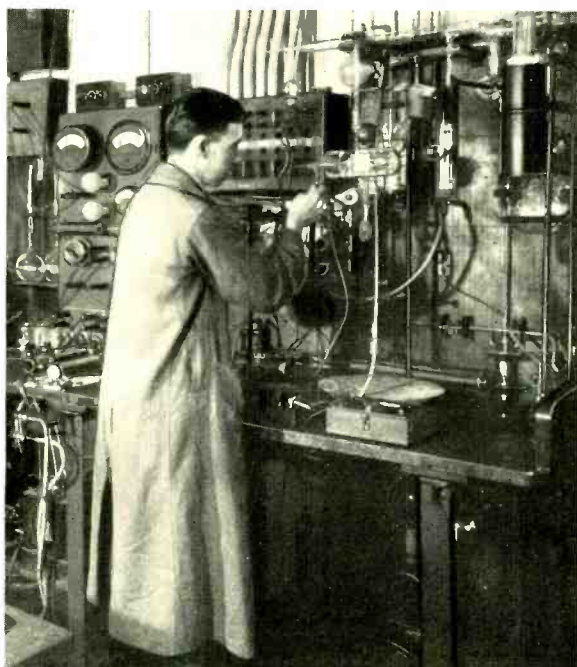


*Bell Laboratories
Record*



*September 1929 to August 1930
Volume VIII*

Bell Laboratories Record

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BELL TELEPHONE LABORATORIES, INCORPORATED

463 West Street, New York, N. Y.

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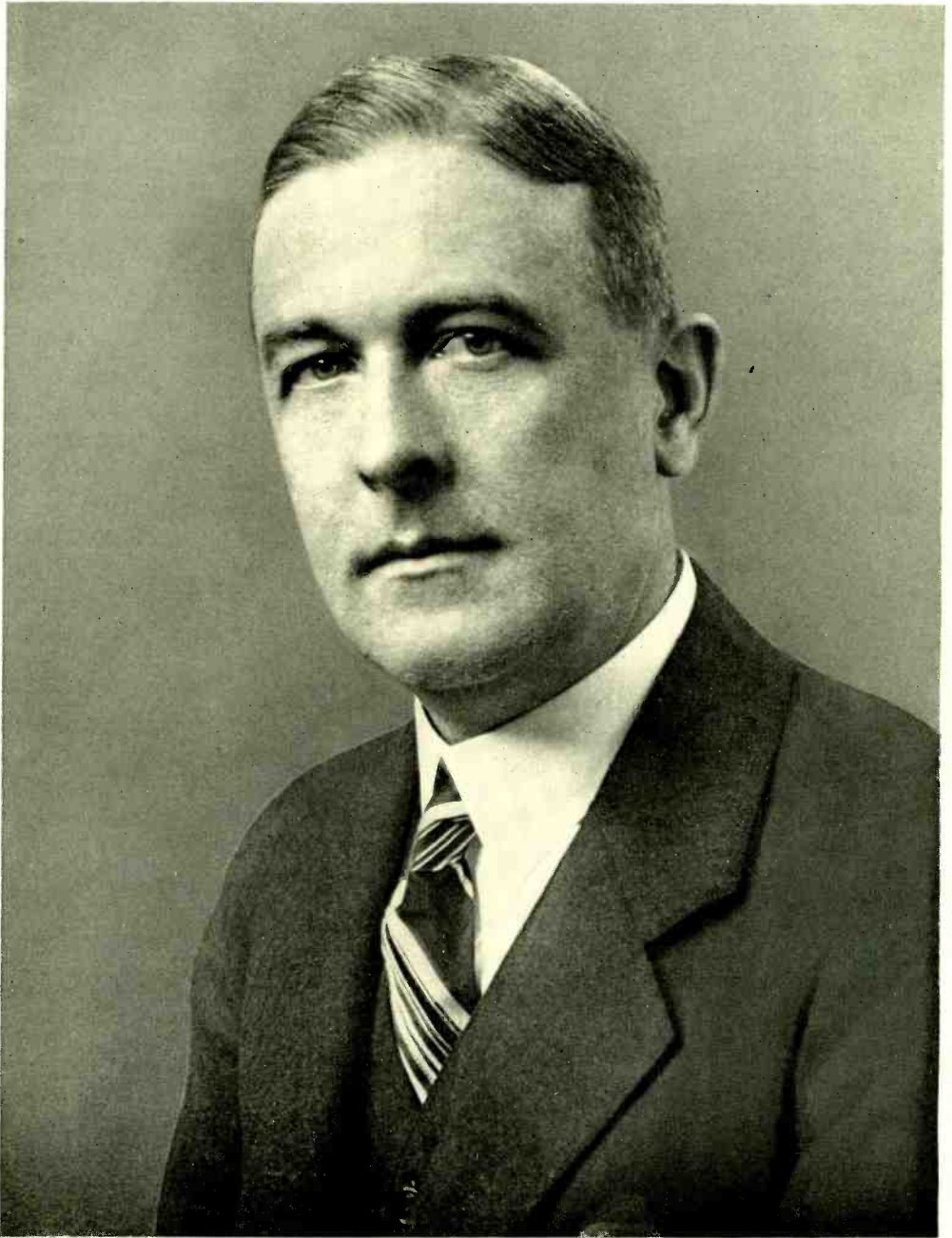
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EDWARD BEECH CRAFT
1881-1929

An Appreciation

Twenty-two years of intimate daily business and personal association with Edward B. Craft have made his death far more than a passing tragedy for me. The associations of these years have created in me an affection for him and an esteem and respect for his ability which men seldom entertain for one another. For practically the whole of my active professional life, and for all of it that has been concerned with what is now Bell Telephone Laboratories, Mr. Craft and I have worked together.

In so long an association, concerned with so many vexing problems of science, policy and organization, it was inevitable that we should have had numerous differences of opinion. They were always honest differences, however, and each year of our work together enhanced my regard for him.

His creative imagination was of an outstanding high order and the tangible evidences of it are to be found wherever telephone plant exists. His indomitable determination, his indefatigable energy and the resourcefulness he displayed in overcoming obstacles made many of his dreams turn into valuable practical realities, when most men would have given up discouraged.

His ability to enthuse his associates in the things he thought worth while, and to maintain that enthusiasm was one of his great assets. It, together with a charm of personality which made loyal friends of all who came in contact with him, contributed largely to the building up of the outstanding organization of which he was so long an active director.

The Laboratories, the Bell System and the communication world can ill afford to lose such a man. We who have been his friends and associates in a great common undertaking can nevertheless take comfort in the remembrance that until the last fatal illness his life ran in the channel he most desired for it. To him more than to most men was given the rare opportunity to play his part in the role and on the stage he cherished most and felt best fitted for the full development of his talents.

FRANK B. JEWETT.



A Biographical Note

EDWARD BEECH CRAFT was born in Cortland, Ohio, September 12, 1881. He received common and high school education in the nearby town of Warren, where he started his work. From 1900 to 1902 he was Superintendent of the lamp department of the Warren Electrical and Specialty Company. He gave up that job to go to Chicago and apply for a position with the Western Electric Company, feeling that that organization was doing the kind of work he wanted and that it offered exceptional opportunity.

His first job was editing orders for telephone switchboards; the interest and ability which he showed won him the opportunity he wanted, and he was put in charge of development work. This opportunity started the first part of his career, that of invention. His first patent was for an indicating device for fuses. This invention was so fundamentally correct in the economies of its design that it has remained constantly in use as the No. 35 type fuse for the past twenty-five years.

Of all his inventive contributions to telephony that of the flat-type relay in 1910 is pre-eminent. Previous designs were based on quantities which would now seem small; they required numerous machining operations and careful fitting. When Mr. Craft became Development Engineer, the problem was pressing of a cheaper and more compact design suitable for quantity production. It was characteristic that a solution came to him

en route homeward, and that the design he sketched is still in production. It was characterized by a magnetic circuit entirely of unmachined punchings; by a simple metal-reed hinge instead of trunnion or knife bearings; and by the possibility of a large number of contact-springs with an almost infinite variety of possible circuit changes. Relays based on this design are now the largest apparatus item in Western Electric production, and they are now an indispensable part of the telephone plant.

With consolidation of the development and research work in the Bell System which occurred under the direction of Theodore N. Vail, Mr. Craft and a nucleus from the force which he had formed at Chicago were moved in 1907 to New York City where he became the Development Engineer of the Western Electric Company.

While this did not represent the closing of the inventive phase of his career, as will be seen later, it did mean the beginning of his real career as an organizer of development activities. The need for development work in the Bell System rapidly expanded and Mr. Craft's responsibilities grew accordingly. By 1918 he had become Assistant Chief Engineer and was responsible for all the development work in the Engineering Department of the Western Electric Company which then operated what is now Bell Telephone Laboratories.

It was in the first part of this period that he made his individual contribu-

President's Office
American Telephone and Telegraph Company
195 Broadway
New York

August 21, 1929.

DR. F. B. JEWETT, President,
Bell Telephone Laboratories, Inc.,
New York, New York.

Dear Dr. Jewett,

I want to express to you, and your associates in the Bell Telephone Laboratories, my sincere sympathy in your great loss in the death of Mr. Craft.

Mr. Craft's ability and achievements were recognized and appreciated throughout the Bell System, and all of us who knew him personally had a real affection for him. He accomplished much and through his charm of personality made innumerable friends.

Sincerely yours,

Walter S. Engford

tion to the dial telephone system. The problems to be met were many and difficult, whether physical, mechanical, or economic. To the main development Mr. Craft contributed certain specific inventions, but perhaps the greatest part of his contribution was his early recognition of the practical possibility and economic desirability of this development; and the firm determination with which he pursued it over several years, develop-

ing men to assist in the work and inspiring in them his own faith.

In the meantime the War came and Mr. Craft's interest in radio and in various other applications of research not only made his advice of value to the advisory board of the Chief Signal Officer and in a mission to England for the Navy, but it gave him that insight in present-day research problems which permitted him in 1922 to take charge for the Western

Electric Company as Chief Engineer of all of its research as well as its developmental activities. With the incorporation of Bell Telephone Laboratories in 1925 he became its Executive Vice-President, and soon after, a Director of the Corporation.

To Mr. Craft's vision and energy the modern talking machine and sound picture are largely due. He early realized that the high-quality microphone, and the vacuum-tube amplifier held possibilities for sound-recording and reproduction of hitherto unknown fidelity. Under his stimulus, a program of development was initiated and carried forward which has led to the public address system; to many of the devices used in broadcasting; to the modern phonograph, and to the Western Electric Systems of sound-pictures.

During the middle of 1928 an ailment of some years' standing became acute, and from October he was absent on sick leave. To obtain the benefits of a sea voyage, in February, 1929, he left with his family by boat for the Pacific Coast, and later travelled to the South Pacific Islands. Re-

turning to his home in July, his health grew worse, and death occurred on the twentieth of August.

Mr. Craft's military service was as Captain from March, 1917, to December, 1917, and as Major to May, 1918, in the Signal Corps, U. S. Army, and as Technical advisor, U. S. Navy at London, England, from June, 1918, to October, 1918.

During his active career he was Vice-Chairman of the Division of Engineering and Industrial Research of the National Research Council; Chairman of the Board of Engineering Societies Library; a Fellow of the American Institute of Electrical Engineers and one of its Managers from 1920 to 1924; a Fellow of the Institute of Radio Engineers; a member of the council of the American Institute of Weights and Measures; a member of the Society of Automotive Engineers; and representative of the Bell System in the Aeronautical Chamber of Commerce. In 1926 he received the degree of Doctor of Engineering from Worcester Polytechnic Institute. On that occasion he was styled:

"Engineer, Inventor and Organizer of Research; whose inventions take part daily in each of more than fifty million telephone conversations; whose genius, initial conception of the practicability of panel systems for machine switching, and continued supervision of its development have contributed largely to the present system of telephony; whose technical experience devoted to the service of his country during the World War hastened advances in radio-communication with aircraft; whose organizing ability continuously applied for a quarter of a century to engineering development and industrial research has increased the social and economic significance of research."



Transatlantic Telephone Cable

WORK is now going forward on the development of a deep sea telephone cable system between London and New York and it is possible that this circuit will go in service as early as 1932. While the new cable will yield only a single telephone circuit, this will be one of maximum reliability, free from variations characteristic of radio circuits. It is not the idea that the cable will replace radio circuits but it will add considerably to the reliability of the New York-London service as well as adding to the total message capacity.

The route of the cable is not settled in detail, but it is probable that the main transatlantic link will extend directly from Newfoundland to Ireland, a cable length of approximately 1,800 nautical miles. From Newfoundland it is expected the circuit will be carried through several sections of submarine cable to Nova Scotia and thence by land circuits through Nova Scotia, New Brunswick and the New England states to New York City where it will terminate. From Ireland the circuit will probably be carried through submarine cable to Scotland and thence by land cable to London, the other terminal.

The new cable will be of the continuously loaded type. For the loading material it is planned to use one of a new series of alloys which are designated as "perminvars." These

are composed of nickel, cobalt and iron to which may be added small amounts of non-magnetic metals such as molybdenum. They are characterized by high resistivity and by having a constant permeability over a wide range of magnetizing force.

The conductor will be insulated with a new material "paragutta." Submarine cables in the past have been insulated with gutta-percha or closely related materials and in a few cases with rubber compounds. Paragutta makes use of similar raw materials but so combined and treated as to give superior electrical properties with mechanical properties similar to gutta-percha.

A remarkable feature of the cable is the high attenuation which it is proposed to use. It is possible that successful operation can be obtained with an attenuation of approximately 150 db for the high frequencies of the voice range. This is a much greater attenuation than that at which telegraph cables are operated. Such a high attenuation depends on two features of the cable. The characteristics of perminvar are such that a relatively high sending level can be used, and by means of special construction the cable will be shielded against interference so that a very low receiving level can be employed. Voice-operated switching mechanisms will be required at the two terminals.

The Master Reference System for Telephone Transmission

By C. H. G. GRAY

Transmission Instruments Research

COMMUNICATION between subscribers to telephone service depends for its intelligibility upon a great variety of interrelated factors. Among them are the relative amplitudes of the original and reproduced speech sounds, the degree to which these sounds are distorted, the amount of extraneous noise in the circuit, and psychological factors introduced by the subscribers themselves.

Thus far it has been impracticable, because of the complex nature of speech sound waves and our psychological reactions to them, to measure and define the phenomena associated with speech sounds in physical terms

which are sufficiently simple to be useful in engineering. Physical measurements for rating the performance of a telephone circuit are, therefore, commonly limited to such considerations as the response-frequency characteristic of the circuit over the range of speech frequencies, and to measurements of distortion due to non-linear elements, of phase distortion, and of extraneous currents which cause noise. These determinations do not include measurements of the speech sounds themselves nor of the functioning of the speaker and listener. In attempting to take these important factors into account no substitute has been found for the human voice as input and for the human ear as measuring device.

In the early days of the telephone art, when the kinds of circuits in commercial use were quite similar in their distortion characteristics, the practice was adopted of rating the performance of a circuit by comparing it on a loudness basis with a reference circuit whose attenuation was adjustable, and whose distortion was closely similar to that of commercial circuits. In such a com-

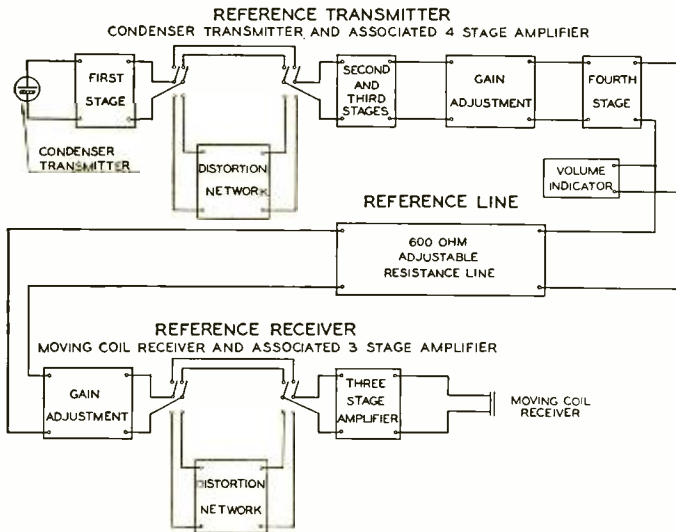


Fig. 1—Schematic diagram of the Master Reference System for telephone transmission

parison, a determination is made of the equivalence of loudness or volume of these two circuits by talking alternately over them and adjusting the reference circuit until the sounds issuing from the two receivers are judged equal. When loudness is taken as the important characteristic of telephone circuits to be controlled, these loudness comparisons constitute a practical and effective means of indicating the performance of the circuits.

The reference circuit adopted about twenty-five years ago for loudness comparisons consisted of an adjustable artificial No. 19 AWG. cable with a standard common battery station telephone set (including the No. 229 transmitter and the No. 122 receiver) connected, through a 25-A repeating coil and a 24-volt battery, directly to each end of the cable. The amount of cable in the reference circuit to give a loudness balance was taken as the rating of the circuit under comparison.

Although the method remains applicable, the development of the telephone art has made it desirable to modify this reference circuit to make it more suitable for its purpose. Telephone instruments have been developed far more nearly constant in their characteristics and uniform in their response to voice-frequencies, and thus better suited as standards, than the old transmitters and receivers. Instruments and circuits have been de-

signed and used in the telephone plant which afford a speech quality so different from that of the old reference circuit as to make loudness comparisons difficult. Finally undue restriction of the frequency band which arti-



Fig. 2—The Master Reference System of the Bell System, with its associated calibrating equipment. At the right are the transmitter, line, and receiver; at the left are the oscillator, thermophone, and voltmeter and volume-indicator

ficial cable will transmit, and the change of transmission unit from the mile of standard cable to the decibel, necessitated a change in the line of the reference system.

In the selection of a new reference system it was apparent that, to make the system assuredly reproducible, its performance should be expressed in terms of measurable quantities and should remain constant for reasonable lengths of time under specified operating and atmospheric conditions. Good speech quality prescribed freedom from non-linear distortion of speech-amplitudes and uniformity of response to speech-frequencies. Cas-

ual noise had to be minimized. The system had finally to be so designed that predetermined changes in attenuation, distortion, and noise could be introduced.

A reference system* such as that to be described affords a convenient means for studying the capabilities of telephone circuits of different physical performances. The essential elements are so constructed as to reproduce speech nearly perfectly, and pro-

* *W. H. Martin and C. H. G. Gray, "The Master Reference System for Telephone Transmission," Bell System Technical Journal, July, 1929.*

vision may be made for modifying speech in definite and reproducible ways. The system consists of a transmitting element, a line, and a receiving element (Figure 1). Their respective output, characteristic, and input impedances are each 600 ohms with negligible phase angle. Associated with them, to provide the means of checking their characteristics, is suitable calibrating equipment. All of the apparatus is mounted on steel panels and racks (Figures 2 and 3) and is electrically shielded. To make comparisons possible between commercial telephone elements and

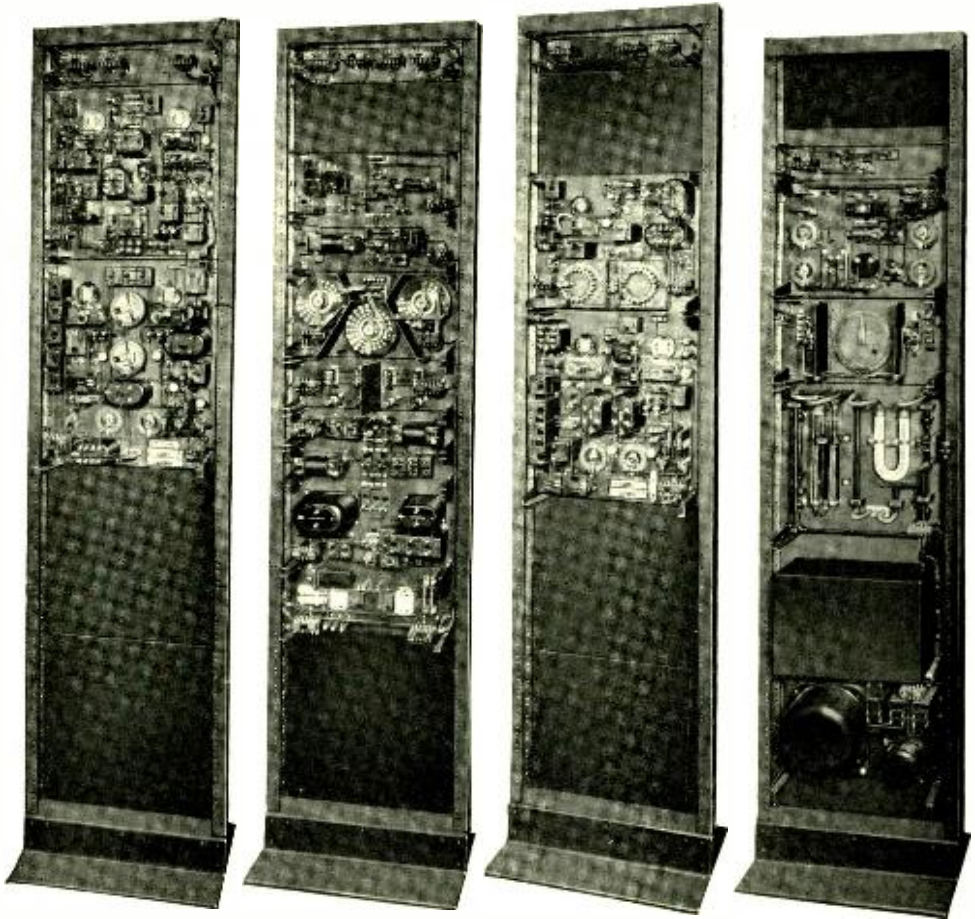


Fig. 3—Rear views of four of the six bays of the reference system. Left to right: transmitter, line, receiver, thermophone

their reference counterparts, the components of the system can be individually replaced by the elements to be rated.

The "Reference Transmitter" comprises a condenser-transmitter and a four-stage vacuum tube amplifier. In the transmitter a thin tightly stretched duralumin diaphragm and a steel plate, grooved and perforated for air-damping, act as the electrodes of a condenser polarized by a battery through a high resistance. Variations in the condenser's capacity, caused by motions of the diaphragm under acoustic pressure, establish across the resistance an alternating potential which faithfully represents the impinging sound waves. The transmitter is held in an adjustable mounting, and is equipped with a guard so that the speaker can keep his lips at a fixed distance from the diaphragm. A volume indicator, with meter visible to him, enables the speaker to maintain an approximately constant calling intensity. Between the first and second amplification stages there is provision for introducing distortion networks to simulate the response-frequency characteristics of commercial transmitters; between the last two stages potentiometers control the output over a range of 22 decibels in steps of 0.1 decibel.

The "Reference Line" is a series of balanced resistance networks. Its characteristic impedance, of 600 ohms, matches the output impedance of the reference transmitter and the input impedance of the reference receiver, and thereby eliminates reflections at its junctions with these elements. Attenuation in it can be varied from 0 to 101 decibels in increments of 0.2 decibel.

A moving coil receiver and a three-

stage vacuum tube amplifier, whose output can be controlled over 22 decibels in steps of 0.1 decibel, compose the "Reference Receiver." In the receiver itself a coil, by vibrating rela-



Fig. 4—Thermophone chamber, showing the thermal elements consisting of two strips of gold leaf

tively to a fixed permanent magnet, actuates a clamped unstretched dome-shaped diaphragm of duralumin to which the coil is attached. Air damping is secured in the receiver by an arrangement somewhat similar to that employed in the transmitter. To avoid resonance effects which would occur in a confined space between diaphragm and cap, the central surface of the diaphragm is protected by a meshed wire screen instead of by the usual type of cap. The contour of the

earpiece, resembling that of the familiar telephone receiver, permits the listener readily to center the receiver cap on his ear. As elsewhere in the system, distortion characterizing com-

ting of an attenuator to obtain a deflection, on the galvanometer of the vacuum tube voltmeter, equal to the deflection produced when measuring the output of the element under calibration. This process eliminates the necessity for having an absolute calibration of the measuring device.

The performance of the condenser transmitter is determined by making its diaphragm a wall of a simple closed chamber filled with hydrogen in which the thermophone (Figure 4) is placed. In the thermophone the alternating current from the oscillator causes variations in the temperature of the gold thermal element. The periodic expansion and contraction of the surrounding gas, resulting from the varying heat transfer occasioned by the periodic changes of temperature, constitute sound waves of precisely determinable pressure.

These sound waves actuate the transmitter whose voltage output is finally related to the sound pressure to obtain the transmitter calibration. The performance of the receiver can in turn be determined by subjecting the calibrated transmitter, again through a hydrogen coupling (Figure 5), to the sound output of the receiver, driven by the oscillator. The receiver's acoustic output, deduced from the transmitter's voltage output, is related to the receiver's voltage input to obtain its calibration. The calibrations of the purely electrical elements of the circuit are made by measurements of input, output, and impedance. In order to tie together ratings established in terms of the old

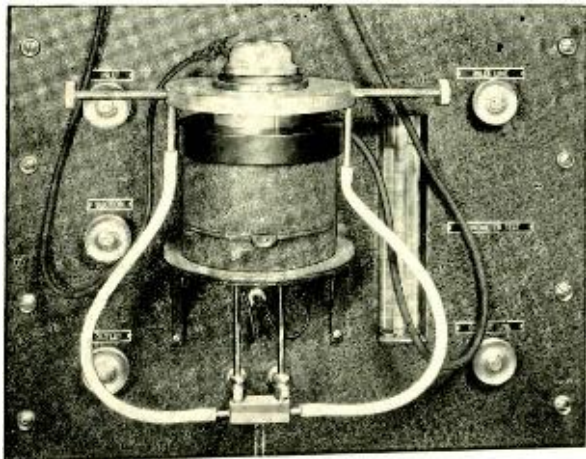


Fig. 5—The moving coil receiver in position for calibration on the thermophone panel. The thermophone itself is not used in this calibration; the panel simply provides convenient means for applying the hydrogen coupling between the receiver and the calibrated condenser transmitter

mercial receivers can be imitated by introducing distortion networks.

The specification of the performance of the reference system is based on the principle of the thermophone, which is a converter of electric energy into acoustic waves. The source of alternating currents for this work is an oscillator, with a harmonic output at least 25 decibels lower in level than that of the fundamental. The measuring equipment consists of a two-stage vacuum tube voltmeter with a tuned circuit across its input. This tuned circuit attenuates harmonics of the fundamental frequency to be measured by at least 20 decibels. In general, the method employed in making these calibrations is to adjust the set-

system with those of the new system, comparisons of the two have been made to determine the adjustments of the new system which make its loudness performance equal to that of the old.

The overall performance of the new system is practically free from distortion, and probably materially excels in this respect that of any previous system. When the reference transmitter and reference receiver are adjusted on the basis of voice tests to equivalence with the corresponding parts of the standard cable reference system, their response-frequency characteristics are as shown in Figure 6. Since these characteristics are primarily intended as specifications of the physical properties of the system, corrections applying to its use by a speaker and listener are not included. In Figure 7 appear the response curves of the transmitter and receiver after the introduction of distortion networks simulating the response of the transmitting and receiving elements of the old standard cable system.

The master system will be employed chiefly to rate instruments and systems to be used as "working" standards. Where the amount of transmission testing is large, as in laboratories and factories, the working

standards may be simplified counterparts of the master system, capable of calibration by similar methods. In repair and recovery shops, where testing is less frequently required, the working standards will resemble the old standard cable reference system. Since the articulation of the master system is practically equivalent to that of air transmission in a quiet room, it will also be useful in studies of the effect of predetermined attenuation, distortion, and noise, on articulation.

In 1926, at the invitation of the Comité Consultatif International des Communications Téléphoniques à

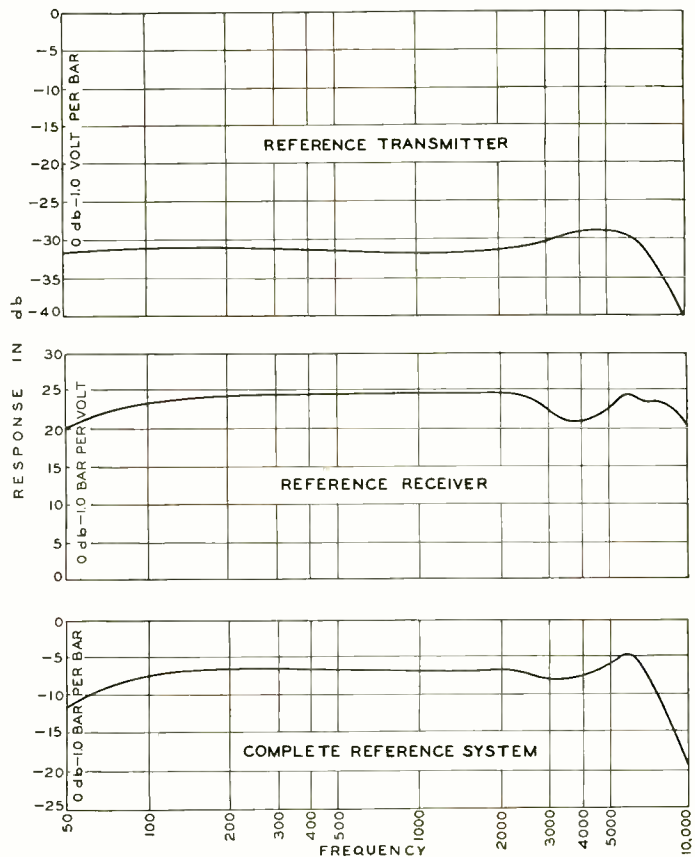


Fig. 6—Response characteristics of reference transmitter, reference receiver, and complete reference system with zero attenuation in the line

Grande Distance (C. C. I.), representatives of the Bell System met in London with a sub-commission of the C. C. I. to discuss the adoption of a transmission reference system. As a result of the discussions at that meeting the sub-commission recommended to the Plenary Assembly of the C. C. I. that a system essentially the same as that described above be adopted, and that such a system, which would be a replica of one in New York, be installed in a laboratory in Paris. This recommendation was subsequently approved. Afterwards some improvements were made in the system, and two duplicate systems, each with its associated calibrating apparatus, were constructed.

One of these, the Master Reference System of the Bell System, is housed in a room, acoustically and electrically shielded, in these Laboratories (Figure 2). The other, known as the European Master Reference System, is installed in Paris. The C. C. I. further recommended that working standards used by telephone administrations adhering to the C. C. I. be calibrated in terms of the Master Reference System. The establishment of these two duplicate systems, therefore, insures the use of a common base-line to express transmission standards, and to rate the performance of telephone circuits, on the two continents where telephony has had its greatest development.

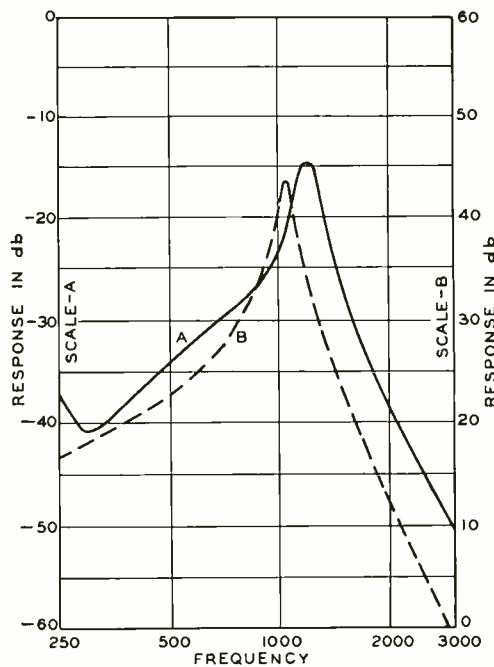


Fig. 7—Response characteristics of reference transmitter (A) and receiver (B) when distortion networks are included



Voice-Frequency Equipment for the Transatlantic Radio Telephone

By J. A. COY

Equipment Development

TO the telephone subscriber who calls a European city from the United States, the procedure is no more complicated than with any toll call, and the connection is not noticeably different. Nor from the point of view of the toll operator is the radio telephone circuit much unlike ordinary toll circuits. Like them it may be connected to local subscribers over switching trunks of the usual type or extended to distant subscribers over other toll circuits.

A few unusual features there are, to be sure. One is that each radio telephone circuit is given the full attention of a "channel operator" at each end throughout the period when commercial service is being given. This insures intensive use of the circuit and prompt attention to any difficulty the subscribers may experience in carrying on a conversation. "Report operators" take care of getting subscribers ready to talk, setting up connections to distant cities, and timing the calls. Tickets and other operating information are passed by telephone typewriter in the intervals between calls, to insure accuracy and aid in the efficient use of circuit time.

Beyond the operating room, however, the radio telephone presents many unusual features of physical plant, personnel and procedure. By radio frequency two voice paths are established across the ocean, one path carrying the voice in one direction,

the other path in the opposite direction, and both terminating at locations advantageous for radio transmission and reception. They are extended at each end by voice-frequency land line or cable to the city selected as most convenient for making connection to the telephone system of the country and there, united in a single circuit for two-way transmission, are terminated with other toll circuits in the toll switchboard. This general scheme differs from the four-wire operation common with toll cable circuits principally in the wide separation of the one-way paths, in the equipment provided for the suppression of echoes and singing, in the arrangements made for continuous manual gain-control and in the close attention given by a special organization of personnel.

In cable operation the one-way paths are kept in the same toll cable and pass through the same intermediate offices. In radio telephone practice the requirements governing the location of radio transmitting and receiving offices make it desirable to separate these offices by considerable distances. The west-to-east radiopath of the long-wave transatlantic circuit is from Rocky Point, Long Island, to Cupar, Scotland, the east-to-west path from Rugby, England, to Houlton, Maine. From these transmitting and receiving offices voice-frequency lines extend the circuit to New York and London. Circuits established more



Fig. 1—Vodas relay equipment at Walker Street

recently and using short-wave radio transmission have their transmitting and receiving offices, at the American end, at Lawrenceville and Netcong, New Jersey, respectively. They likewise are extended to New York.

The tendency for strong echo currents to exist in the radio telephone circuit is considerably greater than in toll cable circuits. The equipment provided at each terminal to interrupt the paths which these echo currents tend to follow is commonly termed the "vodas", from the initial letters of its name, "voice operated device, anti-singing." It has been described in detail and compared with the simpler echo suppressor used on cable circuits, in a previous article.* The latest type of this equipment is shown in Figure 1.

To aid in over-riding the noise frequently found in the radio links, it is desirable that the radio transmitter operate fully loaded on all conversations. This is accomplished by the manual adjustment of gain control equipment by a technical operator at each terminal. Monitoring at the terminal, receiving and transmitting offices is for the most part done through amplifiers which take from the line an amount of energy too small to affect its operation and amplify this energy to a volume which will be satisfactory

* *Echo Elimination in Transatlantic Service*,
by G. C. Crayford, BELL LABORATORIES RECORD,
November, 1927.

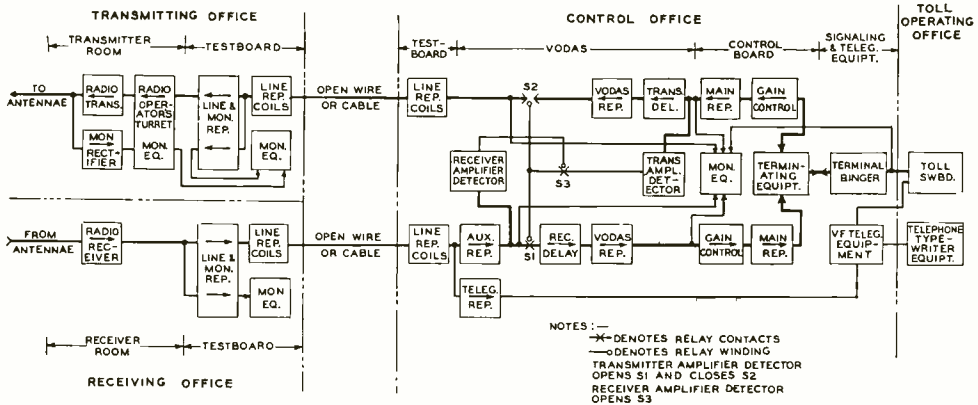


Fig. 2—Schematic diagram of voice-frequency equipment

in an ordinary telephone receiver.

The voice-frequency equipment filling these requirements is schematically presented in the diagram of Figure 2, which shows that used at one end of a radio link. This equipment is divided among the toll operating office, the control office, the radio transmitting office, and the radio receiving office. Although the figures and the following description apply in detail only to the American equipment, the foreign terminals are generally similar.

At the control office are provided a testboard, common to the office; a control board, individual to each radio circuit; a vodas likewise individual; signaling and telegraph equipment, and (not shown in Figure 2) transmission measuring and order wire equipment.

The testboard consists of three bays, shown in the frontispiece.* The bay on the left of the group contains the repeating coil and jack equipment which terminates the land lines from the receiving office and permits the patching out of a defective line with a good one. The bay on the right carries similar equipment for lines from the transmitting office. In the center bay are terminating and patching jack equipment for the telegraph order wires to the receiving and transmitting offices and answering jacks for the telephone order wires to these offices, to the various control boards and to the toll switchboard. On the keyshelves of these bays is located equipment for talking and monitoring

*The frontispiece is a picture taken in the Long Lines Building at Walker Street, and shows, left to right: the three control boards, monitored by T. P. Bruno, Long Lines Department, W. F. Malone, Trial Installations Group No. 4, W. F. E. Droose, Long Lines Department; the testboard, attended by J. Nedelka, Trial Installations Group No. 2; and a unit of transmission measuring equipment.

on the land lines and order wires and for testing lines and equipment for the location of faults.

At the control board, the technical operator watches the radio telephone circuit continually to insure that transmission is satisfactory. Conveniently



Fig. 3—General view of vodas relay and telephone repeater equipment at Walker Street, taken during installation and test

located in a panel just in front of him are meters which indicate the volume of voice energy going out on the transmitting path and of that coming in on the receiving path. In the same panel are dial-operated potentiometers which he adjusts from time to time to bring these levels to the desired value. Most of this adjustment is on the outgoing path and is required to compensate for variations in the energy coming from a local subscriber or over a toll line from a distant city and for strong or weak talkers, so as to maintain constant energy level at the

radio transmitter. The technical operator can also without leaving his position adjust the sensitivity of the vodas to obtain satisfactory operation with variations in the condition of the radio telephone circuit and of connected toll circuits. Monitoring amplifiers and keys permit him to monitor at any of the five points on the circuit indicated in Figure 2, to determine whether the equipment is functioning properly. By telephone order wires he can communicate with the operator at the toll switchboard or with the testboard man in the control office, and by telegraph order wires with the radio transmitter operator at the transmitting office or the radio receiver operator at the receiving office. The terminating equip-

ment, indicated in the sketch, is located at the top of one of the bays of the control board. This equipment joins the one-way paths for connection to the switchboard, informs the toll operator when the circuit is ready for use and in the case of the long-wave channel, sets up the equipment for telephone typewriter service when the operator connects this apparatus at the switchboard.

The telephone repeaters associated with the terminating and vodas equipment are not located with them but are placed in a separate group as in a toll cable repeater office (Figure 3). Five repeaters of the type standard for four-wire cable circuits are required per radio telephone circuit. They are wired uniformly and provided with patching jacks so that they can be used interchangeably and so that a spare unit can be quickly inserted in place of a defective one.

The terminal ringer equipment and the voice-frequency telegraph equipment are quite similar to that used on toll cables, and the telephone typewriters are similar to the commercial type used generally in the Bell System.

At the testboard, the telephone repeater group and each control board, there is provided a unit of equipment for making transmission measurements. This unit consists of a transmission measuring set of the type standard for cable repeater offices and an oscillator, variable in frequency throughout the voice range. At the control board the technical operator uses this equipment to measure the transmis-

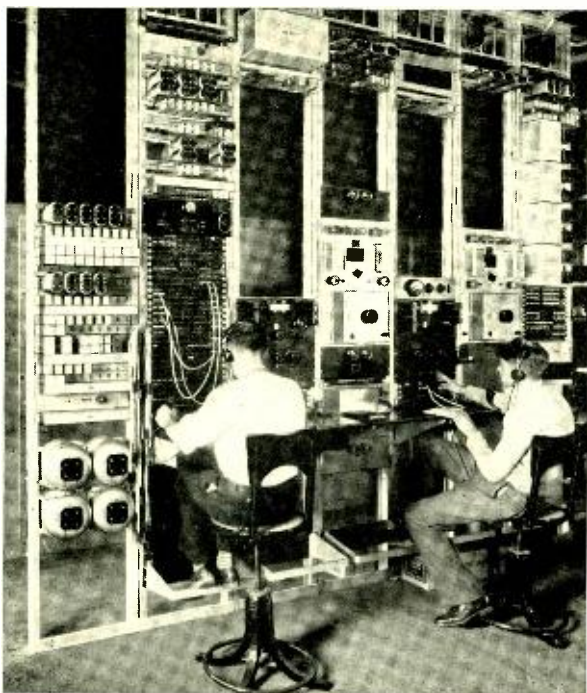


Fig. 4—Line terminal equipment in its copper-shielded room at Lawrenceville, attended by D. B. McKey (left), Technical Employee, and H. T. Ashworth, Radio Man, of the Long Lines Department of A. T. & T.

sion efficiency of the radio telephone circuit as a whole, and to check the efficiency of any part of the circuit when unsatisfactory overall transmission is found. The testboard man uses his set for measurements on the land lines, and the repeater man his for measuring the gain of the repeaters. The two latter sets serve also as reserve units for use at the control board in case of trouble in the regular sets there.

At the transmitting office, as indicated in Figure 2, the voice-frequency equipment is divided between the testboard and the transmitter room. The testboard itself consists of one bay of equipment of the same nature as that in the testboard at the control office. Associated with it are one or more bays of telephone repeaters, and a regular and reserve unit of transmission measuring equipment similar to those at the control office. One telephone repeater per circuit is required to make up for the losses on the land lines. The testboard bay, repeater bays and transmission measuring equipment, together with a fuse panel and small distributing frame, are located in a room which is completely shielded with sheet copper on floor, walls and ceiling (Figure 4). The doors are lined on one side with copper so arranged as to be in contact with the wall shielding when the door is closed and the windows are covered with permanent copper-mesh screens. This shielding keeps out of the voice-frequency equipment radio-frequency energy which would otherwise be picked up from the nearby transmitting antennas.

In the radio transmitter room the voice-frequency equipment is placed in a copper-shielded turret mounted on an ordinary desk (Figure 5). This turret contains facilities for switching the radio circuit from a regular to a spare trunk from the testboard,



Fig. 5—C. W. Millard, Radio Man, of the Long Lines Department, at the control desk and turret in the transmitting room at Lawrenceville

equipment for monitoring on the circuit and for measuring speech-energy levels, and terminating equipment for a telephone order-wire to the testboard and for the telegraph order-wire to the technical operator in the control office. There are also provided tones of 300 cycle, 1000 cycle and 2700 cycle frequencies of standard testing power, for making approximate measurements on the transmitter. The tone apparatus, although considered part of the voice-frequency equipment, really pertains to the operation of the radio link.

The voice-frequency equipment in the receiving office is very similar to that at the transmitting office. The trunks to the receivers appear in the

receiver bay itself instead of in a turret.

In general the equipment used for the voice-frequency portion of the radio-telephone circuits conforms with the usual standards for toll system equipment. Standard nineteen-inch relay rack bays of the channel iron type are used. The methods of cabling and wiring are standard except that, due to unusual variations in

transmission level through the various bays, somewhat more than the usual amount of shielded wiring is employed. To a large extent standard types of apparatus, such as telephone repeaters, transmission measuring sets, oscillators and telephone sets, are employed with no internal modification and with the least possible modification in external wiring as compared with their ordinary uses.



Progress on Sound-Picture Laboratory

Work on the construction of the new Sound-Picture Laboratory of Bell Telephone Laboratories has progressed to a point where the building is completed and the installation of the experimental equipment is under way. It is expected that research and development work in it will be started about September first.

A comprehensive program of investigation of sound recording and reproduction will be continued with the greatly enhanced facilities of the new building. This work is being done for Electrical Research Products, Inc., in fulfillment of that Company's obligation to its licensees to push the technique of sound pictures ever forward. No work of a directly commercial nature will be carried on in the building as it is regarded as a laboratory and not a studio. The building will contain among other things a review room, an experimental sound stage, a monitoring room, dressing rooms for artists, and photographic laboratory. It will be equipped for sound-recording on both disc and film, and for film processing.

The building will also contain a complete air conditioning equipment to care for sound stage and photographic laboratory conditions. The sound stage and monitoring room are acoustically treated according to the latest scientific advances but flexibility for changing these conditions is afforded.



Power Supply for Voice-Frequency Equipment, Transatlantic Short-Wave Radio

By J. L. LAREW
Equipment Development

POWER requirements for the voice-frequency circuits of the short-wave transatlantic service are rather severe. Not only must the voltage of the supply be regulated within close limits but the current furnished must be free from disturbing components and all interference between power supply and the talking or radio circuits must be eliminated. Even slight sparking at contacts a considerable distance from the radio receivers may interfere with satisfactory reception.

Power must be supplied at three separate locations: one for the control room in the Long Lines building at 24 Walker Street; one for the short-wave receiving station at Netcong, New Jersey—some thirty-five miles west and north of New York City; and one for the transmitting station at Lawrenceville, New Jersey—about fifty miles southwest of New York. At all of these points direct current is required at low-voltage for filament supply, and at a higher voltage for plate potential; but the actual voltage and methods of control differ somewhat depending on local conditions.

Motor-generators or some form of alternating-current rectifiers are used for charging the batteries. The outputs of all of these charging sources have small alternating-current components, and to reduce these to negli-

gible values filters using electrolytic condensers are required.

These are of the form recently adopted for central offices, which has already been described in the RECORD.* They are built of aluminum cell condensers, which supply large ca-

* BELL LABORATORIES RECORD, *April, 1927*, page 276.

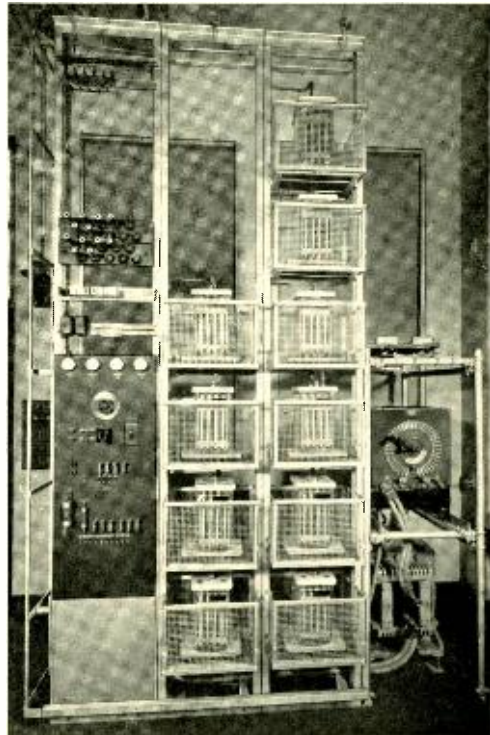


Fig. 1—Automatic voltage regulating equipment for 24 volt, and filtering equipment for 24 and 130 volt, power supplies at the control office at 24 Walker Street

capacitances in a minimum of space, and of iron-core choke coils. Several cells are connected in series or in parallel depending on the voltage or capacity required, and the complete filter may be built in one or two stages. A sin-

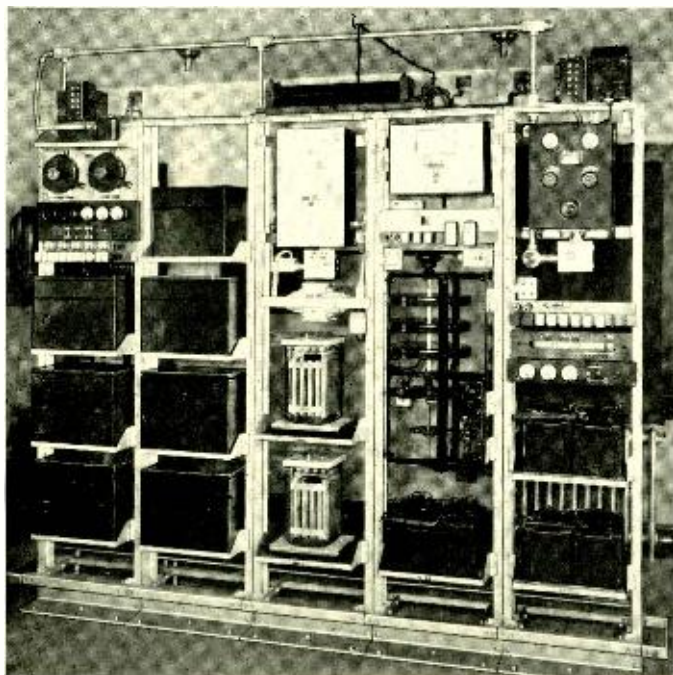


Fig. 2—Power supply equipment for both filament and plate supply at the Netcong receiving station

gle stage consists of a choke coil in series in the line, and a group of condensers bridged across the line. A two-stage filter has a second combination of choke coil and condensers connected to the circuit in the same manner as, and immediately adjacent to, the first.

At the control office, low voltage power is obtained from the battery supplying the dial office in the same building. The voltage of this source—maintained at $23\frac{1}{2} \pm 1\frac{1}{2}$ volts—is not sufficiently constant for the use of the repeaters and other vacuum

tube equipment used for the transatlantic service, so that additional regulation is required. This takes the form of a motor-operated rheostat, connected in series in the main feed line, and a voltmeter relay which indirectly operates the motor to cut in or out resistance as required. The resulting voltage at the distributing point is maintained at $20\frac{1}{4}$ volts with a variation of only $\pm\frac{1}{4}$ volt.

The plate supply is obtained from a battery (also used for other purposes) in the same building. Its voltage is maintained at 130 ± 5 volts; and as this is satisfactory for the vacuum tube plates no further regulation is needed. A two-stage filter is used with this supply, however, but only a single stage for the low voltage.

In addition to these two power sources, a third is required at the control office for operating the telegraph circuits used by the technical operator in communicating with both the receiving and transmitting stations. This supply is at 260 volts with a third wire tapped at the middle point of the battery. By this means 130 volt positive and negative impulses may be sent over the telegraph circuits.

All the power equipment, except the voltage regulator for the low voltage supply and the choke coils, is mounted on the three-bay relay rack shown in Figure 1. At the left is a

panel mounting the various fuses, switches, and meters required, and on the two bays to the right are the electrolytic condensers for the filters. Two condensers are connected in series for the 130 volt supply so that four are required altogether for the two stages. Three condensers are connected in parallel for the low voltage filter—one set on each side of the choke coil.

On the floor to the right of the relay rack is the 300 ampere choke coil used in the low voltage supply; immediately above it is the motor operated rheostat; and above this are the choke coils for the two-stage 130 volt filter. These are long coils of small diameter and low current capacity, and are almost hidden by the insulators and pipe.

On the wall to the left of the relay rack is the voltmeter relay for the voltage regulator and below it a panel of spare fuses.

At the Netcong receiving station the power plant differs somewhat from that at the control office because both batteries and charging equipments must be provided. These plants are located in a shielded room, lined completely with copper, and in addition auxiliary devices are provided on the power plants to prevent radio interference.

The arrangement of the equipment is shown in Figure 2. Two bays at the left contain a standard 604-B power plant for the plate supply. This equipment has already been described in the RECORD.* It includes its own filtering arrangement so that no external condensers or

choke coils are required. The remaining three bays contain the low voltage supply. In the center bay are two electrolytic condensers used for the filter; and the associated choke coil rests on the top of the racks. In the top section of this center bay is an emergency lighting switch which automatically connects several lamps—conveniently located around the building—to the 24 volt battery in case of failure of the outside supply.

The low voltage supply equipment in the last bay on the right is designed for a load of ten amperes. Additional bays—each of ten amperes capacity—may be added up to a total load of thirty amperes without exceeding the capacity of the motor-driven rheostat. This maintains a voltage of $24 \pm \frac{1}{4}$ volts— $3\frac{3}{4}$ volts higher than that of

* BELL LABORATORIES RECORD, *March*, 1929, page 287.

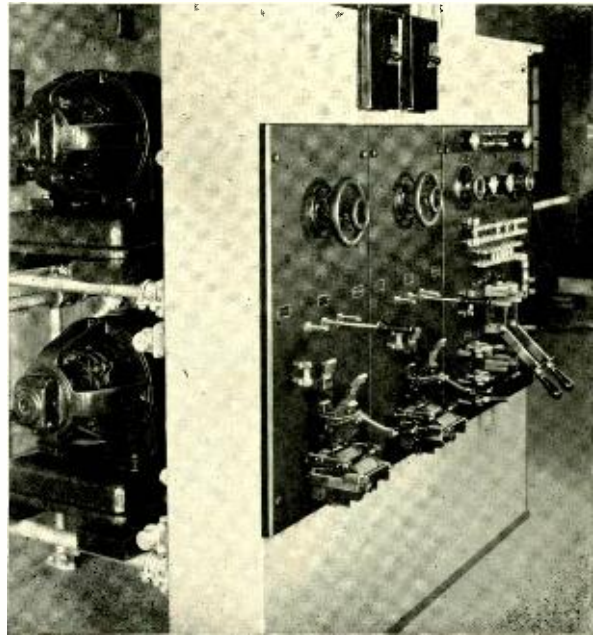


Fig. 3—Low voltage power supply equipment for the Lawrenceville transmitting station

the control office at Walker Street. The rheostat for voltage regulation is in the second bay from the right.

At the Lawrenceville transmitting station the various radio channels are housed in two buildings known as buildings No. 1 and No. 2. The plate power supply in building 1 is exactly like that of the receiving station at Netcong except that the spark quenching and shielding apparatus is not required because of the lesser sensitive-

The equipment for low voltage supply is the same for both buildings. Two 75 ampere motor-generator sets—one used as a spare—are mounted one above the other on a pipe frame work. In front of and fastened to this frame are the generator control panels and an associated battery control panel as shown in Figure 3. Choke coils for the filter used for the low voltage supply are mounted on the frame with the motors but do not show in the photograph.

Duplicate batteries of eleven cells each are provided in a separate room. Here also are grouped the electrolytic condensers for the filters as shown in Figure 4. Although a filter is incorporated in the equipment for floating the plate batteries, as mentioned above, additional condensers are used at the transmitting station to obtain improved results.

With a minimum of special equipment both plate and filament power are thus provided at the transmit-

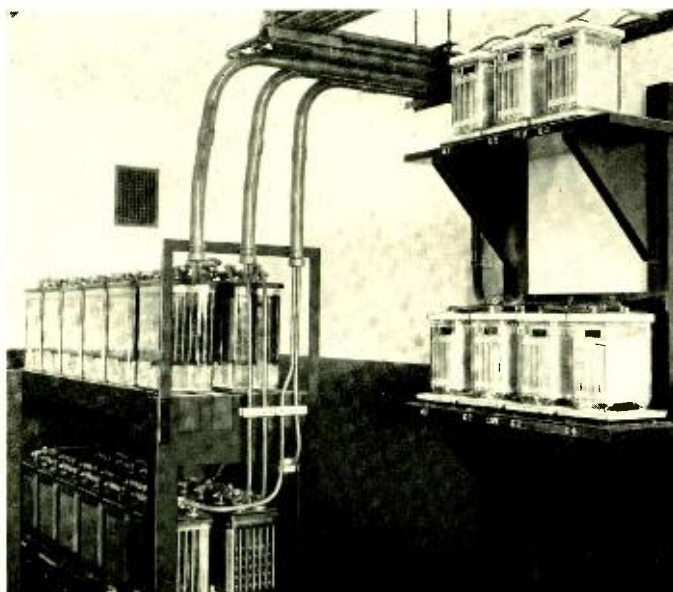


Fig. 4—Battery room at the transmitting station showing duplicate 24 volt batteries and the electrolytic condensers for both 24 and 130 volt supplies

ting and receiving stations as well as at the control office. The supply is maintained not only at very constant voltage but with almost entire absence of ripples which could cause noise in the voice-frequency circuits.

ness of the transmitting equipment. No storage battery plate supply is used in building 2 as dry cells are adequate for the small needs of the voice-frequency equipment; all the line terminal equipment is in building 1.



The Commercial Problems in Engineering the Transoceanic Short-Wave Radio System

By B. B. WEBB

Commercial Relations Manager

THE tasks of manufacturing, delivering, installing and testing the telephone equipment developed and designed by these Laboratories are normally undertaken by the Western Electric Company, the manufacturing organization of the Bell System. It is but rarely that our Shop, primarily an adjunct to development rather than a unit for industrial manufacture, is called upon to build extensive equipment for commercial use. It is sometimes so, however, when complete novel systems are projected—such systems as the Rocky Point long-wave transatlantic transmitter and, most recently, the new transoceanic short-wave telephone for Lawrenceville and Netcong, N. J.

The reason for these exceptions to the System's usual manufacturing procedure is simple. So much of novelty is involved in the principles employed and the designs proposed that it is economically advantageous to secure the closest possible contact between the developing engineers and the manufacturing mechanics. And these intimate relations, valuable in any case, are essential when, as with the transoceanic system, the time schedule is contracted to a minimum.

A manufacturing enterprise so large and complex as that for the transoceanic equipment involves many activities other than those in laboratories and shops—and machinery, tangible and intangible, far more vari-

ous even than that on our fourth floor. To free the engineers and mechanics from all other work than that in which they are specialists, the staff departments undertake these manifold activities, and endeavor to carry them out with minimum distraction and maximum assistance to the engineering and manufacturing personnel. Here again the novelty of the project is operative, offering for solution novel problems of estimating, purchasing, scheduling, costing, accounting, shipping, billing, and the like, and commanding the attention of men not only specially trained and experienced in these matters but also technically trained to be appreciative of the scientific and mechanical aspects of the projected system.

Authorizations from the Western Electric Company, based on cost estimates made by the Commercial Relations Department, led to the origination of cases to which to allocate the expense of manufacturing the five transmitters and receivers (four for the Long Lines Department at Lawrenceville and Netcong, and one for the International Standard Electric Company at Buenos Aires), and the vacuum tubes, sleet-melting apparatus, oil filters, and other equipment, and installing* this equipment at Lawrence-

* The line-terminal equipment and its associated power equipment were installed by the Western Electric Company under the engineering supervision of the Laboratories.



Frank Berger and some of his shop force in 4-K which constructed the radio sets

ville and Netcong. What to manufacture and what to buy elsewhere were decided; orders were immediately placed outside for apparatus whose production would take considerable time; and pressure was exerted on suppliers, in many cases by visits to their factories, to ensure that materials and equipment would be available when needed. Special storage space in a nearby warehouse gave indexed accommodation to materials, between their receipt and their withdrawal for use.

A schedule was set up with the Shop, calling for the completion of the first transmitter on January 15 and one per month thereafter, and of the first receiver on May 15. Since such a manufacturing load could not be handled in other than a special way, additional space and personnel were acquired: a separate group of twenty-five men, occupying the entirety of Section 4-K, undertook the

construction of the sets. Manufacture proceeded smoothly and according to schedule. On the successive completion of the transmitters, they were dismantled, packed bay by bay in specially constructed cases, and shipped by truck to Lawrenceville. To Buenos Aires went, specially packed, a complete consignment of 808 items, weighing 104 tons.

At Lawrenceville other incoming equipment, freighted to Trenton, had to be trucked to Lawrenceville, received, stored and indexed, and certain items purchased from local suppliers during installation also had to be cared for. To afford these and numerous other commercial services, the Commercial Department permanently stationed a representative at Lawrenceville.

Unlike the engineering work on such a project the commercial work involves, sooner or later, every branch of the entire commercial organiza-

tion. The expense is budgeted. Time cards charging labor to the job are rated from payroll records and pass to accounting organizations where, with orders and stock-withdrawals, they are entered in case sheets and case-cost reports, and included in the bills, the journal and the ledger. Invoices from suppliers are checked to requisitions and receivables, and paid by the vouchering and financial organizations. All transactions are continuously audited. Merchandising groups stock and store, ship and receive; service groups blueprint, type and file.

Morning conferences between the engineers and the commercial men coordinated the many endeavors and ensured that all was proceeding as it should. Pending the completion of the task most of these activities still continue. The cost accounting is being carried out currently, to facilitate prompt final billing of the job to the Laboratories' customers. Not until this billing has been rendered, and credit on its account approved and recorded, will the major commercial concern with the transoceanic short-wave project be completed.



A New Airplane for the Laboratories

In order to assure its first-hand contact with the air-transport field, the radio development group has added to its facilities a Ford tri-motor airplane equipped with Wasp engines. In this plane, which will be delivered in the immediate future, the Laboratories will install as regular equipment a complete radio transmitting and receiving set, of the type now standard for air-transport service, purely for communication between plane and ground. Ample space will be afforded for complete laboratory facilities, which will be used for extensive investigations of antennas, apparatus, and transmission phenomena.

The new plane will not displace the Laboratories' present Fairchild ship, which has had over 400 hours of flight since it was placed in service more than a year ago. A great deal of important information has been secured with this plane and it has participated in a number of notable demonstrations. Its carrying capacity, rated at four passengers, is not, however, sufficient for the experiments now planned, for which it is felt that the thirteen-passenger space of the Ford plane is essential.



Reproducing Machine for Picture and Sound

By H. PFANNENSTIEHL
Special Products Development

A NEW projecting machine for reproducing sound from either discs or films has recently been developed by the Laboratories for manufacture by the Western Electric Company and is already extensively used in theatres. To be as nearly universal in its application as possible, the frame is designed to mount practically all of the commercial projector heads in use at the present time. Instead of being arranged in separate units, as has been done previously, all the equipment—consisting of a disc sound-reproducing unit, an optical sound-reproducing

unit, a film take-up mechanism, and a motor drive—is mounted on a single base, as shown in the accompanying photographs.

The motor, which may be for either direct or alternating current, has a double ended shaft connecting at one end with the disc drive and at the other with a main drive gear unit from which three drives—two vertical and one horizontal—are taken. Accurate speed control is obtained by a vacuum tube regulator already described in the RECORD.* For sound

* BELL LABORATORIES RECORD, *November, 1928, page 101.*

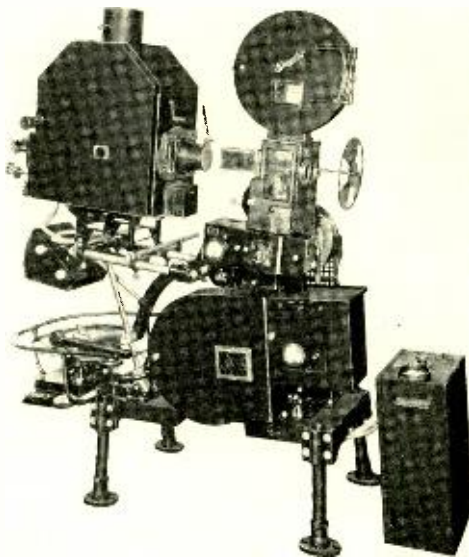


Fig. 1—From the operating side of the new reproducing machine all the principal elements but the drive may be seen



Fig. 2—Part of the main drive gear unit is hidden by the metal guard but the general arrangement is evident

pictures the speed is held constant at 1200 r.p.m., but provision has been made so that, when pictures are to be shown without sound accompaniments, any speed from 900 to 1500

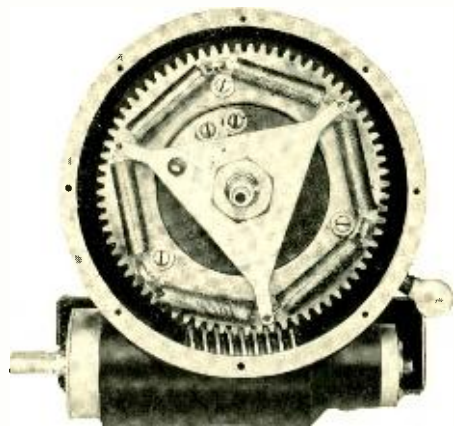


Fig. 3—The mechanical filter in the disc drive is mounted directly beneath the disc itself

r.p.m. may be obtained. This permits an increase or decrease in speed to accommodate a definite time schedule.

Accurate synchronism between the picture and the film or disc record is essential to successful sound pictures and steadiness of motion of the sound film or disc is also required. Vibration must be eliminated. To fulfill these requirements all the gears are made to great accuracy, and the drives for the disc and the sound sprocket have flexible couplings and mechanical filters.

The filter for the disc drive, shown in Figure 3, consists essentially of a flywheel connected by springs to the driving gear. To avoid surges in the filter system, frictional damping of the spring connections is necessary. This is supplied by wrapping each spring with a layer of felt which is kept in contact with the convolutions of the spring by a second and outer

spring winding. Over the felt are strips of metal which prevent the outer spring from imbedding itself in the felt and interfering with the proper action of the inner spring. The turntable itself serves as a flywheel.

The filter used with the drive for the sound sprocket is similar in function but differs in having hydraulic rather than frictional damping.

To prevent mechanical vibration from being transmitted to the disc reproducer, cushioning is provided be-

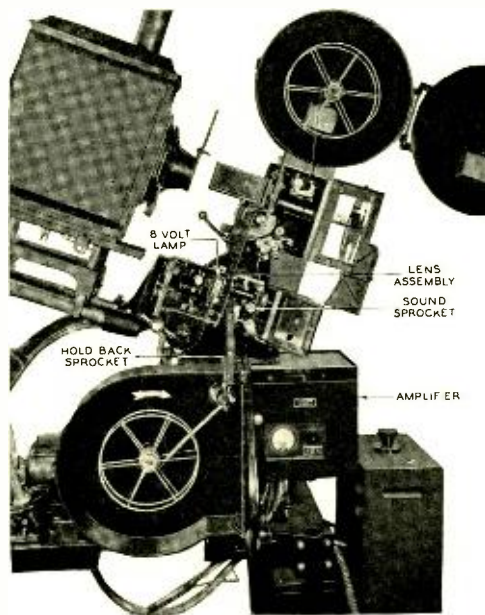


Fig. 4—The course of the film through the machine may be seen from this photograph which shows also the concentrated light source and the lens assembly

tween the pivot of the reproducer arm and the bracket that supports it. As an additional precaution the entire turntable assembly is mounted on a soft rubber pad. A record clamp is provided also to prevent the record from slipping on the turntable and thus destroying synchronism. The clamp is self-locking but is readily released by lifting a small latch.

Of the two vertical drives, geared to the motor shaft in the main drive gear unit, the front one—shown in Figure 2—is connected through two universal joints and a telescoping shaft to the projector head. A sepa-

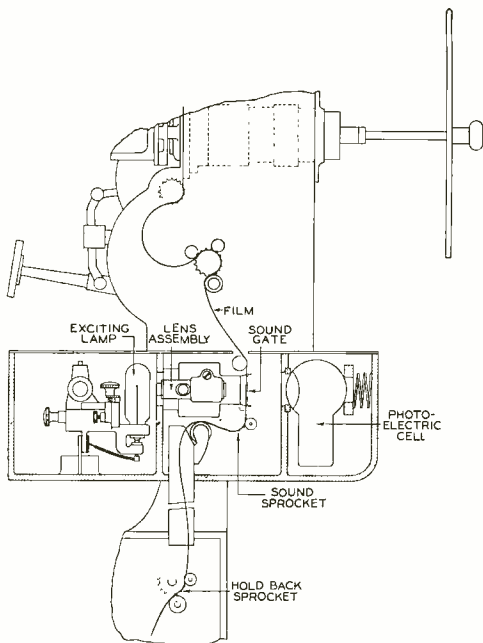


Fig. 5—Details of the sound-film reproducing unit are here shown diagrammatically

rate gear coupling is provided at the upper end for each type of head used. The other vertical shaft is connected by a self-aligning shaft to a set of gears that drives the sound sprocket which pulls the film through the sound reproducing unit.

The horizontal shaft is connected through a chain and sprocket drive to the film take-up mechanism. This consists of a shaft, on which the film reel is mounted driven through a friction-disc type of clutch. A hold-back sprocket mechanism, which serves to prevent any uneven pull of the film take-up mechanism from affecting the uniform velocity of the film as it passes the lens system, is also connected to

this drive. It is mounted in the lower film reel housing, as may be seen in Figure 4.

Mounted on top of the film magazine casting is a pivoted bracket carrying the sound-film reproducing unit, to which is fastened the projector head. The same bracket also mounts the projector arc lamp. It is pivoted about the center of the sound sprocket and may be tilted from the horizontal to 40° below. A jack screw is provided, and adjustment at any angle is obtained by means of a hand wheel.

The sound-film reproducing unit consists of a sprocket for pulling the film at a uniform velocity past an aperture plate, an exciting lamp, a lens system, and a photoelectric cell. The general arrangement may be seen from the diagram of Figure 5 and

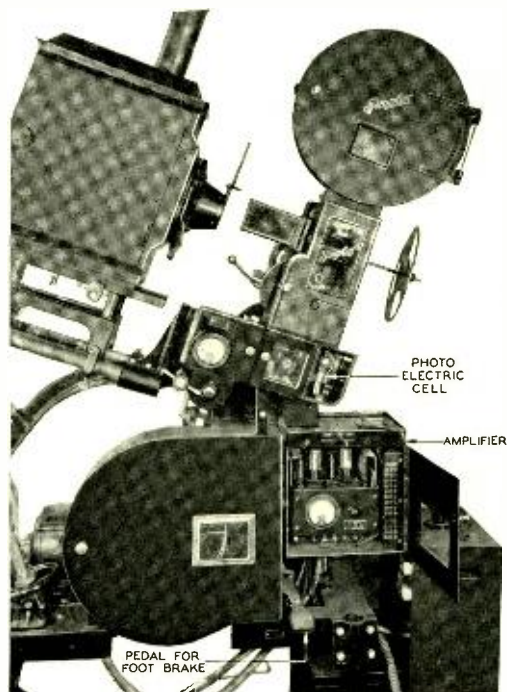


Fig. 6—To avoid local electrical disturbances the amplifier is mounted directly beneath the photoelectric cell. Their relative position is here plainly seen

from the views of Figures 4 and 6.

Light from the concentrated filament source is focused by a condensing lens on a narrow slit as shown in Figure 7. An image of this slit is then focused on the film by a high quality objective lens, and light passing through the sound track on the film falls on the photoelectric cell.

When polarized by a proper voltage, the current output of the photoelectric cell is proportional to the light falling upon it. The cell circuit is inherently of high impedance and small energy output so that it is very necessary to guard against local electrical interference. To accomplish this a vacuum tube amplifier is mounted on the machine as closely as possible to the cell. The amplifier serves the double purpose of increasing the energy level and making the energy available across a low impedance circuit. The vacuum tubes are mounted on a spring-suspended platform to prevent vibration from causing noise in the output circuit.

Due to the addition of several flywheels and various mechanisms to the regular projector mechanism, a longer time than usual is required for the machine to come to rest after the power is shut off. This is objectionable at times of film breakage, and to

correct it a brake has been provided controlled by a foot pedal shown in Figures 1 and 6. Depression of this pedal first shuts off the power and then applies a brake to the motor flywheel. The machine is restarted by lifting the brake pedal, which first re-

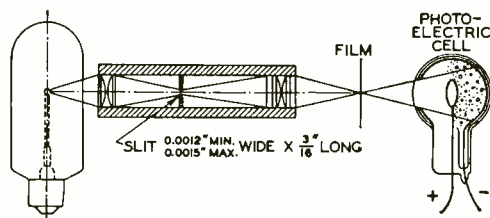


Fig. 7—The optical system is simple in detail but very accurate in adjustment

leases the brake and then closes the motor switch.

Many special features have been provided in addition, such as adjustable legs, allowing a variation of ten inches in height, and a mechanism for shifting the projector a small amount in the horizontal plane to compensate for the difference in width of the picture on the silent- and sound-picture films. Advantage has been taken of all recent improvements and experience so that the new Western Electric reproducing machine embodies the latest improvements in sound-picture projectors.

Tie Lines between Private Branch Exchanges

By R. W. HARPER
Local Systems Development

WHEN business organizations have more than one establishment in the same or another city, or are closely affiliated with other concerns, they often require means for direct interconnection between their private branch exchanges. Circuits used for this purpose are known as tie lines. They correspond in function to the trunks between central offices but have several important points of difference.

Regular trunking between central offices is in general handled on a one-way basis, a separate set of trunks being used for carrying the traffic in each direction. In the case of manual offices these trunks terminate in jacks at the outgoing end and in cords and plugs at the incoming end. PBX tie lines, however, are terminated in jacks at both ends when associated with

manual PBX's and ordinarily on jacks and switches at both ends in PBX's of the dial type; and it has been found more economical because of the smaller groups employed to operate them on a two-way basis, the same circuit being used for calls in both directions.

The most commonly used tie line up to the present time has been arranged for ringdown operation, as illustrated in Figure 1. To originate a call the attendant plugs into the jack and operates her ringing key, which lights the line lamp at the distant end. When the conversation is finished, or should either attendant desire to recall the other, the ringing key must again be operated which, under these conditions, lights the supervisory lamp associated with the operator's cord circuit at the distant end. This type of tie line is simple and has the considerable advantage that it can be used on simplexed, composited or phantom lines.

For use where the simple ringdown tie line is not satisfactory (as for instance where a manual PBX is connected to an unattended dial PBX) there are available automatic tie lines. These circuits, however, require free metallic cir-

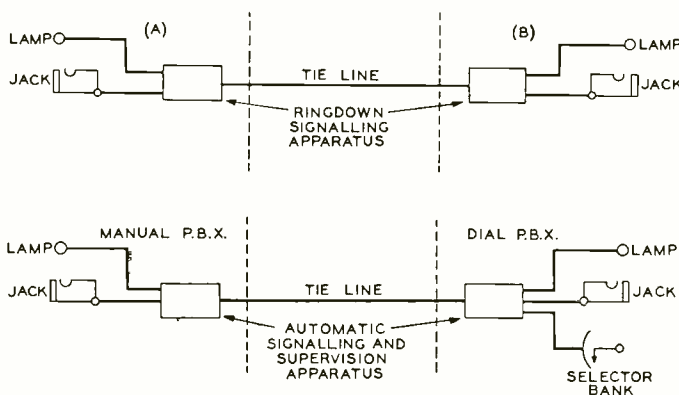


Fig. 1 (above)—Ringdown tie lines have been commonly used up to the present time. Fig. 2 (below)—Tie lines between a manual and a dial PBX permit a dial station to call directly the operator at the manual PBX

cuis without auxiliary telegraph channels in order to permit the automatic feature, and for this reason and the relatively large amount of apparatus involved they are not provided except when their operating advantages are important. In the manual case the attendant originates the call by plugging into a jack whereupon the line lamp lights at the distant end. The cord lamp at the originating end also is lighted and remains burning until the call is answered. Withdrawal of the plug at either end lights the cord supervisory lamp at the other end.

When there is a dial PBX at one end of the tie line, it is desirable to allow a dial station to call the distant manual PBX directly. To connect a dial PBX to a manual PBX, therefore, the tie line circuit is made accessible from the selectors at the dial PBX as well as from the manual board. This arrangement is known as a dialing tie line and is illustrated by Figure 2. The operation of tie lines between attendants, in such cases, is the same as that of the two-way automatic trunks just described. When a station dials the tie line, the line lamp is lighted at the distant end, and disconnection at the dial station causes the supervisory cord lamp at the distant PBX to light.

If dialing service is required from both ends of the tie lines, the circuits are arranged to function at each PBX from the selector banks as well as from the manual switchboard. This

arrangement is depicted in Figure 3.

In each of the circuits referred to above the services of the attendant at the incoming end are required to complete the connection to the called station. With a dial PBX, however, the

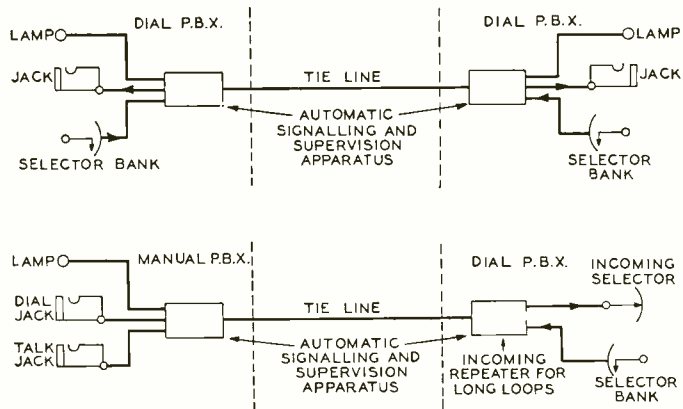


Fig. 3 (above)—When the tie line is between two dial PBX's, stations at either end may call the distant PBX but with the scheme shown here the call is completed by the manual operator. Fig. 4 (below)—With repeating tie lines the operator at the manual board may directly dial a station at the dial PBX

connection can be completed directly through the switches to the called station. This necessitates the transmission of dial pulses over what are known as "repeating" tie lines.

With one-way repeating tie lines an incoming selector is directly connected with the tie line at the dial PBX, and a dial jack, in addition to the talking jack, is provided at the manual board as shown in Figure 4. When the two exchanges are not very far apart the attendant at the manual board dials directly into the switches at the dial PBX, but if, due to greater distance, the conductor loop resistance is beyond the operating range of the switches an incoming repeater is provided to operate the switches. With these circuits the manual attendant

receives cord-lamp supervision when the dialed station answers or disconnects.

Two-way repeating tie lines (Figure 5) are provided to connect two dial PBX's and may be used for direct service between dial stations of the two PBX's. Provision can be made also so that the attendant at either PBX may use the circuit to call stations at the distant PBX. Outgoing repeaters are provided at the originating end to hold the selector and to transmit the dial pulses to the distant PBX, and incoming repeaters may or may not be provided, depending upon conductor loop resistance.

To interconnect PBX's in distant cities special consideration has to be given to signalling, supervision, and transmission because such circuits are

given by talking battery supplied from the cord circuit. To give the higher transmission level required for long haul connections, circuits known as terminating tie lines are used. These are equipped with repeating coils through which talking battery can be supplied to the station as is done for regular toll switching connections, and sensitive alternating current relays are used to receive and transmit the ringing signals from the distant PBX to the line or cord supervisory lamps. The attendant inserts the front or trunk plug of the cord into the tie line jack and a relay in the sleeve circuit cuts the cord through in the same manner as on a central office connection, so that the station is supplied with talking battery through the repeating coil in the tie line. This

circuit, shown in Figure 6, is quite a recent development and eliminates the need of adding any universal cord circuits at PBX's when long distance traffic is to be handled.

There is still one more and very important phase of PBX tie line traffic. An organization often has branches in three or more distant cities. all of which wish direct tie line service. This sometimes requires that provision

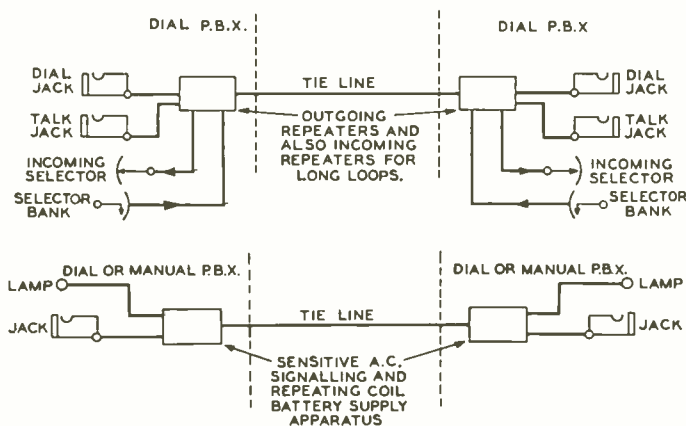


Fig. 5 (above)—Two-way repeating tie lines permit calling directly to extensions in the distant PBX. Fig. 6 (below)—“Terminating” tie line to connect PBX boards in different cities

practically toll lines. Signalling and supervision is usually handled on a ringdown basis although in some cases repeating types of circuits are provided. Since the tie line circuits just described are used for fairly short-haul service, satisfactory transmis-

be made to establish a through connection between two of these long-haul tie lines at an intermediate PBX. For transmission reasons, no repeating coils are permissible at the intermediate point on connections of this sort; the connection must be cut

through as in regular toll practice. "Through and terminating" tie lines are provided, therefore, for this purpose as illustrated in Figure 7.

This circuit was developed very recently and is an important contribution to PBX service. Heretofore special toll cords have been required for through service which necessitated a considerable change at the PBX when a subscriber found it necessary to provide for through traffic after the board was in service, and also complicated the stocking of PBX's since the number of boards which would require these special cords, and the actual number of toll cords that would be needed, could not be readily pre-

determined. The "through and terminating" tie line, however, functions with the regular cord, and the tie line apparatus can readily be furnished as required. Each circuit is equipped with two jacks: one for terminating connections, and the other for through connections. On terminating connections the tie line is used as outlined for the terminating circuit referred to above.

On through connections the through jack, recognizing the end of the cord connected to it, disconnects all of the terminating apparatus from the tie line when a plug is inserted. When the front cord is connected to the through jack the local battery is removed from the cord circuit and the cord is cut through directly. When the station end of the cord is con-

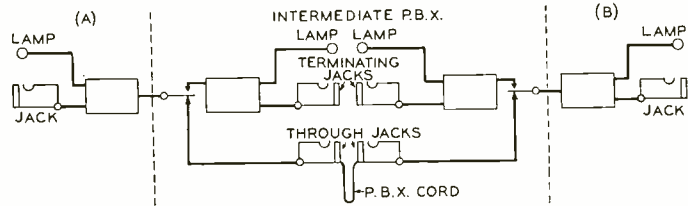


Fig. 7—"Through and terminating" tie lines are used to connect a chain of private branch exchanges in different cities. A call may be terminated at, or merely pass through, an intermediate station

nected to the through jack of another tie line, a sensitive relay is connected across that tie line, which responds to ringing signals from either end of the connection, and the supervisory signals are transmitted to the rear cord supervisory lamp.

By these eight different types of tie lines almost any kind of interconnecting procedure desired may be secured, and the usefulness of the PBX is considerably extended.

A New Dial PBX of Large Capacity

By H. G. BLOCKLIN
Equipment Development

BUSINESS organizations requiring between eighty and two thousand extensions may be served by a new dial PBX known as the 701-A. This PBX and the recently developed 740 types* which

give service to a smaller number of extensions, will take care of the majority of subscribers requiring dial type equipment. This latest addition to the family of dial-type private branch exchanges replaces the 700-C, and incorporates materially different circuits and equipment.

Because of the large range in the number of extensions that the new PBX is designed to serve, it will naturally be used in a wide variety of establishments, which means that the calling rates and the holding-times will vary considerably for different installations. Realizing these facts, Bell System engineers have made every effort to work out a design that would permit this wide range in size and traffic density to be handled with the smallest possible number of different types of equipment units. This is of prime importance for equipment that is to be produced on a quantity basis and for short deliveries.

The method of handling calls in this PBX closely resembles that for the 700-C PBX. All calls between different dial extensions in the PBX or from an extension to the PBX attendant are handled over dial equipment but outgoing calls, to a central office, to the attendant at a connecting PBX, or to an extension in the connecting PBX may be completed either by dial equipment or manually by the

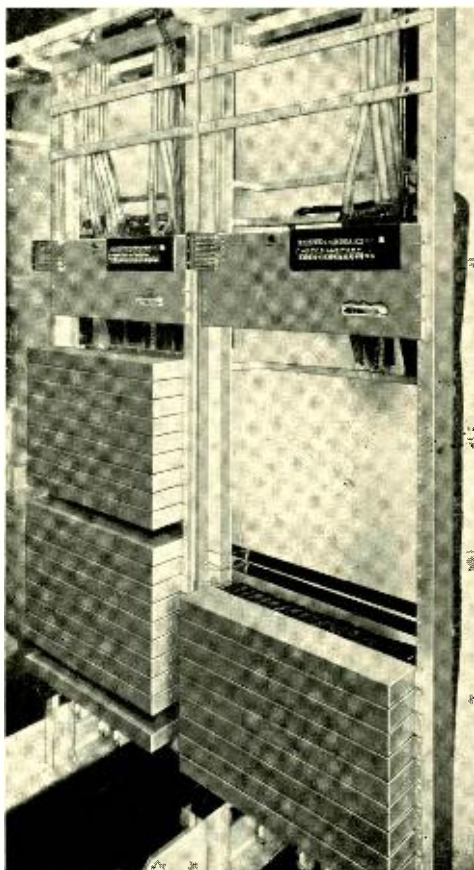


Fig. 1—Each line relay rack mounts equipment for 200 lines and is provided with fuse panel and terminal strips as well as space for a distributing rack at the top

* One of which has already been described in BELL LABORATORIES RECORD, Vol. VI, No. 6, pp. 399-402, August, 1928.

attendant. All incoming calls from a central office, however, are completed manually by the attendant who plugs a cord into the extension multiple in front of her.

Depending on the number of extensions, two, three, or four digits must be dialed to secure a local connection. To obtain a central office only one digit need be dialed; to obtain a tie-line one or two digits may be dialed, depending on the number of groups of tie-lines in use. In no case will more than one digit be required to call the local attendant, the number zero usually being retained for this purpose.

One of the major improvements incorporated in the new exchange, as compared with the earlier one it replaces, is the use of 200-point line finders, which are employed in the more recent step-by-step central offices, to establish connection between the calling extension and the dialing equipment. These function in a manner similar to that of the "A" or answering cord of a manual board. The instant a subscriber lifts his receiver from its hook a line finder starts hunting for the calling line, and when it is found a dial-tone is given—equivalent to the "Number Please" of an operator—which means that dialing may be begun.

Permanently connected to each line finder is a selector, or a selector-connector in the case of a two-digit system, which is equivalent to the calling cord at the "A" position of a manual board. It acts at the beginning of

dialing to pick a trunk to the destination wanted—much as the calling cord would be plugged into the proper jack of a manual board. When only three digits are required to call a local extension, this trunk leads directly to a connector which, upon the dialing of the two additional digits,

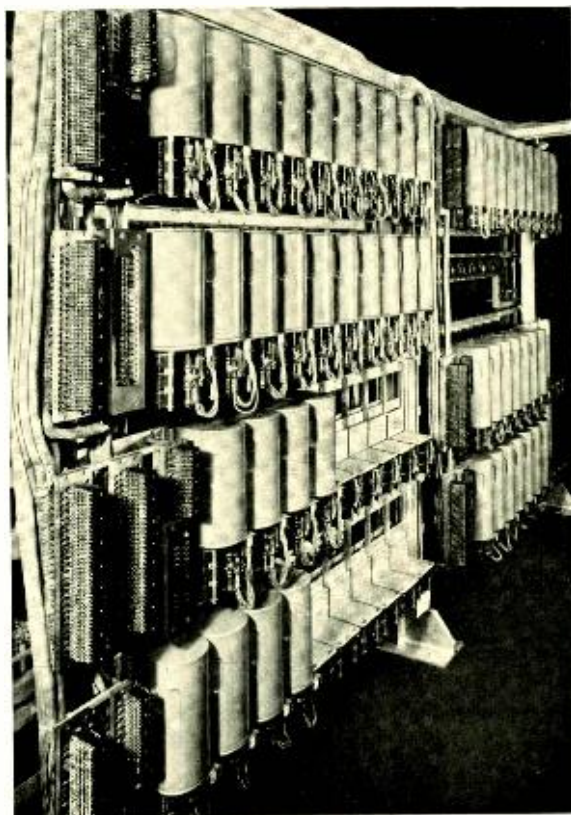


Fig. 2—200-point line finders are mounted with nine switches on a single shelf unit or twenty on a double, as may be seen here

completes the call as would the operator's cord at a "B" position of a manual board. When four digits are required for calling, a second selector is required between the first selector and the connector to make the additional selection required by the larger number of trunks. The connector re-

turns a "ringing" tone to the subscriber, to indicate that the station bell is being rung, or a "busy" tone in case the line is busy.

Line finders, selectors, and connectors are all of the same general type of step-by-step switches, which is

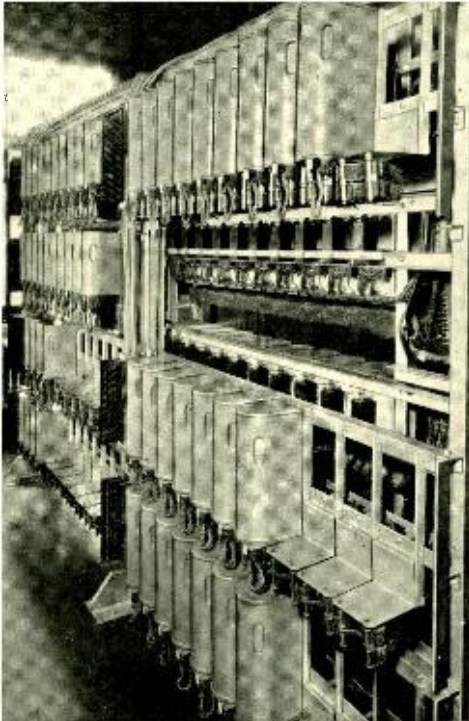


Fig. 3—Connectors are supplied in units of ten or twenty. The universal switch frame mounts four rows, each of ten switches, on both sides

a great advantage in giving uniformity of installation and simplifying maintenance. The manual switchboard associated with the new PBX is usually of the non-multiple type for the smaller (two or three digit) installations, and of the multiple type for the larger installations where more than two attendants are required. The non-multiple board is the same as the 551-B* PBX, except in details of

cord circuit supervision; and for the multiple board, the 605-A, a new manual board is used. This possibility of using standard multiple boards with the new dial PBX is of considerable value, because it reduces the amount of equipment that must be stocked, and simplifies a conversion from manual to dial equipment.

The dialing equipment consists of relay racks for both line and miscellaneous relays; shelf units for mounting the line finders, selectors, and connectors; and switch frames—channel iron frameworks on which any of the shelf units can be fastened in any location. The relay racks and switch frames are self-supporting and their height has been limited to seven feet so that they may be installed in rooms of ordinary ceiling height.

On each line relay rack, two of which are shown in Figure 1, are mounted the line and cut-off relays for a group of two hundred lines, together with the group and sub-group relays used for controlling the operation of the line finders. Fuse panels and terminal strips are also provided, and at the top is space for additional terminal strips which may be used in the smaller installations for distributing purposes. With the larger exchanges separate distributing frames are used. On the miscellaneous relay racks are mounted all the apparatus such as relays, resistances, and condensers required for the various trunks and tie-lines. As twenty-three inch mounting plates are required for the line relays, all relay equipment is designed for this width of plate so that only one width of rack would be required.

The universal switch frame is five feet ten inches wide and shelf units may be mounted on both sides. It is

* BELL LABORATORIES RECORD, Vol. VI, No. 5, pp. 363-365, July, 1928.

so arranged that the various types of shelf units—single or double, for selectors, line finders, or connectors—can be mounted on it interchangeably. This universal arrangement permitting all types of shelves to be mounted interchangeably as well as the provision for mounting shelves on both sides, results in a considerable economy in floor space. This is desirable since a PBX may be located in an office building where space is particularly valuable.

Shelf units are angle-iron structures which fasten directly to the universal switch frames. They are all of the full width of the frame but of two heights depending on whether they mount two rows or only a single row of switches. The shelf units for line finders and selectors are of the same height but differ from those for connectors. Each double unit mounts twenty switches and each single unit, ten; except the single-shelf line-finder unit which mounts only nine switches. Only nine could be used in this case because each group of line finders requires two one-hundred-line terminal strips. One of these is mounted at one end of each shelf with the double unit, but with single shelf units additional space must be provided for the second terminal strip.

Two types of line-finder units are thus available: a single-shelf unit mounting nine line finders, and a double-shelf unit mounting twenty. These may be mounted singly or multiplied together so that line finders in groups of 9, 20, 29, or 40 can be supplied. This makes it possible to take care of a wide variation in the originating traffic as it allows anything up to a maximum of forty simultaneous connections in a group of 200 lines, thus permitting eighty extensions to

hold conversation at one time. Connectors in groups of either ten or twenty per hundred lines may be furnished which should care for all ordinary variations in traffic density.

This unit method of mounting equipment has been extended in the new PBX, to the miscellaneous relay racks. Equipment for trunks, tie-lines, and miscellaneous circuits has been arranged on self-contained units of which a total of about thirty has been designed to care for different types of circuits. Each unit usually mounts the equipment for a single circuit but in a few cases multi-circuit units have been provided when it seemed more economical to do so. All these units, as well as the various shelf units, are assembled, equipped, and wired at the factory and are provided with a terminal strip to which the switchboard cable can be connected.

The power plant is of the automatic type. Different sizes are available and are arranged for either alternating or direct current operation. A trickle charger to supply continuous charging, is used for the smaller installations while for the larger, the amount of charging is governed by an ampere-hour meter. Voltage regulation is obtained by relays which cut in or out the required number of end-cells. Ringing current and tones are obtained from a machine which, under the control of the switches operates only when required. Ringing current for the manual board, however, is furnished from the central office.

The new 701-A PBX is thus equipped with the latest type of apparatus throughout and at the same time is conveniently and compactly arranged. It should require less maintenance than its predecessor and give the best possible service.



The Life-Insurance Trust

*Excerpts from an article by Wallace Ames,
Financial Editor of Popular Science Monthly*

"I could dig up seventy-five dollars a month for more insurance," said Walter Hopkins, "but I'd hate to think of all the sharps and swindlers who would be following up Lucy if she suddenly fell heir to the fifty thousand dollars. She is a wonderful wife, but she has had no business experience. She would be the prey of all the phoney stock salesmen in existence."

"There are several ways for you to protect your wife against bad business judgment," said Allan Case, his insurance counsel. "One way is to make your insurance payable as monthly income. You could get a \$50,000 policy which would pay back \$250 a month for about 400 months before both principal and interest was gone. That's nearly 34 years. Such a policy would provide your family with that part of your future earnings which they will enjoy if you continue to live and earn your present income.

"There is another plan that has gained great popularity of late years—the life insurance trust plan. You create your estate by taking out life insurance and you arrange to have your life insurance estate administered in much the same way you would an estate consisting of cash and securities. This is a fairly modern idea, but already there is substantially over a billion dollars of life insurance in force under the plan.

"Broadly speaking there are two forms of life insurance trust, one set

up with a trust company, and the other arranged with the insurance company. The chief difference between the two arrangements is the matter of flexibility. In the insurance company plan your beneficiaries are paid a regular income, which is close to 5% of the principal amount. The insurance company is not permitted to meet emergencies or special conditions not covered in the original agreement. For example, it could not pay an extra \$1,000 out of principal to defray hospital expenses. It could not make a special payment for educational expenses unless a special policy was provided for that purpose. Your beneficiary gets a definite sum at regular periods.

"If you set up a life insurance trust with a bank you can make various stipulations, just as you would in drawing a will. You can specify that the estate be invested in certain types of securities, or you can leave that to the bank's discretion. You can arrange so that special sums can be paid under certain circumstances, such as in case of sickness, or when your children are ready to go to college. You can if you like set a maximum that will be paid out on these special occasions.

"Under the bank-trustee plan your estate may grow in principal value, or it may decline. Under the insurance company plan your beneficiary continues to draw her income from a stipulated, non-fluctuating principal sum."



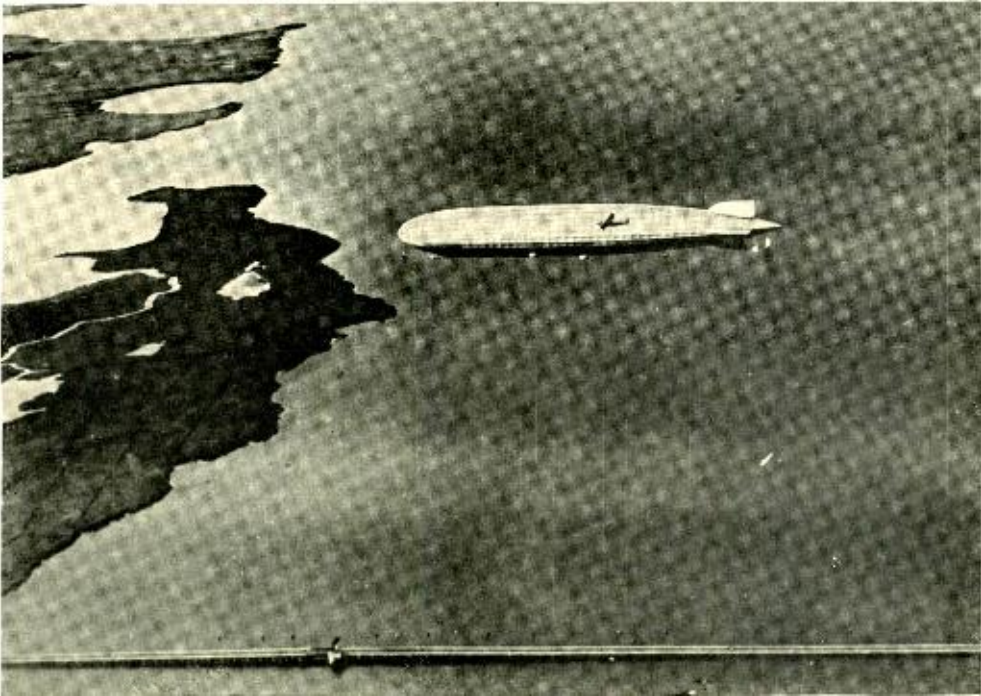
The Month's News

IN

STORIES AND PICTURES

INCLUDING

NOTES OF THE CLUB



Fairchild Aerial Surveys, Inc.

As the Graf Zeppelin approached the New Jersey coast, a word-picture of its arrival was radioed from the Bell Laboratories plane



News of the Month

AT the request of the American Telephone and Telegraph Company, personnel and equipment of the Laboratories played a considerable part in the communication system set up for the arrival of the "Graf Zeppelin" on its visit early



J. F. Byrne monitors the plane-to-ground radio link as was done during the Graf Zeppelin arrival

in August. The radio transmitting and receiving apparatus on our airplane was one terminal of a network which extended to press association offices and to broadcasting stations of the Columbia Chain. In the plane were A. R. Brooks, pilot; F. S. Bernhard, in charge of the radio apparatus, and for the occasion representative of International News Service; the Columbia announcer; and a

representative of Associated Press. When word came that the "Graf Zeppelin" was nearing the coast, the plane took off from Hadley Field and flew for some time between Lakehurst and Barnegat. On the dirigible's arrival they accompanied it to Lakehurst while the speakers described the scene to their associates in New York, all the talks being broadcast.

At the ground station at Whippany were F. M. Ryan as liaison man; D. K. Martin, in charge of station; J. F. Byrne at the transmitter, F. W. Boesche at the receiver and W. K. Caughey at the line terminal panel. A receiver was installed at our Cliffwood laboratory and operated by H. B. Fischer and W. Van Rosenbergh: transmission from the plane was supplied to the network from this receiver and from the one at Whippany, at the option of the control operator. The ground force at Hadley Field included R. S. Bair, W. C. Tinus, W. E. Reichle and R. J. Zilch.

A number of Bell System stations maintained a continuous watch for telephone transmission from the "Graf Zeppelin." For this purpose a receiver at Cliffwood was manned day and night by E. Bruce, L. R. Lowry, W. W. Mutch, and W. M. Sharpless. One of the experimental transmitters at Deal Beach was made ready to transmit on an available channel and a suitable antenna was put up by E. B. Ferrell, W. McH. Goodall and A. E. Kerwien, assisted by the Long Lines personnel of the transatlantic station.

DR. JEWETT has been designated as one of the delegates to represent the engineering and technical organizations of the United States at the World Engineering Congress to be held in Tokio this Fall. Serving with him is F. F. Lucas of the Apparatus Development Department.

* * *

Special acoustic equipment for the deaf, designed by Laboratories engineers, has been installed in the Brooklyn Paramount Theatre. The installation, made by Electrical Research Products, Inc., is part of a nation-wide campaign to make the entertainment facilities of sound pictures available to persons hard of hearing.

The equipment installed at the Brooklyn Paramount Theatre was tried out at the recent annual meeting of the American Federation for the Hard of Hearing in Cleveland before 300 delegates from the United States and Canada. Dr. Harvey Fletcher and representatives of Electrical Research Products conducted the tests.

* * *

C. J. KUHN has been admitted to membership in the Edward J. Hall Chapter of the Telephone Pioneers of America.

RESEARCH

A NEWSPAPER REPORT from Stanford University states that Karl K. Darrow has been appointed acting professor of Physics for the summer quarter. Mr. Darrow has been in California since the early part of June and will return to the Laboratories about the middle of September.

D. G. BLATTNER was in Atlantic City to observe the operation of the loud speaker system installed in the new municipal auditorium there.

W. C. JONES was in Hawthorne during the early part of the month to discuss the preparation of a limited number of special quality deskstand transmitters.

A. N. GRAY visited Hawthorne in connection with Catalina cable work.

HARVEY FLETCHER and J. C. STEINBERG attended a conference at New Haven held by the Linguistic Institute of the Linguistic Society of America. The subject of the conference was *An American Dialect Atlas*.

C. J. DAVISSON participated in the Symposium in Theoretical Physics at the University of Michigan. He spoke on *Properties of Electron Waves*.

SYSTEMS DEVELOPMENT

J. H. SOLE went to Greensboro and Durham, North Carolina, to make tests on automatic voltage regulators now being tried in repeater stations at these places.

V. T. CALLAHAN discussed the application of Godward generators to type "R" engines with engineers of the Buffalo Gasolene Motor Company at Buffalo.

H. McK. SPICER visited the General Electric Plant at Schenectady to confer on control equipment for the emergency alternator sets on large toll installations.

D. E. TRUCKSESS attended an inspection conference at the Holtzer-Cabot factory, Chicago, during the month. He also visited the Westinghouse works at East Pittsburgh to discuss copper-oxide rectifiers with Westinghouse engineers.

R. L. LUNSFORD in company with J. Davidson, Jr., of the American Telephone and Telegraph Company, visited the headquarters of most of the associated companies as far west as Denver. They discussed recent

power plant developments and inspected a number of new installations. The places visited were Pittsburgh, Columbus, Cleveland, Detroit, Chicago, Milwaukee, Minneapolis, Des Moines, Omaha, Denver, and St. Louis. In addition trial installations of voltage regulators and automatic power plants were inspected at Greensboro and Durham, North Carolina.

A. F. BURNS visited Syracuse in connection with trial installations of inductor alternators for generating tones required in central offices. J. M. Duguid visited Syracuse and Springfield, Massachusetts, on this same work.

W. WHITNEY and F. R. LAMBERTY made an inspection trip of small step-by-step unattended offices in Rockland



and Westchester Counties. They also inspected the step-by-step tandem system of the Southern New England Telephone Company at New Haven.

JAMES G. FERGUSON is now on the Pacific coast supervising the installation of the step-by-step PBX equipments on the airplane carriers *Saratoga* and *Lexington*. Both of these ships are stationed at San Pedro, California, and the installations are taking place while the boats are engaged in actual maneuvers.

H. KEPPICUS went to Albany in connection with the trial installation of a complete shop-wired and tested bay of repeaters.

G. A. BENSON observed the installation of a simplified pneumatic ticket

distributing system for the new toll board at Des Moines, Iowa, placed in service late in July.

G. K. SMITH made an inspection trip to Syracuse in connection with the equipment arrangement of the improved out-trunk preselector and also of switch wiper cords.

G. N. SAUL was at Allentown to review the laboratory installation of the foreign-exchange lines between Allentown and New York.

A. E. BACHELET, D. T. OSGOOD and B. A. FAIRWEATHER have been engaged in testing the trial installations of cable circuits for broadcast program transmission. Messrs. Bachelet and Osgood were at Bedford and Mr. Fairweather visited Morristown, Reading, Pittsburgh and Bedford.

H. M. PRUDEN and H. L. JONES made several trips to Lawrenceville in undertaking tests on the voice frequency equipment at the short-wave transmitting station located there.

A. M. KOERNER and J. L. HYSKO are doing field work in connection with the elimination of static interference on open wire carrier telegraph lines. Mr. Koerner is located at El Paso and Mr. Hysko at Denver.

G. A. LOCKE arranged and recently tested a device to count the number of contacts on closely spaced open wire lines on a line section between Rockland and Bath, Maine. This work is in conjunction with experiments now being made to determine how closely wires can be spaced with safety. R. S. Alford and J. T. Lowe of the Development and Research department of the American Telephone and Telegraph Company and J. A. Carr of the Outside Plant Development department were at Rockland with Mr. Locke.

W. J. LACERTE made two trips during the month. The first was to Olean, N. Y., where he observed the operation of a trial installation of eight party rural line service, and the second was to Hartford for studies of double connections on line switches.

M. A. FROBERG visited the Bull Dog Electric Products Company at Detroit to discuss the application to Bell System needs of safety type fuse mountings and switches for use in telephone power plants.

PATENT

THE FOLLOWING MEMBERS of the Patent department visited Washington, D. C., during the period from July 6, to August 6, 1929, in connection with the prosecution of patents: J. H. Cozzens, E. V. Griggs, and G. H. Stevenson.

J. W. SCHMIED has been in Europe, stationed for the most part in London, and making trips to the Continent assisting the Electrical Research Products, Inc., in prosecuting applications for patents.

OUTSIDE PLANT

C. S. GORDON made a trip to M. Klein & Sons Company and to the R. H. Buhrke Company in Chicago to observe the manufacturing progress of linemen's climbing equipment. Mr. Gordon also visited the Reliable Electric Company in connection with the production of mechanical attachments for drop wire.

C. R. MOORE made several trips to the Reliable Manufacturing Company at New Haven, in connection with developments on strand dynamometers.

E. M. HONAN visited the Solar Compound Corporation at Linden, N. J., where he discussed matters in

regard to the manufacture of weatherproofing materials for braided rubber insulated wire.

C. H. AMADON has been at the plant of the National Lumber and Creosoting Company at Salida, Colo., to observe full length creosote treatment of lodgepole pine poles.

C. H. KLEIN spent a few days at Clarksburg, West Virginia, in connection with work on transposition brackets in the Cumberland-Parkersburg line.

J. G. BREARLEY has been transferred to the Lead Covered Cable Development department from the New York Telephone Company and will be engaged in trial installations and other field work on lead covered cable. He recently visited Hawthorne in connection with tests of the handling qualities of some new types of cable.

R. C. JONES of the Lead Covered Cable Development department at Hawthorne was in New York to discuss general cable problems.

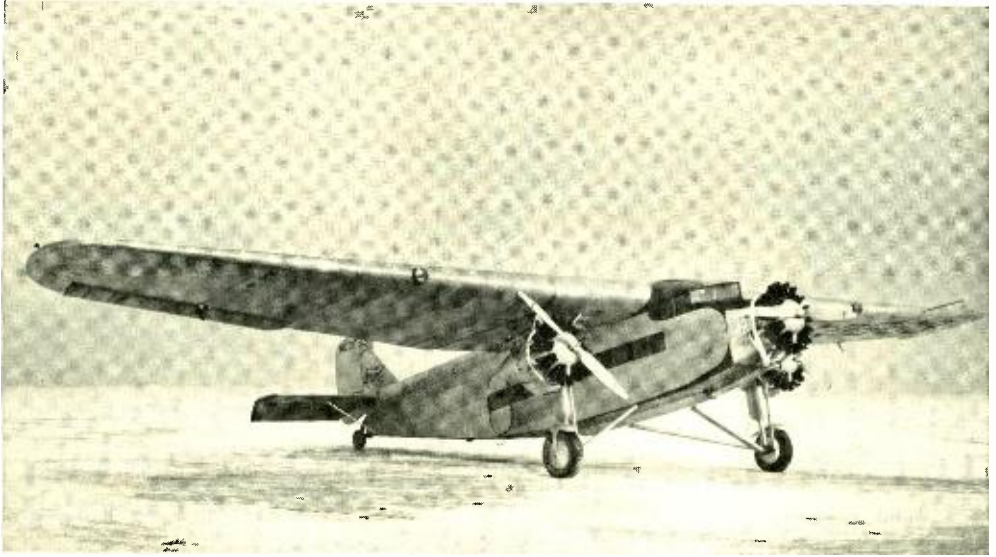
INSPECTION ENGINEERING

A. F. GILSON and E. G. D. PATERSON visited Brazil, Indiana, where



they attended three conferences at the plants of clay products manufacturers to inaugurate inspection surveys on clay conduit. The following week Mr. Paterson attended a similar conference in Aultman, Ohio.

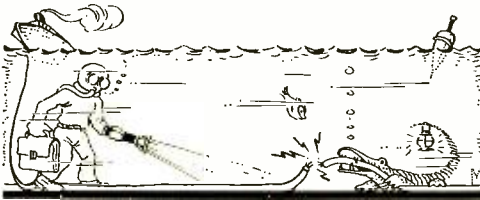
W. A. BOYD and L. G. HOYT attended the first inspection survey con-



Ford-Stout airplane similar to the one recently ordered for the Laboratories (p. 27)

ference on sound picture apparatus which was held at Hawthorne during the second and third weeks of July.

O. S. MARKUSON during the early part of the month conducted an investigation of cable trouble encountered



in the lead covered submarine cable crossing the Mississippi River near Greenville, Mississippi.

S. H. ANDERSON attended an inspection survey conference on ringing machines at the plant of Holtzer-Cabot Electric Company in Chicago.

R. J. NOSSAMAN attended a conference of representatives of the New England Telephone and Telegraph Company and Western Electric Company in connection with field engineering work in Boston.

C. A. JOHNSON, JR., has been ap-

pointed field engineer in the Chicago territory, replacing H. J. Knowlton who has been transferred to Western Electric Company.

P. H. BETTS visited Hawthorne to study inspection procedures applying to amplifiers and allied apparatus used in radio broadcasting.

APPARATUS DEVELOPMENT

F. F. LUCAS has been appointed a delegate to represent the American Society for Steel Treating at the Fiftieth Anniversary celebration of the American Society of Mechanical Engineers. Anniversary meetings will be held in New York and Washington during the week of April 7, 1930.

L. E. DICKINSON and D. W. MATHISON visited Stamford, Connecticut, in connection with contact resistance studies and the installation of step-by-step equipment.

DURING THE LATTER PART of July and the first two weeks of August C. E. Nelson was at Harrisburg, Pennsylvania, making contact-noise

studies. E. Montchyk also visited Harrisburg in this same connection.

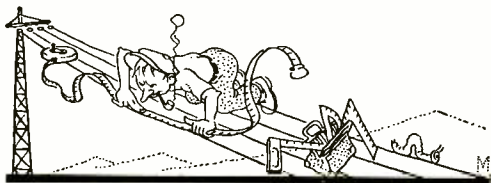
C. H. GREENALL visited Waterbury to discuss hardness testing standards with representatives of the American Brass Company.

T. E. SHEA is co-author with K. F. Morgan of the Electrical Research Products, Inc., of a paper *The Electrical Engineering of Sound-picture Systems* to be presented this month at the Pacific Coast Convention of the American Institute of Electrical Engineers.

J. E. CROWLEY spent several days in Atlantic City inspecting the operation of the Public Address System installed in the Atlantic City Convention Hall.

R. V. TERRY visited the Bausch & Lomb Optical Company in Rochester.

F. W. CUNNINGHAM and L. G. YOUNG visited stations WKBW, WGR and WMAK to measure an-



tenna characteristics. These stations are located in Buffalo and are operated by the Buffalo Broadcasting Corporation.

W. L. BLACK was in Cincinnati to confer with representatives of the Crosley Radio Corporation on speech input equipment for the enlarged studio to be located in their new manufacturing building.

J. C. HERBER was in Memphis on a survey to relocate the broadcasting station of *The Commercial Appeal* in that city.

F. A. HINNERS supervised the conversion to crystal control of the 1000-

watt broadcasting equipment of the Defenders of the Truth Society at Carlstadt, New Jersey.

O. W. TOWNER supervised the installation of a 1000-watt broadcasting equipment for the Reynolds Radio Company of Denver, Colorado. He was also in Enid, Oklahoma, on a survey for a 5000-watt broadcasting equipment for the Champlin Refining Company.

J. N. REYNOLDS, JR., and O. F. FORSBERG were in Hawthorne recently to confer on developments in dial-system apparatus. While at Hawthorne Mr. Forsberg attended a meeting of the sub-committee on dial cost reduction.

V. F. MILLER visited Hawthorne in connection with developments on terminal banks for step-by-step switches.

R. A. OGG was at Hawthorne during the early part of the month to confer on recent developments in resistance apparatus.

R. L. TAMBLING spent several days in Kingston, New York, making contact studies on pilot-wire regulators in the toll system.

GENERAL STAFF

INFORMATION has been received that Miss Gertrude M. Hanlon, a general clerk in the Personal Purchase department, died July 24, 1929. Miss Hanlon's connection with the Laboratories began in September, 1928.

DURING THE MONTH H. W. Dippel visited the Quackenbush Manufacturing Company of Cleveland to confer with company representatives in regard to supplies of welded leads for use in vacuum-tube manufacture. The following day, in company with Pilot A. R. Brooks, a visit was made

to the Ford Motor Company at Detroit to discuss delivery of a tri-motored airplane for the Laboratories.

B. B. WEBB made a trip to Lawrenceville to discuss commercial matters concerned with the installation of short-wave transmitter equipment.

W. L. KIDDE went to Boston to

relating to procurement of material for the Laboratories' use. Mr. Lillis' stay extended to a week.

R. W. MUTCHLER visited the John A. Roebling and Sons' factory at Trenton concerning the purchase of special wire for use in vacuum tube manufacture.

PUBLICATION

JOHN MILLS delivered a talk before the physics teachers group at the summer session of Columbia University on the physics of speech and hearing. Mr. Mills' remarks were supplemented by demonstrations with phonograph records and sound picture films in charge of G. F. Fowler.

* * *

Under the title "Elementare Einführung in die Wellenmechanik," K. K. Darrow's paper "Introduction to Wave Mechanics" is reprinted in German. The translation is by Dr. E. Rabinowitsch, who has added material on the statistical significance of wave mechanics and its application to complex systems. In an introduction, Professor Schrödinger refers to Dr. Darrow's paper as one "an der ich den klaren, leichtverständlichen Aufbau und die einfache, folgerichtige Linienführung bewundere."

This paper—the fourteenth in Dr. Darrow's series, "Contemporary Advances in Physics," appeared originally in *Bell System Technical Journal* for October, 1927, and is available in pamphlet form as No. 273 of the Laboratories' Technical Reprints.



Foreman J. M. Reilly instructing Watchman James Sullivan in his duties at the entrance to the new sound-picture laboratory (p. 20)

confer with representatives of the New England Telephone Company on billing problems arising in connection with trial installations.

L. S. LILLIS was at Hawthorne to discuss with the Manufacturing and Merchandise departments questions



Club Notes

THE cry of "Play Ball!" by Umpire McMann on the evening of July 8 started one of the hardest fights a Laboratories ball team ever took part in. Our opponents on that memorable evening were our old enemies from the New York Telephone Company's Long Island Division. The West Street men had their backs to the wall, fighting for the chance to meet the Eastern Manhattan team in the post-season series. Every man on the team was up on his toes giving the best that was in him but that was not enough. Our opponents too wanted to take part in this little "world's series" and a share of the prize money.

Both could not win and it was our misfortune to be on the short end of a 6-4 score. The game was all that a ball game should be but all the breaks of the game went to Long Island and this, coupled with two errors by our team cost us the chance to put out of the running the team that had stood between us and the championship series for two consecutive years.

In the Club Departmental League history repeated itself again in 1929. The team representing the Systems Development department duplicated their performance of 1928 and carried off the departmental championship. This group of men, captained and managed by Lew Drenkard, completed the league schedule with five victories and one defeat, winning from teams that were considerably stronger than those that

they met in 1928. Each player on the team will receive a prize and the championship trophy will presumably rest alongside those now reposing in Mr. Dixon's office.

TENNIS

The Bell Laboratories Club will hold a doubles tennis tournament during September and October. All matches will be played at the Mammoth Courts, New York Avenue, Brooklyn, starting at 2 P.M. Saturday afternoon, September 7, 1929.

Players will do their own pairing except where a player is unable to secure a partner. In such cases he will be assisted by the Tennis Committee. Play in the semi-final and final matches will be the best three out of five sets. All other matches will be two out of three sets.

Teams winning their first match on September 7 will be requested to play their second round matches at 4 P.M. that day. An entry fee of two dollars will be charged for each man competing. All other costs will be carried by the Bell Laboratories Club, according to arrangements made by the Tennis Committee.

BOWLING LEAGUES

The 1929-1930 Bowling Season will open Friday, September 27, at Dwyer's Alleys, 1680 Broadway, near 53rd Street. Four groups of eight teams each will furnish the regular competition. As in the past years, provision will also be made for the

use of a few alleys for bowlers other than the regular team members. Announcements will be made later.

All those who desire to bowl during the coming season should inform the committee as soon as the notices come out so that final arrangements for the teams and alleys can be made early in the month.

Women's bowling will start Friday evening, September 27, and continue regularly during the season.

Vacancies left by regular players on the teams have been filled by former substitutes so that four teams have been made up. However, this does not close registration for this activity. Two alleys will be reserved for those desiring to be entered as substitutes, with the possibility of becoming members of the teams. Further information may be obtained by calling Marion Kane, Chairman of the Substitute Committee, Extension 774.



EMILE BERLINER, *inventor of the variable contact transmitter, and of the use of the induction coil as applied to the telephone, died at his home in Washington, D. C., on August 3, in his seventy-ninth year.*

In November, 1878, Mr. Berliner became identified with the Bell Company, and at their request, early in 1879, he was instrumental in putting the newly developed Blake transmitter into commercial shape. His later activities in the field of sound recording and reproduction are marked by a number of patents, dating as far back as 1887, which embody methods and apparatus still recognizable in present-day systems.

Mr. Berliner has been a frequent visitor to the Laboratories in recent years. His well-known signature appears in the Visitors' Register in the Historical Museum, among the signatures of other famous men. During his visit in February, 1926, he was photographed with W. L. Richards, Consulting Historian, who worked with him in the Laboratories in Boston in 1879; this photograph appeared in the April, 1926, issue of the RECORD.

Contributors to this Issue

H. G. BLOCKLIN came from German schools to the United States, to continue his training at Cooper Union. In 1911 he received the B.S. degree in electrical engineering and in 1916 the E.E. degree, meanwhile holding positions first with the New York Edison Company and later with the New York Telephone Company. Coming to the Systems Development Department of these Laboratories in 1922, he was concerned with cost estimating, then with dial equipment engineering, and later with the development of private branch exchange systems. He returned to the Telephone Company last May.

J. A. COY received the E.E. degree from Syracuse University in 1915 and, after one year as technical apprentice with the Westinghouse Electric and Manufacturing Company in East Pittsburgh, joined the Equipment branch of the Long Lines Department of the American Telephone and Telegraph Company. First in

Buffalo and later in New York he received twelve years of wide equipment experience in the field. A year ago he was transferred to the Systems Development Department of these Laboratories for the development of toll equipment.

C. H. G. GRAY received the S.B. degree from Massachusetts Institute of Technology in 1918. After a year as instructor in electrical engineering there, he joined these Laboratories. In addition to his work on the Master Reference System, he has worked on the development and application of machine testing methods for the inspection of transmitters and receivers.

R. W. HARPER's telephone career began as soon as he came to America from Scotland. After three years with the Plant Department of the Cincinnati and Suburban Telephone Company, and seven years of wide field experience with the Installation Department of the Western Electric



J. A. Coy



C. H. G. Gray



R. W. Harper



B. B. Webb



J. L. Larew



H. Pfannenstiehl

Company, he entered the Engineering Department of the Michigan Bell Telephone Company in 1917. During the World War he served in the Signal Corps, and at its conclusion he joined these Laboratories. His work here has been in circuit design, especially, for the past six years, that of private branch exchanges, on which he now supervises the work.

J. L. LAREW received a B.Sc. degree in mechanical engineering from Rutgers College in 1917, and during the following five years he held positions with several engineering and construction companies, gaining a varied engineering experience. In 1922 he joined the Laboratories and was assigned to the power division of the Systems group. Since then he has been engaged in the development of manual and toll power equipment.

H. PFANNENSTIEHL, after graduating from Lowell Institute in 1909, spent a short time with the B. F. Sturtevant Company and the Mergenthaler Linotype Company and joined the Engineering Department of the

Western Electric Company in 1911. He spent two years on the development of printing-telegraph apparatus, and in 1913 was transferred to the Bell Telephone Manufacturing Company in Antwerp, Belgium, for machine switching developments. In 1914 he returned to New York to engage in the development of apparatus for the printing telegraph, picture transmission, and sound pictures.

B. B. WEBB received the B.E. degree from Union College in 1912 and, coming to the Engineering Department of the Western Electric Company and passing through its student course, joined the Research Department in 1913. There he worked on the telephone repeaters whose development culminated in the transcontinental line, and participated in the early ship-to-shore and transatlantic radio development, on the steamship "New Hampshire" and at Arlington and Montauk. Becoming interested in the commercial phases of the work, he took charge of the Purchasing Department in 1920, and later became Commercial Relations Manager.