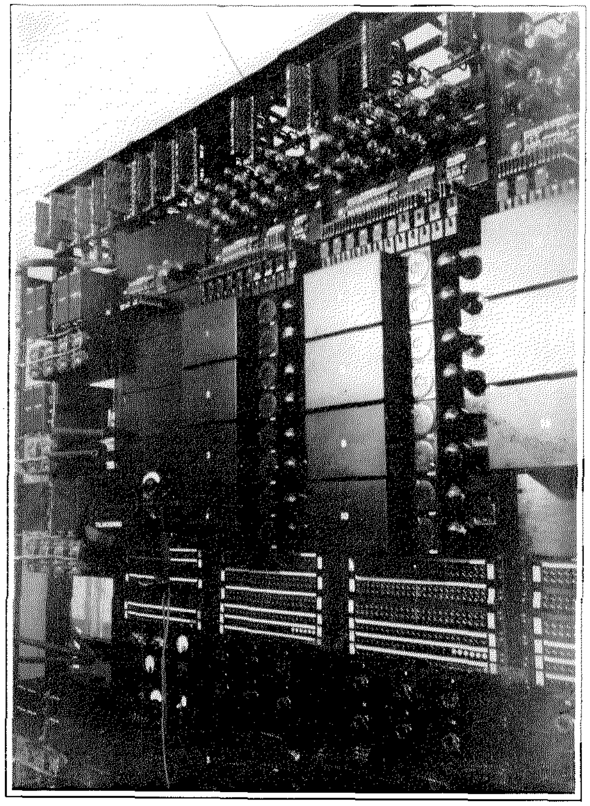


Figure 12—Repeater Bays.

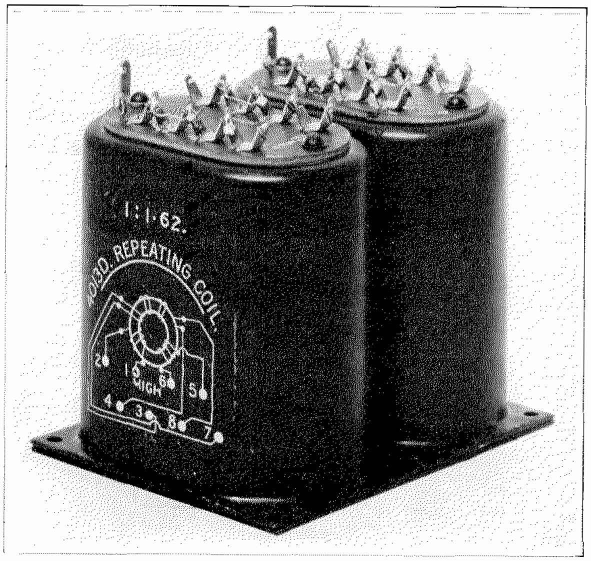


Figure 13—Type of Repeating Coil Associated with Repeater.

and a retard in the filament circuit for the suppression of battery noise are provided. A portable ammeter is also provided for the measurement of filament current.

The following variation in supply voltages is tolerated:

Filament Supply	24 volts ± 1 volt.
Plate Supply	130 volts ± 5 volts.

Overall Results

In the specification for the repeaters the following clause covering the overall characteristics was included: "The overall net loss for the circuits Stockholm-Malmö using 1.4 mm. conductors, loaded 160/63 mH, having an attenuation of 0.0105 néper per kilometre and a cut-off frequency of 2,950 p: s, employing three repeaters (Norrköping, Nässjö and Hässleholm) should

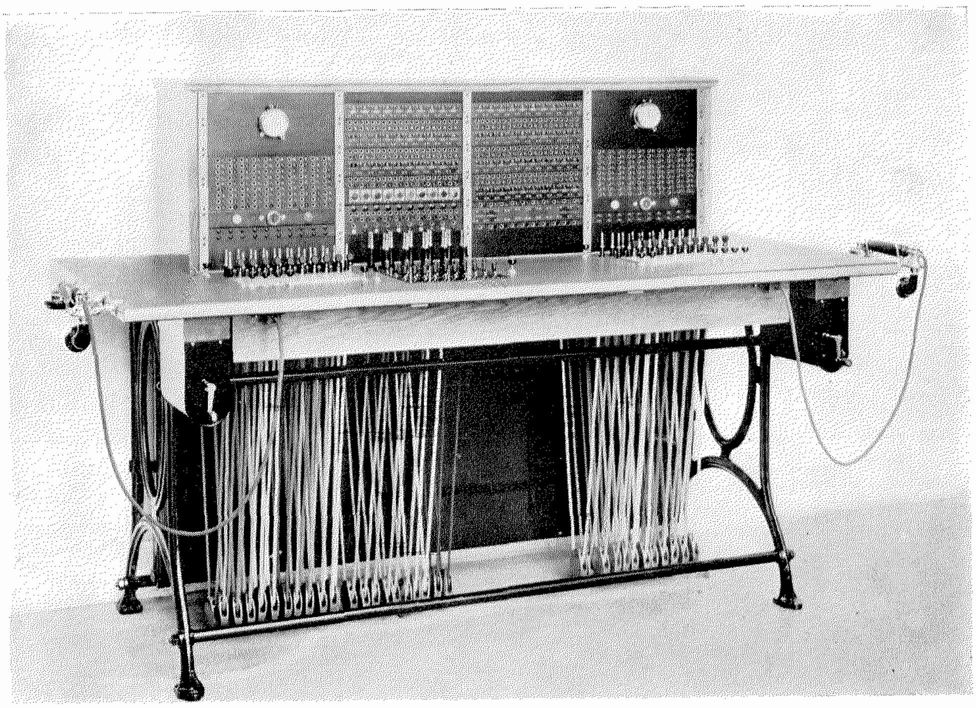


Figure 14—Switchboard.

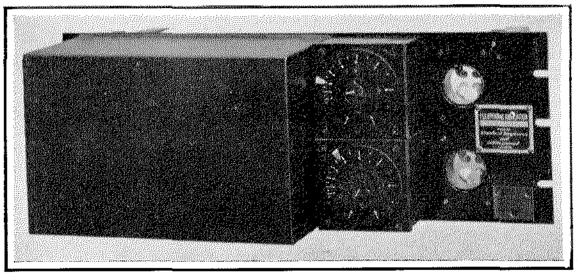


Figure 15—Repeater Unit.

not exceed 1.5 néper over the range 300 — 1,800 p: s, and otherwise to be in accordance with the C. C. I. recommendations."

The results obtained during the acceptance, compiled in Table III, show that the attenuation constant for the circuits of the above mentioned type, excluding the line transformers, is 0.0095 néper. In the final tests on the repeatered circuits, with the repeaters adjusted to give the gains indicated in the level diagrams in Figure

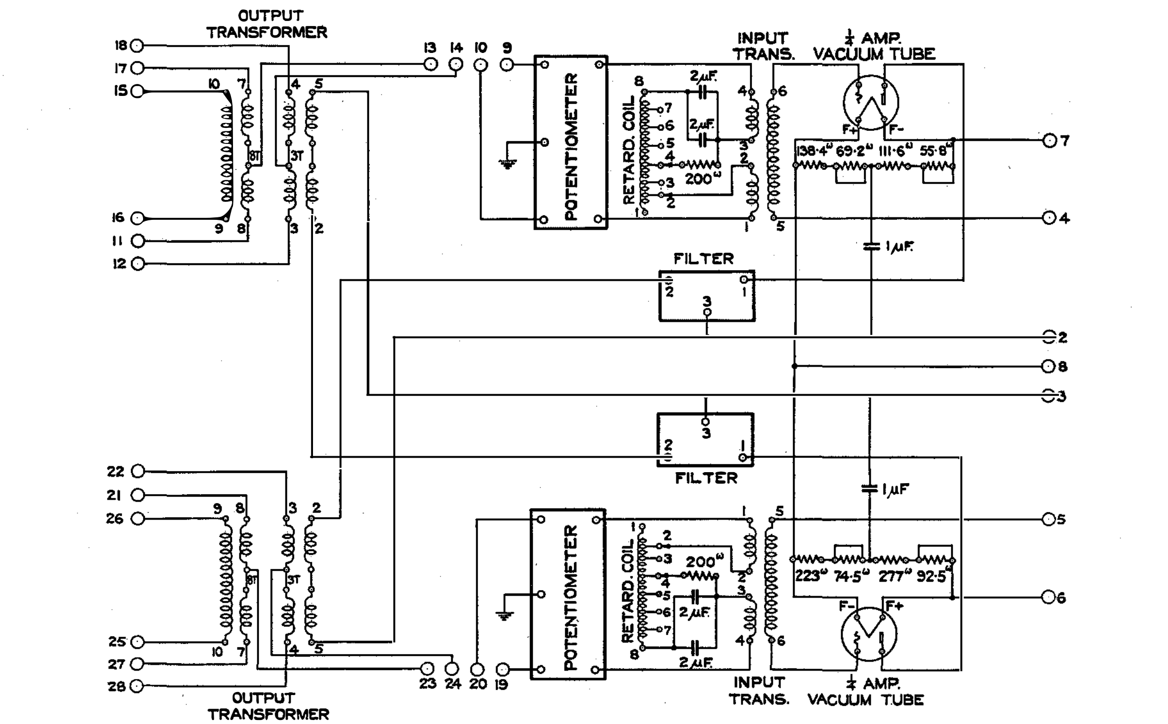


Figure 16—Schematic of Two-wire Repeater.

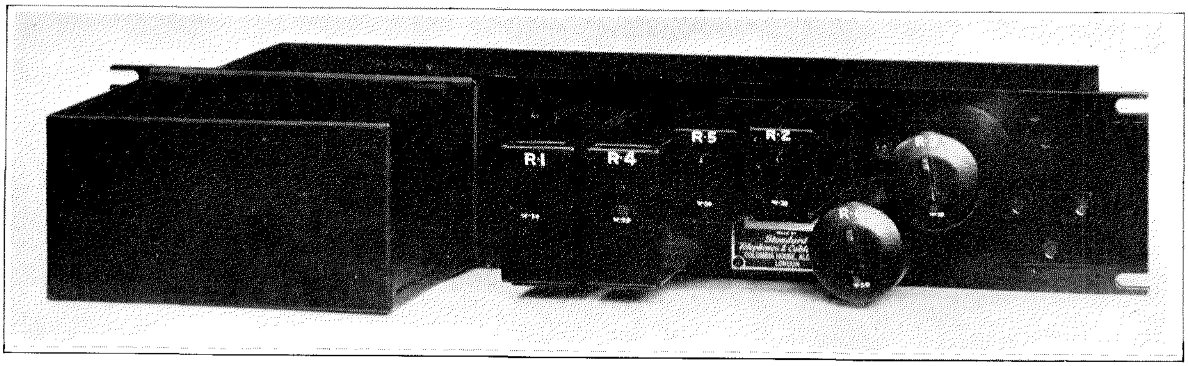


Figure 17—Ringer Panel.

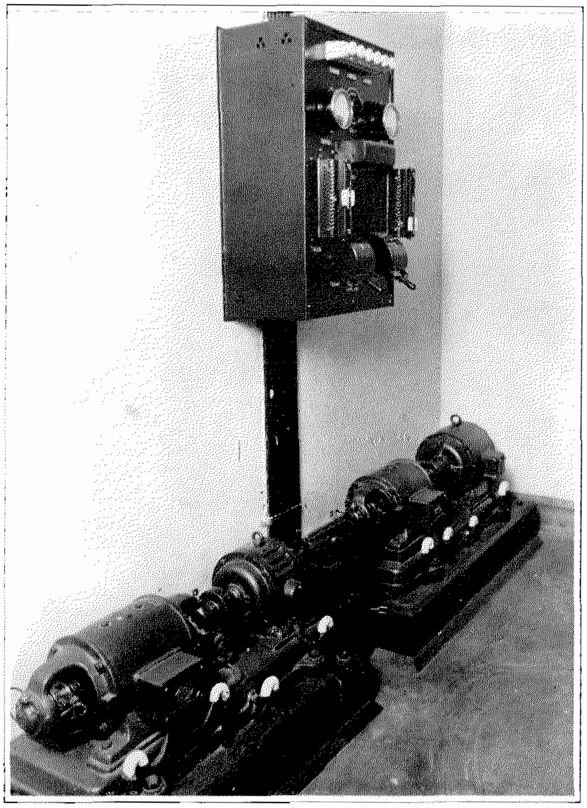


Figure 18—Motor Generators and Associated Switchboard.

19, an overall attenuation of 1 néper was obtained on both phantom and side circuits. The relation between the overall attenuation and frequency is illustrated in Figure 20.

In order to avoid readjustments of the repeaters because of temperature changes throughout the year, the repeaters have been set to give an average yearly overall attenuation on the Stockholm-Malmö circuits of 1.3 népers at 800 p: s.

It is interesting to note that the attenuation values of the 0.9 mm. circuits (Table III) enable a circuit between Stockholm and Norrköping with one intermediate repeater to be worked at an overall loss of 1.5 — 1.6 népers, which values are also obtained on a circuit Stockholm-Nässjö with three intervening repeaters. A similar circuit Malmö-Nässjö with two repeaters gives an overall attenuation of 1.8 — 2.0 népers.

The results obtained for the repeater sections, the repeater stations and for the overall performance of the circuits are most satisfactory. The installation, as a whole, fulfils all the requirements of a modern long-distance telephone system.

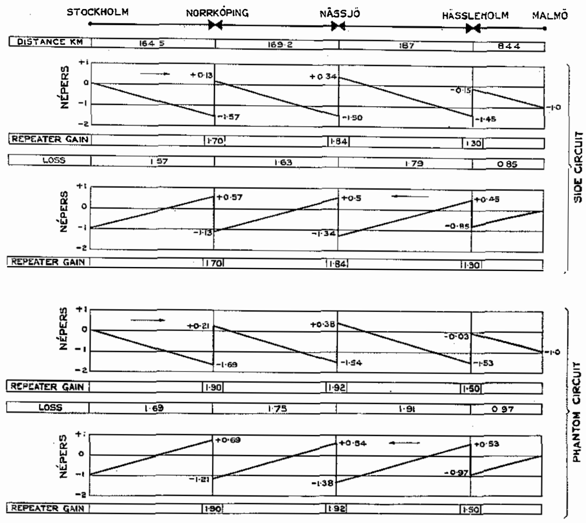


Figure 19—Level Diagrams for Stockholm-Malmö Circuits.

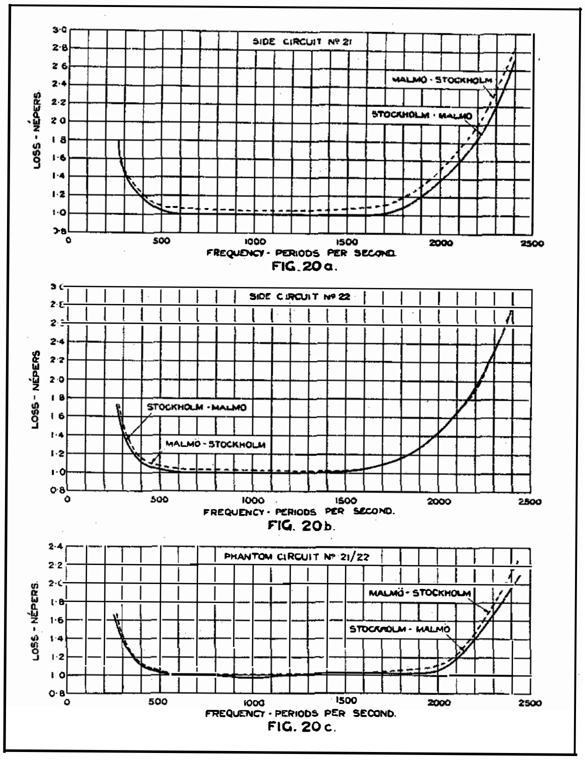


Figure 20—Overall Loss-Frequency Curves for Stockholm-Malmö Circuits.

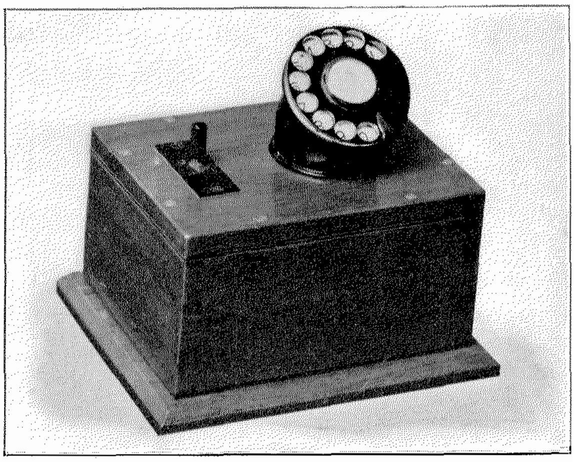
Standard
TRAIN DESCRIBING SYSTEM

Supplied in 6 standard sizes to handle 6, 12, 24, 48, 100, or 200 different descriptions.

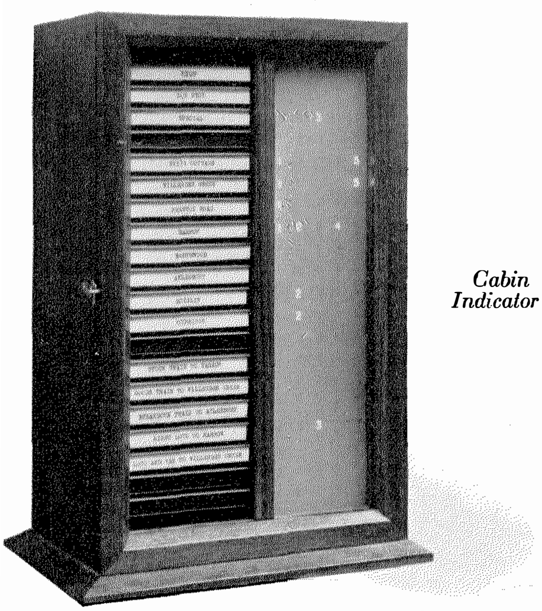
Only one set of control wires required for any number of parallel tracks in each direction.

Description storage facilities provided, according to traffic requirements.

A passenger train is described by indicating all the intermediate stations at which it will stop, making the system well suited for the display of information to the public. In signal cabins only the destination of the train need be shown, unless more detailed information is required.



Description Transmitter (Dial Type)



Cabin Indicator

Trains despatched at intermediate points can have their descriptions interpolated. These descriptions are stored up at the despatching point until ready to take their appointed places in the regular sequence.

A description already transmitted can be cancelled without disturbing other descriptions.

Descriptions may be originated by means of a telephone dial, or of a transmitter equipped with a plunger relating to each possible description.

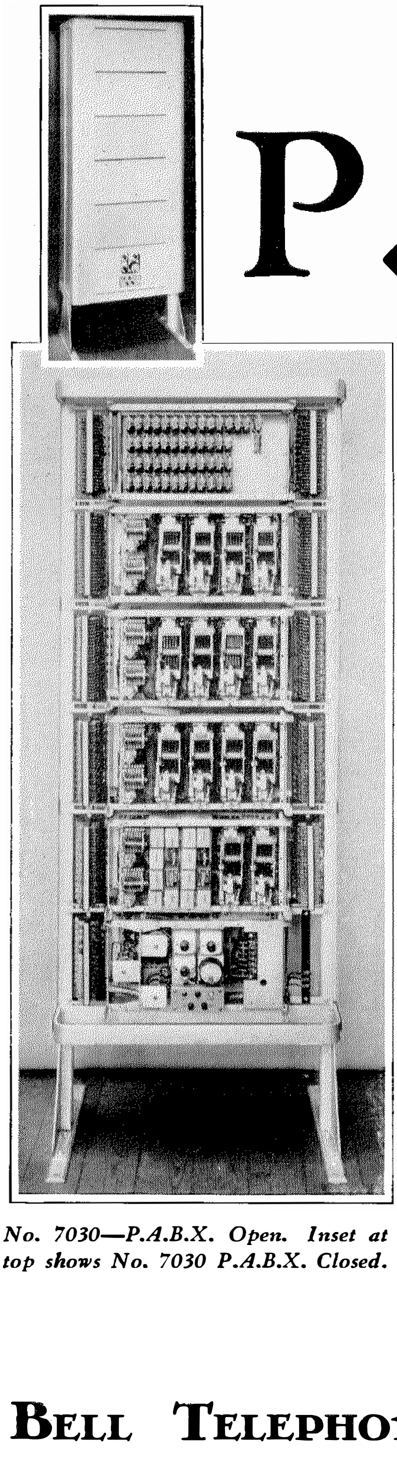
Descriptive booklet No. **605** *and other particulars are obtainable from:*

Standard Telephones and Cables Limited

CONNAUGHT HOUSE, ALDWYCH, LONDON, W. C. 2

or from any of the companies listed on the inside rear cover

Telegrams: Relay, Estrand, London **Telephone: Holborn 8765**



No. 7030—P.A.B.X. Open. Inset at top shows No. 7030 P.A.B.X. Closed.

The No. 7030

P. A. B. X.

In this novel equipment designed for capacities of 25-99 lines, the latest developments in public exchange equipment are applied to the requirements of business organizations.

The No. 7030 P.A.B.X. is built on the unit principle, and the self-contained and interchangeable units are mounted on floor type racks and are completely enclosed.

The compact design provides accommodation for a large number of lines in a small space. The adoption of the unit principle of construction permits easy alteration of the equipment to meet changed requirements. Boards with almost any combination of circuits can be built with practically no changes in framework and cabling.

As space for the 24-volt power equipment is provided in the switchboard itself, the No. 7030 P.A.B.X. is virtually self-contained.

Outgoing calls and local calls between P.A.B.X. stations are entirely automatic.

Incoming calls are handled by the attendant, whose station apparatus is little larger than the normal type table telephone set.

Particulars are obtainable from:

BELL TELEPHONE MANUFACTURING COMPANY

4 Rue Boudewyns, Antwerp, Belgium

or from any of the Companies listed on the inside rear cover.

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

BOARD OF DIRECTORS

OFFICERS

THE International Telephone and Telegraph Corporation was organized to co-operate and assist technically and financially in the general development of electrical communications in a broad international sense, and, with respect to the organization and development of national communications systems, it is the purpose of the International Telephone and Telegraph Corporation to develop truly national systems operated by the nationals of each country in which the International Corporation is or may become interested. The International Corporation was not organized with the desire of imposing American practices in its foreign activities. There appeared to be a fruitful field of service to be rendered in bringing together under one general organization electrical communications systems, and the extension by the International Corporation to the associated companies of the technical and financial facilities and direction that might be needed for their intensive and efficient development. The best American practices have been suggested but never imposed. On the contrary, the International Corporation has always been ready and quick to adjust American practices to local conditions and to adopt such local practices as were conducive to the successful development of the various entities. The combined and co-ordinated effort of the associated companies of the International System is today justifying the plans and purposes of the Corporation.

Licensee Companies

BELL TELEPHONE MANUFACTURING COMPANY.................... *Antwerp, Belgium*
Branches: Brussels.
BELL TELEPHONE MANUFACTURING COMPANY............... *Berne, Switzerland*
BELL TELEPHONE MANUFACTURING COMPANY.............. *The Hague, Holland*
STANDARD ELECTRIC DOMS A SPOLECNOST............... *Prague, Czechoslovakia*
Branch: Bratislava.

CHINA ELECTRIC COMPANY, LIMITED............................ *Shanghai, China*
Branches: Canton, Hankow, Harbin, Mukden, Peiping, Tientsin.

COMPAÑÍA STANDARD ELECTRIC ARGENTINA............... *Buenos Aires, Argentina*

INTERNATIONAL STANDARD ELECTRIC CORPORATION, *Branch Office,*
Rio de Janeiro, Brazil

INTERNATIONAL STANDARD ELECTRIC CORPORATION OF MEXICO.... *New York, N. Y.*

LE MATÉRIEL TÉLÉPHONIQUE.................................... *Paris, France*
Rabat, Morocco

NIPPON DENKI KABUSHIKI KAISHA................................ *Tokyo, Japan*
Branches: Osaka, Dalny, Seoul, Taihoku.

FERDINAND SCHUCHHARDT, BERLINER FERNSPRECH-UND TELEGRAPHENWERK
AKTIENGESELLSCHAFT.. *Berlin, Germany*

STANDARD ELECTRIC AKTIESELSKAP............................... *Oslo, Norway*
AKTIESELSKABET SKANDINAVISKE KABEL- OG GUMMIFABRIKER..... *Oslo, Norway*

STANDARD ELECTRIC AKTIESELSKAB......................... *Copenhagen, Denmark*

STANDARD ELECTRICA ROMANA S/A.......................... *Bucharest, Rumania*

STANDARD ELÉCTRICA, S. A.................................... *Madrid, Spain*
Branches: Barcelona, Santander.

STANDARD ELETTRICA ITALIANA..................................... *Milan, Italy*
Branch: Rome.

STANDARD TELEPHONES AND CABLES, LIMITED.................. *London, England*
Branches: Birmingham, Glasgow, Leeds, Manchester, Dublin, Cairo, Johannesburg, Calcutta, Singapore.

STANDARD TELEPHONES AND CABLES (AUSTRALASIA), LIMITED..... *Sydney, Australia*
Branches: Melbourne, Wellington.

STANDARD VILLAMOSSÁGI RÉSZVÉNY TÁRSASÁG.................. *Budapest, Hungary*

SUMITOMO ELECTRIC WIRE & CABLE WORKS, LIMITED................ *Osaka, Japan*

ÖSTERREICHISCHE TELEPHON-FABRIK AKTIENGESELLSCHAFT......... *Vienna, Austria*

VEREINIGTE TELEPHON-UND TELEGRAPHENFABRIKS AKTIENGESELLSCHAFT,
CZEIJA, NISSL & CO.. *Vienna, Austria*

STANDARD ELECTRIC COMPANY W POLSCE SP. Z. O. O.............. *Warsaw, Poland*

Sales Offices and Agencies Throughout the World