BELL LABORATORIES RECORD

1883
HAROLD D. ARNOLD
1933

Articles Descriptive of

RADIO TELEPHONE EQUIPMENT FOR CARIBBEAN SERVICE

AUGUST 1933 VOL. 11 NO. 12

Bell Laboratories Record

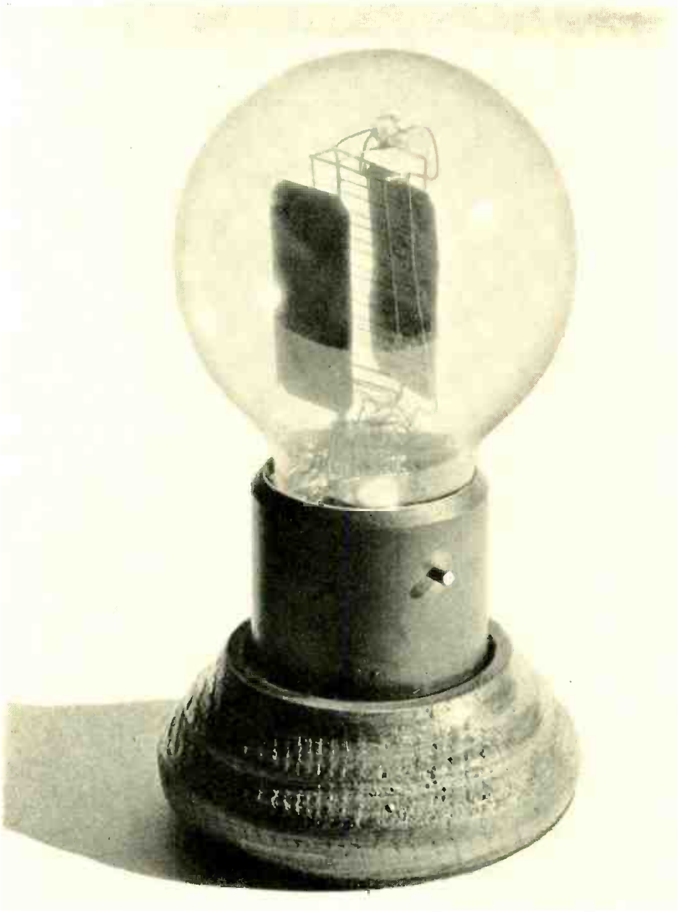
Edited by the Bureau of Publication:

Paul B. Findley — *Managing Editor*
Philip C. Jones — *Associate Editor*

Bell Telephone Laboratories, Incorporated
463 West Street, New York, N. Y.

In this Issue

BELL LABORATORIES RECORD



Three electrode high-vacuum thermionic tube, developed by H. D. Arnold; used in 1914 as a repeater element in transcontinental telephony

VOLUME ELEVEN—NUMBER TWELVE

for

AUGUST

1933

H. D. ARNOLD

Director of Research, Bell Telephone Laboratories

1925 — 1933

Harold de Forest Arnold

Born September 3, 1883, at Woodstock, Connecticut

Died July 10, 1933, at Summit, New Jersey

A HEART attack, after only a few hours' warning, abruptly terminated a life of many helpful friendships and a career of great importance to the arts of electrical communication.

Completing his formal education in 1911 with his doctorate in physics at the University of Chicago, Harold Arnold became a research physicist in the Bell Telephone System. Within three years, as a result of his development of the three-electrode vacuum tube into a stable and distortionless amplifier of telephone currents, new engineering techniques were available in telephony and the modern basis had been established for all forms of electrical communication. Telephony was no longer limited to distances like that between New York and Denver: nationwide telephone service became possible and was signalized by the opening of New York-San Francisco service in 1914.

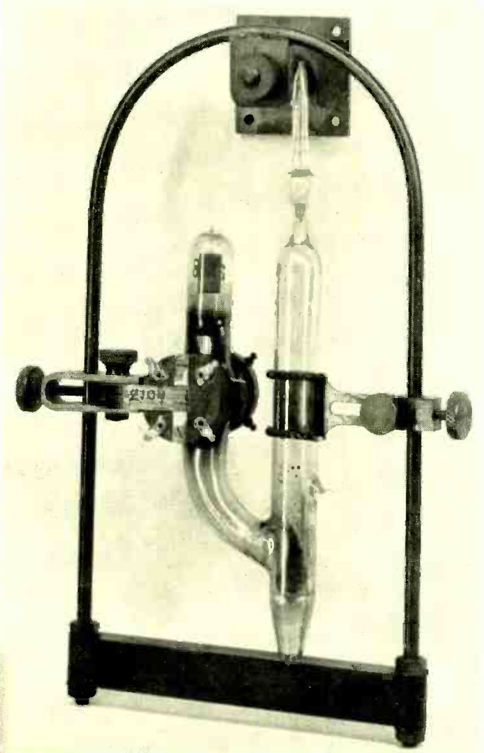
A year later Dr. Arnold's further developments and his appreciation of the physical principles involved in vacuum-tube operation and in electrical communication permitted the then startling achievement of radiotelephone transmission from Washington to Paris. World-wide telephone communication became practicable; and in addition there was laid a foundation on which was to rise the entire art of radio broadcasting.

The vacuum tubes which he developed, because they could amplify telephonic currents without distortion, permitted the use of smaller gauge and less expensive transmission lines than would otherwise have been required. A series of economies in long-distance transmission was thereby initiated, to which contributed also the utilization of these tubes in "carrier-current" terminal equipment for the simultaneous transmission of several messages over a single pair of wires. The present long-lines plant of the Bell System, in every mile of its wide-spread network and in each of the quarter million vacuum tubes which are employed in repeater or terminal stations, bears witness to the importance of Dr. Arnold's contributions and to their utilization and extension.

With his development of the vacuum tube and his early conclusions as to its application to wire and radio transmission, telephony began a new era. It passed the limits normally defined by the word "telephony" and became a new art of electrical communication with broader basic principles and with concern for the electrical transmission of intelligence in any form. Hundreds of explorers poured through the pass which he had opened into a new field of scientific investigation and the combined result of all their activities is the present high state of the communication arts.

His contribution to telephony began in January, 1911, when he entered the Engineering Department of the Western Electric Company and started work under the supervision of Dr. E. H. Colpitts. The necessity of extending the length of its long distance circuits had been fully recognized by the American Telephone and Telegraph Company, and the problem was to be undertaken with every aid of scientific knowledge and research technique which was available. A successful transcontinental telephone circuit was the immediate goal as set by General J. J. Carty, its Chief Engineer. To establish such a service economically, it was also recognized, there was necessary a telephone repeater certainly greatly improved over anything then available but more probably operating on an entirely different principle. Appreciating that the field of electron-discharge phenomena offered very substantial possibilities of affording a solution of the repeater problem, Dr. F. B. Jewett wrote to Professor Millikan, recognized even then as preeminent in that field of physics, and asked him if he could recommend a man to undertake the development of electron-discharge repeaters. Professor Millikan replied saying that he had a man

"who is taking his degree this fall, so that he could go into the employ of the telephone company, if you can make arrangements with him right away. His name is H. D. Arnold. I have had intimate association with him ever since 1907; I regard him as one of the ablest men whose research work I have ever directed and had in classes; and also I know him intimately as a man of the highest character in every particular, and a man who would be satisfactory for the purpose you have in mind."


Mercury-arc element for telephone repeater, developed by Dr. Arnold in 1912

After a brief review of certain aspects of the telephone repeater problem, Dr. Arnold turned his attention to the development of a suitable element. He first directed his efforts to devices employing a mercury arc; and by July, 1912, he had produced a repeater element employing a mercury arc. This was used commercially to a limited extent.

Quite promptly, however, his attention was called to the "audion" of Dr. Lee DeForest, one of the most interesting and important inventions in modern electrical art. Although at that time a very crude instrument incapable of being used as a repeater in the telephone plant, Arnold recognized the possibilities inherent in this instrument and with the full concurrence and support of those responsible for the long toll-line program, he undertook the development which, starting on the basis of DeForest's three-electrode audion, resulted in the production of the modern three-electrode high-vacuum thermionic tube.

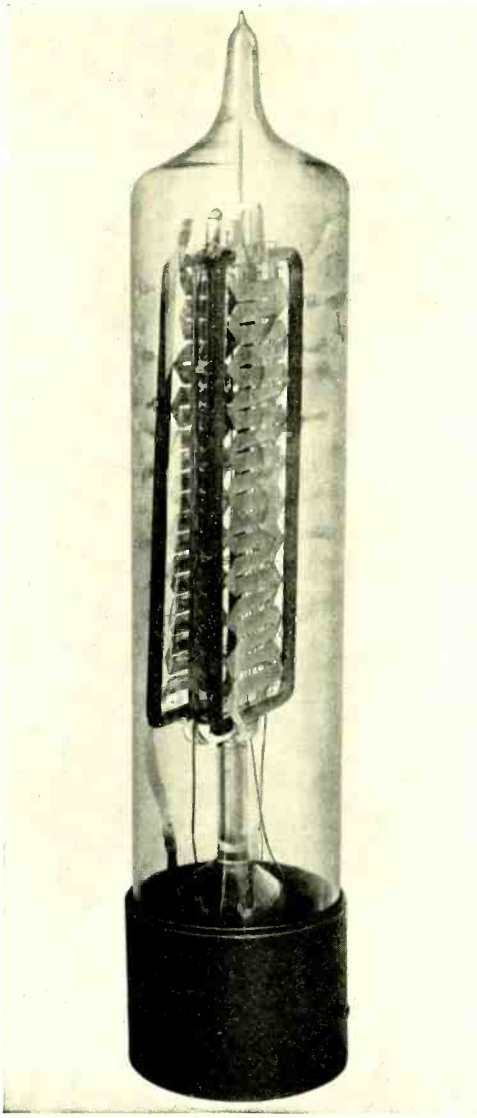
Dr. Arnold's contibutions at that time may be briefly listed as: first, the appreciation of the necessity of a high vacuum, and the development and application of methods for obtaining such a vacuum; second, the recognition of the existence and the importance of the space-charge effect of electrons in such a high-vacuum device, and the calculation of the magnitude of this effect and methods for its adaptation to commercial purposes; third, the development of the theories as to and means for obtaining proper physical constants for the tube in the way of input and output impedances and amplifying ratios; and fourth, the adaptation of tubes involving these newly developed principles to the telephonic problems of long-distance wire telephony and also of radio telephony. He developed designs for these tubes and methods for their manufacture such that they could be reproduced with accuracy and that dependable and interchangeable tubes could be made to meet the telephonic requirements of reliability and ease of maintenance. This work included not only the development of principles as to the spatial relations of the mechanical parts of the tubes but also the development, under his immediate direction and at his suggestion, of an oxide-coated filament as a source of electrons within the tube.

These advances in electronics were so quickly accomplished primarily because of his unique ability in research.

Snapshot of Harold Arnold taken at Arlington in 1915 during early experiments in transatlantic radio telephony

Instead of looking at the audion as did radio engineers, to whom it had been for years a familiar device, he considered it as a specific instance in the general problem of conduction of electricity through vacua. Instead of studying it first by its action when supplied with alternating current whether of radio or telephonic frequencies he investigated its static characteristics with direct current. Invariably in attacking a problem he saw it so broadly and philosophically that it usually fell into its proper scientific relationship and disclosed thereby the desired line of attack. A philosophical attitude, real intellectual curiosity, and good manipulative ability, with an up-to-date background of education in physics, made his investigation rapid and creative. A marked modesty, however, withheld him from publication of even those portions of his work which involved no patentable material. The records of these important researches are largely contained in intracompany memoranda and in his laboratory notebooks.

The series of advances in communication which his work stimulated, and also his own researches, suffered some delay during the next few years due to the World War. For a portion of that time he served as a Captain in the Signal Corps and personally conducted researches in problems of submarine detection while directing other wartime investigations by his group of assistants in the Western Electric Company.



Twenty-five watt power-tube designed by Dr. Arnold, and used in the first transatlantic radio-telephone transmission

During these years he had supervisory responsibility for a rapidly growing corps of assistants who continued investigations in the field of thermionics or struck out as pioneers in other fields of research which were similarly essential to the progress of the communication arts.

One of these fields was the physics of speech and hearing. Ever since the epoch-making invention of Alexander Graham Bell that had continued as a field of investigation fundamental to telephony. Much had been learned in the years between Bell's work and Arnold's; but the total volume of knowledge acquired was relatively microscopical as compared to that which derived from the Bell System scientists whose investigations Arnold inspired and directed.

It was Arnold more than anyone who first visualized the vacuum-tube amplifier as a research tool in these investigations. And it was Arnold who conceived a basic philosophy of research in this almost unexplored field which has led to the most varied and remarkable achievements of communication engineering. Through hours of conference each day, enlivened by his quick penetration and scientific ingenuity, he worked for years guiding, stimulating and occasionally correcting the efforts of several scores of investigators in a coordinated attack on the fundamental problems of speech and hearing.

Modest and retiring, he kept back

his own name; and the researches are known, as he wished them to be, by the names of those who conducted them, rather than by that of the master mind who broadly conceived and sympathetically coordinated. That attitude is illustrated in one of his few published papers, a description of the objectives and activities of the Research Department of Bell Telephone Laboratories, of which he was the Director from the time of its formation in 1925 until his death. He there said in part:

"The fundamental duties of the Research Department are to obtain new scientific knowledge which may serve our art, and to consider ways in which this information may be utilized. Of its output, inventions are a valuable part, but invention is not to be scheduled nor coerced: it follows research through the operation of genius; and the best that any department can do to promote it is to provide a suitable environment. . . .

"When we plan to find new facts of Nature we must approach with care and circumspection, for she indeed 'speaks a various language,' and her response can only be obtained by those who devote themselves patiently and with the utmost skill to her pursuit. She reveals herself most readily and understandably through the medium of ingenious and precise experiments, and for these experiments diverse and often complicated facilities are required. So for the pursuit of new knowledge the Research Department must equip itself with facilities which often little resemble the ordinary tools of our industry, and must seek continually new and more ingenious devices by which to compel Nature's secrets. . . .

"It is not, however, so much the nature of the facilities as their diversity which is most impressive. Our research problems are scattered along the whole frontier of the sciences which contribute to our interests, and extend through the fields of physical and organic chemistry, of metallurgy, of magnetism, of electrical conduction, of radiation, of electronics, of acoustics, of phonetics, of optics, of mathematics, of mechanics, and even of physiology, of psychology, and of meteorology.

H. D. Arnold, champion, with E. B. Craft, during the 1925 *golf tournament of the Bell Laboratories Club*

"With problems and facilities so diverse, but with specialists chosen for each field, the administrative function of the Research Department resolves itself chiefly into the maintenance of facilities and the coordination and distribution of information in such a way that each man may take to his own problem the most adequate

Dr. Arnold demonstrating to Dr. C. E. Seashore the operation of the audiometer, an early development in the series of investigations of speech and hearing

means of solution and may at all times be in touch with progress at other points. It would be deadly to standardize too rigidly this administrative assistance. It can, however, be coordinated in such a way as to produce real economy of operation if in its giving there is always the keenest appreciation of the specific needs of the individual investigator and if the line of supplies and service is kept in personal touch with him as he advances.

"No organization or method of administration can create the vital spark of the investigator. It is born in the fiber of the individual. It can, however, be encouraged to expression; and working in contact with like spirits it gains an associated strength that is indomitable.

"The Research Department, then, to fulfill its fundamental duties, is organized and administered with a view to fostering the spirit of research in its individual investigators, to associating them so that individual and group experience may find its most useful expression, and to providing the best possible facilities for the materialization of their ideas."

Such was his attitude; and that combined with his own scientific genius and his clear philosophy of objectives and methods is credited as a major cause of their individual and group achievements by the scores of scientists who during the past twenty years have explored the fields of speech and hearing.

The only published record of that guiding philosophy is contained in the introduction which he wrote to the book on "*Speech and Hearing*" by Dr. Harvey Fletcher. Only in a portion of a sentence can one glimpse in that introduction the profound influence which he had in the work the book records. His responsibility for the broad plan of investigation is implicit in this sentence:

"The work is not complete—indeed some parts of it are hardly more than started; yet its results have been so great, both for the original purpose which was planned and for the many issues which have since arisen, that it presents a unique exemplification of the worth of systematic and sustained research."

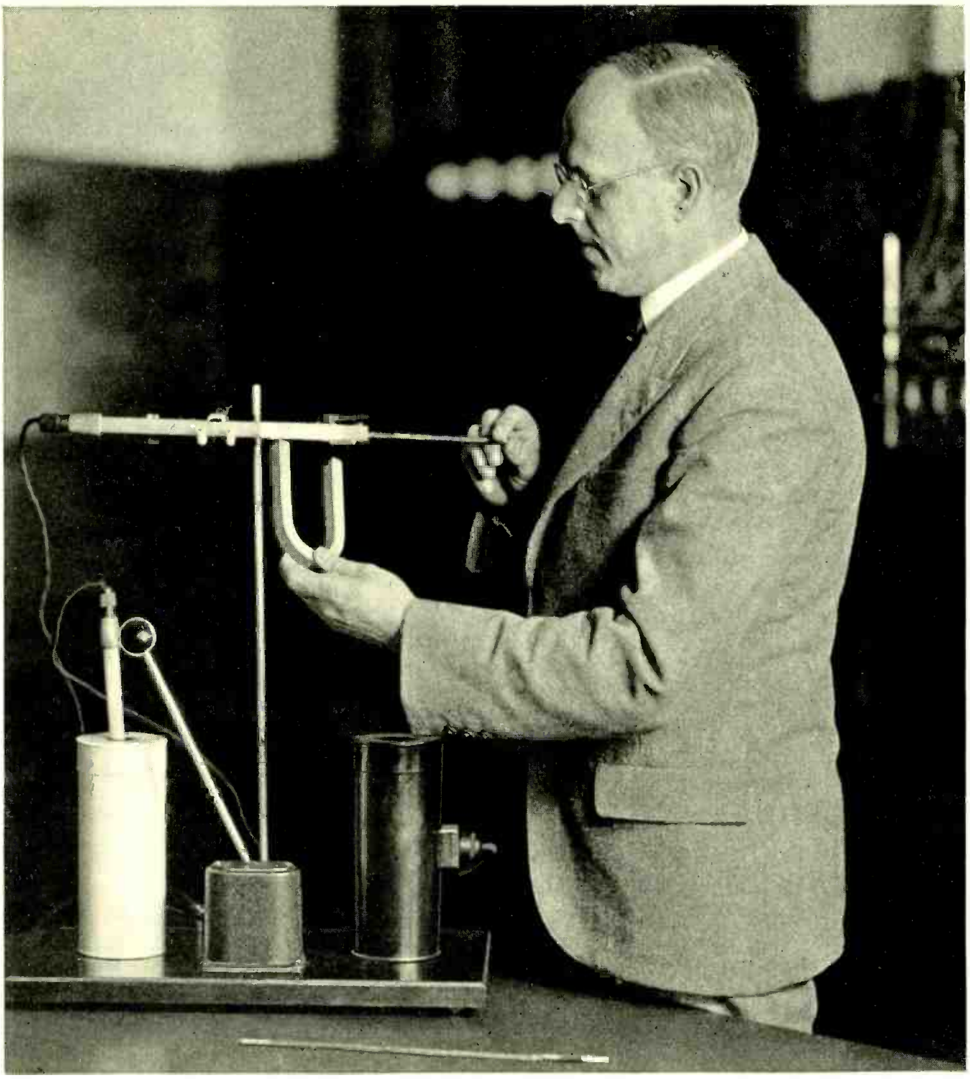
The philosophy which underlay all the Laboratories' researches relating to speech and hearing, Arnold expressed briefly in that introduction in the following words:

"Our ears are only machines to translate air waves into a form suited to stimulate the auditory nerve; and as machines we may measure and describe them in the same terms that apply to devices we ourselves construct. We may compare them as to performance, and may accommodate our devices to their requirements. But, to understand the mechanism of the ear is by no means to understand the act of hearing, for we have not heard until the brain has perceived the message sent by the auditory nerve. We cannot explain in precise mechanical terms how this is done, nor indeed have we any very clear comprehension of the process at present. Some important factors relating to the process of hearing we can, however, determine by measuring the least changes in sound which can be detected under a variety of conditions of pitch, loudness, and accompanying noise. Thus we may obtain a quantitative means of comparing individuals in this respect and establish a standard of average hearing.

"There is a most important factor in hearing, however, which is much more difficult of analysis and measurement. This is the individual's ability to recognize small defects in those sounds with which he has become especially familiar. We all know how quickly we note a slight change in a friend's voice, and with what uncanny skill a trained musician will detect minute imperfections in very complex sounds. Our approach to a quantitative understanding of the importance of this must be by an indirect method. First we must construct devices so perfect that even the keenest ear cannot find a flaw in their rendition, and then step by step we may introduce measured imperfections until an observer can detect a fault. In the response of individuals to this test there will, of course, be great differences; but when we have collated opinions from a wide variety of observers we may forecast in a reasonable way the degree of mechanical perfection that may be demanded of our instruments.

"This, then, has been the philosophy of the investigation of hearing which has been carried on in Bell Telephone Laboratories during the past fifteen years: to get an accurate physical description and a measure of the mechanical operation of human ears in such terms that we may relate them directly to our electrical and acoustical instruments; to test the keenness of the sound-discriminating sense and find what is the smallest distortion which the mind can perceive and how it reacts to somewhat larger distortions; and thus to reach a reasonable basis of design both for separate instruments and for systems as a whole, to give a proper balance between cost and performance.

"With hearing, speech and music are linked inseparably for they only bring a meaning through our aural sense. It is an instinctive first thought that they must be heard to be criticized. They can, nevertheless, be investigated by mechanical means and be described in the same physical terms that we use in describing hearing; and thus to an extent we may consider them both objectively. But if we attempt to divide the study between speech and music we come at once upon the difficulty that speech conveys information by intonation as well as by articulate syllables; and this makes it infeasible to set a definite boundary between them. A division, however, between vocal sounds



Dr. Arnold as he demonstrated the Barkhausen effect in a lecture on "Science Listens" before the American Association for the Advancement of Science, Pasadena, June, 1931

and instrumental sounds proves more useful, for in the one case we are limited by our vocal organs which we must take as they are, while in the other we have a definite control and can adapt the nature and complexity of the sounds produced to conform to our sense of hearing and our musical appreciation. The investigation of speech and music has been governed by these general considerations. An attempt has been made to establish in definite terms the performance and limitation of the voice and, although so far in much less detail, to find the corresponding factors in instrumental music.

"With a clear knowledge of the nature of the sounds that we must produce and the accuracy with which we must maintain their form, there remains the problem of securing instruments which are sufficiently refined for the purpose. Instruments of remarkable precision are required in the conduct of the investigation, since if we are to measure the smallest detectable variations in sounds we must obviously use equipment which is capable of a degree of exactness beyond these small quantities. Such instruments would appear at first sight not to have much utility outside the laboratory, since they are costly and often complicated and hard to adjust.

"It is interesting to note, however, that some of the instruments, in essentially their original laboratory form, have found other important uses. Indeed, a surprising number of modern acoustical accomplishments have come about through the use of slightly modified forms of the apparatus which was originally developed for these investigations. Modern phonographic records are produced with an electrical transmitter which was developed in the very early stages of these studies; and radio broadcasting has grown up around this same 'microphone.' The reproducing equipment of the modern phonograph and of the radio were predicated directly upon these investigations; and talking motion-pictures owe their success and much of their apparatus to this same source.

"Although the results which relate to normal speech and hearing are naturally the most familiar and widely known, there have also been important outgrowths in the way of aids to those handicapped in one or the other of these faculties. In establishing the functioning of the average ear it was obviously necessary to investigate a large number of cases and among them some which departed rather widely from the average. For this study an instrument was devised, now known as the audiometer, which has put within the reach of all who need it the possibility of an accurate measure of their hearing. In quite analogous fashion there grew out of the investigation of the limits of hearing a better knowledge of ways to provide aids for those partially deaf.

"Valuable as these results are, economically the most important outcome of the work has been the increase of exact knowledge as to the requirements and limitations to be placed upon the transmission of speech in the telephone system. As time goes on there must be an evolution toward even greater perfection in those particular elements which are most important to intelligibility. The system is so large that the cost of such an evolution is immense and changes undertaken without an accurate knowledge of their value might lead to burdensome expenditures for disproportionate results; but, with the facts established by this investigation in hand, we can weigh any contemplated change and judge whether it is the one that offers most improvement at the moment and what its ultimate effect will be in its operation with other elements of the system."

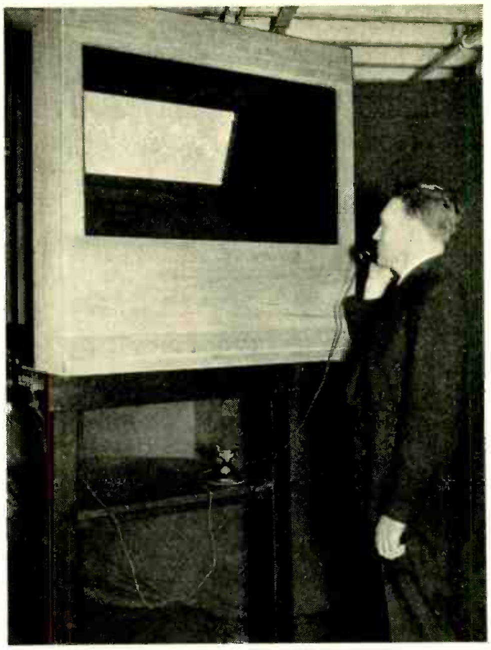
In that introduction Dr. Arnold passed over in a paragraph as merely "interesting to note that some of the instruments in essentially their original laboratory form have found important uses." The latest practical achievement, resulting from that series of researches and one in which he took great interest, was publicly demonstrated only a few weeks before his death. There was a reproduction in Washington, before a large audience, of orchestral music transmitted by telephone lines from an auditorium in Philadelphia and reproduced not only with perfect quality but also in auditory perspective.

Many other researches were conducted in his department and received his sympathetic attention. Those in magnetism, which led to the development of the remarkable magnetic alloy known as "permalloy," however, are the only ones with which his name is publicly associated.

Among the researches with which he was concerned those in the fields of electronics and of speech and hearing are the ones to which his individual contributions were greatest, and they appear to be of great ultimate value. Everyone who uses a telephone, who listens to radio-broadcasting, who attends a sound-picture performance owes a debt of gratitude to the genius of H. D. Arnold.

Research is not constructing and manipulating; it is not observing and accumulating data; it is not merely investigating or experimenting; it is not "getting the facts"; although each of these activities may have an indispensable part to play in it. Research is the effort of the mind to comprehend relationships which no one has previously known. And in its finest exemplifications it is practical as well as theoretical; trending always toward worthwhile relationships; demanding common sense as well as uncommon ability.

—From a lecture delivered by H. D. Arnold at the Lowell Institute, Boston, on January 5, 1932



Seeing Sound at the Chicago Exposition

By R. F. MALLINA
Acoustical Development

IN acquainting the visitors to the Century of Progress Exposition with some of the essentials of modern electrical communication, it seemed very desirable to allow them both to hear and to see the forms of the signal waves sent over certain types of telephone circuits, and to compare them with actual speech waves. By using an available type of loud speaker, the signals could easily be heard by a large audience. No apparatus was available, however, which would make the signals easily visible to the larger groups that gather at the exhibit, although an ordinary oscilloscope would serve to make the signals visible to one or two people at a time. But by adapting telephone apparatus to serve as the actuating element of the oscilloscope, there was developed in Bell Laboratories a new oscilloscope, shown in the photograph at the head of this article, which throws the image of the signals on a large screen where they may be seen by a considerable number of people.

The function of an oscilloscope is to represent an electric current, that varies in strength with time, by a point of light that varies in vertical distance above some base line with distance along that base. The transformation is accomplished by two separately acting mechanisms, and by employing a powerful source of light, reflected by a mirror, as the visible image. The current to be depicted is passed through a telephone receiver such as is used in the ordinary hand-set. A small spherical mirror is attached to the diaphragm of the receiver so that variations in the current tilt the mirror up and down. The mirror reflects a ray of light from a small electric lamp, like those used in automobile headlights, onto a small motion picture screen, where it may be seen by the spectators. The up and down motion of the reflected ray of light accurately corresponds to the variations of the current, and thus to

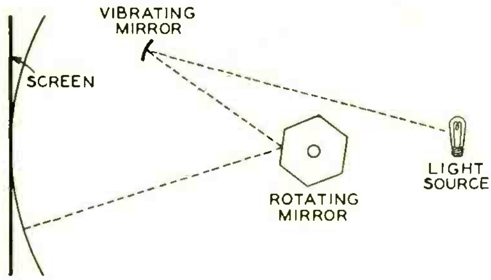


Fig. 1—*Simplified schematic of the mirror arrangement of the large oscilloscope*

the variation in pressure of the original sound.

The motion of the light across the screen is provided by a rotating mirror as shown in Figure 1. Here the mirror is shown as consisting of six plane mirrors forming a hexagon; in the actual oscilloscope twenty mirrors are employed, arranged in a regular polygon and rotated by a small motor. Light from the lamp falls on the mirror on the receiver and then is reflected to the rotating mirror. The motion of this rotating mirror throws the beam across the screen at the same time that it may be rising or falling due to the vibration of the mirror on the receiver. The faster the mirror rotates the more will the waves be spread out on the screen, and a speed is selected that will give the best effect for the ordinary sounds of speech and music.

The twenty faces of the rotating mirror successively pick up the beam reflected from the small mirror on the receiver and flash it across the screen. The mirror is rotated at thirty-three revolutions per minute, so that the time required for one of the twenty sides to flash its image across the three-foot screen is a little less than one-tenth of a second. What one really sees, therefore, is a succession of pictures, each representing the sound wave for a period of about a tenth of a second. The persistence of vision is long enough so that the curve is seen over the entire length of the screen, but not long enough to cause interference between successive images.

These oscilloscopes are used at the Exposition in association with two of the Bell System exhibits. One of them is employed to show some of the essential characteristics of speech and music. Typical speech sounds are listened to, and at the same time their wave form is watched on the oscilloscope. High-pitched sounds show waves close together, and loud sounds result in waves of greater height. Filters of various types are also inserted and their effect in cutting out certain of the frequencies is both seen and heard.

The other oscilloscope is employed to illustrate the principle of carrier current systems. Since some of the carrier currents used for carrier telephony are above the audible range of frequency, and thus could not be heard on a loud speaker, the multichannel telegraph system is used for the demonstration. The principles involved are the same, however. Multichannel telegraphy differs from carrier telephony chiefly in the value of the frequencies employed.

With the system demonstrated, twelve telegraph messages are all

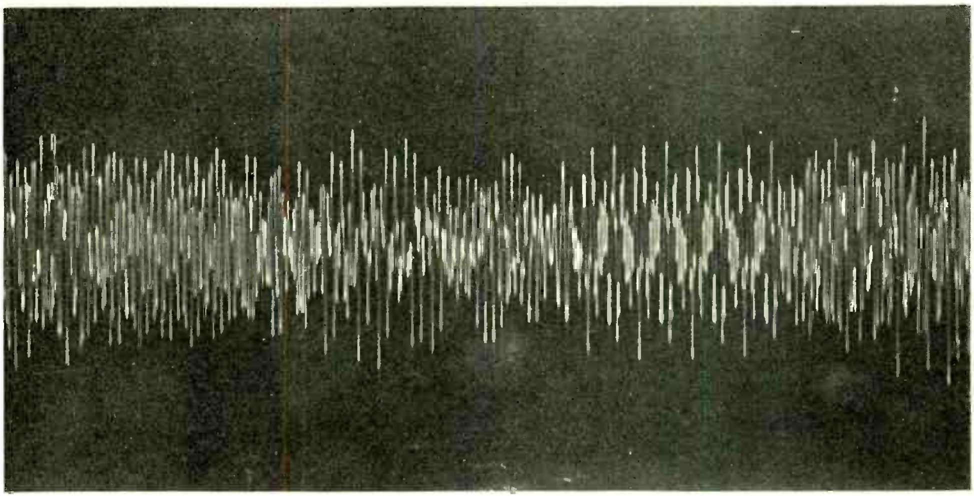


Fig. 2—The combined signal from twelve telegraph messages gives no indication of the type of message actually being transmitted

transmitted at once over a single pair of wires. At the terminals of the line is apparatus for separating the messages and routing each one to its proper receiver. This method is widely employed by the Bell System to give leased wire service for telegraph and teletype messages. To avoid the constant use of twelve senders and a valuable circuit between Chicago and some other large city during the demonstration at the Century of Progress Exposition, twelve simultaneous messages were recorded on a phonograph record at Bell Telephone Laboratories and this record is used for the demonstration.

One of the messages is in Morse Code and another in the Continental Code which is used in radio telegraphy. Nine of the messages were sent from teletypewriters and are in the code of current impulses required to operate these machines. The twelfth message is devised to operate switches in the associated demonstration apparatus.

Visitors to the exhibit can listen to the curious musical sounds which this medley of twelve messages produces on the loud speaker, but even the most experienced telegrapher can make no sense of them until the complex line current has gone into the terminal apparatus and the different messages have been separated. The appearance of the combined signal on the oscilloscope is shown in Figure 2. Visitors to the exhibit may also listen to one after another of the separate messages. When they are in Morse or Continental Code they may be easily read by a skilled telegrapher, but when they are in the teletype code, the sounds from the loud speaker have no meaning and the currents must go to a teletypewriter for interpretation. The appearance of such signals, before and after rectification, is shown in Figure 3.

Although the principles involved in the construction of this large oscilloscope were for the most part not new, a large amount of design and development was required to meet the requirements imposed by the unusual size of the image. The availability of such a piece of apparatus, however,

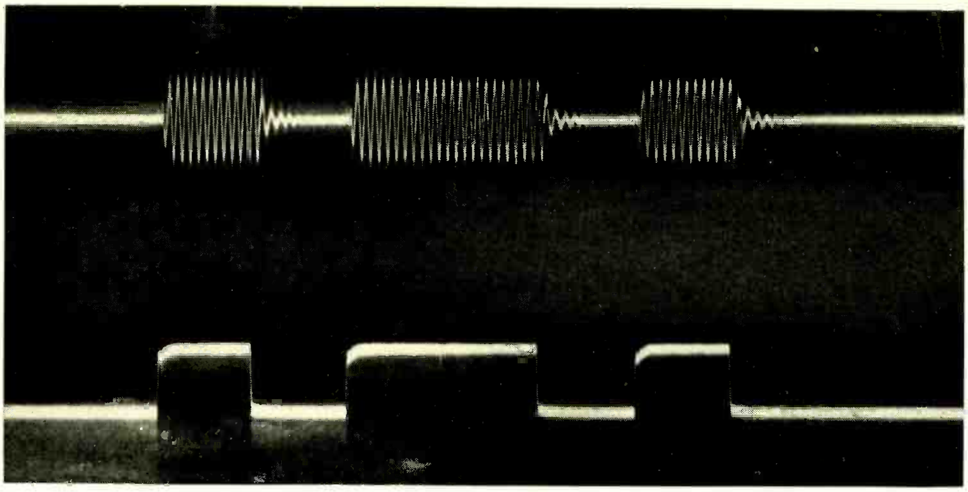
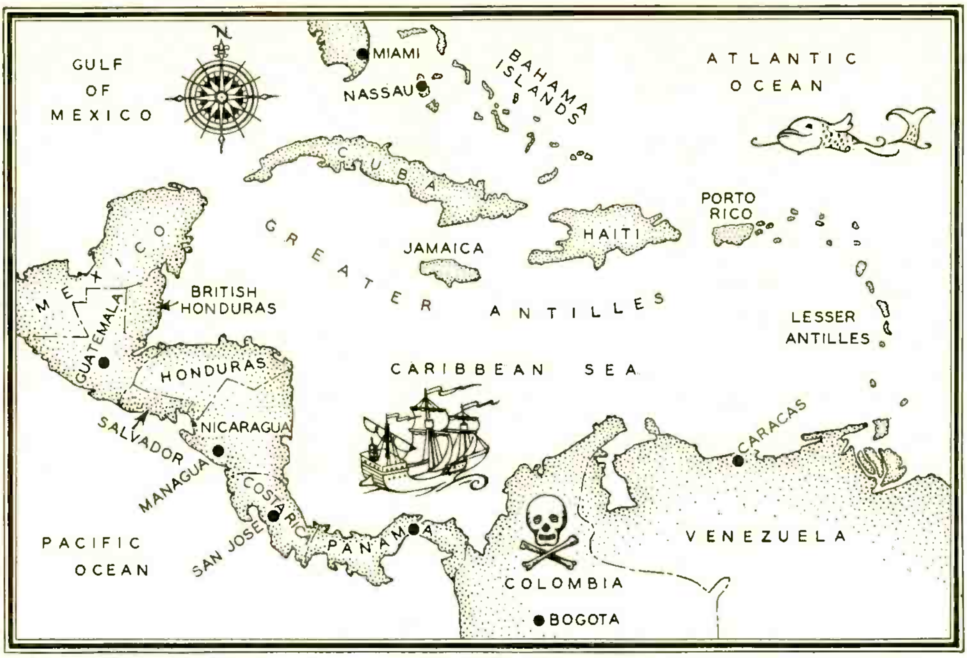


Fig. 3—Above: a short section of the carrier signal from a single teletype machine. The tone which this represents is heard by the audience. Below: the same signal after rectification; the pulses of direct current operate the teletypewriter

will not only serve to clarify to the visitors to the Bell System exhibit many of the characteristics of speech and music but may later prove very useful in colleges and lecture halls where it is necessary to explain the characteristics of various vibratory phenomena.



Radio Telephone Communication with the Caribbean Countries

BOUNDED on the north by the Greater Antillean Islands of Cuba, Haiti, and Porto Rico, on the east by the Lesser Antilles, on the south by Venezuela and Colombia, and on the west by Central America, the blue waters of the Caribbean Sea are encircled by some of the richest lands of tropical America. From these countries the Great White Fleet of the United Fruit Company brings us the prolific produce of these equatorial regions. Nearly sixty million bunches of bananas alone were shipped in during the past year. To maintain better communication with its various ports of call, the United Fruit Company, at the beginning of this century, began to establish a series of radio telegraph links which were later placed under the control of its subsidiary, the Tropical Radio Telegraph Company.

When it became evident that short-wave radio was likely to enable the Bell System to extend telephone circuits overseas to distant countries, a comprehensive plan was drawn up by engineers of the American Telephone and Telegraph Company looking toward the establishment of direct telephone connections between the United States and each of the major areas of the world. The countries of the Caribbean comprise one of the regions included in this plan. There was in mind particularly the appropriateness of connecting the Isthmus of Panama into the North American telephone network. As a result of the interest of both organizations in a

Caribbean communication system, a plan was drawn up for the joint development of the service. Somewhat later arose the opportunity of giving service to radio telephone stations which were about to be established in Venezuela and Colombia. The project which was formulated to meet these situations has now materialized as a radio telephone system linking the United States with the major Caribbean countries and with the Bahama Islands, to the southeast of the Florida coast.

The American terminal, operated by the American Telephone and Telegraph Company, occupies space leased from the Tropical Radio Company just outside Miami, Florida. The transmitting station at Opa Locka is shown in Figure 1. Transmitting equipment, described elsewhere in this issue, consists of a transmitter operating at a frequency between 4 and 5 megacycles for communication with the Bahamas, and another transmitter operating at about 15 megacycles for communication with the Caribbean countries. To minimize the amount of equipment required the system provides for the operation of only one link at a time; contact is made successively with each of the seven countries so that each receives a fair share of the daily operating time. The receiving station, shown in Figure 2, is at Hialeah, Florida. The building shown in Figure 3 houses the radio receivers and voice frequency control equipment also described in this issue.

Service arrangements in the Caribbean countries vary considerably. In Costa Rica, Guatemala, and Nicaragua connection is established to only one pay station in each country. These stations are located in the cities of San Jose, Guatemala City, and Managua respectively, but those called may be summoned to the designated pay station over the lines of the local telephone systems. The equipment in Guatemala and Nicaragua is owned by the Tropical Radio Telegraph Company, but in Costa

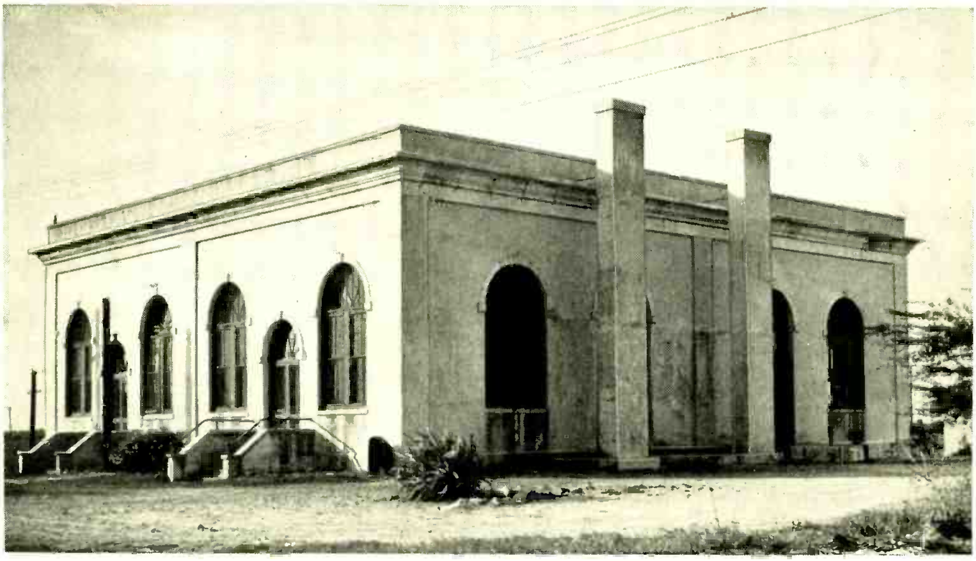


Fig. 1—Radio transmitter building of the American Telephone and Telegraph Company at Opa Locka, Florida

Rica by the Compania Radiographica Internacional de Costa Rica.

In Panama, where the equipment is also owned by the Tropical Radio Company, the facilities are available to all subscribers of the Compania Panamena de Telephonos and to all telephones of the United States government in the Canal Zone. Service to these four Central American countries is carried on at a single frequency but a separate frequency is allotted to Colombia and to Venezuela. In Colombia connections may be made with all telephones of the Compania Telephonica Central in the Departments of Tolima Cundinamarca, Boyaca Valle del Canca, and Caldas. The facilities here are owned by both the Marconi Wireless Telephone Company and the Bogota Telephone Company. In Venezuela connections may be made to practically all of the telephones of the Compania Anomina Nacional Telephonos de Venezuela, the facilities being owned by this company and by the Venezuelan government. In the Bahamas, where the equipment is owned by the Bahamas government, service is available only at three special pay stations. At the North American end the service includes all telephones of the Bell System in the United States, and telephones in Canada, Mexico, and Cuba which connect with the Bell System.

All apparatus and equipment for the new service was designed by Bell Laboratories and furnished by the Western Electric Company, except in Venezuela and Colombia, although the latter country is using Western Electric voice-frequency control equip-

Fig. 2—At Hialeah, five miles from Miami, is the radio receiving station with its rhombic receiving antennas

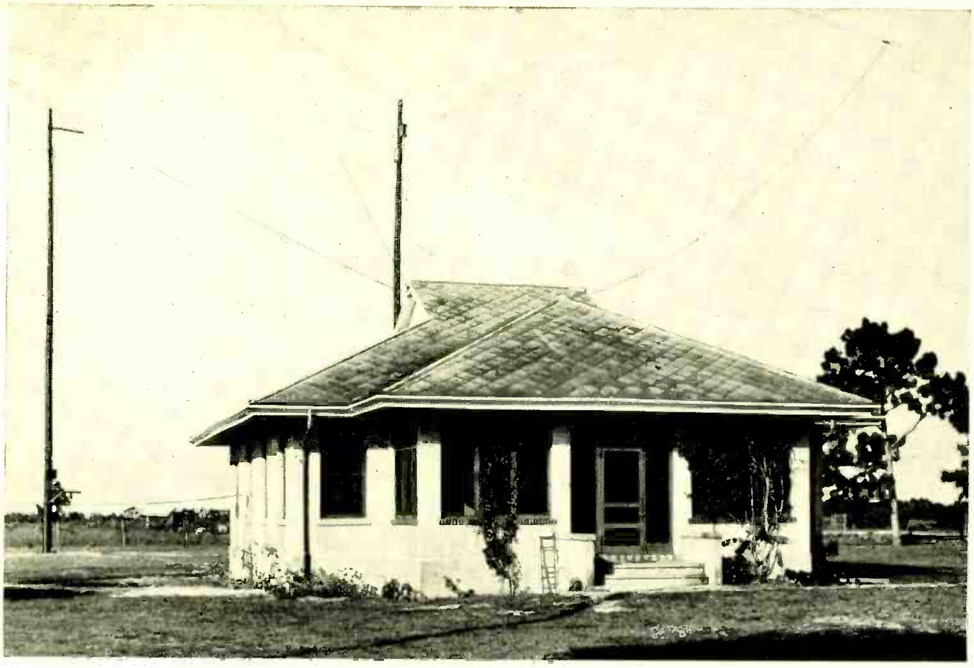
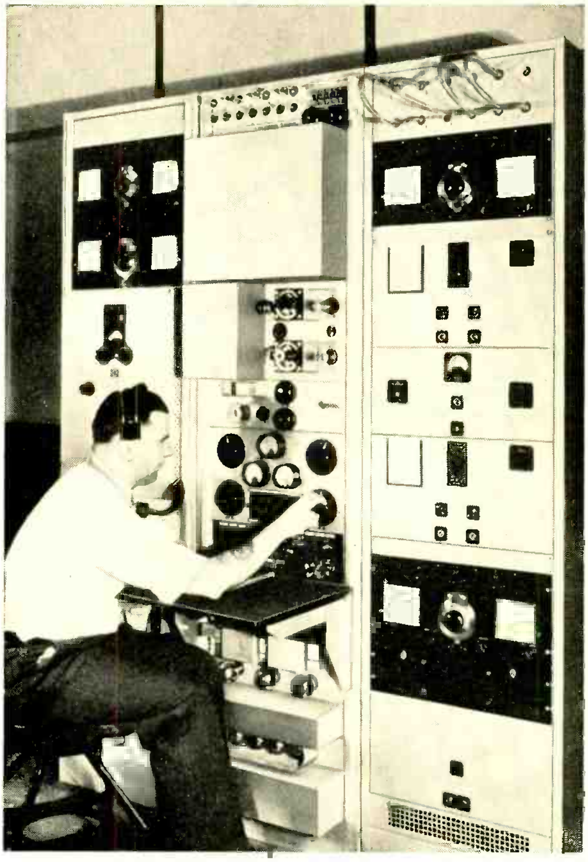


Fig. 3—Radio receiver building of the American Telephone and Telegraph Company at Hialeah

ment. Service to the different countries has been established as soon as the apparatus was installed and proper arrangements made. The Bahama circuit was opened on December 16, 1932, that with Venezuela on December 18, with Colombia on December 20, with Panama on February 24, 1933, with Costa Rica on March 20, with Guatemala on April 17, and with Nicaragua on June 7. In the accompanying articles the major features of the transmitters, of the receivers, and of the voice frequency control equipment are described and illustrated. The apparatus is of the most modern design and incorporates all the features which are essential to high grade radio telephone communication.



Voice Frequency Control Terminals for Caribbean Radio Systems

By W. A. MacMASTER
Equipment Development

LONG distance radio telephone services available to telephone users in the United States represent the utmost in quality and dependability that constant research and development has been able to produce in this branch of communication. One of the many factors contributing to the reliability of this Bell System service is the introduction of a control terminal in the voice frequency portion of the circuit between the talker's telephone set and the radio apparatus. The primary purpose of this apparatus—as of many special features included in the radio frequency equipment—is to attain the optimum ratio of useful signal to noise unavoidably introduced by radio transmission. Its purpose is accomplished chiefly by means of speech volume regulation in the two one-way circuits which pass through it—one outgoing to the radio transmitter

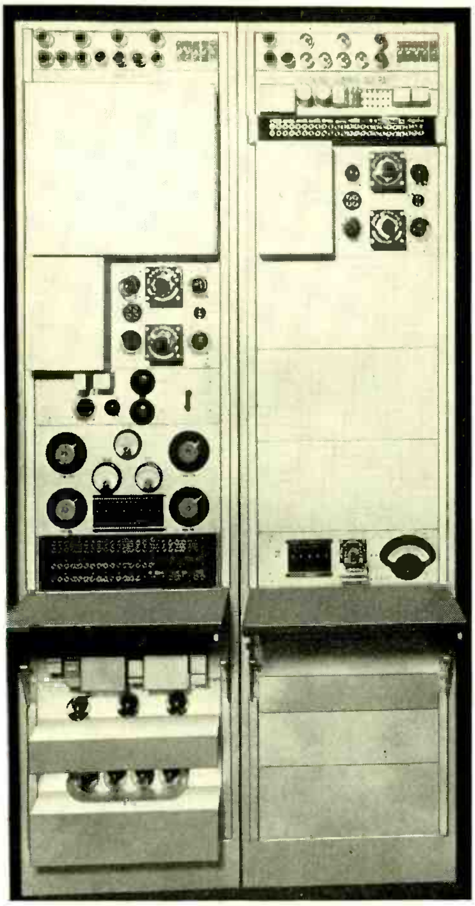


Fig. 1—Main B2 control bay at the left and an auxiliary bay, required only for some installations, on the right

and one incoming from the radio receiver. Voice frequency regulation in the transmitting path insures that there will be delivered to the radio transmitter at all times the particular constant speech volume which brings about a maximum speech energy content in the transmitted radio frequency carrier. Assuming constant output from the radio receiver, voice frequency receiving path regulation permits adjustment of received volume to the optimum value for differentiation between speech and noise.

The requirements placed on voice frequency control equipment and the apparatus it incorporates vary greatly with the type of facilities with which the unit is to be associated. In all cases the control terminal includes a voice frequency amplifier and associated manually variable attenuating networks in the transmitting path to compensate for differences in talker volume and wire line losses, and auxiliary facilities to enable the terminal attendant to observe speech volumes and to monitor and talk on all connections. However, a terminal including only these facilities is suitable for use only where connection to the radio channel is limited to special four-wire subscriber sets. When the radio circuit is to be switched to the subscribers of a telephone system over land lines of widely varied lengths and types, the control terminal must also include a device which will prevent "singing" loops and the reradiation of received speech, which might arise from land line echoes and imperfect balances at hybrid coils. Such a device is known as a vodas, and has already been described in the Record*. Receiving path volume control is always included in terminals of the latter type and may be included in the more simple type or incorporated in the associated radio receiver. Both of the above fundamental types of control terminal may or may not include maintenance facilities and line terminating equipment, depending upon local requirements and the relative locations of subscribers' stations or switchboard, terminal, and radio apparatus.

An example of highly complicated voice frequency control equipment intended to be associated with a telephone switchboard is the type A Control Terminal† used at New York

*Record, *November*, 1927, *p.* 80.

†Record, *September*, 1929, *p.* 15.

and San Francisco on transoceanic channels to Europe, South America and the Orient. This terminal consists of from six to eight relay rack bays per channel, and is designed to meet conditions where the radio apparatus is at some distance from the terminal, and to include all facilities required for the maintenance of highly important long distance radio channels.

The control terminal designed for use on shipboard* to handle ship-to-shore traffic is typical of the terminals which may be classed at the other extreme of voice frequency control equipment. Here the small number of subscriber stations to be served, all of which are of a special four-wire type and hence eliminate the need for a vodas equipped control unit, the shorter length of the radio link, and the relatively close proximity of subscriber stations, control terminal, and radio apparatus, permit of a very simple single-bay terminal.

Between these two extremes is the voice control equipment designed for the shore terminal of a harbor craft radio service which has already been described in the RECORD†. Although the desired functions of this equipment are essentially the same as those of the type A terminal, less rigid requirements as to flexibility and performance, the shorter length of the radio path and the smaller amount of traffic anticipated permitted of a much simpler design which is known as the B1 Control Terminal.

Within a year after the first B1 terminal was installed, inquiries were received for equipment suitable for operation on several proposed point-to-point radio telephone channels between the United States and countries bordering the Caribbean Sea. The general features of these projects, described elsewhere in this issue of the RECORD, indicated that control terminal facilities of the two general types—that is, with and without a vodas—would be required.

Because of the diversity of local requirements, facilities in general similar to those provided by the type A equipment seemed necessary at those points where the new circuits were to tie into the local telephone system. The limited traffic expected, however, made the cost of the type A equipment prohibitive, and although the radio distances involved are not great compared to the trans-atlantic and trans-pacific circuits, the facilities of the B1 terminal were not adequate. Development, therefore, was undertaken of a new voice frequency control unit which is known as the B2 Control Terminal.

The new equipment will serve not only for those points of the Caribbean projects where connections are to be made to the local telephone system, but for any short haul point-to-point service, and also for the shore stations of harbor systems where similar requirements are to be met. Sufficient flexibility has been incorporated in the design to allow its many possible adaptations to local conditions to be made without additional engineering. Exclusive of privacy equipment, and except for certain non-associate installations where an auxiliary bay containing supplementary facilities is required, the terminal consists of only one seven-foot bay (Figure 1).

In addition to the amplifiers, attenuators, and the vodas, the main control unit includes a rectifier type ac voltmeter for indicating speech levels, a signalling oscillator for making simple routine tests, and facilities

*RECORD, *January*, 1930, *p.* 204.

†RECORD, *November*, 1932, *p.* 62.

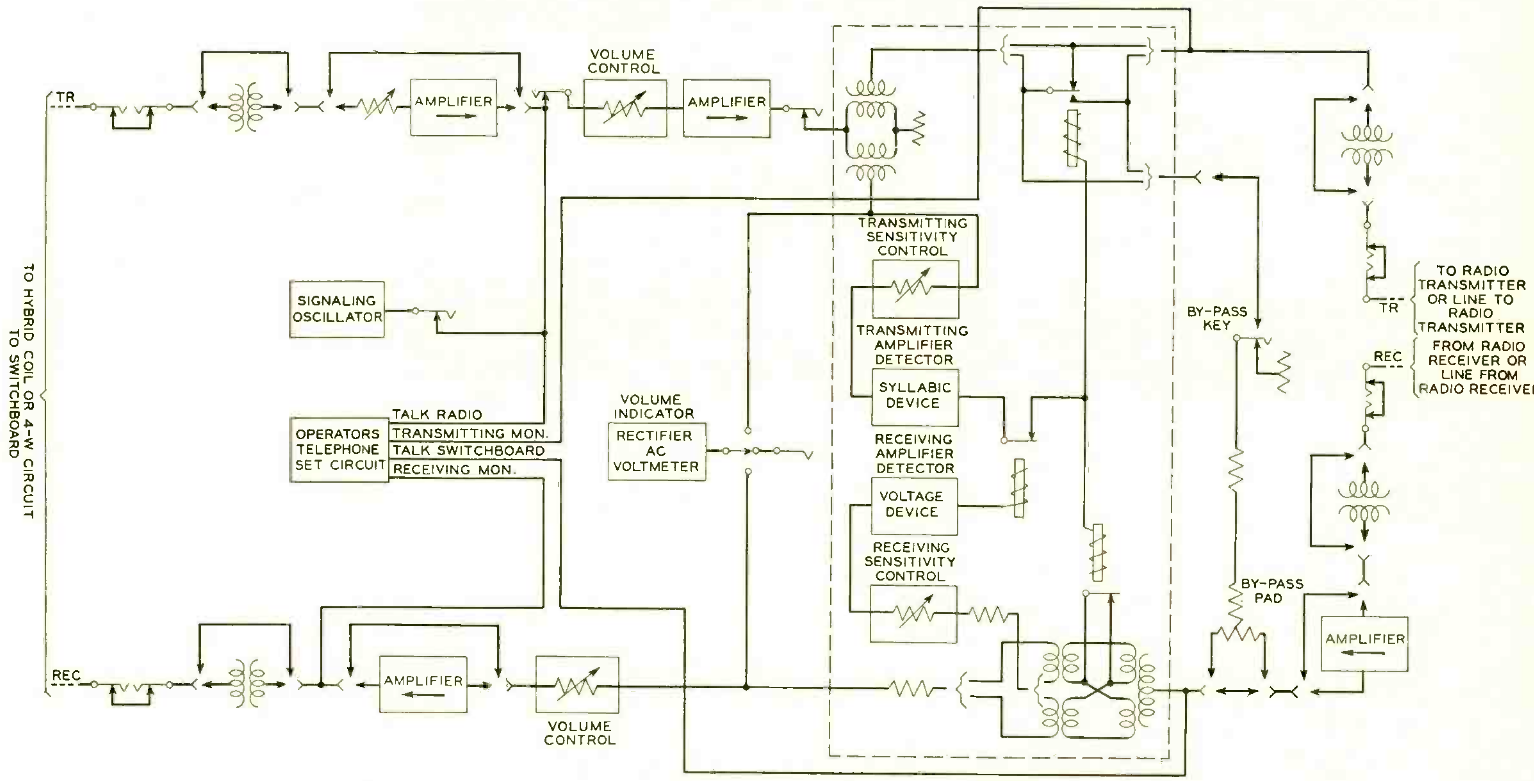


Fig. 2—Simplified schematic of B2 control circuit

for enabling the technical operator to monitor and talk on the radio circuit, and to signal and talk to the switchboard operator. Suitable line repeating coils for the two two-wire circuits to the radio apparatus are provided, and on connections to the switchboard either a two-wire or four-wire circuit may be used depending on conditions, and either a hybrid coil or phantom repeating coils accordingly provided. A by-pass pad with cut-out key permits inter-craft communication under control of the technical and switchboard operators when the terminal is used for ship-to-shore service. Twenty-four, and one hundred and thirty volt filament and plate power is obtained from a double voltage motor-generator equipped with suitable filters and designed to operate from commercial ac power supplies.

The control functions of the B2 control unit, a simplified schematic of which is shown in Figure 2, are identical with those of the B1 equipment used for harbor craft service and already referred to. Sufficient flexibility has been incorporated, however, to enable it to be connected to a switchboard regardless of whether the latter is equipped with terminal repeaters, and also to allow it to be located near the switchboard and connected to remote radio apparatus, or near the radio receiver and connected to a remote switchboard. Depending on existing conditions various pieces of apparatus may be included in the circuit or omitted from it as required. These are indicated on the diagram by alternative connections around various units of the equipment.

The several units of the B2 control terminal are assembled in a floor-supported steel cabinet instead of on the customary channel-iron relay rack framework, and, insofar as possible, all front mounted apparatus has been placed under common covers. This departure from standard practice was made so that the control terminal might harmonize well with the radio receiver with which it will usually be closely associated physically. Access to the wiring is gained through a door

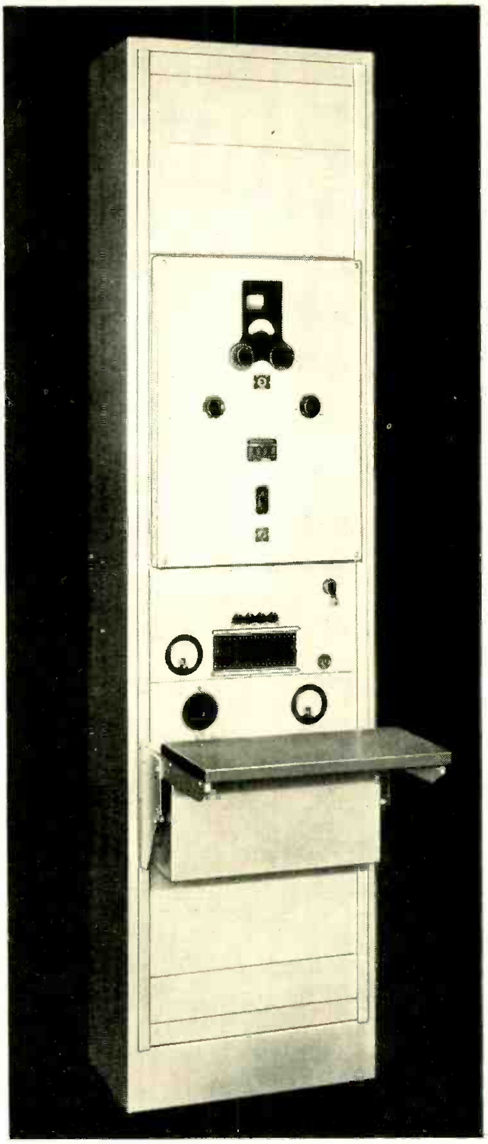


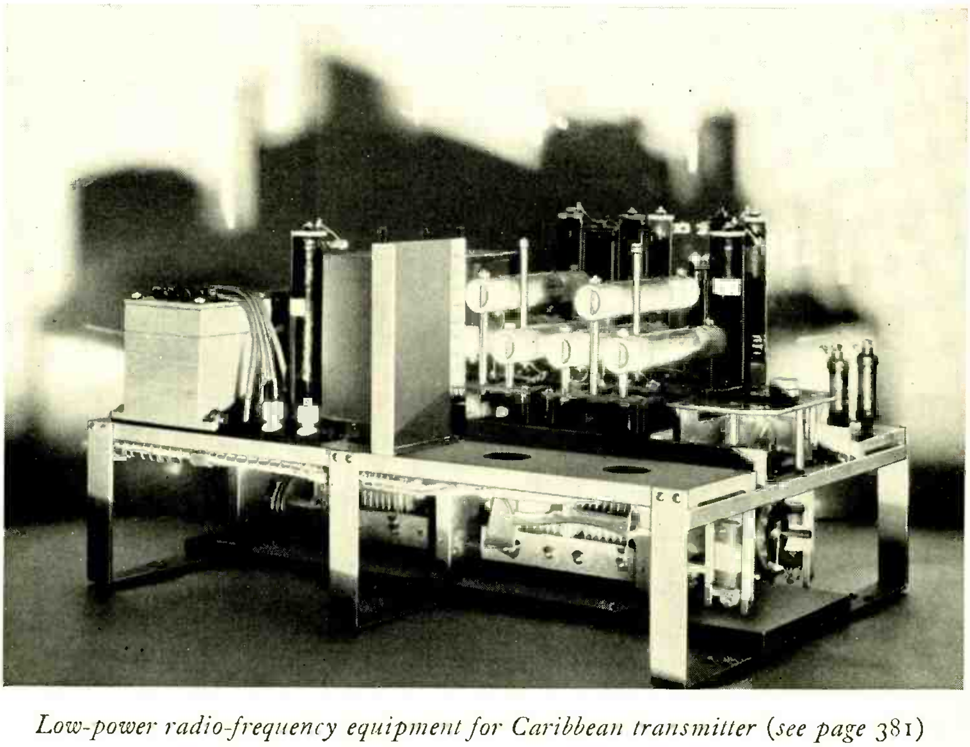
Fig. 3—Simplified voice frequency control unit where connection is required only to 4-wire subsets

in the rear of the containing cabinet.

In addition to the B2 Control Terminal, another control unit, even more simple and compact than the ship control terminal, has been designed for those points where connections are to be restricted to a few special four-wire subscriber sets.

This simple "four-wire" control terminal, shown in Figure 3, while designed primarily for the Tropical Radio Company, is suitable for use on shipboard or elsewhere where connections are to be restricted to one or more special four-wire subscriber sets. These terminals are of particular interest from the standpoints of size and simplicity of operation and maintenance. The equipment, which consists of an ac operated voice frequency amplifier, a self-contained dry cell battery supply for the microphone of the attendant's telephone set, and the customary facilities to enable the terminal attendant to observe and adjust speech volumes, monitor and talk on all connections, and signal the local four-wire stations, occupies only 31½ inches of bay space. The amplifier, control, and battery supply units are mounted in a seven-foot steel cabinet similar to that used for the B2 Terminal, and the remaining space either filled up with blank steel panels, or used to mount an associated radio receiver as shown in Figure 3.

The only "operating" of the simple control terminal required during the progress of a call consists of an occasional adjustment of the variable attenuator associated with the voice frequency amplifier to keep the volume of transmitted speech at the predetermined value required to fully load the radio transmitter. All adjustments of received speech volume are made in the associated radio receiver.



Low-power radio-frequency equipment for Caribbean transmitter (*see page* 381)

The 13A—A Radio Receiver for Diversified Uses

By H. T. BUDENBOM
Radio Development

A RECENT request from the Tropical Radio Telegraph Company for radio telephone equipment to supplement their telegraph links with the Caribbean countries, calling for apparatus somewhat wider in scope than existing equipment, has hastened the development of the most recent addition to the Western Electric line of radio receivers. It is known as the 13A. Like the 11A aviation ground station receiver, the new model is a sensitive superheterodyne, operating from the usual 110 to 120 volt supply system at any frequency from 50 to 60 cycles. It incorporates continuously variable tuning, and covers the frequency range from 2.2 to 25 megacycles. This range includes all the frequencies above the broadcast band now used commercially for medium and long range radio communication, except a narrow band—from 1.5 to 2.2 megacycles—just above the highest broadcast assignment.

The purchaser of a 13A radio receiver acquires a suitable number of individual panels mounted in a seven-foot cabinet. The number of panels supplied will in most cases be less than the total number available but will be adequate to render the particular service desired. By suitable choice of units either telephone or telegraph facilities or both are available at any frequency within the total range covered. The standard interpanel wiring, however, will take care of any

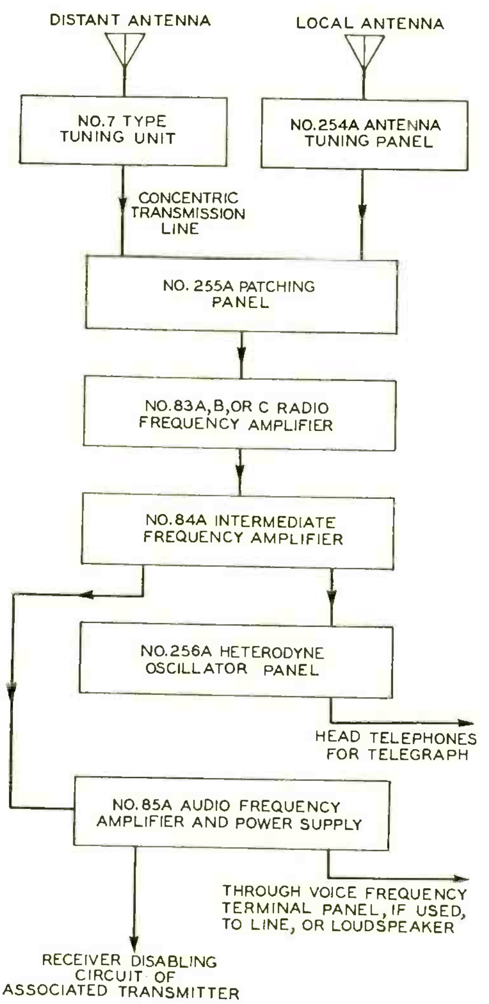


Fig. 1—Block schematic of the various units comprising the 13A radio receiver

combination of panels ordered so that the customer may add to his receiver at any time.

The units available and their functions are indicated in Figure 1. In general there may be: one or more antenna tuning units or an antenna tuning panel, depending on the number, type, and disposition of antennas employed; an antenna patching panel to permit the radio frequency panels to be connected to the different antennas as required for directional reception; one, two, or three radio frequency amplifiers, depending on the frequencies to be received; an intermediate frequency amplifier and detector; and an audio-frequency amplifier, which incorporates the power supply. In addition, a heterodyne oscillator panel is available for continuous-wave telegraph reception. Of these all but the antenna tuning units are mounted in a metal cabinet as shown in Figure 2.

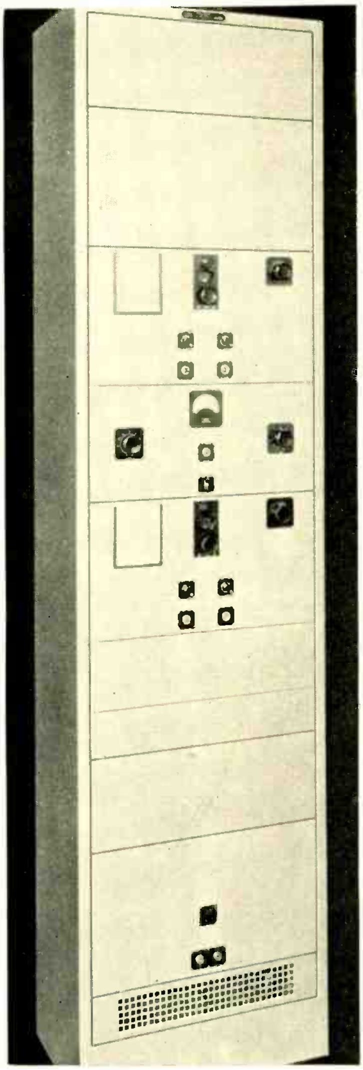


Fig. 2—Front view of the 13A receiver cabinet for the Tropical Radio project showing, from top to bottom, an 83B radio frequency amplifier, an 84A intermediate frequency amplifier, an 83A radio frequency amplifier, and—at the bottom—an 85A voice frequency amplifier and power supply

Three radio frequency amplifiers are provided to cover the entire frequency range. These are known as 83 type amplifiers with letters suffixed to the type number to indicate the frequency range. Thus the 83A covers the band from 12 to 25 megacycles, the 83B, from 6 to 13.2, and the 83C, from 2.2 to 6.2. All three are of similar design, and feature single control gang tuning of three tuned circuits ahead of the amplifier stage, two tuned circuits between amplifier and modulator stages, and the beating oscillator. The six condensers operated from the single control are shown in Figure 3, which shows the rear of the panel with lid removed. When three tuned circuits ahead of the amplifier are not required for adequate selectivity, one or more may be cut out by a strap and bus arrangement. A slow motion condenser drive, with a 2700 division double dial, provides an average frequency increment of only about 5 kilocycles per division, even for the highest frequency amplifier. All the radio frequency amplifiers terminate in intermediate fre-

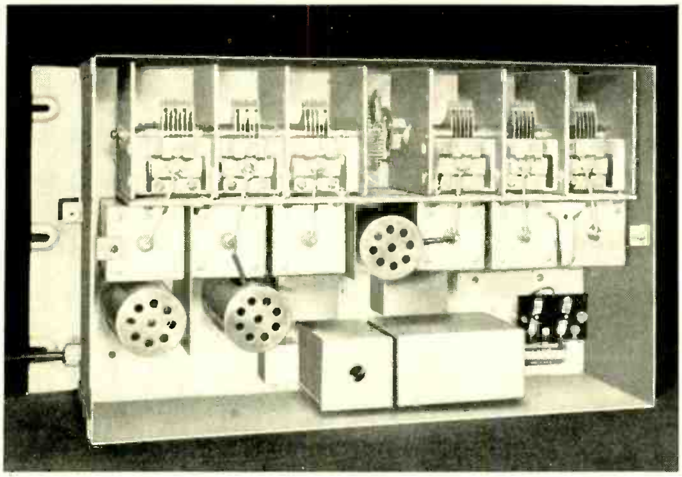


Fig. 3—Rear view of 83B amplifier with rear lid removed

signal, such as those from the local transmitter where constant-carrier transmission is used. Unusually small frequency and antenna distance separations are thus feasible with this receiver.

The provision of a complete radio frequency panel for each frequency range admittedly adds to the cost of the receiver compared to a plug-in coil or selector switch arrangement. Together with the feature of connecting the outputs of the radio frequency amplifier in series with the input of the intermediate frequency amplifier, however, it eliminates series contacts in the low impedance circuits, which would be present with plug-in coils, and which would be very undesirable in the corrosive atmosphere of the tropics or on shipboard. Furthermore, it facilitates the use of ganged condensers, since the frequency ratio of the beating oscillator and signal circuits, the condensers of which are ganged, is different for each

quency output circuits, which step down to a very low impedance, and the outputs of all the radio frequency amplifiers employed are connected in series with the input circuit of the intermediate frequency amplifier.

Inductances of the coils of the 83A amplifier are given their factory adjustment in a novel manner. The coils are of copper tubing supported only at their ends and under slight tension. The inductance is changed by increasing or decreasing this tension, which slightly pulls out the turns or allows them to come closer together.

A variable-mu pentode is used for the modulator, and the voltage of the beating oscillator is supplied to the suppressor grid as shown in Figure 4. This type of modulation lightens the output requirement of the beating oscillator and results in improved stability without reradiation difficulties. The five tuned radio frequency circuits and the variable-mu modulator tube, provide outstanding selectivity against cross talk from a strong unwanted

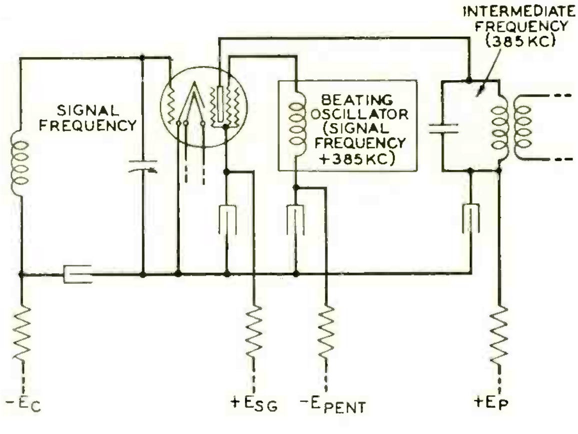


Fig. 4—Simplified schematic of suppressor grid modulation circuit

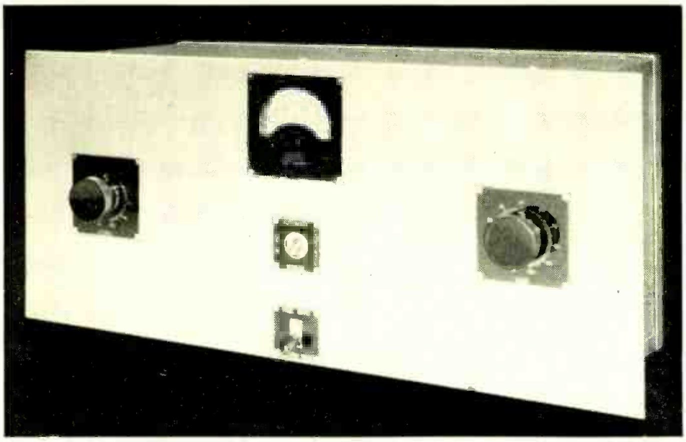


Fig. 5—Front view of the intermediate frequency panel

as already noted. It provides for slowing down the time constant of the automatic gain control circuit for telegraph reception, and also for peaking the audio-frequency characteristic to improve telegraph selectivity. In telephone reception this panel may be used to keep the radio receiver at approximately zero beat frequency with the distant carrier, without disturbing the conversing subscribers.

Two stages of audio frequency amplification are obtained from the 85A amplifier, which also furnishes the power supply. Both input and output impedances are 600 ohms, and the final stage is push-pull, which increases the stability. This amplifier may be used separately from the receiver if desired. To attenuate any disturbances or undesired signals ap-

of these frequency ranges. Also this arrangement makes it possible to monitor simultaneously on three channels, one in each radio frequency range, as well as permitting a much more rapid change from one frequency to another.

In the intermediate frequency amplifier, known as the 84A, is obtained the greater portion of the radio gain and the closeup selectivity. This amplifier has three stages coupled by eight tuned circuits, including the one terminating the radio frequency amplifier, and an almost linear diode detector. Shunt capacity coupling is used in the filter circuits, which has permitted a band width changing feature to be incorporated. By operating the band width switch on the front of the panel, Figure 5, the received band may be narrowed, a feature of considerable value for both telegraph and telephone reception in the presence of severe interference. Both automatic and manual gain control are provided, and the time constant of the automatic control may be easily altered in the field.

The use of a 256A (heterodyne oscillator) panel adapts the receiver to continuous wave telegraph reception

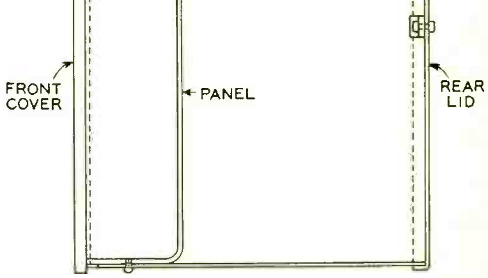


Fig. 6—Cross-section of the dished type panel used for the various amplifier units

pearing in the power supply, filters (719 A, B, and C) are available as optional equipment.

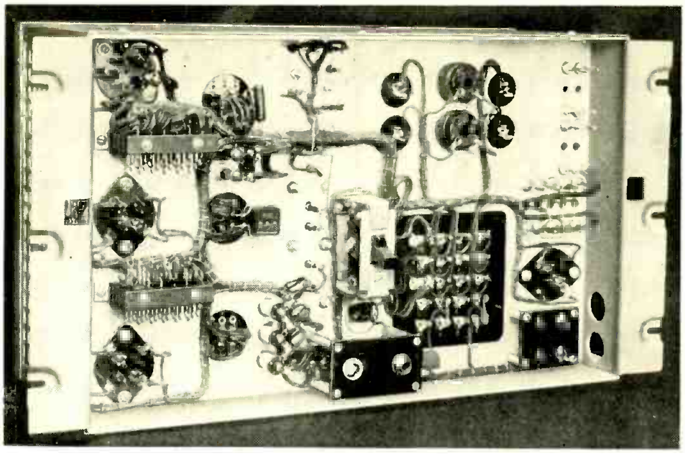


Fig. 7—Front of 85A amplifier panel with front cover removed

Two types of antenna tuning elements are available: the 7 type antenna tuning units for coupling distant antennas, and the 254A panel for coupling local antennas. Both are suitable for either balanced or unbalanced antennas. The tuning units are adapted to out of doors location. The tuning units and radio frequency amplifiers include means whereby the operator may, in effect, move the tuning meter on the receiver to the remotely located tuning unit and thus make the required antenna tuning adjustments without the aid of another man or of an order wire.

All of the amplifier units that, in various combinations, form the 13A receiver, employ the new dished type of panel. This construction, shown in cross-section in Figure 6, provides effective shielding and at the same time gives a rigid construction while employing relatively thin and easily fabricated material. In general all wiring and small components are placed on the front of the panel, where they are readily accessible for maintenance, and all large components are mounted on the rear of the panel. Metal covers form the flush front of the cabinet as shown in Figure 2, and when removed, give access to apparatus mounted on the front of individual panels, as shown in Figure 7. Studs, spot welded to the rear of the front covers, pass through rectangular holes in the side lips of the panel and are drawn up from the rear, as may be gathered from inspection of the left side of the panels, Figures 3 and 7. The back of the panel is completely enclosed by the rear cover and lid.

Standard overall sensitivity of the 13A receiver is one microvolt, or better, which, considering circuit noise and other interference, is about the maximum ordinarily usable. This sensitivity is maintained with good uniformity over the tuning range of each panel. Eight microvolts input modulated 30 per cent is sufficient for a 20 db signal-to-noise ratio. Maximum audio output is about 23 db above six milliwatts. Normal telephone fidelity is 3 db down at 100 and 3000 cycles; the upper value is cut to 6 db at 1750 cycles by operation of the band width switch. By field changes requiring perhaps five minutes, this fidelity may be improved to 6 db down at 35 and 4500 cycles. Telegraph fidelity with the peaking circuit is down 20 db at 200 and 2000 cycles referred to the 800 cycle peak. The normal telephone selectivity is over 60 db when

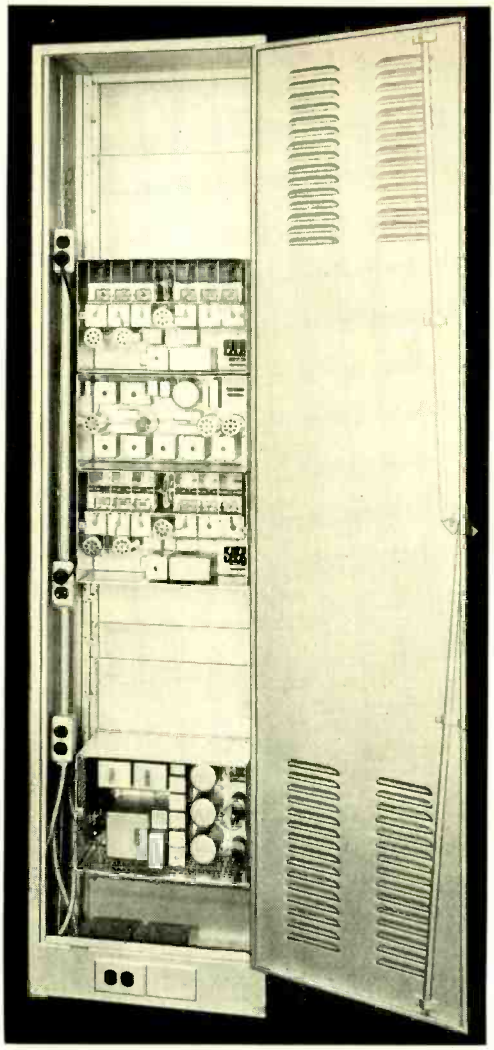
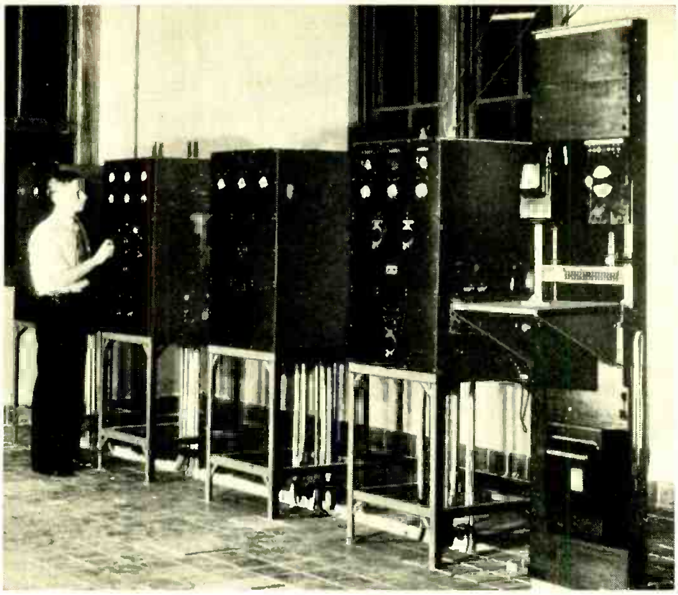


Fig. 8—Rear of 13A receiver cabinet for Tropical Radio with door open, and rear lids of units removed

ten kilocycles off tune, and telegraph selectivity, about 50 db when five kilocycles off tune. The automatic gain control has a range of about 60 db for a 6 db change in output, which is ample for ordinary conditions.

Relays are provided in both the 83 and 85 type amplifiers which enable the receiver to be used in cut-carrier transmission systems. Operated through the control circuit in the local transmitter, they disable the receiver when the transmitter comes on, and restore it when transmission ceases. The action is rapid enough to restore the receiver by the time the distant talker replies. This arrangement allows the receiver to be operated at the same frequency as the transmitter while located in the same room with it and with antennas closely adjacent.

Careful scrutiny has been given the component parts of the receiver to insure their stability under the extremes of temperature and humidity which may be found in tropical countries, or on shipboard. Every effort has been made to insure satisfactory life and performance over an atmospheric temperature range of at least from −40° to +120° F., accompanied by humidities up to 85%. Adequate precautions against the corrosive effects of salt air have also been taken.



A Radio Transmitter for Central American Service

By J. G. NORDAHL
Radio Development

FOR radio telephone communication with the Bahamas and the Caribbean countries, radio transmitters were required which, while capable of giving a good grade of transmission, would not be more expensive than was warranted by the limited traffic expected. Fortunately the 9 type transmitter*, designed as the ground station transmitter for airplane service, met the requirements for the Bahama service. Its output of 400 watts was adequate for the moderate distance involved and its frequency range of from 1.5 to 6.0 megacycles covered the frequencies chosen for the Bahamas, which were between 4.0 and 5.0 megacycles. The 2B rectifier*, also used at aviation ground stations, was likewise found to be suitable as a power supply, not only for the Bahama service but for that to the Caribbean countries as well. For communication with the Caribbean countries, however, a transmitter operating at a frequency in the neighborhood of 15 megacycles was required, which was well beyond the frequency of the airport transmitter. A new transmitter was therefore developed for the Central and South American countries, but its design was based upon that of the airport transmitter and many of the parts are the same.

Complete transmitter equipment for this new project thus includes a 9C transmitter for the Bahama link, which is essentially the airport trans-

*RECORD, *Oct.*, 1930, *p.* 65.

mitter, and one of the new high frequency transmitters — coded as the D-95539—for communication with the Caribbean countries. Each of the transmitters has associated with it a 2B rectifier which serves as the power supply. This apparatus, installed in the Opa Locka transmitting station just outside of Miami, Florida, is shown in the photograph at the head of this article. In order from left to right are

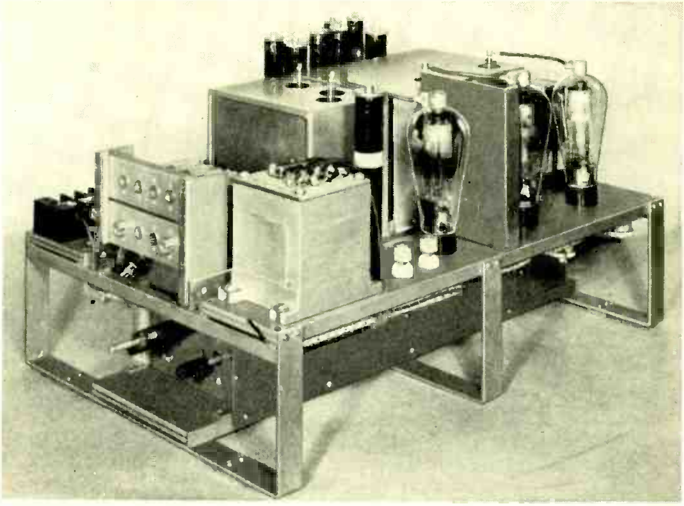


Fig. 2—Front end of radio frequency unit, which may be easily removed from the cabinet for maintenance

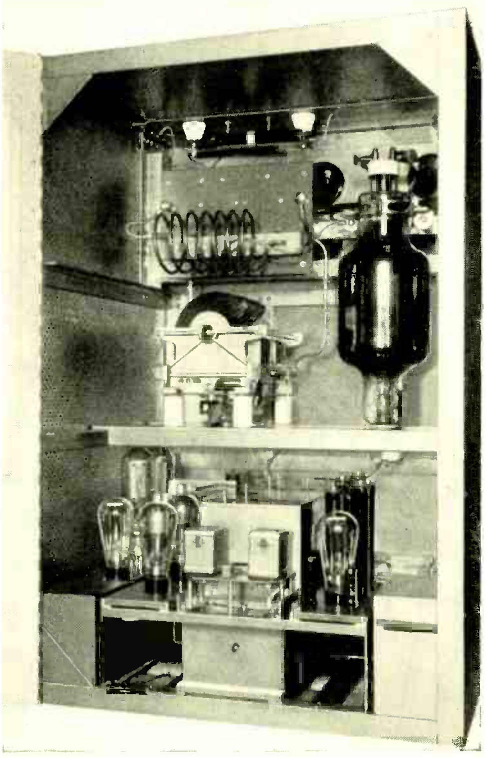


Fig. 1—One of the features of the D-95539 transmitter is the grouping of all low-power radio frequency equipment on a removable frame in the middle at the bottom

the 9C transmitter, a 2B rectifier, the D-95539 transmitter, and its 2B rectifier. The bay on the extreme right is for power and line terminal equipment.

From the outside, the new transmitter resembles the 9C, but the internal arrangement, shown in Figure 1, is distinctly different. It was found desirable to split the total frequency range covered by this transmitter into two bands: one from 6.0 to 9.6 megacycles and the other from 9.6 to 16.0 megacycles. Although there is ordinarily no need for changing from one band to another under usual operating conditions, the change may be very quickly and easily made when necessary. The output tuning coil, shown at the upper left in the photograph, is a plug-in unit with adjustable taps for connection to the transmission line. By unfastening these two leads at the binding posts, the entire coil may be removed without changing the inductance adjustment. The only other change required in shifting from one band to the other is to push or pull the small push rod shown between the two crystal units on the central portion of the lower section. The operation of this rod changes the tuning inductances in the intermediate radio-frequency stages.

One of the interesting features of this transmitter is the assembly of all the low-power radio-frequency equipment on a separable unit shown in Figure 2, which is a left side and front view, and in the photograph at the foot of page 374 which is a left side rear view but with some of the apparatus removed to reveal the arrangement. The equipment carried by this unit may be seen in the photographs and by reference to the circuit diagram of Figure 4. It has two side sections, and an upper and lower middle section. The lower section carries the ganged tuning condensers which permit all tuning to be done by a single dial located at the bottom of the front panel. The upper middle section supports the tuning coils—one of each set being cut into or out of the circuit by the push rod already referred to, when it is necessary to change from one to the other of the two frequency bands.

Two 3A quartz plates are mounted at the rear of the upper middle section. Only one is in use at a time, but both are maintained at operating temperature. The control circuit employed for this purpose uses a copper oxide rectifier to supply direct current for the control relays. With these crystals, the carrier frequency is maintained to better than .025%. The oscillator tube used with the crystal, shown at the lower right of Figure 1, is of the indirectly heated cathode type. Two frequency doubler stages and a modulating amplifier follow the oscillator and are shown at the right of Figure 2. These tubes are of a recently developed four element type with unusually large allowable plate dissipation. The inductance in the modulating amplifier stage is tapped to supply neutralizing and input voltages to the power amplifier.

The power amplifier, at the upper right of Figure 1, is a radiation cooled

Fig. 3—Dummy plugs, inserted in the lower front of the D-95539 transmitter, permit readings of plate and grid current of the low power stages

251A tube already described in the Record*. This tube has given extremely satisfactory service at aeronautical ground stations, and was chosen because it could be made to operate with great reliability. With its tuning condenser and coils it occupies the upper part of the cabinet. The grid connection of the tube is at the bottom, close to the stud connected to the grid winding of the

*Record, *Oct.*, 1932, *p.* 30.

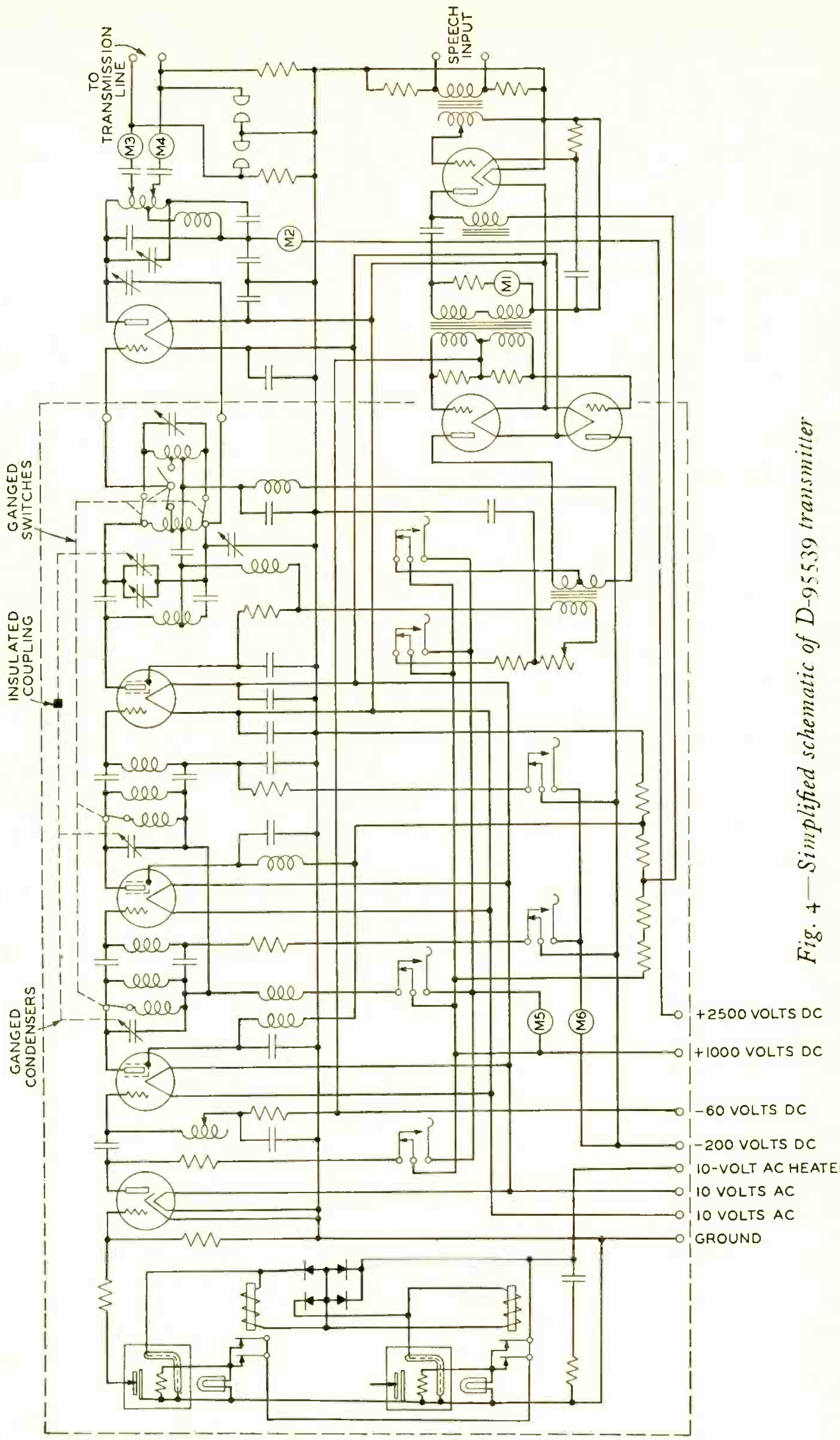


Fig. 4—Simplified schematic of D-95539 transmitter

modulating amplifier coil—an arrangement giving the shortest possible length of lead. The output of the power amplifier may be smoothly controlled by a variable resistance in the combined dc and ac supply path to the modulating amplifier. This method has the advantage not only of being inexpensive but—with the proper design of circuits—of keeping the degree of modulation very nearly constant with changes in power. Measurements have shown that the input audio-frequency voltage required for complete modulation is constant to within .5 db for all positions of the power control.

Two stages of amplification, shown at the extreme lower left of Figure 1, supply audio frequency power to the modulating amplifier. The first input transformer has a tapped secondary, which furnishes the necessary variation to take care of differences in line loss between the transmitter and the voice-frequency control equipment described in an accompanying article. A rectifier type voltmeter connected across the output of the first amplifier stage indicates the audio frequency power level. The second audio stage has two tubes connected in push-pull. This arrangement, together with the employment of a heater type tube for the first stage, reduces the ripple on the carrier to a very much lower value than obtained from other radio transmitters using the same power supply. The secondary of the output transformer of the second audio frequency stage is connected in series with the dc plate supply leads of the modulating amplifier tube, and impresses the modulating voltage on it.

Adjustment of the circuits or the location of trouble has been made easy by bringing the necessary plate and grid circuits to a set of jacks on the front of the removable radio-frequency unit. By inserting a dummy plug through marked holes in the front of the panel, as shown in Figure 3, the current in any circuit may be read on grid and plate current meters mounted at the top of the panel. This simple switching arrangement greatly reduces the number of meters and the wiring required. Two small lamps, mounted at each end of the lower row of jacks, flash intermittently when the quartz plates have reached operating temperature. Protection from lightning and atmospheric potentials is provided by spark gaps and leak resistances at the terminals of the radio transmission line. Overload and control circuits are located in the 2B rectifier.

Since only five of these new high frequency radio transmitters were required for the Caribbean project, the preparation of the usual complete manufacturing information was omitted. Sketches from which the development model was constructed were modified in accordance with test findings, and from these the commercial transmitters were built in the Development Shop of the Laboratories.

Contributors to This Issue

R. F. MALLINA received an M. E. degree from the Vienna Technical College in 1912 and then studied textile engineering for two years at the Textile Engineering College in Austria and at the London Institute in England. He came to this country in 1922 and was engaged as designer and engineer by several concerns, spending over two years with the Victor Talking Machine Company. In 1929 he joined the technical staff of Bell Telephone Laboratories where with the Apparatus Development Department he worked on disk recording and call announcers. At the present time he is with the Acoustical Research Department.

R. F. Mallina

W. A. MACMASTER received a B.S. degree in physics from Union College in 1927, and joined the Technical Staff of the Laboratories in the same year. After a short period with the Personnel Department, he transferred to the Research Department and engaged in carrier transmission problems. The following year he transferred to the Systems Department where after a short period with the Trial Installation group, he joined the Toll Equipment group. Here he has been engaged chiefly in the development of voice - frequency control equipment for radio telephone channels.

J. G. NORDAHL received the B.S. degree in E.E. from the University of Washington in 1925 and immediately joined the technical staff of the Bell Laboratories where he was associated with the development of broadcast and other radio transmitters. From this group he transferred to the radio receiver development group where at the beginning of our work on

W. A. MacMaster

J. G. Nordahl

H. T. Budenbom

communication with aircraft, he designed some of the first models of airplane receivers. Since the latter part of 1928, he has been engaged in the development of aircraft and point-to-point radio transmitters.

H. T. Budenbom received a B.S. degree in electrical engineering from Purdue University in 1922, and immediately joined the technical staff of the Laboratories. Here, with the Transmission Engineering Department, he acted as a consultant to the local systems group on transmission practices. While here he received an E.E. degree from Purdue and also took post-graduate work in electro-physics at Columbia University. In 1928 he transferred to the radio development group where his work, except for some radio interference studies, has been on radio receiver development.

Vail Medal Awards for 1932

The National Committee of Award for the Theodore N. Vail Medals has announced the award of three silver medals, each accompanied by a cash award of $250, to employees of the Associated Companies of the Bell System for noteworthy public service.

To be selected for National Vail Medal recognition an act must have for its objective the accomplishment of something of real value in the public interest through the medium of Bell System facilities, organization, training or experience, and must reveal to a high degree many, if not all, of the positive qualities of intelligence, initiative and resourcefulness, and usually courage, endurance and fortitude.

The citations are:

Lila Cook Gaddy, operator of the Three States Telephone Company:

For alertness and initiative which led to the apprehension of two desperate criminals.

While on duty on January 3, 1932, at Streetman, Texas, she learned that two men had ditched a car on a nearby highway, had disappeared and that firearms and a Missouri automobile license plate had been found near the scene of the accident. Suspecting that they might be two fugitives whom she had heard described the previous evening in a radio broadcast concerning the shooting of six police officers at Springfield, Missouri, she obtained a description of the men and, finding that this tallied closely with that of the fugitives, notified the authorities at Streetman and Springfield. As a result, the fugitives were pursued, and later they shot themselves rather than submit to capture.

Irene Regina Duncan, operator of the Southwestern Bell Telephone Company:

For courage and perseverance in delivering an urgent telephone message.

On the evening of September 9, 1932, at St. Joseph, Missouri, the messenger service usually employed having failed to locate a man for whom there was a long distance telephone message, announcing the death of his son, she volunteered to find him and deliver the message. Nothing was known of the man's whereabouts except that he was employed on a government dredge somewhere along the Missouri River, near St. Joseph.

With a younger sister, at night, she searched from boat to boat, traveling thirteen miles, in part by automobile and in part by foot, largely through a rough and dangerous area, until she finally found the man and delivered the message.

Henry R. Bell, line foreman of the New England Telephone and Telegraph Company:

For prompt, courageous, intelligent and effective action in rescuing a man caught by fallen debris in a partially burned building.

On December 1, 1932, while working with a crew of four men at Peabody, Massachusetts, he learned that a man had been caught by the collapse of a portion of the second floor of a nearby tannery building, which had been partially destroyed by fire.

With his men, Bell hurried to the scene, taking with him bars, ropes, chains, blocks and tackles. At once realizing the necessity of undertaking the rescue work with extreme care, in order to avoid causing further sliding or falling of debris and weakened timbers, which would have imperiled the victim and rescuers alike, he warned a fire captain, who had arrived with his men, of this danger. At the latter's suggestion, Bell continued in charge of the rescue work.

He ordered the weakened walls and floor timbers, together with bales of hides, machinery and other material resting upon them, to be secured by ropes fastened to nearby buildings. This done, he directed the removal of timbers and other heavy objects which were holding the man a prisoner. With the help of a fireman, Bell pulled the victim free, carried him to a place of safety and placed him in an ambulance, which took him to a hospital, where he fully recovered. Between Bell's appearance in the building and the patient's arrival at the hospital only twenty minutes elapsed.