BELL LABORATORIES RECORD

PANEL
DIAL SYSTEM

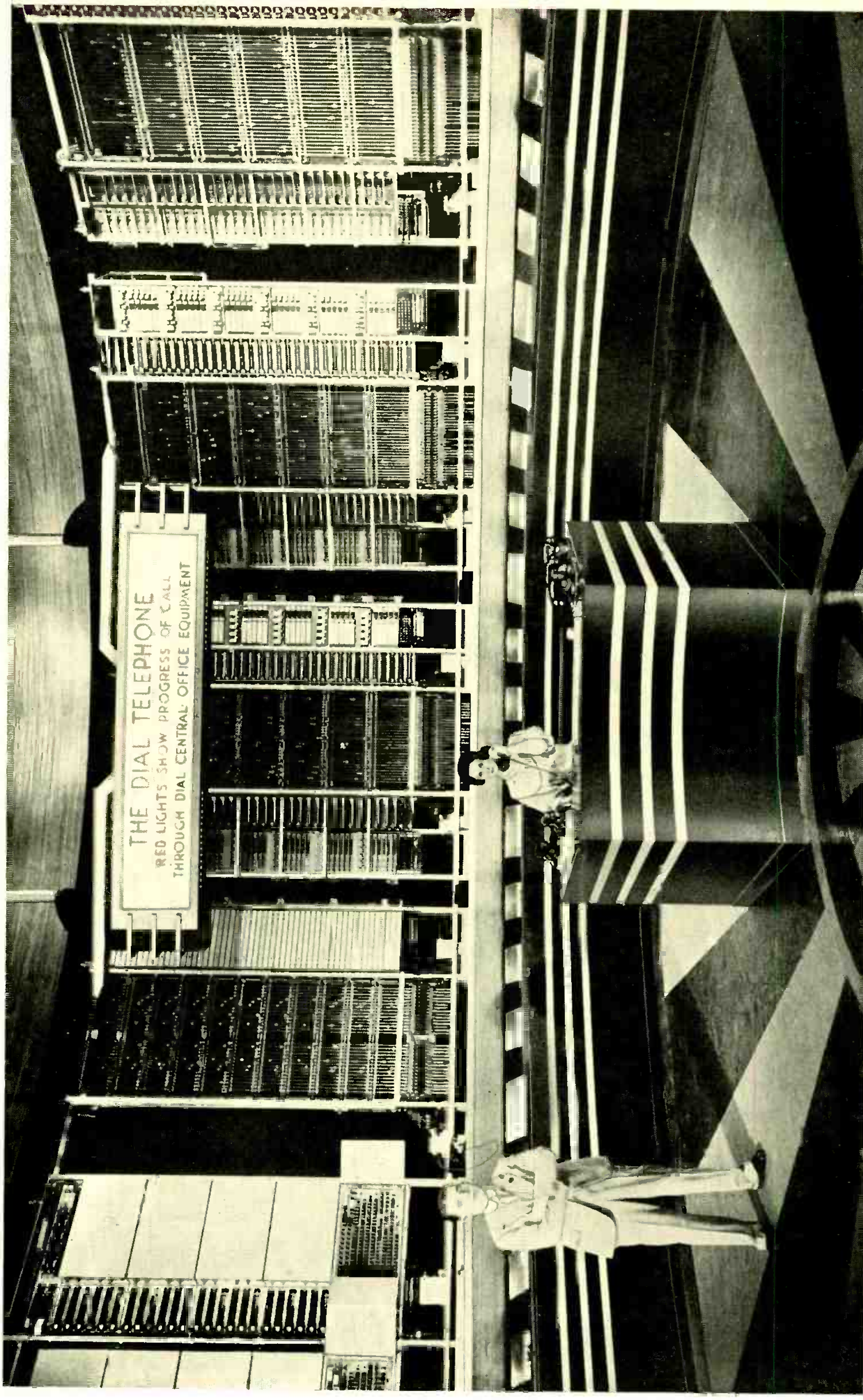
—

BELL SYSTEM EXHIBIT
AT CHICAGO

—

NEW EARPIECE
FOR THE AUDIPHONE

JULY 1933 VOL. 11 NO. 11


THE DIAL TELEPHONE
RED LIGHTS SHOW PROGRESS OF CALL
THROUGH DIAL CENTRAL OFFICE EQUIPMENT

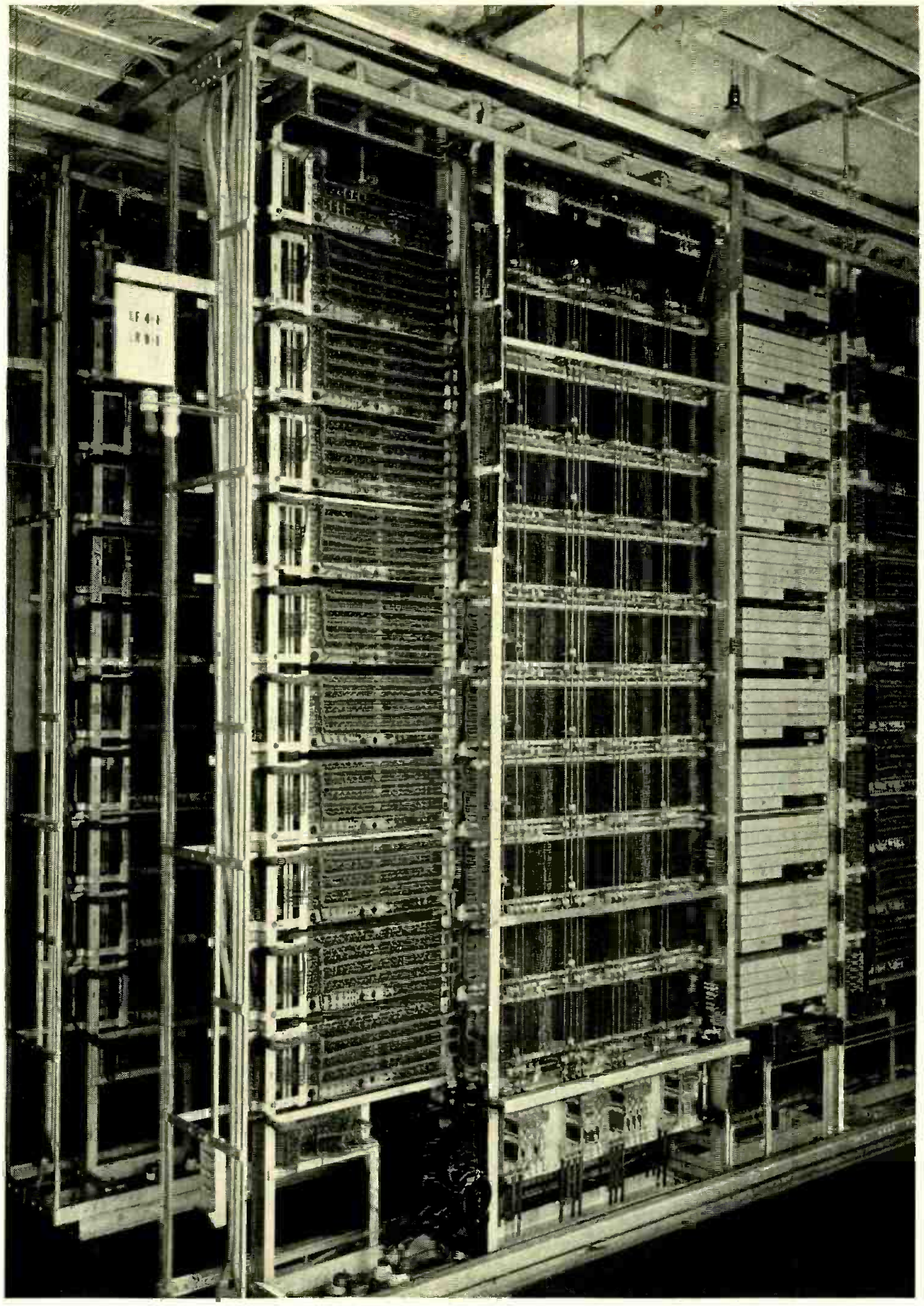
The Panel Dial System

An illustrated narrative in eleven short chapters telling how the panel dial system works, each with an appended note to supply details as to construction and operation. At the Century of Progress Exposition in Chicago, the five major types of switching frames—shown here by individual photographs—are installed on an elevated platform where visitors may watch the progress of a call.

CHAPTER I

To connect your dial telephone with that of the person you are calling, several connections must be made one after another. Some of them are made in the central office serving you and some in the office serving the person you are calling. In the dial system developed by Bell Telephone engineers, these connections are made on large frames on which are mounted several hundred terminals, grouped into a number of banks. Connections to the terminals are made by brushes carried on vertical rods, called elevators, which move up and down under the control of a mechanical brain known as the sender.

Note: Sheets of metal about 40 inches long, punched to provide thirty projecting terminals on each side and piled one above another, form the banks. Insulating strips are used to separate adjacent sheets. Sets of either three or four of these metal sheets furnish the terminals for a single line or trunk, and a number of such sets of sheets, varying somewhat for the different types of frames, are built up to form the complete bank. From the panel-like appearance of these banks, the entire system derives its name of the panel system. Except for the line finder (the first frame on which a connection is made) five of these banks are mounted in each of the major switching frames, and each elevator is provided with one set of brushes for each bank. Thirty elevators may be provided on each side of a frame, and because of the thirty projections on each side from each metal sheet in the bank, each elevator may make connection to any of the lines or trunks connected to the bank. At the bottoms of the elevators are flat strips, called racks, which are pressed by electromagnetic clutches against continuously rotating cork rolls when the elevator is to be driven upward.



Line Finder Frame

This panel frame is employed to connect your line to the central-office circuits when you are placing a call

CHAPTER II—LINE FINDER FRAME

When you lift your dial telephone receiver from the hook, an elevator rod with its brushes—like an operator's arm and fingers—moves upward and makes a connection on this line-finder frame to the terminals of your line. The action of the elevator is controlled by three groups of relays known as the line, start, and trip circuits.

Note on Chapter II

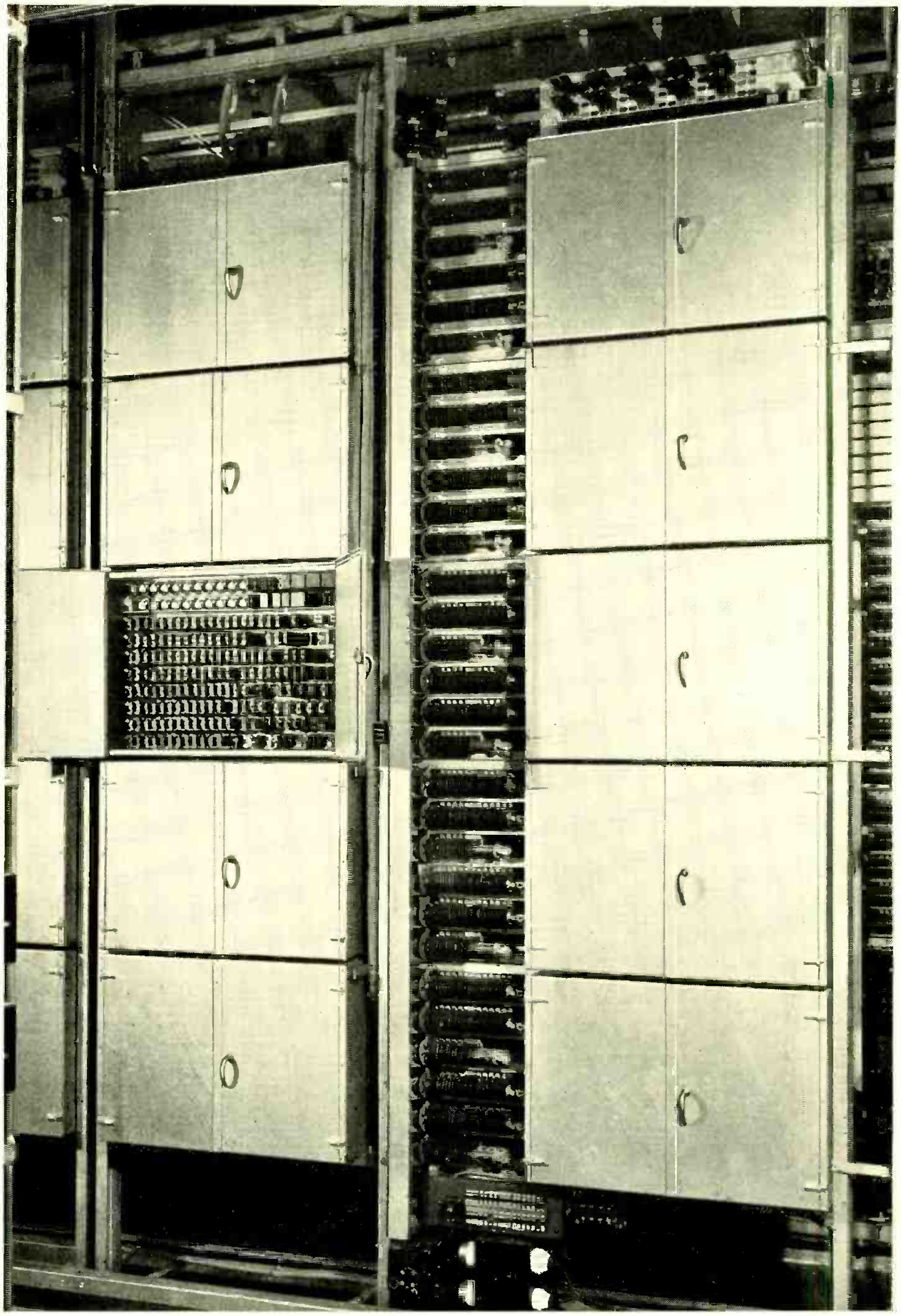
A relay in the "line" circuit associated with your line operates when you lift the receiver from the hook and causes a relay in the "start" circuit to actuate the clutch of an idle elevator on the line-finder frame which has your line connected to its banks. Immediately afterward the brush that serves the particular bank in which your line appears is "tripped" (moved into contact with the terminals of the bank) by the action of relays in the "trip" circuit. The lifting of your receiver has also resulted in a battery connection being made to one of the terminals of your line in the bank. When a tripped brush of the elevator reaches a terminal that has battery connected to it, a relay in the circuit operates, which through other circuit elements causes the clutch to release and the elevator to stop. This operation is called hunting, and, combined with the tripping of the proper brush, has resulted in the connection of your line to the central-office circuits through an elevator brush on the line finder.

CHAPTER III

While the line finder has been taking the necessary steps to make a connection to your line, other circuits and apparatus have connected an idle sender to the circuit, which will direct the action at the subsequent switching frames to make the connections necessary to extend your line to that of the person you are calling.

Note on Chapter III

The demonstration equipment at the Century of Progress Exposition is merely representative, and includes one each of only the major switching frames. In an actual central office other switching frames, known as links and not represented in the exhibit, are employed to connect a sender to your line when you wish to put through a call. The number of switching frames of the various types in an actual central office varies with local conditions, but is usually from 5 to 25 of each type so that the apparatus shown at the Exposition represents only about five per cent of the amount normally employed.



Sender

Acting as the brains of the system, the sender records the number you dial and directs the establishment of your call

CHAPTER IV—THE SENDER FRAME

Large assemblages of intricately connected relays comprise the panel senders, which act as the brains of the system. While you are lifting the receiver to your ear a sender has been connected to your line and at once transmits dial tone—a low buzzing sound—to indicate that you should begin to dial. The sender, by the operation of relays, then records the number you dial and immediately proceeds to direct the completion of your call.

Note on Chapter IV

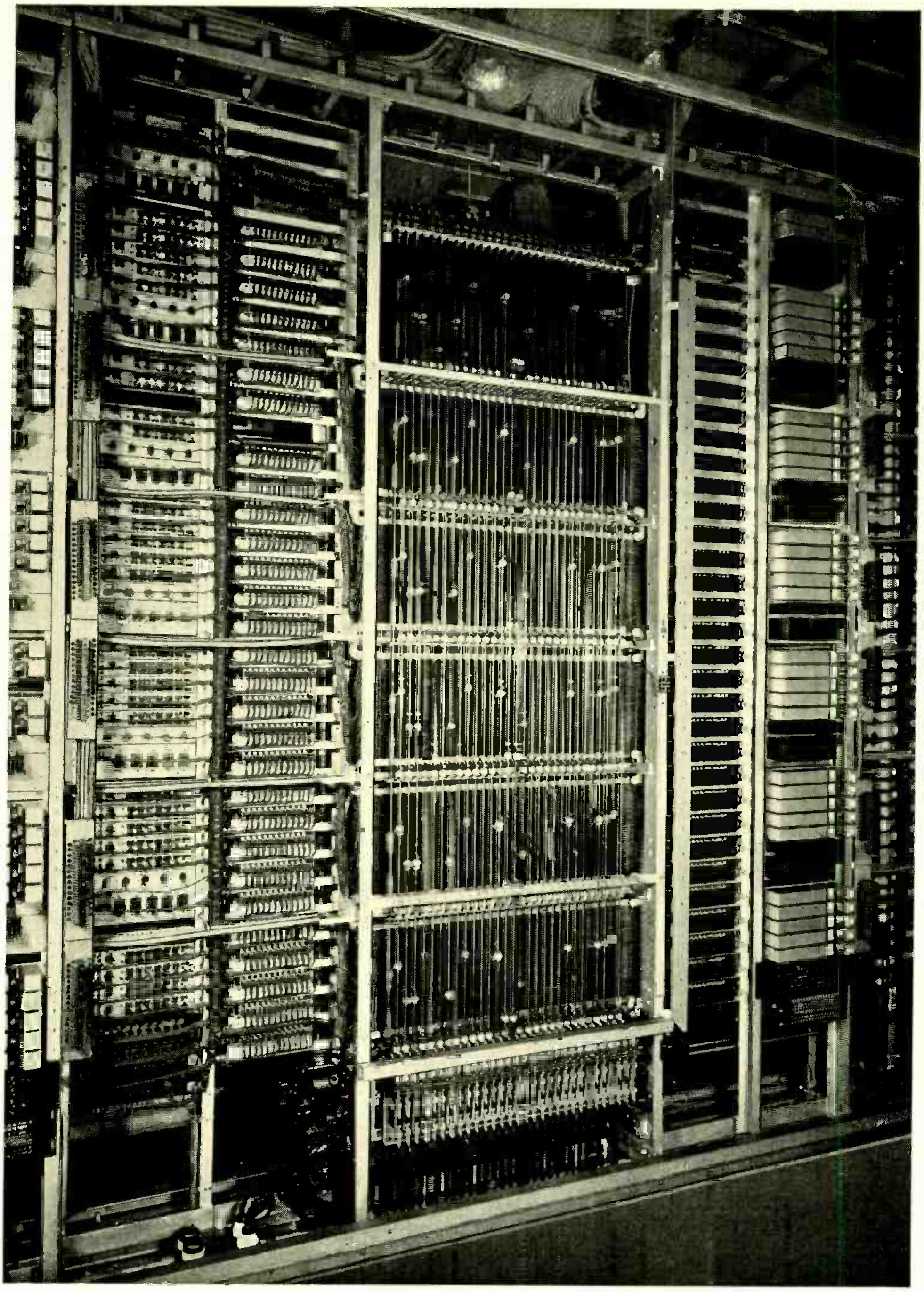
The sender has been aptly called the brains of the panel system for it must be able both to remember the number you dial and to know how to direct the many actions necessary to make a connection to the line you are calling. In an actual office, part of its memory function is performed by decoders, large groups of relays that act as a card catalogue of information for the sender. The sender is associated with a decoder for only a fraction of a second and during this short interval secures information as to how to reach the central office serving the person you are calling. It then proceeds on its own initiative.

CHAPTER V

After you have told the sender, by dialing, what number you want, it starts upward an elevator on the district-selector frame to select a trunk line running to the proper central office. This elevator on the district frame is one permanently assigned to the elevator on the line finder that answered your signal. The two elevators, one on the line-finder frame and one on the district, thus act like the arms of an operator—one to find your line and the other, a trunk to the proper central office. The circuit between them is like a double-ended cord with which the operator, in this case the sender, makes the connection you want.

Note on Chapter V

The talking circuit between line finder and district elevators is not completed while the connection to the person you are calling is being established. Your line, through the line finder, is extended to the sender so that the sender can return dial tone to you, and so the dial pulses may be transmitted to the sender. In the other direction the circuit is completed from the sender out through the district selector to control the various steps in the switching process. As soon as the final selection is made, the sender completes the talking connection at this point and then disconnects itself.



District Selector Frame

This frame selects a trunk running to the central office to which the person you are calling is connected

CHAPTER VI — DISTRICT SELECTOR FRAME

To the terminals of the district frame are connected groups of trunks running to other offices, and the sender guides the elevator associated with your line to the group running to the office to which the person you are calling is connected. Within this group the elevator brush, of its own accord, selects the first idle trunk it meets.

Note on Chapter VI

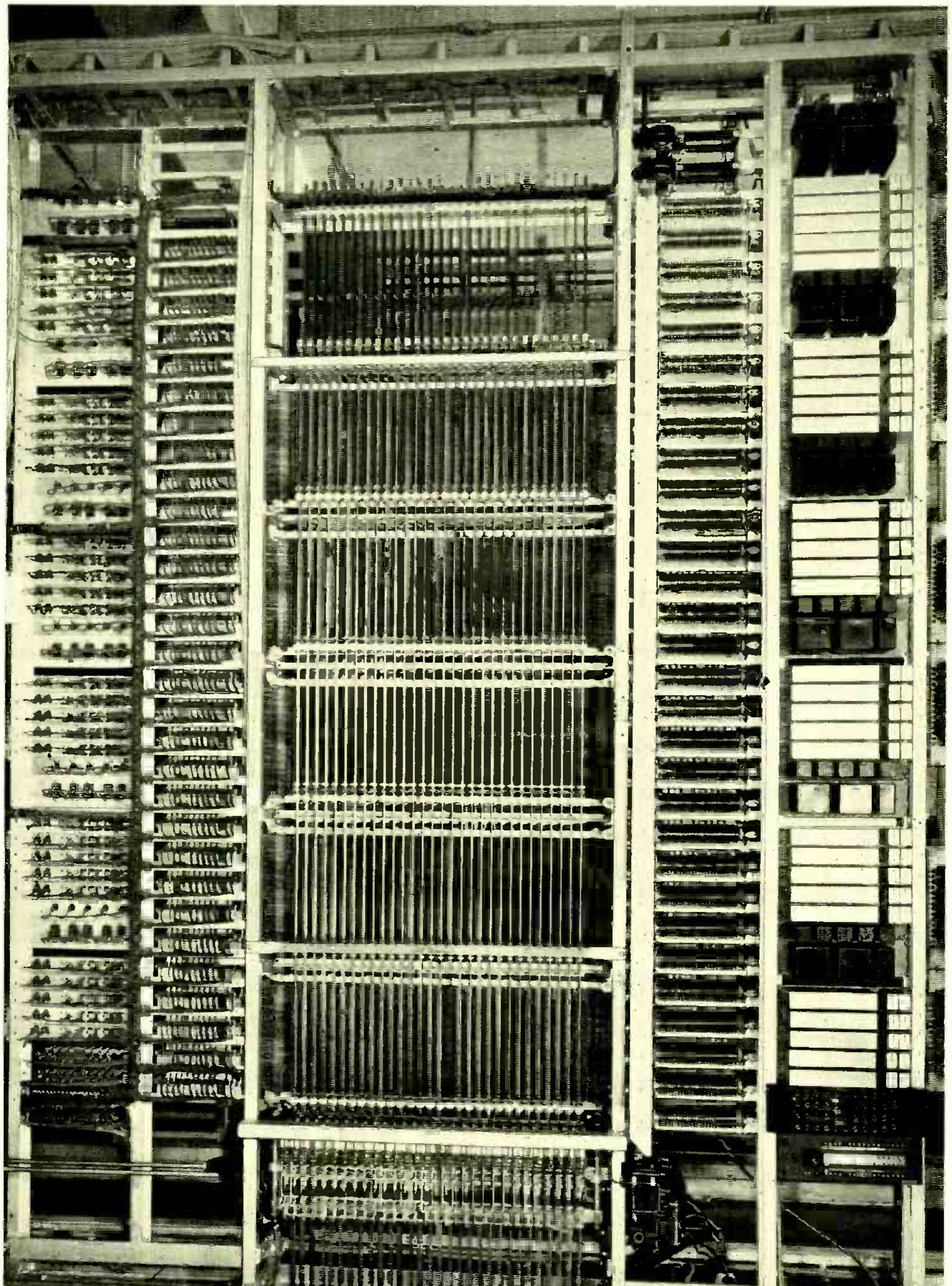
The district selector frame, like those on which the subsequent connections are made, has five banks each with terminals for 100 trunks. Since there will be a number of trunks to each office, the banks are divided into groups of trunks; each bank providing eight groups of eleven trunks and two, of six. The sender guides the elevator only to the proper group but within the group the elevator hunts and makes connection to the first idle trunk it reaches in much the same way that an elevator chose your line on the line finder. Adjacent groups may be combined when the number of trunks to any one office is greater than can be supplied by a single group.

CHAPTER VII

Your call now leaves your central office and (passing through cables laid underground) arrives at the office which serves the person you are calling. The sender at your office still remains connected to the trunk, however, and will direct the actions which are required to establish your connection at the central office you are calling.

Note on Chapter VII

In most of the central offices in the larger cities another group of switching frames, called office-selector frames, is usually required at this point. Such units resemble the district frames in appearance but their elevators are wired to terminals of the district banks and thus multiply the possible number of outgoing trunks. With the district selectors alone there may be only 50 groups of outgoing trunks (5 banks of 10 groups each) while with office selectors there may be 2,500 groups — each group in the district selector having access to 50 groups in the office selector. For any one call all apparatus described up to this point is at your office and all beyond in the office serving the person you are calling, which may be the same or a different office. Actual central offices thus have all types of frames.



Incoming Selector Frame

This switching frame is in the central office serving the subscriber you are calling and makes the first of the two remaining selections required to complete your call

CHAPTER VIII—INCOMING SELECTOR FRAME

Each incoming trunk from other central offices is connected to an elevator on an incoming selector frame. Since an incoming selector can accommodate but 500 trunk lines, an intermediate selection is necessary to reach the 10,000 lines that may be served by a single central office. Each bank of the incoming frame therefore has trunks running to elevators of final frames, and the incoming selector elevator that carries your call will select a trunk running to an elevator on that particular final frame to which is wired the line of the person you are calling.

Note on Capter VIII

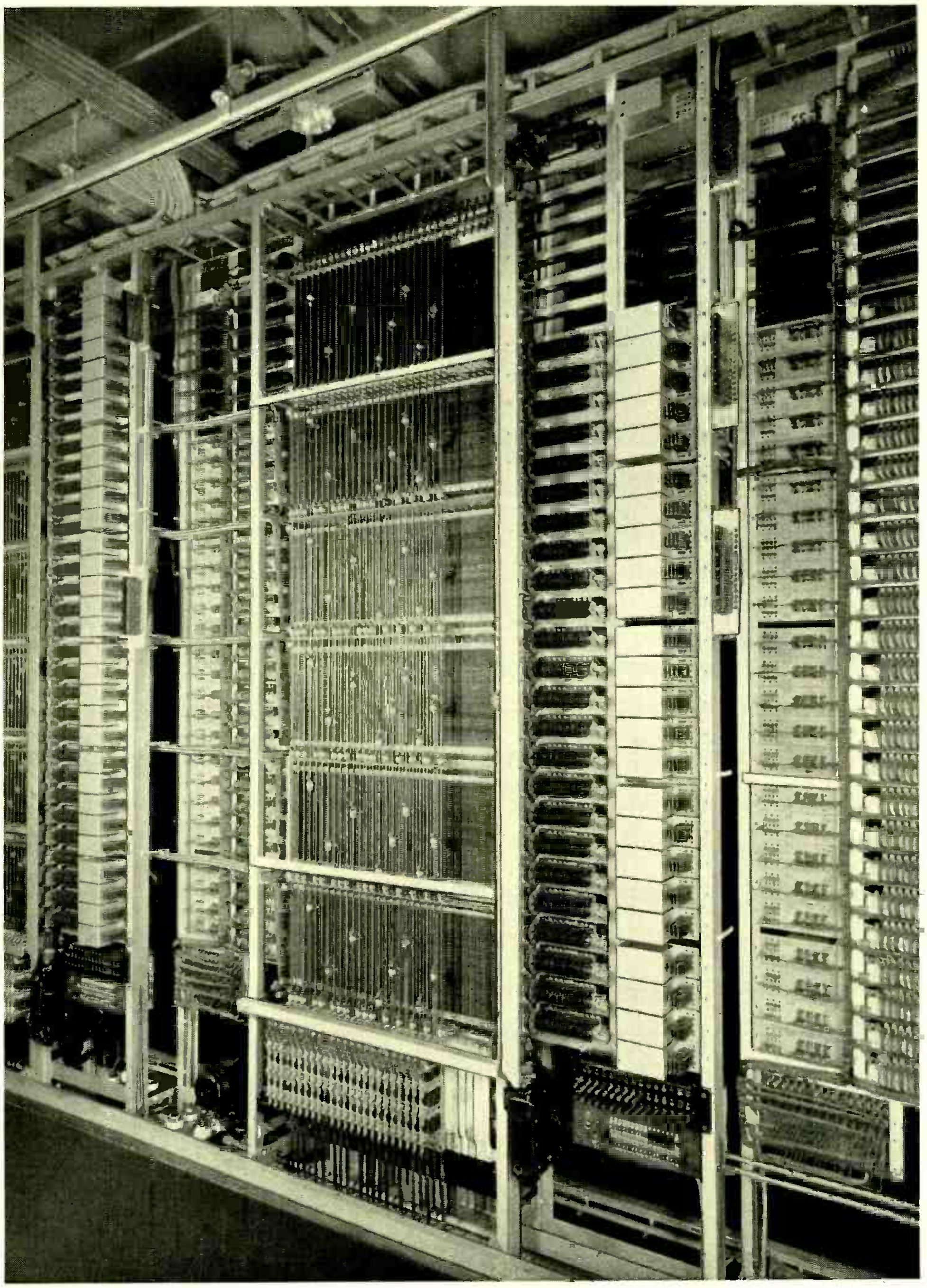
The number of incoming selector frames in an office depends on the number of incoming trunks, since one trunk is connected to each "incoming" elevator, of which there are sixty per frame. The bank terminals of all incoming selectors are in parallel so that each elevator has access to the same five hundred trunks which run to elevators on final selector frames, where the last connection will be made. While your connection is being made, the talking circuit is open here as well as at the district frame. As soon as the connection to the person you are calling has been made at the final selector, the circuit is joined at the district frame, and after the person you are calling has lifted his receiver, it will be completed here.

CHAPTER IX

In addition to the actual connections made at the selector frames, there is a large number of functions that must be performed for the successful handling of a call; and all are done by collections of relays and apparatus known as circuits. There are various control circuits used in starting the elevators upward, in guiding them to the proper terminals, and in stopping them. There are also many signals that must be provided, such as line busy, trunk busy, out of order, and the dial tone and ringing already mentioned. Then there are circuits for supplying talking battery, for controlling the action of coin boxes and for controlling disconnection when you and the person you are calling hang up.

Note on Chapter IX

At the sides of the various selector frames are groups of relays arranged in horizontal rows. Each group is associated with one elevator and makes or breaks contacts at various times to perform certain required operations. Also, at each side of all frames but the line finder, is a column of sequence switches—one of the distinctive pieces of apparatus in the panel dial system. These switches consist of a central shaft with a number of small disks—usually from 20 to 25—and small brushes riding on the disks permit a large number of circuit combinations to be made in sequence. The central shaft is driven through a small electromagnetic clutch by the same source that drives the cork rolls at the bottom of the selector frames. One of these sequence switches is associated with each elevator, to control, in conjunction with associated relays, all circuit functions such as those required to start and stop the elevators, to close the talking circuit at the proper times, and to start and stop the motion of the elevator rods.



Final Selector Frame

At this frame a connection is made to the line of the person you are calling

CHAPTER X—FINAL SELECTOR FRAME

The elevator on this frame, to which your call has been connected, now moves up, still guided by the sender, until it reaches the terminals to which is connected the line of the person you are calling. At this point the sender, having accomplished its task, disconnects itself from the line and is ready to serve another call. Before making a connection to the line you are calling, the final selector tests the terminals to determine whether or not it is busy. If the line is found to be idle, the connection is made, but if it is found to be busy, the final selector causes the busy signal to be returned to the person calling.

Note on Chapter X

To be able to guide the elevator of a selector to the desired line or trunk, the sender must know the position of the elevator at each instant. This information is sent to it by means of vertical commutators and brushes fastened to the upper end of each elevator. All selector frames are equipped with such commutators, three of which are employed to transmit pulses back to the sender to keep it continually informed of the position of the elevator. Other commutators are employed to establish the connections to the elevator brushes, and to perform other functions.

CHAPTER XI

After the connection is made to the line of the person you are calling, the auxiliary equipment of the incoming selector circuit sends ringing current over the line and transmits the audible ringing tone back to you so that you will know the progress your call has made. When the person you are calling lifts his receiver to answer, the incoming selector discontinues ringing and joins the two parts of the circuit together so that your conversation can proceed.

Note on Chapter XI

Your line divides into two branches in your central office: one going to a group of terminals on a line-finder frame, and one to a group on a final frame. Connection is made to your line through the first set when you are making a call and through the second set when someone else is calling you. While you are using your telephone, a ground is placed on one of the terminals of your line in the final selector banks, which gives a busy indication to any elevator brush attempting to make a connection to it. When you and the person you have called hang up your receivers, all selector elevators are automatically returned to their original positions, and the busy indication is removed from your line so that other calls may be received.

A Stroboscope for Checking the Speed of Subscribers' Dials

By H. BROADWELL
Telephone Apparatus Development

IN certain parts of the telephone system such as remote step-by-step areas and manual areas having step-by-step P.B.X.'s, it is not always feasible to provide the regular central-office type dial testers* for checking the speed of subscribers' dials. A form of dial tester which can be carried in the maintenance man's tool-kit, and which works on the stroboscopic principle, has therefore been developed for these dials. The device consists of a target (Figure 1) which can be attached to the finger wheel of the dial, and a tuning fork in a case (Figure 2) with an opening through which to view the divisions on the target.

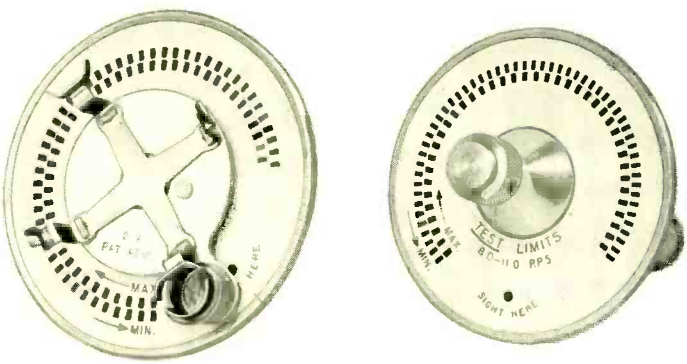


Fig. 1—A target, which can be attached to the finger wheel of a dial, is marked with divisions which are viewed stroboscopically to test the speed of the dial as it unwinds

The manner of using the stroboscope is shown in Figure 3. The maintenance man winds the dial, partly depresses the button in the case so that he can see past the fork, and sights the fork on the reference mark on the target. He then fully depresses the button to start the fork, and releases the dial. If a row of divisions on the target appears to stand still when viewed through the fork, the dial is running at the speed for which that row was figured. If the divisions appear to run in the direction of the arrow located alongside the row, the speed is within the limit which the row represents, and if in the opposite direction, the speed is outside that limit. The velocity of the motion as seen through the fork indicates the extent of the deviation from the speed represented by the row.

The upper and lower limits of speed established for the subscriber's dial as most satisfactory from both circuit and design standpoints are eleven pulses per second, and eight pulses per second, respectively. These limits, known as "test" limits, are represented by two rows of divisions on one side of the removable disc on the

*The 51-type Dial Tester (RECORD, *August*, 1927, *p.* 427), and the 50A Dial Tester.

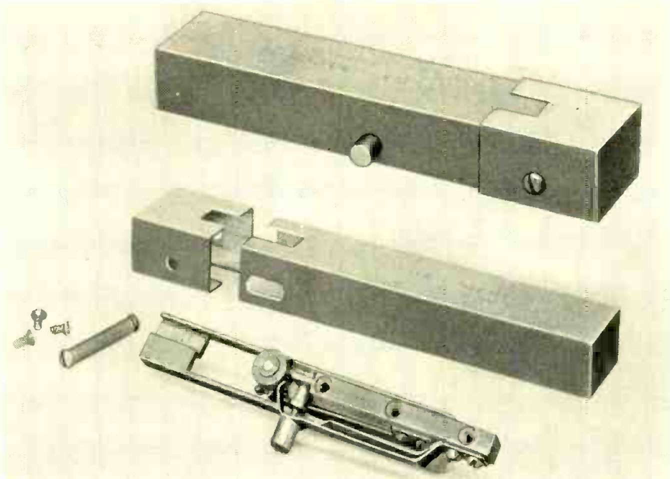


Fig. 2—The divisions on the target (Figure 1) are viewed through the opening in the case, past the prongs of the tuning fork which are set in motion by pressing the button. Each prong bears a shutter, as can be seen at the lower left, and the space between the shutters opens and closes as the fork vibrates

target. If the dial is found to run faster than the maximum or slower than the minimum speed, the dial governor is readjusted to within a closer set of speed limits, 9.5 and 10.5 pulses per second, in order to allow a margin for future changes in speed due to wear and the like. These "readjust" limits are represented by two rows of divisions on the other side of the target disc. The disc is readily reversed for selection of the proper limits by unscrewing the knurled knob which clamps it to the base.

The stroboscope is very sensitive to slight changes in speed, and it was found necessary to employ non-uniformly spaced divisions to compensate for the decrease in the velocity of the dial as it unwinds. The width of each division was determined separately from data obtained by testing a representative lot of dials. The targets were then laid out on a large scale and photographically reduced.

In designing the target mounting, it was necessary to take into account the importance of not marring the finish of the new colored dials. A push button was provided in the knob, which can be depressed to expand the fingers and prevent their marring the finish while the target is being mounted. The flexibility of the fingers also insures a satisfactory grip on dials having the ordinary black finish.

The tuning fork vibrates at fifty cycles per second. Depressing the starting button in the case rotates a ratchet wheel having teeth arranged to lift flat springs which distend the prongs of the fork and then drop back into the space between the teeth. The

Fig. 3—S. J. Stockfleth demonstrates the use of the stroboscope for checking the speed of a subscriber's dial

case for the fork consists of a box and cover which shield the mechanism and exclude dirt when the fork is not in use. Sliding the cover partly off the box provides an opening for viewing the target.

The accuracy of the device depends on a number of factors, such as the extent to which the speed characteristics of the dial under test conform to the average data used for calculating the targets, and the ability of the user to detect slight movements of the divisions when the speed of the dial is close to the upper or lower limit. On most dials tested, an accuracy of 0.1 to 0.2 pulse per second has been obtained, with an occasional instance showing twice this deviation. This accuracy has been found satisfactory.

The Laboratories' Part in the Exposition

In describing the progress of a visitor through the Electrical Building at the Century of Progress Exposition, the Electrical World for May 27 says:

"He comes first on the telephone and telegraph exhibit, a sort of amphitheatre around a well opening to the floor below and whose walls are lined with the infinite complexities and ingenuities which are the means of modern local and long-distance communication. Here are all the wonders of the Bell Telephone Laboratories, scrambled speech, delayed transmission, graphic transmission, all of the related developments of sound and electricity plus, also, some very intriguing possibilities in the field of sight and electricity."

News and Pictures of the Month

GHERARDI HONORED BY HIS ALMA MATER

At the seventy-eighth annual commencement exercises of the Polytechnic Institute of Brooklyn, N. Y., held on June 14, Bancroft Gherardi, Vice-President and Chief Engineer of the American Telephone and Telegraph Company and a director of Bell Telephone Laboratories, received the honorary degree of Doctor of Engineering.

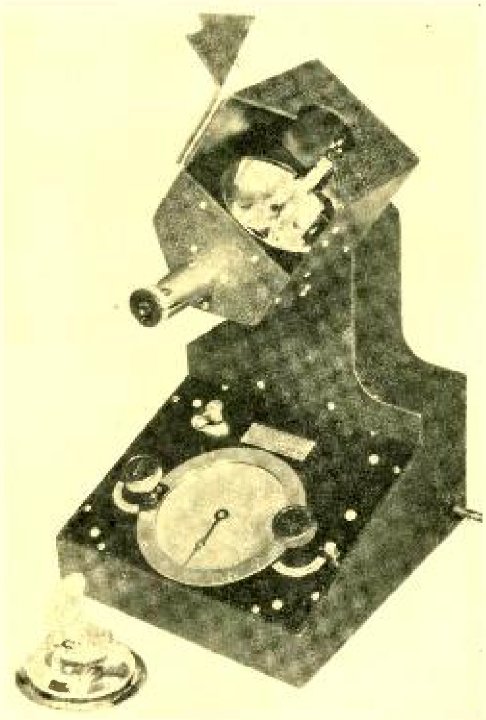
ELECTRIC WATCH TIMER

An electric watch timer developed by H. M. Stoller and E. R. Morton of the Special Products group, with the collaboration of C. H. Fetter of ERPI, was demonstrated before the Horological Institution on May 8. The timer permits any jeweler to regulate a watch to the maximum of its time-keeping efficiency in ten minutes, compared to about ten days now required by jewelers to adjust watches properly. The device is approximately the size of a standard typewriter.

When the watch is placed in a compartment of the timer an image of the balance wheel is reflected on a mirror, permitting a stroboscopic comparison of the watch speed with a flashing lamp. By a very simple adjustment of the timer, the actual loss or gain in seconds per day made by the watch may be read directly from a dial on the timer. Readings are taken with the watch in four different positions so that it may be corrected for any position in which the watch may be used.

The motive power which drives the timer is a one hundred cycle per second current, for this demonstration transmitted over wires and furnished by the telephone company from a constant frequency generator located in these Laboratories. The frequency of this current is accurate to one part in ten million.

With the timer it is perfectly possible to adjust any high-grade watch in good condition in about ten minutes time, al-



though watches which are in poor running condition should be observed over a twenty-four hour period. With such a device in his repair department no jeweler need keep a customer's watch more than one day for accurate adjustment.

50 KW TRANSMITTER IN UTAH

A new 50,000 watt Western Electric radio broadcasting transmitter was recently installed for Station KSL, owned by the Radio Service Corporation of Utah, at Salt Lake City, under the supervision of O. W. Towner of our Radio Development Group. Located in a practically flat valley which in ancient times was the bottom of a lake extending over a great portion of the surrounding country, it is approximately twelve miles west of the city and about three miles from the shore of Great Salt Lake.

The radio power is carried from the transmitter to the antenna by a transmission line which extends from the transmitter building to a coupling house midway between the towers. The antenna consists of a half-inch copper cable supported by two 225-foot steel towers. These towers are painted and lighted in accordance with the Department of Commerce recommendations for the protection of aircraft which daily fly past the new landmark.

The ground system for this transmitting equipment consists of nearly thirteen miles of copper wire in the space between the towers, forming a network which is buried about two feet deep to keep it in contact with moisture from the lake. This alkaline moisture is believed to contribute materially to the efficiency of the transmission of radio power from this station.

LIGHTING EFFECTS TO ACCOMPANY MUSIC

An important adjunct of the recent demonstrations of orchestral music in auditory perspective was the visual accompaniment of lighting effects and projected pictures in color. During the preliminary tests it was felt that since there would be no orchestra to watch, the audience would appreciate some visual spectacle to engage their eyes. This must harmonize with the music and be sufficiently subdued not to divert attention from the music itself. Engineers of Electrical Research Products, Inc., had made some studies in the field, and with the cooperation of S. R. McCandless, of the Yale School of Drama, a program was planned and the installation engineered under the supervision of J. S. Ward, Director of Operations.

When velour curtains were withdrawn there was revealed a curtain of gauze scrim, through which could be seen a rear curtain of gray velour. Spot and flood lights could be played on each curtain independently, and appropriate scenes could be projected on the rear curtain by lanterns concealed in various places including a draped podium. Since the projection angle was acute, distortion in the pictures was minimized by countervailing distortion in the drawings. These, all in color, were made by Eugene Savage and George Davidson.

The lighting effects were controlled from four portable switchboards placed in the orchestra pit. A prompter, following a marked musical score, gave cues to the operators, who could observe the effects through overhead mirrors. A telephone line, with voice-silencing transmitters, connected Mr. McCandless in the gallery, Mr. Ward in the main control box, the prompter, and the stage switchboard. Since Constitution Hall does not have a theatrical stage with curtain, flies, etc., it was necessary to erect two pipe frameworks with a substantial cross-member to hang the draperies and curtains. The lighting effects aggregated a connected load of about 100 kw.

SYSTEMS DEVELOPMENT

R. C. Hersh has been at Richmond, Virginia, in connection with the trial installation of type D carrier terminals modified for use with one-half ampere vacuum tubes.

E. J. Kane discussed dial system development problems with the Engineer of Manufacture and members of the Equipment Engineering organization at Hawthorne.

A. J. Busch was in Chicago the greater part of May testing a group of exhibits of telephone equipment at the Century of Progress Exposition, and assisting in selecting and training a maintenance force which will maintain this equipment for the duration of the Exposition.

The News Notes are continued on page iii of this section

Visitors to the Century of Progress Exposition who cross the lagoon by the bridge from the Hall of Science and swing south through the Social Science Hall, come upon a crowd around the balcony rail and in front of a large map, in the Bell System's exhibition space in the Communication Building

The Bell System Exhibit at the Century of Progress Exposition

At the Century of Progress Exposition in Chicago is an exhibit of the American Telephone and Telegraph Company on behalf of the Bell System. It was arranged under the direction of Vice Presidents A. W. Page and F. B. Jewett. Its execution was assigned by them to John Mills, Director of Publication, Bell Telephone Laboratories, whose individual contribution was primarily to the general plan and motif. An artistic setting of communication equipment in operation was to interest and instruct.

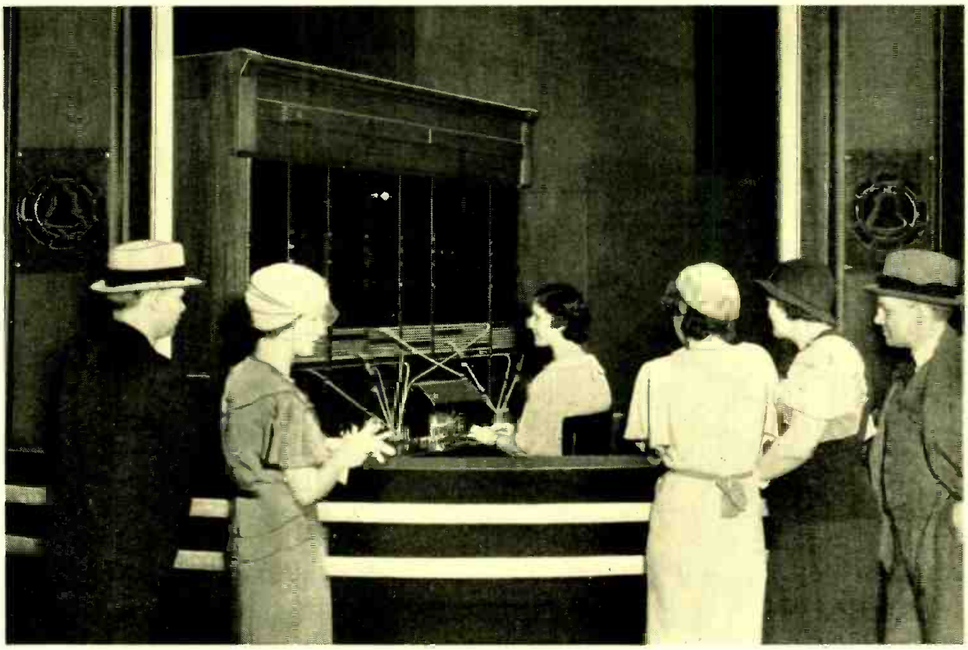
The exhibit required considerable engineering and development work, which was carried out by the Research, Apparatus Development, and Systems Development Departments of the Laboratories under the coördination of M. B. Long, Assistant Director of Publication. With the assistance of W. C. F. Farnell and R. L. Shepherd of his group, Mr. Long also coördinated the activities of the decorators and various other contractors and the installation of the equipment by the Western Electric Company and the Illinois Bell Telephone Company. Testing and final adjustment of the complicated special equipment were under the expert supervision of engineers from the Laboratories; and the perfection of the mechanical and electrical features was the result of attention by L. P. Bartheld, T. J. Greiser, L. B. Cooke, A. J. Busch, and F. S. Kinkead.

The nine exhibit areas on the second floor, containing most of the operating equipment, were decorated by Ivel Exhibits, Inc. The pavilions and two first floor areas were decorated by Jenter Exhibits, Inc. Changes in the building plans and special constructions were arranged by Raymond Hood, the architect for the building, and by Voorhees, Gmelin and Walker, respectively. The attractive tile bottom of the pool in the Communication Court was designed by Miss Hildreth Meiere.

A visitor who comes in the early morning, before the crowd becomes congested, may see a few unoccupied seats around the semicircular balcony, and on a bench in front of them the receivers with which to observe the demonstration of acoustic illusions

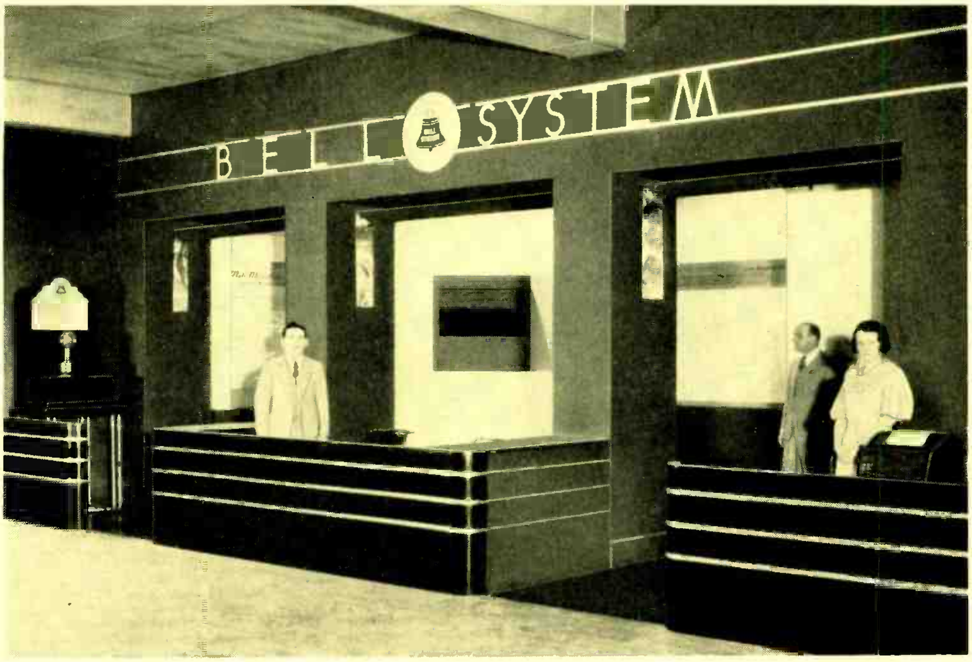
Since May 27 the Bell System exhibit has been in operation under the direction of Dr. Sergius P. Grace, Assistant Vice President, Bell Telephone Laboratories, who is executive representative of the American Telephone and Telegraph Company at the Exposition. Mr. Grace is assisted by H. S. Hanna of the Operation and Engineering Department of the American Company and by R. L. Shepherd from the Laboratories' Bureau of Publication. Mr. Hanna is in charge of the demonstrations to the public, and Mr. Shepherd of the engineering and maintenance of the exhibit's plant. Their staffs of assistants were recruited from the Illinois Bell Telephone Company, the Western Electric Company, and the Long Lines Department.

Passing around the balcony and then looking back, the visitor will see the balcony seats from the other direction, and in the distance the exhibit of panel-type central-office equipment. On his right is the niche containing the teletypewriter switchboard (to which also connect two teletypewriters on the floor below) which demonstrates the procedure taking place in the central offices which render nationwide teletypewriter service



Opposite the teletypewriter switchboard is the booth in which inverted speech is demonstrated. By making speech unintelligible in this way, privacy may be assured in transoceanic radio-telephone communication

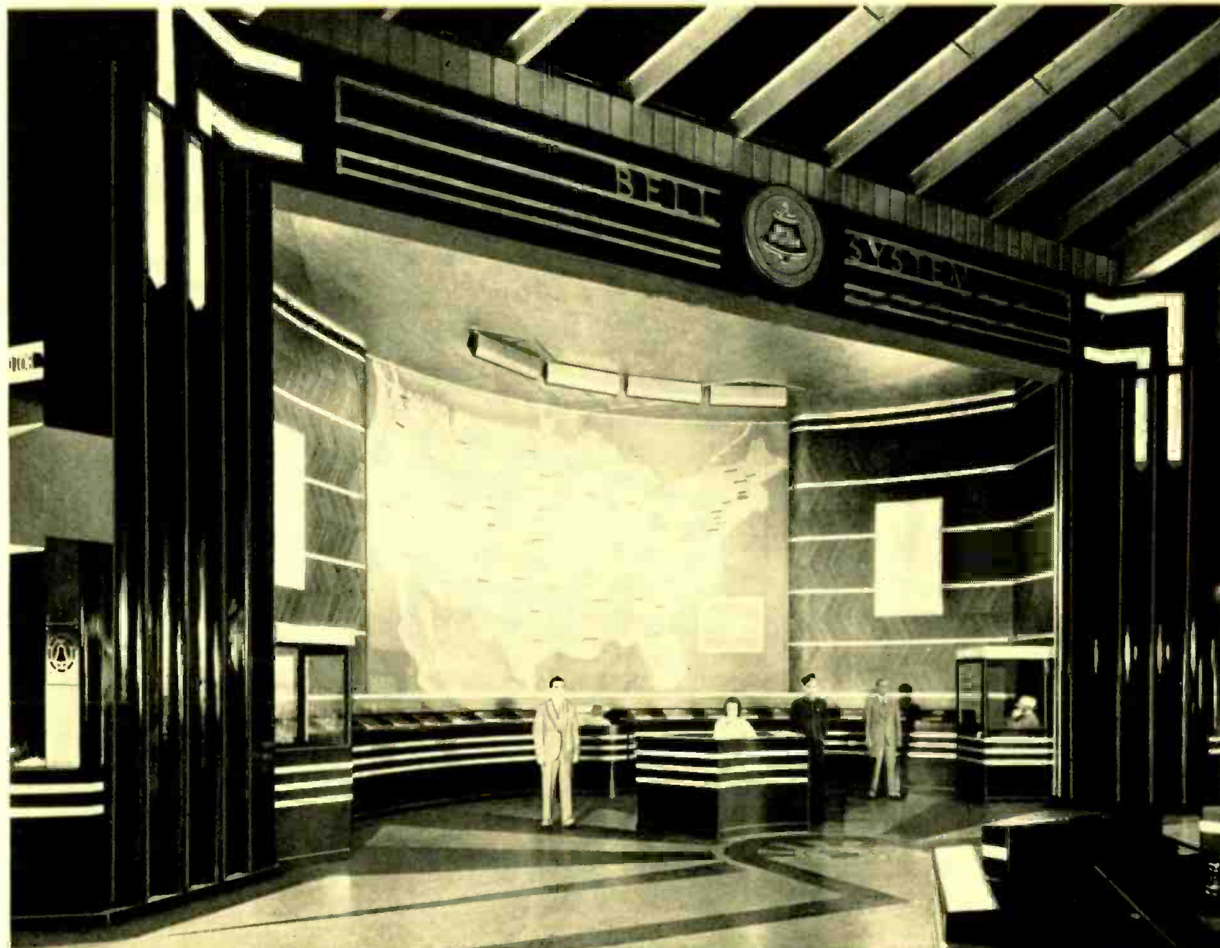
Below this booth, on the first floor, is one in which some of the facilities for intercity communication are explained. Among the exhibits is a vacuum tube whose plate, coated with a fluorescent material, glows in proportion to the plate current



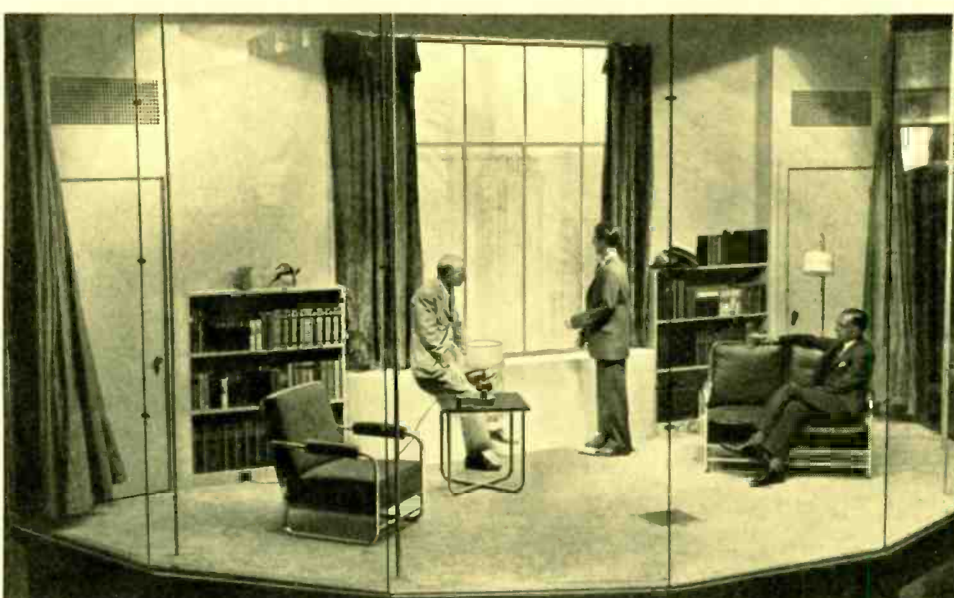
On the opposite side of the balcony and symmetrical with the exhibit of inverted speech is the demonstration of multi-channel transmission. Twelve telegraph messages, coming in over a single pair of wires, are separated by filters and demodulated, to demonstrate carrier-current transmission (at voice frequencies). Two teletypewriters, an oscilloscope and loud speaker, and five listening posts equipped with receivers let visitors see, hear and read the various messages. ¶On the first floor, below this demonstration, is a booth devoted to showing the convenience of the telephone in home and office

The exhibit of dial equipment typifies the machinery required to complete a call from a subscriber in one central-office area to a subscriber who is connected to another central office. Lights trace the motions of the elevators in response to dialing. One call is automatically put through each half minute and there are three telephones for visitors who wish to trace calls which they dial themselves to telephones on the right of the attendant's desk.

The visitor can assist in the demonstration of long distance telephony by placing a souvenir call. Lights on the map show the route of each call. Other visitors may listen to the call through head receivers, arranged on the shelf beneath the map. To the left of the souvenir calling space is a niche in which the call indicator and call announcer are demonstrated, and to the right is the teletypewriter exchange niche. Corresponding niches at either side of the panel system exhibit display manual switchboard and dial service board operation



The call indicator and call announcer methods of transmitting dial calls to operators at manual switchboards are shown in one of the niches. Loud speakers mounted behind the Bell System seals let visitors hear the call announcer and the explanations of the operator, who uses a lapel microphone for the purpose. ¶Few visitors will wish to leave the Bell System exhibition without experiencing the acoustic illusions afforded by Oscar, the Dummy with the Microphonic Ears, who is shown below being inspected by John Mills and M. B. Long, prior to the opening of the Bell System exhibit



Photograph from Wide World

F. S. KINKEAD went to Chicago in connection with the Bell System's teletypewriter exhibit at the Century of Progress Exposition.

RESEARCH

AMONG THOSE who attended the summer convention of the Acoustical Society of America, which was held on May 1 and 2 in Washington, were H. Fletcher, E. H. Bedell, L. J. Sivian, K. D. Swartzel, W. A. Munson, A. L. Thuras, K. E. Hammer, R. F. Mallina and A. R. Soffel. The convention heard papers by Mr. Mallina, by Messrs. Fletcher and Munson, by Mr. Sivian and S. D. White, and by E. C. Wente and Messrs. Bedell and Swartzel. H. A. Frederick presided over, and C. F. Wiebusch attended, the meeting of the Standardization Committee of the Acoustical Society and later the convention itself.

TO FINISH the work in acoustical and electrical research done by the Laboratories in conjunction with Dr. Stokowski and the Philadelphia Orchestra, A. R. Soffel, R. W. Buntenbach, W. B. Snow and K. E. Hammer were in Washington and Philadelphia during the first week in May.

R. C. MATHES completed twenty years of service in the Bell System on the thirtieth of last month.

INSPECTION ENGINEERING

ON THE FIRST of this month H. F. Kortheuer retired from active service after a long association with the Bell System. An account of Mr. Kortheuer's telephone career appeared in the RECORD for May, 1932, on the occasion of his thirty-fifth service anniversary.

APPARATUS DEVELOPMENT

F. M. RYAN acted as chairman of the Technical Session on the subject of Aeronautics at the Northeastern District Convention of the American Institute of Electrical Engineers in Schenectady. He also represented the Institute of Radio Engineers at a meeting of the Liaison Committee on Aeronautic Radio Research, in Washington. At this meeting the Committee prepared its third report which is published in full in the issue of the Air Commerce Bulletin for May 15. H. C. Atkinson accompanied Mr. Ryan to Langley Field, Virginia, to attend the annual Aircraft Engineering Research Conference of the National Advisory Committee on Aeronautics.

F. H. MCINTOSH supervised the installation of speech input equipment in the new studios of Station WRVA, Richmond, Virginia, and also inspected Station WSAZ at Huntington, West Virginia.

G. E. PERREAULT visited the Chelsea Clock Company, Chelsea, Mass., in connection with clock mechanisms to be used in a new development.

J. R. FRY visited Hawthorne in connection with relay developments.

R. L. HANSON attended the meetings of the Acoustical Society of America in Washington.

TO DISCUSS matters relating to message register cameras, T. E. Shea, W. Herriott, and J. Crabtree visited the Eastman Kodak Company in Rochester.

G. Q. LUMSDEN visited Gulfport, Mississippi, for the annual inspection of the pole-testing plot maintained by the Bell System there.

H. T. Martin

THE DEATH of H. T. Martin, which occurred on the first of last month, deeply shocked the many friends which he had made during his twenty-one years of service with the Western Electric Company and the Laboratories. The facts that in 1912 he joined the Shops at West Street as a model maker, and that last April, when illness forced him to abandon his active duties, he had earned the title of Manual Apparatus Engineer, testify to qualities which made him as highly valued in his profession as in his friendships.

When Mr. Martin transferred from the Model Shop to the Apparatus Development Department, he was assigned to the design of such manual switchboard apparatus as keys, plugs and jacks. Later the design of transmitters and receivers and certain special apparatus was added to his responsibilities.

In the earliest stages of sound picture development, for about a year, he had charge of the apparatus design for the project. This was a fascinating period in sound-picture history, when several tentative designs were built, some with large fly-wheels now no longer in evidence. The mechanical design of the handset and its mounting came into Mr. Martin's hands in its final stage, and this side of the development was under his supervision during the initial production period.

In 1928, when Mr. Martin became Manual Apparatus Engineer, all manual apparatus design was placed under his supervision. Since that time he had been responsible not only for such manual apparatus as had already been in his charge but also for station apparatus, and for many types of auxiliary equipment such as tools and transmission measuring apparatus.

THE FIRST of this month saw the retirement from active service of O. F. Forsberg, after a thirty-three year association with the Bell System. Mr. Forsberg's wide experience with telephony, which began as a model maker at Clinton Street, was recounted in the RECORD for June, 1930, p. 501, on the occasion of his thirtieth service anniversary. An excellent mechanical designer, he contributed to many telephonic developments, notably the coin-collector, the substation ringer and dial and the elevator drive for the panel system. His knowledge of manufacturing economics and his mastery of technique have left their impress on Bell System apparatus. His sincerity and friendliness will long be remembered by his associates in the Laboratories and in the Western Electric Company.

THE RETIREMENT of W. Scharringhausen on July 1 brought to a close a telephone career of more than thirty-two years, described in the RECORD for October, 1930, p. 97. Forty-two members of the Manual Apparatus Department tendered Mr. Scharringhausen a luncheon in the penthouse of the Hotel Brittany, and presented him with several gifts in token of esteem. Among the speakers at the luncheon were E. C. Mueller, O. A. Shann, and D. H. King.

PERSONNEL

G. B. THOMAS and R. J. HEFFNER attended the spring meeting of the Middle Atlantic Section of the Society for the Promotion of Engineering Education, at the University of Delaware, Newark, Delaware.

AT THE INVITATION of the Massachusetts Institute of Technology, Mr. Heffner went to Boston, as a member of a group of industrial representatives, to discuss with members of the faculty matters of engineering curricula and cooperative training.

PATENT

J. G. ROBERTS and M. R. MCKENNEY were in Detroit in connection with patent litigation.

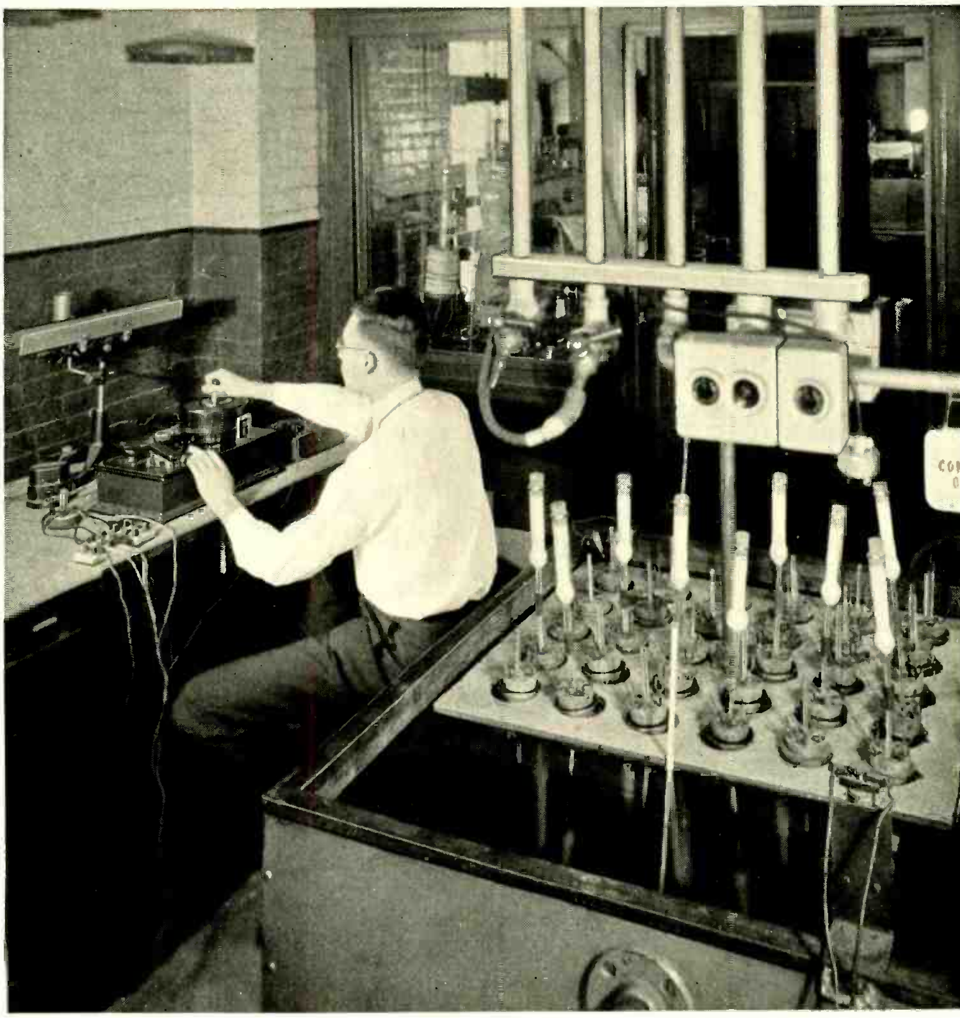
T. P. NEVILLE attended a hearing before the Examiner of Interferences in Washington.

PATENT MATTERS required the presence of J. W. Schmied in Washington.

G. H. HEYDT was in Boston in connection with interference proceedings.

PLANT

WILLIAM BODENSTEDT completed 20 years of service in the Bell System on the tenth of last month.



A Sensitive Method of Measuring Corrosion

By W. E. CAMPBELL
Chemical Laboratories

SOME years ago certain lead-covered cables, laid in creosoted wooden conduits, started to fail in as short a time as six months.* An investigation of the trouble indicated that the cause of corrosion was an attack by acidic vapors emanating from the wood of the conduit. To verify this indication, it was decided to measure the corrosion of lead sheath in the presence of the vapors from the wood.

In general, it takes too long to obtain data on the breakdown of materials in a corrosive environment by subjecting the materials to the actual conditions. To meet the need for more rapidly obtaining reliable

*Record, *April*, 1927, *p.* 275; *January*, 1929, *p.* 187.

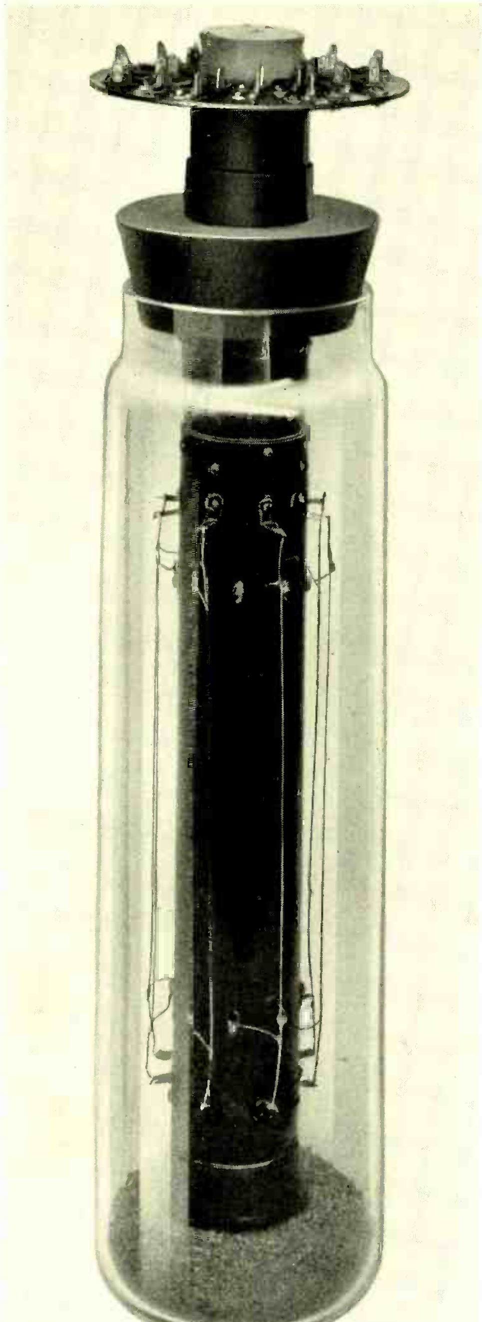


Fig. 1—The rate of corrosion of lead when exposed to wood vapors was determined by measuring the rate of increase in the resistance of lead wires as the attack of vapors from sawdust reduced their cross-section

data on the comparative merits of different materials, accelerated corrosion tests* have been developed which have proved of great value in the solution of corrosion problems, both individual and fundamental. In general these tests accelerate corrosion by raising the temperature or by increasing the concentration of the corrosive constituents in the environment. The extent of corrosion of a specimen after a given time is determined by measuring its change in weight or its loss in tensile strength.

These tests were not well suited to the case in hand for several reasons. In the first place, the concentration of the vapors from wood cannot readily be greatly increased. Furthermore the increase in the rate of corrosion obtained by raising the temperature proved insufficient to afford in a reasonable time a total corrosion which could be measured accurately by change in weight or loss in tensile strength. It was therefore found necessary to develop a more sensitive test.

The method devised depends upon the fact that as a narrow strip of material undergoes corrosive attack and thus becomes reduced in cross-section, its electrical resistance is increased. The electrical resistance of a strip can be measured with very high accuracy, and the amount by which it changes with a given reduction in cross-section can be made large by using a very thin strip.

In most of the actual tests, wires instead of strips of lead were used because they were easier to handle. The support on which the wires were mounted was placed in a jar containing moistened sawdust, obtained from one of the types of wood from which the vapors were to be tested. The jar was placed in a thermostat and the

*Record, *January*, 1933, *p.* 141.

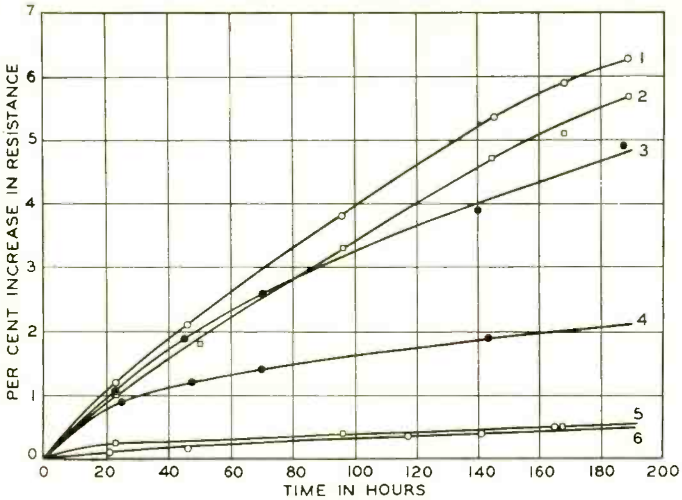
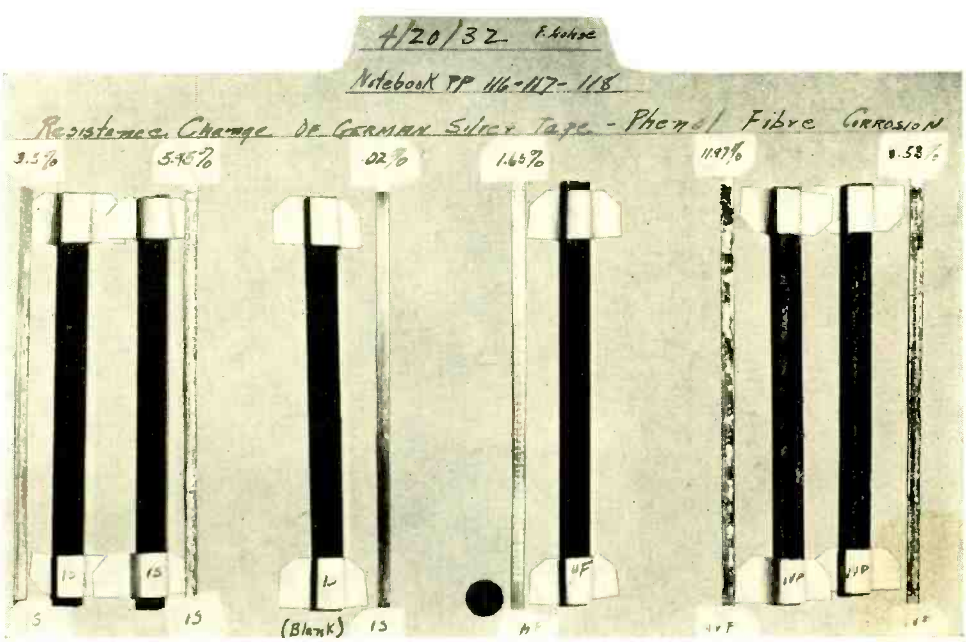


Fig. 2—The per cent increase in resistance of lead wires was followed while the wires were exposed to vapors from (1) *kiln-dried Douglas fir*, (2) *raw Douglas fir*, (3 *and* 4) *raw yellow pine of two different lots*, (5) *raw oak, and* (6) *raw hemlock*

resistances of the lead wires were measured daily for one or two weeks, using a current of one-tenth ampere.

The tests clearly showed that the vapors from different woods varied considerably in corrosiveness toward lead (Figure 2). Douglas fir, the wood used in the ducts where trouble was experienced, was appreciably the most corrosive. Remedial measures, taken on the assumption that acids from the wood were responsible for the difficulty, eliminated the trouble.

Though originally developed to solve this particular problem, the measurement of corro-



2 CONTROL 1 3

Fig. 3—This page from the notebook of F. Lohse shows that the resistance change of german silver tape, subjected to a voltage and in contact with various kinds of phenol fibre in a moist atmosphere, corresponds with the corrosion observed. The three kinds are numbered to correspond with Figure 4. The control was not subjected to voltage

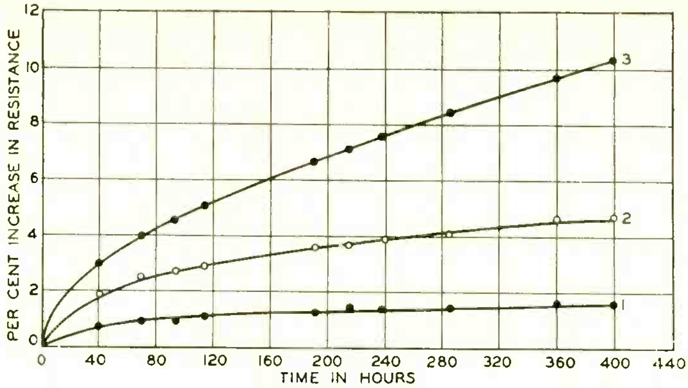


Fig. 4—The three types of phenol fibre shown in Figure 3 differ considerably in their corrosiveness toward german silver

sion by the change in electrical resistance which it produces has since been successfully applied to several other corrosion testing problems. One such application* is that of measuring the corrosive effects of insulating materiials in contact with metals subjected to voltage in a humid atmosphere. For example, the composition of the phenol fibre used in the back spool-heads of relays may be such as to cause corrosion of the lead-out wire, and subsequent failure of the relay. Similarly the front spool-heads may build up corrosion products on the spring tang, and so put the relay out of mechanical adjustment.

To test effects of this kind, narrow strips of metal were clamped between rectangular blocks of insulating material of the same width as the strips (Figure 3), and placed in a chamber of high, regulated humidity operated at a constant temperature. The blocks were then subjected to a voltage of 95 volts. This exposure resulted in more or less corrosive attack, which was subsequently measured in the usual manner. It is noteworthy that the quantitative results plotted in Figure 4 correlate very closely with qualitative effects observable from the condition of the strips at the conclusion of the test, shown in Figure 3. These results also place the types of phenol fibre in the same order of excellence as do insulation resistance measurements.

The same method is now being used for making quantitative tests on the corrosiveness of oils. Except in the case of very badly refined oils which may contain dangerously high percentages of mineral acid used in the refining treatment, corrosion by oils is generally due to organic impurities. These organic impurities may consist of sulphur compounds not refined out of the oil, or-

Fig. 5—The corrosiveness of a liquid toward a metal can be determined by measuring the change in resistance of wires when immersed in the liquid

*Made in the Chemical Laboratories by F. Lohse.

ganic acids formed by oxidation of the oil in service, or fatty acids and other materials added to the oil to improve its "oiliness"* or film strength. Corrosion by these organic substances, even when they are present in relatively high concentration, is very slow in comparison with most corrosive processes, and seldom produces breakdown by corroding parts completely away. Indirectly, however, it may cause considerable trouble by forming an insoluble sludge in the oil after a relatively short time.

In spite of the importance of these facts, no reliable evidence is available regarding the limiting concentration of organic acid which can be tolerated, nor has any work been done on the possible accelerating effect on corrosion of other impurities. The resistance method is proving a useful tool for obtaining such data. It was possible to make the apparatus for this purpose considerably more compact than that used for lead corrosion, since the metals under test are less ductile than lead and the wires could be wound into spirals without serious deformation (Figure 5). Each of the bottles shown immersed in the constant-temperature bath in the headpiece contains two such spirals. Data have already been obtained on the corrodibility of copper and iron by oleic acid, one the most commonly occurring fatty acids. It will be observed from Figure 6 that when this acid absorbs moisture, thereby becoming more acidic in character, the rate of corrosion of iron is considerably increased, while that of copper is relatively slightly affected. This behavior is in accord with corrosion theory.

It is believed that many of the problems connected with the corrosiveness of non-aqueous solvents,

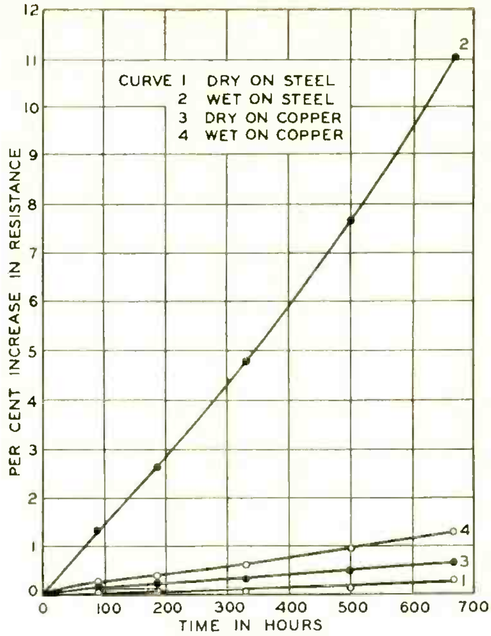


Fig. 6—The equipment shown in Figure 5 and the headpiece has been used to demonstrate that when oleic acid has absorbed moisture, its corrosiveness toward both steel and copper are increased, but far more toward steel than toward copper

such as carbon tetrachloride and gasoline, can be successfully attacked by the electrical resistance method. Recent tests indicate that it is even possible to follow corrosion in highly conducting liquids such as sulphuric acid.

All measurements of accelerated corrosion must be interpreted with care if the results of a test are to correlate with experience in service. In the case of most methods of test, the danger to be guarded against is that the rates of corrosion of individual members of a series of materials may be modified in different degrees when accelerated by the testing conditions. In applying the resistance method, it is important to remember that the test would not reveal any large changes in the rate of corrosion which might develop after a few months of service.

*Record, *August*, 1932, *p*. 406.

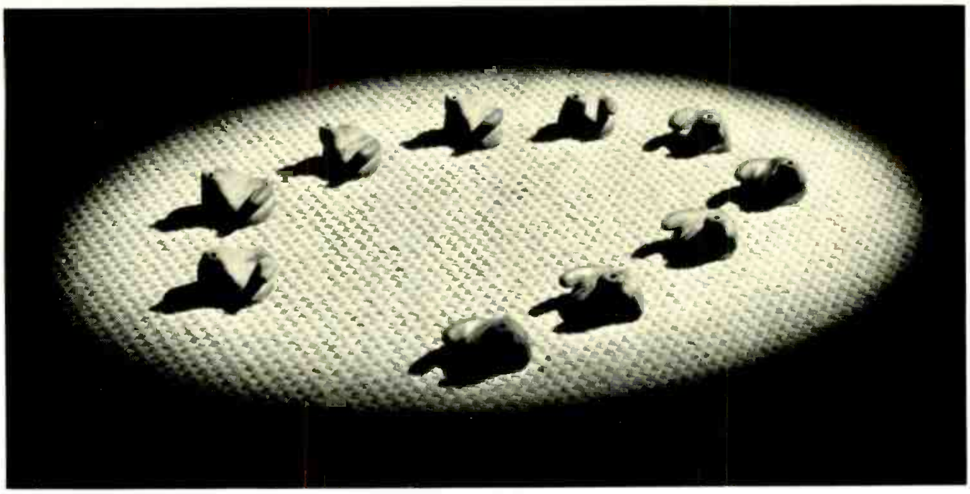
If such discontinuities in rate of corrosion are characteristic of a material, the ultimate resistance of the material to corrosion might differ greatly from that determined by a test of a few weeks. Constant improvements of technique are steadily bettering the agreement between the results of these tests and experiences in service.

The examples cited well illustrate the especial convenience of the resistance method in following the course of corrosion over a period of time. Measurements of change in weight or tensile strength necessitate the destruction of the samples but measurements of the change in resistance do not. For example, in order to follow in triplicate the course of corrosion for a year by testing at intervals of a month, pre-existing methods would require that thirty-six samples be set out initially. For resistance measurements, three wires suffice.

Nicaragua and United States Connected by Telephone

Regular telephone service between the United States and Nicaragua began on the seventh of last month, through the cooperation of the American Telephone and Telegraph Company and the Tropical Radio Company. In addition to United States telephones, the service embraces those in Canada, Cuba, and Mexico. A three-minute conversation between New York and any point in Nicaragua costs $21, *with* $7 *for each additional minute.*

The opening of service to Nicaragua completes the immediate Caribbean linkage project, first announced in the RECORD *for September,* 1932, *p.* 28. *Several articles describing the technical features of this project will appear in a forthcoming issue.*



Soft Rubber Earpiece for the Audiphone

By M. B. GARDNER
Acoustical Research

WHEN a person of impaired hearing considers a hearing aid, one of the most important points to him—and particularly to *her*—is lightness and inconspicuousness. Designers of hearing aids have always had these requirements in mind, and the latest Western Electric sets have left little to be desired in these regards as well as in such other important characteristics as loudness, gain and intelligibility. Because the receiver must be worn where it is difficult to conceal, it received early attention by our engineers, and in 1924 a midget type was developed which is now widely used. Since it weighs only a fraction of an ounce, it can be supported by the external ear and the headband can be eliminated.

To give the receiver a firm yet comfortable grip on the pinna—that part of the ear which projects from the head—and to prevent sound leakage from the coupling between the receiver and the ear, the earlier practice was to attach the receiver to a hard rubber mounting* which was made from a plaster cast of the pinna. This arrangement is ideal because a perfect fit is obtained, but it is expensive because the casts are made by ear specialists and the mountings are then made up individually. To provide a mounting which could be stocked by dealers and adapted to different ears, the No. 6 Type was developed with a spring, similar to that used in spectacle bows, which could be bent to fit the ear.

As part of their work on hearing aids, engineers of the Acoustical Research group have occasion to measure the hearing of many different people. Collaterally, it became apparent that there was sufficient similarity in ears so that a limited number of soft rubber mountings which closely approximated the individually moulded mounting could be developed which

*Known as the 5-A Receiver Attachment.

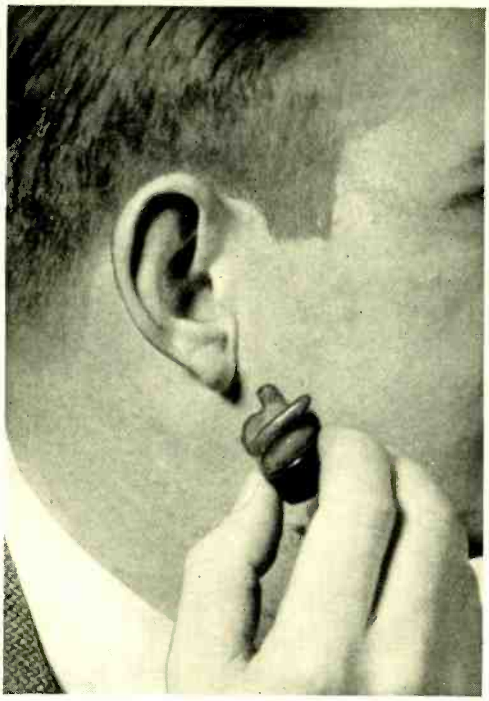


Fig. 1—The soft rubber earpiece is easily placed in or removed from the external ear

would fit almost any ear, and would cost the user much less, since the expensive individual work would be eliminated.

To appreciate the steps necessary and the problems met with in this development a general description of the outer ear is helpful. In the external ear are included the pinna—the part of the outer ear which projects from the side of the head—and the meatus or passage which is closed at its inner extremity by the eardrum—a membrane interposed between it and the middle ear.

The general form of the pinna or auricle, as seen from the outside, is concave, but it is thrown into various elevations and hollows, to which distinct names have been given. The largest and deepest cavity is called the concha. It surrounds the entrance to the meatus, and is interrupted at its upper and anterior part by a ridge, which is the beginning of the helix. In front of the concha, and projecting backwards over the meatus, is a conical prominence, the tragus. Behind the tragus, and separated from it by a deep notch, is another elevation, the anti-tragus. The thinner and larger portion of the pinna is bounded by a prominent and incurved margin, the helix. Within the helix is another curved ridge, the anthelix, which beginning below at the anti-tragus, sweeps round the hollow of the concha, forming the posterior boundary of that concavity, and diverging above it into two ridges.*

If a plaster impression be taken of the outer ear cavity it will be found that this "individual ear cast," as it is called, does not readily slip out of the ear, but is held quite securely. This is due to the irregular contour of the ear cavity and in particular to three specific parts of the pinna—the tragus, which projects out over the auditory meatus, the anti-tragus, which projects upward above the lobule, and a somewhat long narrow recess on the upper extremity of the concha, formed by a fold in the anthelix. Nearly every ear exhibits these three characteristics although the relative dimensions of each vary somewhat.

In order to facilitate the determination of the shape of the soft rubber earpiece a visit was made to the S. S. White Dental Manufacturing Company at Princes Bay, Staten Island. At these laboratories are made the hard-rubber 5-A Receiver Attachments, and there are available several thousand plaster ear casts which have been taken over a period of years of persons who were hard of hearing. From observation and measurement

*Gray's Anatomy.

of a great number of these casts a very good insight to the problem was obtained. These measurements gave an index as to the number of sizes of earpieces necessary, for, like any other part of the body, the ear also varies, so that each ear is slightly different, both in size and shape, from any other ear. The measurements indicated that four different sizes would be sufficient.

The process of developing the first soft rubber earpiece consisted of selecting from a great number of individual earpieces one which seemed to embody the characteristics common to all of the earpieces observed. This piece was then tried in the ears of a number of members of the Laboratories and notes made on features which seemed to deviate from a shape which should be universal. The cast was then reshaped by adding new material at given points and cutting away material at other points wherever it seemed necessary. These adjustments being made, the cast was again fitted in the same individuals and the same process repeated. Obviously, the first few corrections as to shape were readily observed, but at each new trial the process became more exacting and changes of much smaller magnitude were necessary.

It might be supposed that a universal earpiece could be designed by taking casts of a great number of individuals who fell approximately in one size class and making a piece which would have its dimensions equal to the mean value of the different dimensions of the individual casts measured. Although this would give an approximation, it in itself is not sufficient. An example will illustrate this. Between the tragus and anti-tragus in most human pinnas there is a deep notch. However in many cases this notch is almost entirely absent. An earpiece then which was determined from mean measurement would have a resultant projection to fill in this notch which would be much too prominent for many individuals.

After the first size had been developed to a point where it was satisfactory it was thought that possibly the other sizes could be made by reducing and expanding respectively in a given proportion. Two factors entered, however, to make this impracticable. It was found that from one size of ear cavity to another all dimensions do not vary in the same ratio. For example, the depth of the concha varies much less than its lateral dimensions. This means that a large ear cavity is not as a general rule associated with a deep cavity; on the contrary, the depth of a large ear cavity is not much greater than the depth of a small ear cavity. In the second place, just how to expand or reduce a very irregularly shaped body in the same proportion in all dimensions is not at once obvious. The other sizes were therefore developed similarly to the first size by fitting

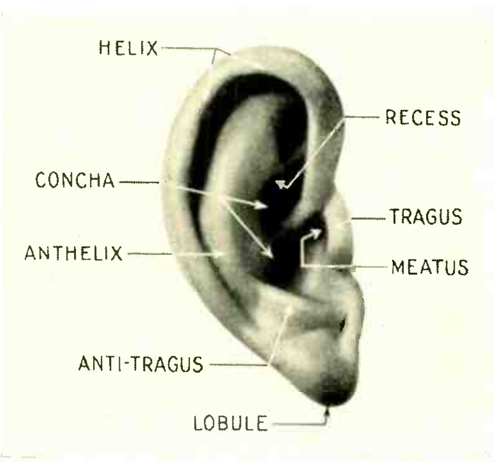


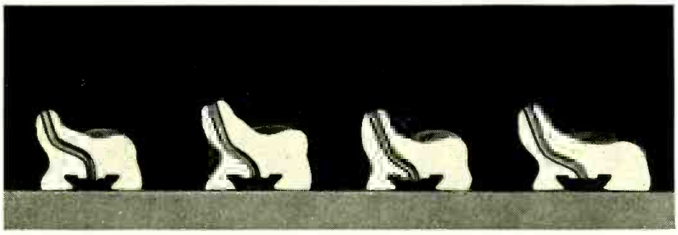
Fig. 2—Parts of the external ear

models into a number of individual ears which had previously been classified into different size groups.

All the development up to this point was completed using plaster models despite the fact that the final product was to be in soft rubber. This procedure was necessary due to the high cost of the steel dies which are used to produce soft rubber models. Hence only the final models were made in soft rubber. The question naturally arose as to whether a soft rubber duplicate of a satisfactory plaster model would also be satisfactory. To cut dies to find this out would be an expensive experiment if the answer were to be no. But since there was no other way to determine this, the dies were made, with a result which was quite satisfactory. It was found, however, that the soft rubber models would not remain in the slightly large ear as well as the plaster models due to being quite pliable. Also, most of the development work was carried on by fitting the models into individuals who were members of the Laboratories and consequently were younger than the average hard-of-hearing person. It was found that as an individual advances in years the ear cartilage loses its firmness and elasticity and unless the earpiece fits quite snugly it does not stay in the ear as well as in the case where the cartilage is firm. However the earpieces fit very well into ear cavity sizes very slightly smaller than those they were designed for. This failure to fit the upper limit of ear cavity size when the pinna had lost its firmness necessitated the design of a still larger size, making five sizes in all. These it is felt will accommodate every one except possibly a few individuals who, due to accident or other causes, have malformed ears.

In this development work the models were developed for the right ear only. But since the left ear is a mirror image of the right ear and since a method of inverting an irregularly shaped body is available, no additional experimentation was required to design earpieces for the left ear. It is interesting to note that so close is one ear to being a mirror image of the other that if impressions of both ears of any number of individuals are taken and then these earpieces be shaken up together in a box it is possible to pair the earpieces correctly.

Immediately upon completion of this soft rubber earpiece in the various sizes, their manufacture was begun and they are now available as the "No. 14 soft rubber earpiece" at all retail distributors of the Western Electric Audiphone.



Charging Batteries Without a Generator

By D. E. TRUCKSESS
Equipment Development

IN providing assurance of continuous service, much use is made of storage batteries as a reserve power supply in the telephone plant. These batteries, of course, require charging, and various means, such as motor generators and rectifiers, have been used for this purpose. With all of these types of charging equipment certain developments have been necessary to provide arrangements adapted to the requirements for telephone power supply, which necessitates close regulation and freedom from noise. Among these various charging arrangements, the rectifiers have been of greatest advantage in the smaller installations. The various types used have included the mercury arc rectifier, which requires mechanical manipulation to establish an arc, the hot cathode, argon, and mercury vapor rectifiers such as the Tungar, and copper oxide rectifiers.

An interesting recent development has been in connection with the provision of the hot-cathode tube rectifier in a form suited to certain telephone applications. Consisting essentially of a two-element gas-filled tube with a suitable transformer, this rectifier has no moving parts and is thus easier to maintain than a generator and, in capacities less than a thousand watts, is more efficient. Its operation also is simpler since it is not necessary to adjust the charger voltage to that of the battery every time they are connected together. Merely turning a toggle switch is all that is needed to start the charging operation.

Hot-cathode tube rectifiers were designed primarily for charging automobile ignition batteries. Those first put out used only a single tube, and thus rectified only half of the alternating current wave. Since their employment in the telephone plant did not at that time require them to be charging while the battery was de-

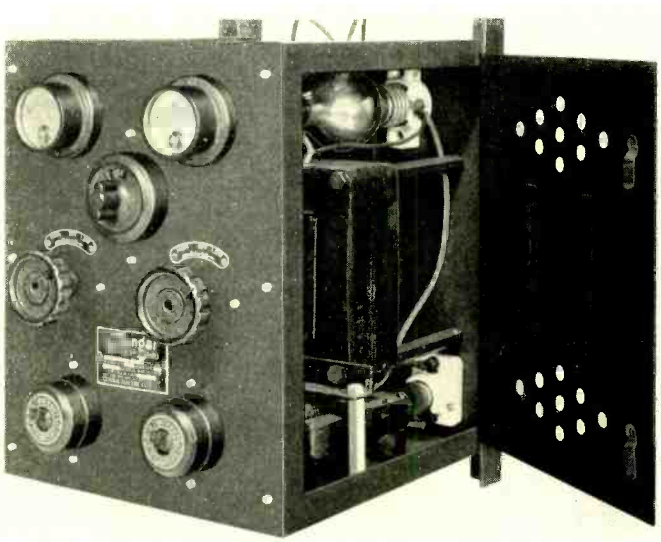


Fig. 1—A full-wave rectifier of the wall-mounting type

livering current, the greater noisiness of half-wave rectification was not objectionable, and this type was used for the original installations. As their value became more fully recognized, however, and their field of use extended, full-wave rectifiers were adopted instead, so that by the addition of filters they could be used to charge batteries supplying current to telephone circuits.

As originally manufactured the rectifiers were housed in a rectangular metal box designed for mounting on a wall. A full-wave twelve-ampere rectifier of this type is shown in Figure 1. Most of the power apparatus in telephone plants, however, is mounted on the power board: a set of 18 or 36 inch vertical panels supported by angle or pipe framework. When the commercial type rectifier was mounted on such a board it not only presented an awkward appearance but projected into the aisle in an objectionable manner. To improve this condition without losing other advantages, a group of panel-mounted rectifiers have been developed by the Laboratories. One of them is shown in Figure 2.

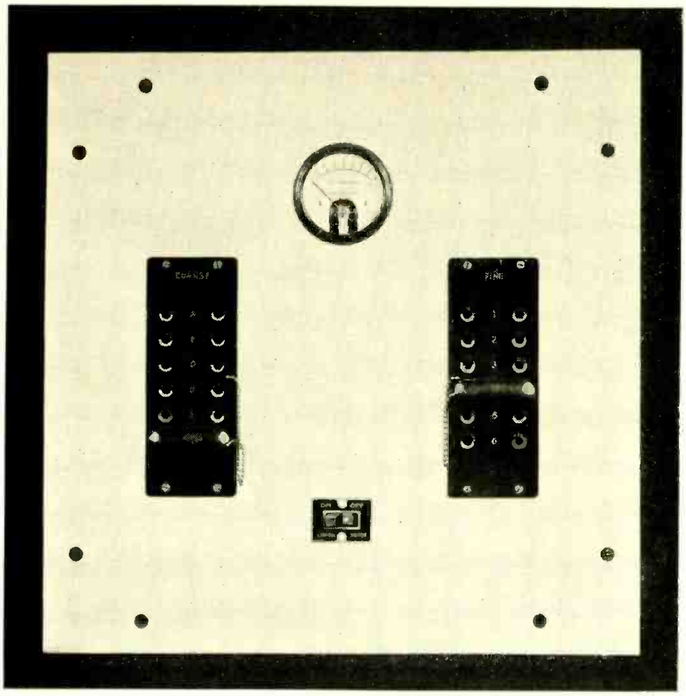


Fig. 2—A panel-type rectifier of the same capacity provides current control by two-prong plugs

With this new arrangement all the apparatus except the ammeter, current control, and switch, is mounted behind a steel panel eighteen inches square which mounts directly on the power board line up. The apparatus on the back of the panel has an enclosure with a solid top and perforated-metal sides and bottom. The rear of this enclosure is a removable panel which allows the bulbs to be removed or adjustments made without removing the entire case. Three capacities—three, twelve, and thirty amperes—have been designed; all with the same size of front panel, and differing in physical dimensions only in the depth of the rear enclosure.

The circuit arrangements for the three types are similar but with minor differences. That for the twelve-ampere size is shown in Figure 3. Both the primary and secondary winding of the transformer have taps. Those on the primary are to adjust for variations in line voltage. There are either three or four of them, depending on whether the supply current is 115 or 230 volts, and they are brought to terminals on a small panel mounted on the transformer. When the rectifier is installed that tap is selected which most nearly corresponds to the line voltage. The taps on the secondary are brought to two plug boards: one to give coarse and the other fine adjustment. This control makes it possible both to charge batteries of different voltages and to adjust the charging rate from about one quarter to full rated values.

Because of the use of two rectifier bulbs to obtain full-wave rectification, two taps must be changed simultaneously to divide the load equally between the two bulbs. The double plug arrangement makes this a simple matter. The secondary winding is split in the middle from which point is taken the positive connection for the charging circuit. Taps are taken from both the inner and outer turns of each half of the secondary; one set forming the fine and the other the coarse adjustments. Relays, not shown in the illustration, are connected in each negative lead from the bulbs to give an indication when a bulb burns out.

In addition to the current and voltage control obtained by the use of taps, additional regulation is required to compensate for minor variations in line voltage. The greater part of the charging voltage is required to balance the back electromotive force of the battery. Only a small percentage of the charging voltage is needed to overcome the impedance of the battery and rectifier, so that ordinary changes in line voltage, although only a small per cent of the total voltage, represent a large per cent of the small difference-voltage that is actually forcing current through the battery. To decrease this large effect of small variations in line voltage, it is necessary to increase the impedance of the battery circuit by the use of ballast impedances.

In addition to these ballast impedances, reactors are employed to smooth out the rectified wave when it is essential to have a quiet supply. A filtering reactor is available for each size of rectifier, with sufficient inductance to reduce noise so that it is almost inaudible under the most unfavorable conditions. The reactor for the three-ampere rectifier is small enough to be mounted inside the rectifier case, but those for the twelve and thirty ampere sizes are mounted externally and shielded.

With the thirty-ampere rectifier the filter reactor has sufficient impedance to serve for a ballast as well, so that an additional ballasting impedance is not required. With the three- and

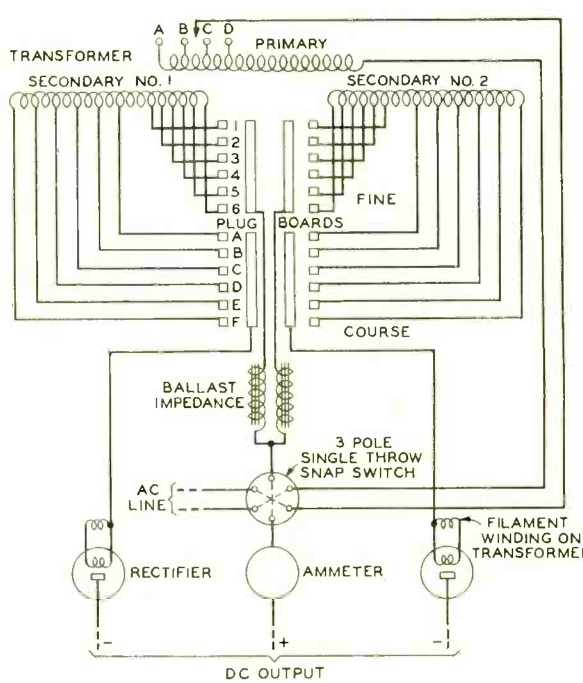


Fig. 3—Schematic arrangement of the 12-ampere rectifier

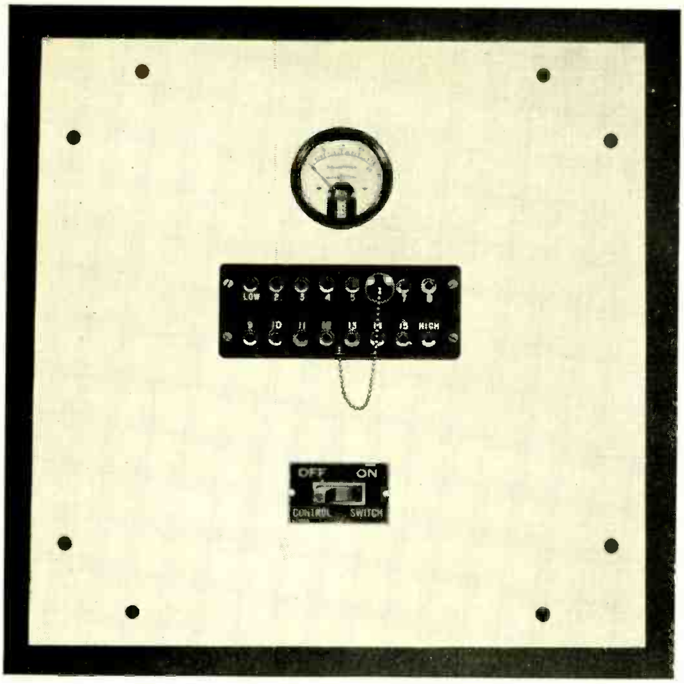


Fig. 4—With the 30-ampere rectifier only a single plug board is required

this size cannot be supplied without provision for filtering. The two smaller sizes may, however.

In addition to this difference in the arrangement of the filtering and ballast units, the three sizes of rectifier differ somewhat in their method of obtaining voltage and current control. The twelve-ampere sizes use the two double-plug boards as already described. The three-ampere sizes use a plug board for the coarse adjustment but a rheostat for the fine. With the thirty-ampere size, shown in Figure 4, the transformer taps are on the primary winding alone so as to take advantage of the smaller primary current and a single plug board is used as a control.

twelve-ampere sizes, however, the ballast impedance is separate from the filtering reactor and is mounted within the rectifier housing. For the three-ampere size a resistance is employed since with the small current flowing the losses in it are not of any great consequence. For the twelve-ampere size, however, where the losses in a resistance would be of more consideration, an impedance is employed. Although the ballast impedances are connected in the direct-current side of the rectifier, they furnish considerable reactance because of the large alternating component in the charging current. Since the same coil serves both as a ballast and as a filtering reactor in the thirty-ampere rectifier,

These three sizes of rectifiers provide a very flexible arrangement for charging telephone batteries. The three-and twelve-ampere sizes charge batteries of from 8 to 24 cells, and the thirty-ampere rectifier, batteries of from six to twelve cells. Since all capacities have the same size of case and have mounting details of like dimensions, a small rectifier may be replaced by a larger one as the plant grows and requires more charging current. It is thus unnecessary to incorporate the ultimate charging capacity in the original installation.

Contributors to This Issue

D. E. Trucksess received a B.S. degree from Pennsylvania State College in 1926, and joined the Technical Staff of the Laboratories in the same year. With the Systems Development Department he has been chiefly engaged in the development of power apparatus. Recently he has given particular attention to the development of copper-oxide and hot cathode rectifiers.

After graduation in 1930 by Brigham Young University, where he majored in physics and mathematics, M. B. Gardner entered the Acoustical Research group of these Laboratories. His work has been in connection with hearing aids, particularly in the development of a method of determining the response characteristics of these devices.

After receiving the degree of B.S. in Electrical Engineering from the University of Pennsylvania in 1909, H. Broadwell joined the Western Electric Company at Hawthorne. On completion of the one-year student course there, he entered a branch of the Apparatus Design Department then located at Hawthorne, and in 1912 this work brought him to New York. Three years later he transferred to the Dial Apparatus group where, except for a brief period of vacuum tube development during the war, he has since been engaged in the design of various units for dial and toll telephone systems.

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1929 he conducted research in electroplating and corrosion, in the course of which he developed a method of accurately measuring the corrosiveness of the fumes from wooden cable duct on the lead sheath of the cable. Meanwhile he continued his studies of chemistry at Columbia, receiving the A.M. degree in 1929. Recently he has been investigating the properties of materials in relation to their behavior as lubricants, in the attempt to lay a groundwork for the solution of the lubricating problems which are of increasing importance in telephony.

Manual switchboard exhibit at the Century of Progress Exposition, Chicago