BELL LABORATORIES RECORD

INDEX

VOLUME 20

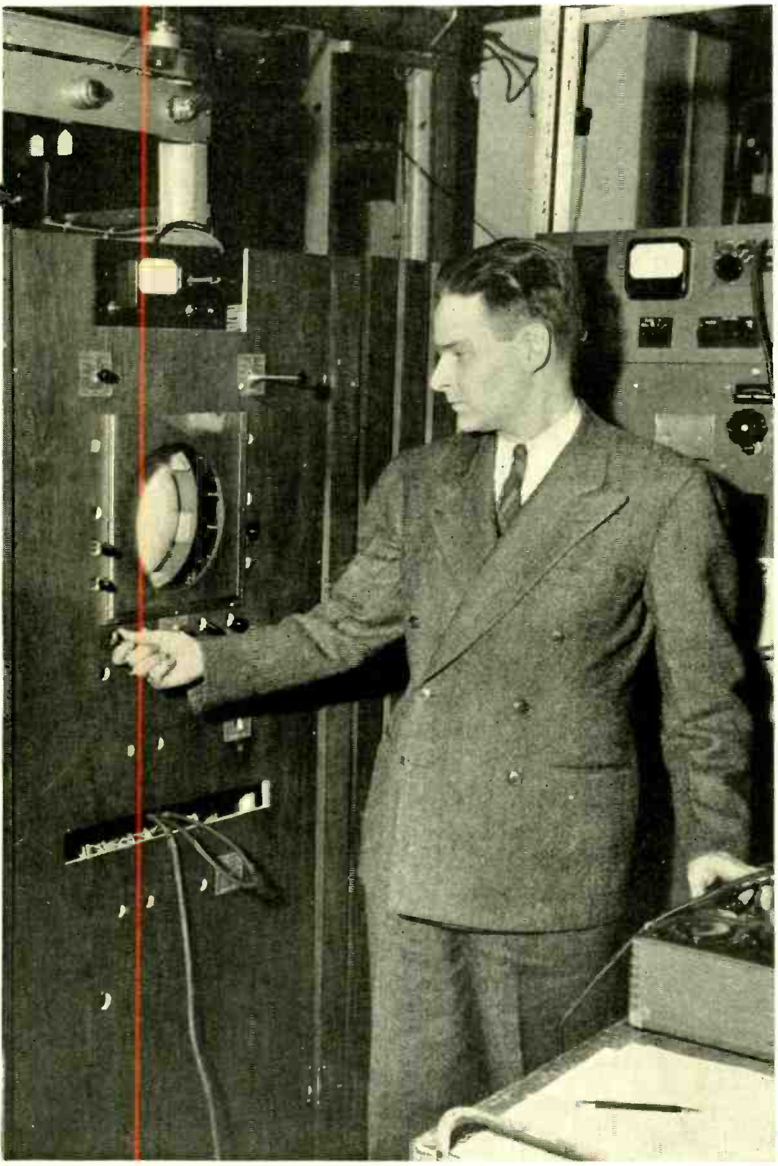
from September 1941 to August 1942

BELL LABORATORIES RECORD

BELL TELEPHONE LABORATORIES, INCORPORATED
463 West Street, New York, N. Y.

LIST OF ISSUES IN VOLUME XX

ELL LABORATORIES RECORD



SEPTEMBER

1941

VOLUME XX

NUMBER I

A new high-frequency oscilloscope under laboratory test

The Mirrophone

Magnetic Sound-Recorder and Reproducer

FOR many years telephone engineers have been experimenting with sound recording, because it is a most useful tool in studying the characteristics of speech. Reproducibility of a recorded sound, and its permanency, make possible detailed analysis of a particular word or phrase. There are three methods of recording sound: mechanically on wax, photographically on film, and magnetically on a steel wire or tape. The first method has found wide commercial application in phonographs and the second in sound pictures; but the third has until recently been used only in experimental apparatus. Recent developments, however, have made it a practical means of high-quality sound recording and reproducing. These new developments have been incorporated in the Western Electric "Mirrophone." It handles higher frequencies than previous magnetic sound recorders and is freer from distortions. These improvements largely account for its faithful reproduction of speech and music.

That sound could be recorded on a steel wire drawn at a uniform rate past the poles of an electromagnet, which carried voice currents from a microphone, was discovered by Poulsen, a Danish physicist, about forty years ago. This method has the advantage that the records are ready for immediate reproduction, since no processing is required as with sound recordings on wax or film. Moreover, recordings can be retained practically indefinitely without appreciable deterioration; but if wanted only temporarily they can be erased and used immediately for other records.

Attempts to commercialize the magnetic method of sound recording met with little success, however, until the improvements of recent years in which Bell Telephone Laboratories have been largely concerned. These improvements include the use of better magnetic materials and thin, narrow tape instead of round wire. Round wire twists and the magnetic elements have to be recorded along it instead of transversely across so as to maintain in reproduction the same direction of polarity. This result was achieved by offsetting the pole pieces of the recording magnets along the wire. The highest frequency that could be reproduced depended on the length of the longitudinal magnetic elements and high wire speeds were necessary to obtain faithful reproduction by this method. These high speeds not only required long recording wires but they wore the pole pieces excessively.

Flat tape does not twist and this permits magnetizing the recording medium transversely instead of lengthwise. The magnetic elements can then be shorter and this allows the speed of the tape to be reduced without losing the higher frequencies in the recorded sounds.

Before a magnetic record is made, the tape is strongly magnetized in a direction opposite to that produced by the recording magnet. It is then partially demagnetized by a direct biasing current, which is applied through the recording magnet to condition the tape so that the record will not be distorted. The reason for this procedure can be explained by referring to the magnetization curve in Figure 1 which shows the intensity of magnetization of a typical magnetic material plotted against the corresponding magnetizing force, which is proportional to the microphone currents. When the tape is between the poles of the polarizing magnet it is brought to magnetic saturation as indicated by the flattening of the curve at P in Figure 1. As the tape passes beyond the pole pieces its magnetism decreases along curve B to R, which shows its residual magnetism when the magnetizing force has been reduced to zero.

A biasing winding on the recording magnet reduces the magnetism of the tape still further to N, if there are no voice currents in the recording coil. When the tape leaves the field of the recording magnet, the magnetization

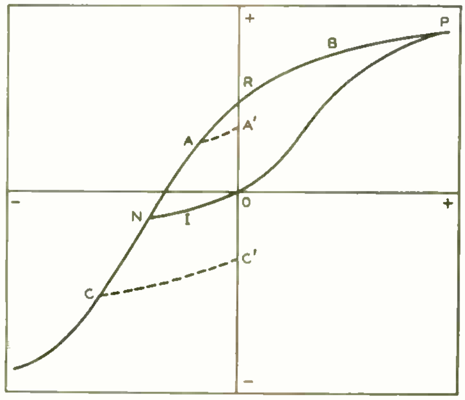


Fig. 1—To avoid distortion the magnetic record is confined to the nearly straight portion, AC, of the hysteresis loop

follows curve I to O. If there are voice currents in the recording winding the magnetic flux varies, as for example between A and C, while the tape is between the pole pieces. The nearly straight portion, AC, of the magnetization curve is thus used for recording because the magnetizing effect is proportional to the magnetizing field, and distortion is effectively eliminated. After the tape passes the recording magnet the flux range AC becomes A′C′, as shown in the figure.

Voltages induced during reproduction are proportional to the rate of change of magnetization and hence, for a constant tape speed proportional to the frequency of the recorded sound. The response, in other words, increases directly with the frequency. This holds true, however, only at low frequencies. At higher frequencies the response diminishes because of the finite width of the pole pieces and because of hysteresis and eddy current effects. The frequency at which this decrease begins is higher in proportion to the speed of the tape. The response of a magnetic recorder thus rises steadily with the frequency to a maximum determined largely by the design of the pole pieces and the speed of the tape. Beyond that the response decreases progressively. In practice an equalizer is inserted in the circuit to make the response essentially constant for all frequencies.

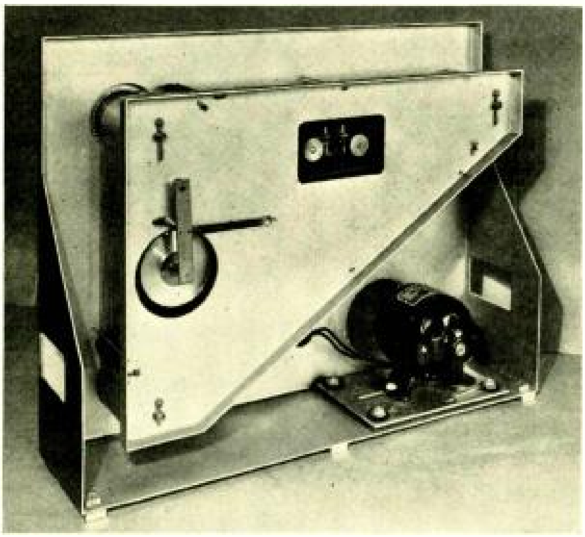


Fig. 2—The recording tape is held on drums which rotate to pass it between the poles of an electromagnet to which the amplified microphone currents are applied. No rewinding is required because the ends of the tape are welded together

These principles of magnetic recording are incorporated in compact practical form in the Mirrophone, shown in the photograph on page 2. Housed in a small cabinet is the recording-reproducing unit, an amplifier and a loud speaker. Associated with this unit there is a high-fidelity crystal microphone. The thin narrow tape on which the recordings are made is mounted on drums, Figure 2, which rotate to draw the tape between the poles of the recording magnet. To allow the tape to repeat without rewinding, its ends are welded together to form an endless belt. The material of the tape is a special magnetic alloy recently developed by the Laboratories which is superior to other materials for magnetic recording.

In reproduction the recording magnet serves as the pickup device. Figure 3 shows the recording and the polarizing magnets; a short loop of tape illustrates the method of threading. These magnets are a removable unit with plug connections. The dynamic loud speaker is supplied by a two-stage amplifier which develops exceptionally high gain. An acoustic chamber encloses the back of the speaker. Its field coil also serves as a filter in the amplifier plate-circuit.

Alternating current from any 110 to 120-volt lighting circuit operates the Mirrophone. A volume control regulates the intensity of the recording or the reproducing currents; and an electronic volume indicator shows when the level is correct for recording. To indicate the length of the recording there is a moving pointer which makes one complete revolution per minute and can be reset at any time.

A record once made can be reproduced as often as desired and kept indefinitely or until the switch is again thrown to the recording position.

Doing so automatically clears the tape as it passes the polarizing magnet and prepares it for a new record. The switch also has a stand-by position which leaves the tape running but disconnects the erasing, recording and reproducing units. An output jack permits connection to an external loud speaker or another recording machine when permanent records are wanted.

Best quality recordings are obtained when the speaker is close to the microphone, but the results are entirely satisfactory from greater distances. Group conversation can be picked up when the speakers are several feet away. Intelligible recordings have been made in large auditoriums with the sound source many feet from the microphone. On the other hand whispered words can be reproduced loud enough to be heard by all present in a large audience.

A person who hears a recording of his own voice for the first time usually insists that it does not sound natural. His friends on the other hand assure him that the reproduction of the Mirrophone is faithful. This is because one's own voice is ordinarily heard not only through the air but also internally by conduction through the bones of the head. Thus its true quality is unfamiliar.

In the Mirrophone, therefore, instructors in voice training have an effective new tool. Public-speaking classes and music schools find it helpful in developing good diction and correcting faulty technique in the rendition of vocal and instrumental music, for it has the great advantage of permitting a student to hear his own efforts as others hear them and to listen critically to the faults which his teacher wishes to correct. An experimental model in use at the Juilliard School of Music in New York City is shown on page 8.

As a lecture demonstration for talks and at expositions and conferences, it has the advantage of being able to reproduce recorded speech immediately and of preparing itself automatically for a new record. The

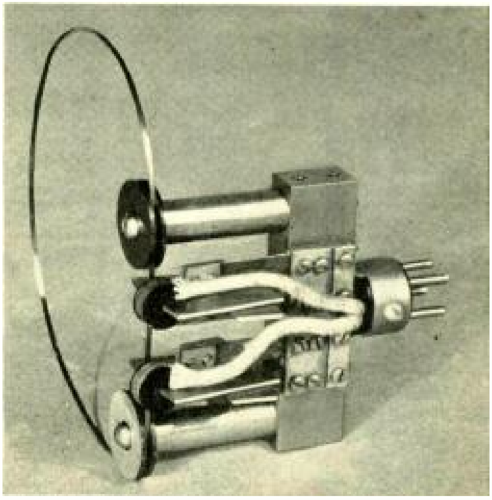
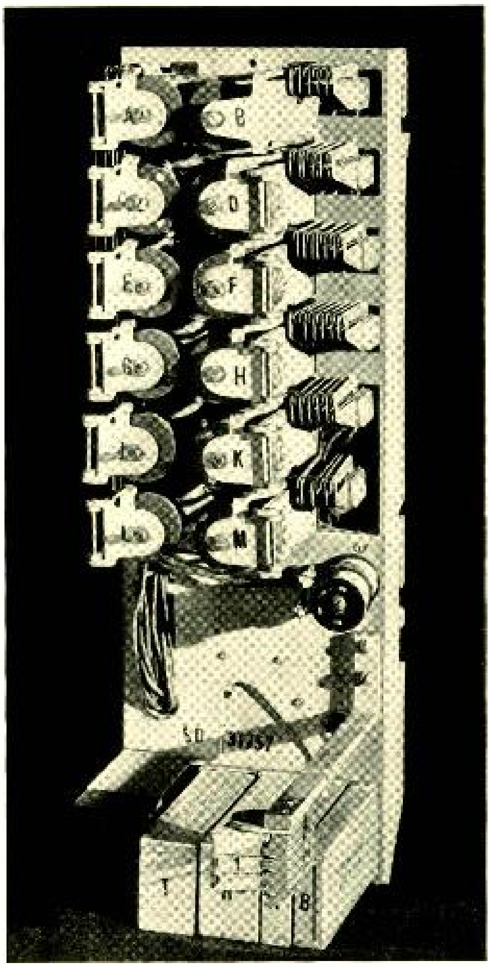


Fig. 3—The recording-reproducing element of the Mirrophone comprises two electromagnets. The upper magnet is the polarizing unit and the lower one is that used in recording and reproducing

Mirrophone is also an effective aid in teaching the correct pronunciation of foreign languages. Large commercial organizations and retail establishments can use it to train their personnel in correct diction for contacts with their customers both face to face and over the telephone. For the first time those interested in cultivating the voice and studying instrumental music have in the Mirrophone the opportunity of immediately reviewing their renditions—a privilege long enjoyed by devotees of the literary and graphic arts.



Facilities for Handling Large PBX Trunk Groups

By H. HOVLAND
Switching Development

A STEP-by-step switch has ten terminals in each of its ten levels, and when private branch exchanges in a step-by-step area do not require more than ten trunks, connection to the trunk is made through a step-by-step connector as for private lines. If the PBX had five trunks, for example, numbered 7434 to 7438 inclusive, only the number 7434 would be listed in the directory, and on a call to the PBX, the connector would step to the third level and then to the fourth terminal. If this particular trunk were busy, the connector would hunt over the next four terminals until the first idle one was reached. If all were busy, the connector would automatically return the busy signal.

When the private branch exchange requires more than ten trunks, however, some modification of the switch or wiring is necessary. The level-hunting connector was developed some years ago* to provide for these larger trunk groups. These connectors are arranged to hunt successively over one level after another, and thus provide for hunting over as many as 100 trunks. They are used in place of the rotary hunting connectors when more than ten trunks are required in a PBX group. Besides having the ability to hunt over more than one level, they perform the usual connector functions, including that of distinguishing between the various PBX's that are reached through the same connector.

This method of serving large PBX's has worked very well, but when as many as 100 trunks must be provided for a single PBX, and particularly when an office includes a number of these very large PBX's, it has several disadvantages. In the first place, the trunk group selecting feature is not utilized when each group of level-hunting connectors serves only a single PBX, and as a result full use is not made of their capabilities. In

*Record, *March*, 1929, *p.* 291.

addition, the hunting period may be relatively long and involve considerable movement and thus wear of the switch is incurred because of the many terminals over which the wiper must move. The hunting is minimized by causing the various connectors to hunt over the levels of the group in different sequences but even with this arrangement there may be considerable hunting during busy periods. A still further disadvantage is that each PBX having 100 trunks ties up 100 numbers—preventing their assignment to other lines.

To overcome these difficulties while still retaining the advantages of the level-hunting connector, a new PBX trunk circuit has recently been developed using the level-hunting connector as an auxiliary element. With this new trunk circuit an additional selector is ordinarily used ahead of the level-hunting connectors. The vertical stepping of this selector is controlled by the interruptions resulting from the dialing of the tens digit, and the switch may thus be referred to as the tens-digit selector. With this new arrangement, and assuming the PBX number was 6711, the dialing of the 7 would establish a connection to one of these tens-digit selectors. Dialing 1 would step the wiper of this selector up to the first level, which is assigned to PBX 6711, and over this level the selector will hunt for an idle trunk. An initial set of terminals, the first five for example, will be connected directly to trunks to the PBX through the new trunk circuit, and if one of them is idle it will be seized. The last five terminals connect to level-hunting connectors, which will have access to all the trunks if there are not over 100, or to 100 of them if there are more than a hundred. The final digit 1 dialed by the subscriber serves to start the level-hunting connector and is absorbed if the call is completed by way of the trunk circuit.

This arrangement is shown in schematic form in Figure 1, which indicates the arrangement in somewhat idealized form. There will, of course, be a large number of these tens-digit

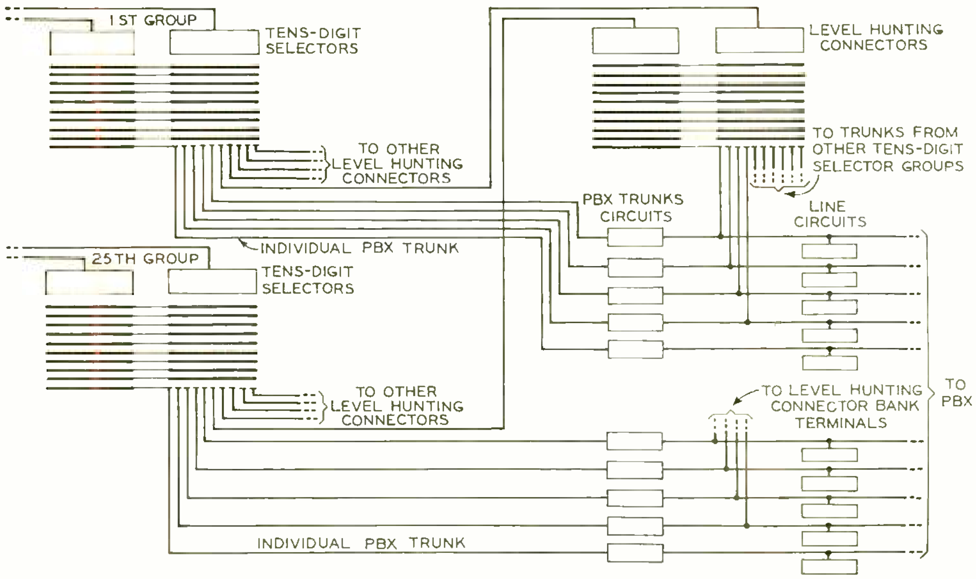


Fig. 1—Schematic of the new PBX trunk circuit

selectors, since they are capable of serving as many as ten large PBX's—one on each level. As an example, it may be assumed that the PBX connected to the first level of these selectors has 125 trunks. The terminals of the first levels of the selector would be multipled in 25 groups, and for each group the first five terminals would be connected directly to five of the PBX trunks through the new trunk circuits. In this way all of the trunks will appear as the first five terminals of the 25 groups of selectors. The remaining five terminals of the level would be connected to level-hunting connectors. The terminals of these level-hunting connectors would be connected directly to 100 of the PBX trunks without going through the new trunk circuits. Since there are 125 trunks, twenty-five trunks cannot be reached through the level-hunting connectors, and those not so reached would in general be the trunks connected to the first terminal of the twenty-five groups of tens-digit selectors.

With such an arrangement a large percentage of all calls to the PBX, especially during the less busy periods, are handled without use of the level-hunting connector, since all may be reached directly from the tens-digit selectors. In this way both the additional hunting time required and the additional wear and maintenance on the connector is avoided without losing the advantage of being able to hunt over a large group of trunks.

In the step-by-step system, talking battery, ringing, busy signal, and supervisory signals are supplied by the connector. Since with this new arrangement many of the calls to the PBX do not pass through a connector, but go directly from the tens-digit selectors, other arrangements had to be made to accomplish the various functions of the connectors. It is this that the new PBX trunk circuit does. The circuits are mounted on regular PBX mounting plates as shown on page 6, and may thus be mounted on regular step-by-step frames.

An experimental magnetic recorder-reproducer, similar to the "Mirrophone" described on page 2, being used by Professor Roland E. Partridge of the Juilliard School of Music

Conservation of Defense Materials in the Bell System

PHRASES strange to the ears of the average American have cropped up in the nation's press of late. We hear much of priorities, of "critical" materials, of raw material shortages in what had seemed a land of industrial plenty. To telephone engineers everywhere, to the men in Western Electric's manufacturing and purchasing departments, to engineers of Bell Telephone Laboratories, to officials of the Nassau Smelting and Refining Company, these phrases and their important connotations are part of the day's work.

Protection against raw material shortages, the source of so many production bottlenecks, is in normal times merely a matter of good industrial housekeeping. Now such protection is as vital to the national defense as production itself, for upon this protection production depends.

For a long time the Bell System has been studying how to make most effective use of materials currently employed, and of new materials as they became available. In 1931, Western Electric acquired the Nassau Smelting and Refining Company for the primary purpose of reclaiming materials in outworn telephone equipment—foresight that is paying dividends today.

Studies over the years have accumulated information which permits the Bell System to make numerous substitutions in ways that produce a

Steel is now being used for the manufacture of the telephone dial finger wheels in place of aluminum, a vital defense material

minimum of interference with the rendering of grade-A service.

However, whenever the opportunity to use the best possible material is restricted, some penalty is unavoidable. Also some materials have no substitutes for certain uses.

Without going into all the myriad details of the materials problem, we can see the broad consequences clearly. One is that some parts of our new plant, while they will be well made and capable of giving good service, will not be just as we would like to have them under ideal conditions. Another is that substitutions cannot by themselves solve the whole problem because for some uses there are no suitable substitutes.

Every associated company is participating in the conservation effort.

Thus far, by their own efforts and with the help of the materials substitution program voluntarily undertaken by the System, the telephone companies have been generally able to get the equipment they have needed. If, however, the essentials cannot be obtained as required in the future, the companies must have recourse to various sorts of expedients in increasing degree, and perhaps quite rapidly.

Just as the present emergency has given rise to a demand for ever-increasing production, so it has stepped up the search for substitutes. So too it has redoubled the Company's efforts for increasingly thrifty use of basic materials.

Since 1939, this vital activity to reduce Bell System usage of materials needed for defense purposes has been correlated in the System by an Inter-company Committee consisting of H. S. Osborne, A T & T's Plant Engineer, D. F. G. Eliot, Western Electric's General Purchasing Agent, R. L. Jones, Director of Apparatus Development at Bell Telephone Laboratories, and Stanley Bracken, Western Electric's Engineer of Manufacture. Back of them, however, the prompt coöperative effort of many other groups is putting the material changes into effect. Telephone engineers at A T & T and in the associated companies plan to use old equipment which might normally be replaced, so that the new equipment which might have replaced it can be used somewhere else where the need is greatest.

Dial installations in some communities can be deferred, used switchboards can be re-used, cables can be re-sheathed and re-used, desk telephones can be held in reserve so that they will be available for re-use.

Bell Laboratories' engineers consider the technical questions involved and pass on the suitability of available materials to replace those needed for defense. Manufacturing Department engineers review the piece parts affected by the shortage of a given material, consider available supplies, discuss the manufacturing features with Bell Laboratories' engineers and revise manufacturing information after agreement has been reached on the substitute to be used. Representatives of Western's Purchasing Department immediately place new orders, revise outstanding contracts, and attempt to keep a smooth flow of the new material coming in with a re-

Substituting for critical items on the Nation's list of vital defense materials cuts down on shortages. This Hawthorne girl replaces rubber with wood fibre board in terminal strips for central-office equipment duced volume of the old. Likewise, the Western Electric Works Departments carry a large part of the responsibility, in promptly arranging for the new material to be put into stock and adapting their operations to the new material and methods of manufacture.

That this work has been successful is evidenced by the fact that as of July 1, 1941, the intended Bell System yearly rate of use of aluminum will be reduced by 1,670,000 pounds. The yearly rate of use of nickel will be reduced by 238,000 pounds; the use of zinc by 3,380,000 pounds; the use of magnesium by 8,400 pounds. Additional reductions are foreseen.

Development of suitable substitutes begins in Bell Telephone Laboratories. The problem is many-faced, and requires a great variety of skills. First come the materials engineers who suggest available materials of suitable properties. Beyond this, the metallurgists and chemists may be consulted. Apparatus designers then take hold of the problem, to see if the changes in strength, conductivity or insulation require changes in the form of the part or device. Their knowledge of Western Electric's manufacturing methods is helpful in recommending designs which can be made with existing or slightly modified facilities. In some cases circuit experts may be called on to decide whether any changes will be needed in existing systems. Finally, manufacturing engineers of the Western Electric Company are responsible for the tool setups, and the actual processes of making and assembling the changed parts. The work of these men constitutes an important function in the defense program even outside the Bell System, for they coöperate with the Government and various engineering societies in developing simplified practices and otherwise alleviating material shortages.

The Western Electric substitution program has a direct and obvious bearing on the outcome of the defense program. For example, it is estimated that about 278 fighter planes might be built with the aluminum the Company will save from its annual rate of consumption this year.

Three classifications have been developed in the substitution work. Class I includes those materials for which substitutes can be introduced without extensive investigation. As an example, Western Electric and the Bell System are substantially reducing their use of zinc by coating much of their outside plant hardware with lead instead of putting these products through a galvanizing process.

In Class II are cases where substitutes may be found, but further work is necessary to determine whether their use is practicable. The Laboratories are studying the possibilities of using lead foil for condensers instead of aluminum, of which we would use 110 tons this year. The difficulty is to get the lead foil into the same dimensions as the aluminum and to thus avoid a redesign of the entire condenser, which might then be too big to fit into the limited amount of space available in certain assemblies of apparatus.

Class III includes those materials for which engineers have not as yet been able to find working substitutes and for which substitution may well prove to be impossible. For instance, there is no known substitute for the zinc electrode in a dry cell.

Generally speaking, the materials used in Western Electric manufacture which have become most critical are copper, aluminum, zinc, nickel, steel, rubber, magnesium, and nickel-steel. Some of the other materials which are rapidly approaching the critical state are phenol plastic, phenol fibre, brass and silk.

Western Electric now saves 65 tons of aluminum annually by replacing the aluminum in the dial finger wheel with steel, which serves the purpose adequately. Copper has replaced aluminum in bus bars, and an annual saving of 100,000 pounds of aluminum has thus been effected.

A thermo-plastic is to some extent replacing Zamak, a zinc-aluminum alloy, in the manufacture of the housing for the combined telephone set. Since the combination of Zamak is approximately 4 per cent aluminum, 0.03 per cent magnesium, and about 95 per cent zinc, this is a substitution which releases for other purposes a sizable quantity of vital metals. Of all the combined sets now in manufacture, as of the middle of the year, 34 per cent are of plastic composition. At this rate the annual saving of zinc in the housing will amount to 1,600,000 pounds. It is interesting to note, incidentally, that the new process developed for the manufacture of the plastic set is believed to be the largest injection molding ever made in regular production.

The defense emergency has, of course, tremendously stimulated the work of the Bell System engineering groups. An immediate survey was made in 1939, based on a study of materials particularly used in the Bell System, and a critical list of materials developed. The critical list consisted mainly of materials which were purchased outside of the United States, or the sources of which were beyond control.

Looking to the future, Western Electric's engineers are considering the use of sisal and ixtle, fibrous materials readily obtainable in this hemisphere, in place of jute and burlap for cable construction.

In compliance with an order of the Director of Priorities and in view of the necessity of conserving the supply of rubber, Western Electric plans a gradual reduction of its use of crude rubber which will reach twenty per cent at the end of the year. This saving will be accomplished chiefly by the use of more reclaimed rubber in rubber compound, and a reduction in the use of hard rubber by the judicious employment of materials having similar properties.

For the purposes of the emergency, temporary manufacturing information permits the manufacturing department to proceed with rapid introduction of substitutes. Because of the many factors involved—processing, engineering, materials and new procedures—manufacturing costs inevitably will rise as a direct result of the use of substitute materials. Nor are manufacturing conditions relieved by the fact that the defense program has greatly stimulated current telephone business, as well as plant expansion.

Observational Standards

By T. C. M. WOODBURY
Specifications Department

TELEPHONE apparatus is usually manufactured from specifications which consist of mechanical drawings and a written text, but some engineering requirements cannot be defined by these means alone. A physical object is needed to specify qualities, such as color and finish, which are judged best by the sense of sight or touch. Reference objects of this type are called "observational standards." Their use depends on the judgments of the inspector who makes the comparisons rather than on some quantitative process such as measuring, weighing or chemical analysis.

Control of the appearance of a wood finish is an example of the need for an observational standard. The required color and also the shade and grain are thereby shown with a definiteness unattainable in a written text or by a mechanical drawing. At times it is desirable to establish a light and a dark limit in addition to the desired shade so that apparatus which fails to harmonize with other equipment will not be passed by the inspector.

Glossiness of a surface can be specified quantitatively in a written text in terms of the amount of light reflected at a given angle of incidence and the amount dispersed at other angles, but it is preferable to specify that the glossiness shall conform to an observational standard which shows the degree of glossiness required.

Certain variations encountered in

commercial production can be defined best by observational standards. Glass insulators, for example, may acquire in handling, or may come from the mold with various imperfections which can be tolerated for reasons of economy unless they interfere with certain engineering requirements. An observational standard is indicated in these cases. In controlling certain surface effects peculiar to molded phenol plastic or die-cast products, observational standards are also desirable.

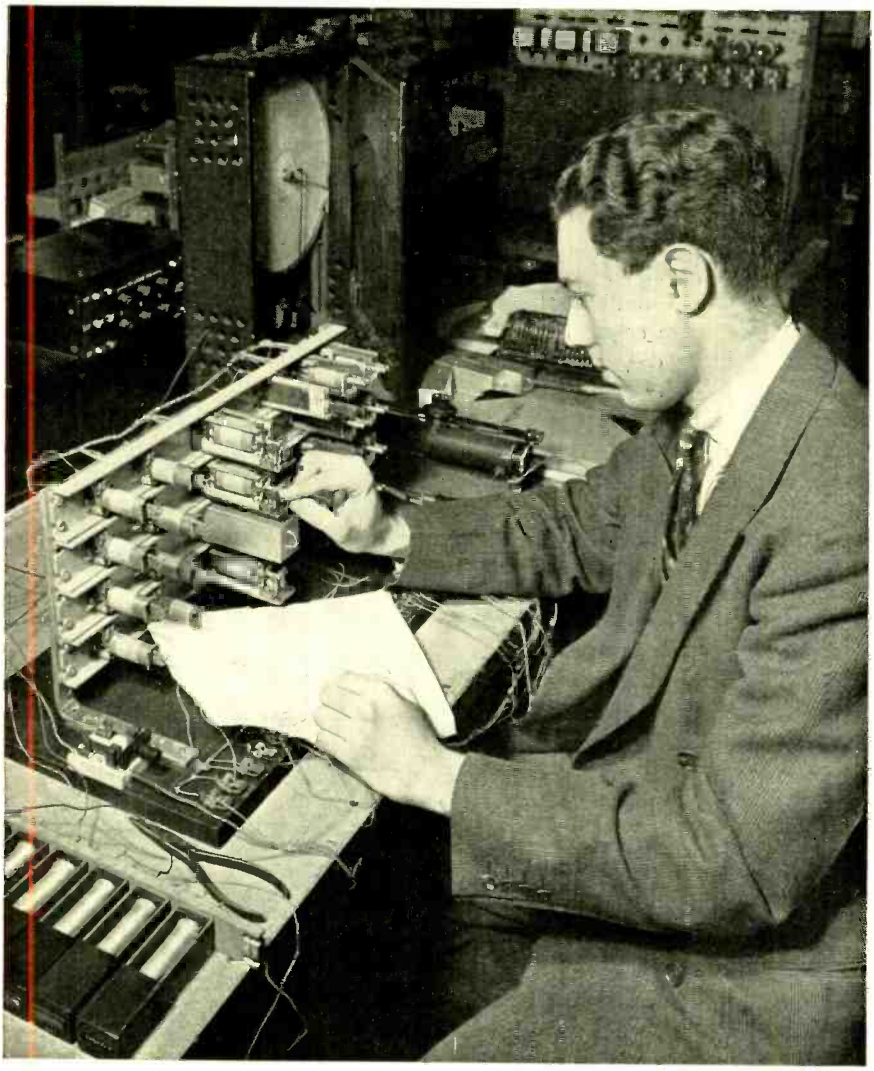
Although several methods are available commercially for measuring quantitatively the roughness or smoothness of a surface, a sufficient quality control, at a satisfactory economic level of production, can be obtained by using an observational standard whose surface is compared with the product visually or by running one's finger in succession over the two surfaces to be compared. Surprisingly small deviations in the roughness of the surface can be distinguished by the sense of touch.

Other characteristics of telephone apparatus which can be controlled to advantage by observational standards include the color opalescence and density of lamp caps, color of porcelain blocks and glass beads, the smoothness of machined surfaces, flaws in the glass structure of switchboard lamps, the color and texture of cotton, silk and other textiles, the degree of porosity in molded rubber insulation, various paper characteristics such as color, stiffness, texture and opacity.

Fig. 1—A group of observational standards including those for finishes, flaws in glass insulators, screw thread fits, color of glass bells, flaws and coverage of the finish on resistors and condensers, and texture of phenol plastic surfaces. C. R. McIver is holding one of the finish standards

Observational standards are stamped or permanently tagged to indicate definitely the characteristics to which they apply. The usefulness of a standard depends on the retention of its original characteristics and therefore precautions have to be taken to avoid deterioration both in storage and in use. The usefulness of a surface to control certain characteristics can be destroyed by contact with harmful substances, by handling with bare hands, and at times by exposure to light, heat or moisture. Special storage and packaging are therefore maintained in a central location for the protection of the master standards. A number is assigned to each standard from a series which is common with the Western Electric Company for reference purposes. Centralized storage for the standards also provides opportunity for keeping them in good condition, disseminating an index and other pertinent information and establishing a procedure for borrowing the standards by interested organizations.

NEWS AND PICTURES OF THE MONTH



Experimental circuit for a permanent-signal timer for unattended dial offices

News of the Month

Transcontinental Cable One-Fourth Completed

Nearly 500 miles of the new buried transcontinental twin cable have now been laid. Cable-laying trains of the Long Lines Department averaging forty miles a month have completed a quarter of the distance between Omaha and Sacramento and are ahead of schedule. While the speed of one of these trains naturally depends on the character of the ground, one train under particularly favorable conditions traveled seventeen miles in one week.

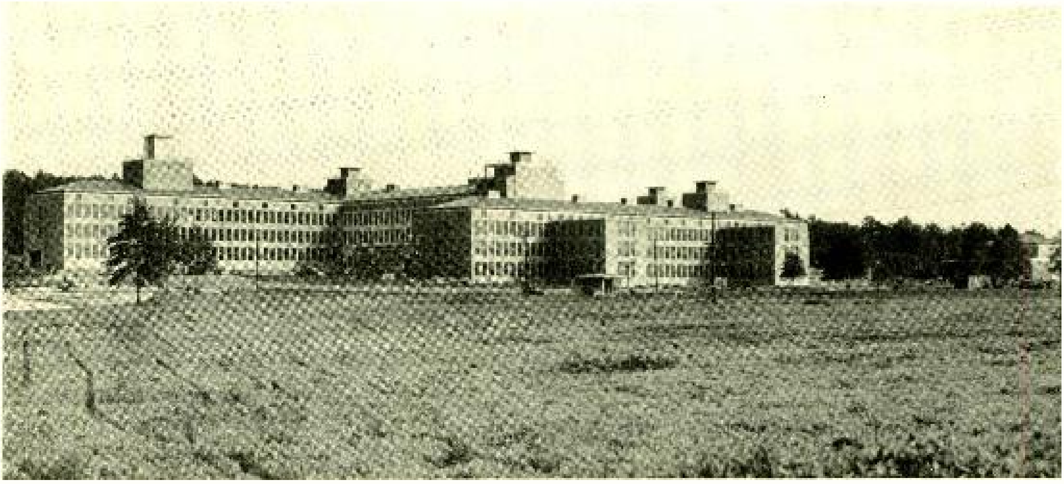
In order to meet the needs of national defense and mounting business requirements, plans have been worked out so that the "plowing in" of this cable could be carried on twenty-four hours a day if necessary. This is made possible by equipping the tractor trains with floodlights which enable them to work at night, as well as in daytime.

There are at present three cable trains engaged in burying this cable. These trains are scattered over the eastern section of the route between Omaha and Denver. One is now operating near North Platte, Nebraska. Another is operating in western Nebraska near the Wyoming border. A third train started at the Nebraska-Wyoming border, passed through Cheyenne and is now working north of Denver.

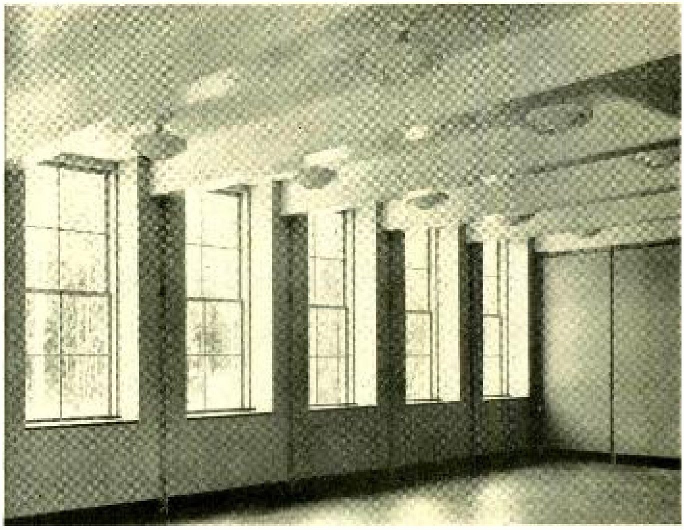
For the most part, the cables are buried with a coverage of earth of about thirty inches, except where variations in the soil or character of the route made it necessary or desirable to vary this depth. In some of the section between Cheyenne and Denver it was considered desirable to bury the cable with a coverage of thirty-six inches because of the experimental farming of beet sugar in this district which necessitates the use of large plows which cut very deep furrows.

Gas pressure is maintained inside the new type cables while they are being laid. The gas pressure is measured after the cable has been placed to make sure that no sheath opening has occurred during the plowing-in operations. Thus the crew is certain that the cable is in good condition after the cable has been buried.

After the cable has been plowed in, other gangs follow along to splice the wires to-

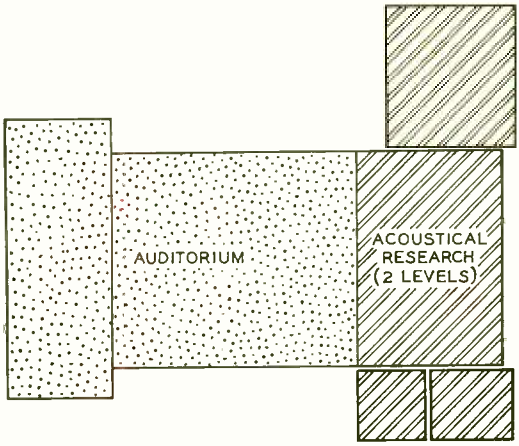


Save for extensive planting of trees and general landscaping, the Murray Hill Laboratories now presents its ultimate appearance gether at the ends of the cable lengths. The cable is for the most part manufactured in 3000-foot lengths so that in general splices will be required at 3000-foot intervals. Several splicing gangs are now working on the cable and have spliced together approximately 125 miles of cable west of Omaha and approximately 60 additional miles west of the Nebraska-Wyoming state line. After the cables have been spliced, tests are made to be sure that the cables have been spliced properly and that the insulation of the conductors and the crosstalk between the conductors is within the proper limits. The final adjustment to reduce crosstalk is done by means of adjusting small balancing coils in the repeater stations. After these coils have been adjusted the repeater equipment is connected to the cable conductors and overall lineup tests are made.



A typical section of the interior at Murray Hill

To date the Long Lines Department has completed about thirty repeater station buildings between Omaha and Laramie and Denver and Cheyenne. Most of these buildings are one story, concrete and brick, twenty feet by forty feet in size. The first buildings constructed, those between Omaha and Grand Island, are slightly smaller and

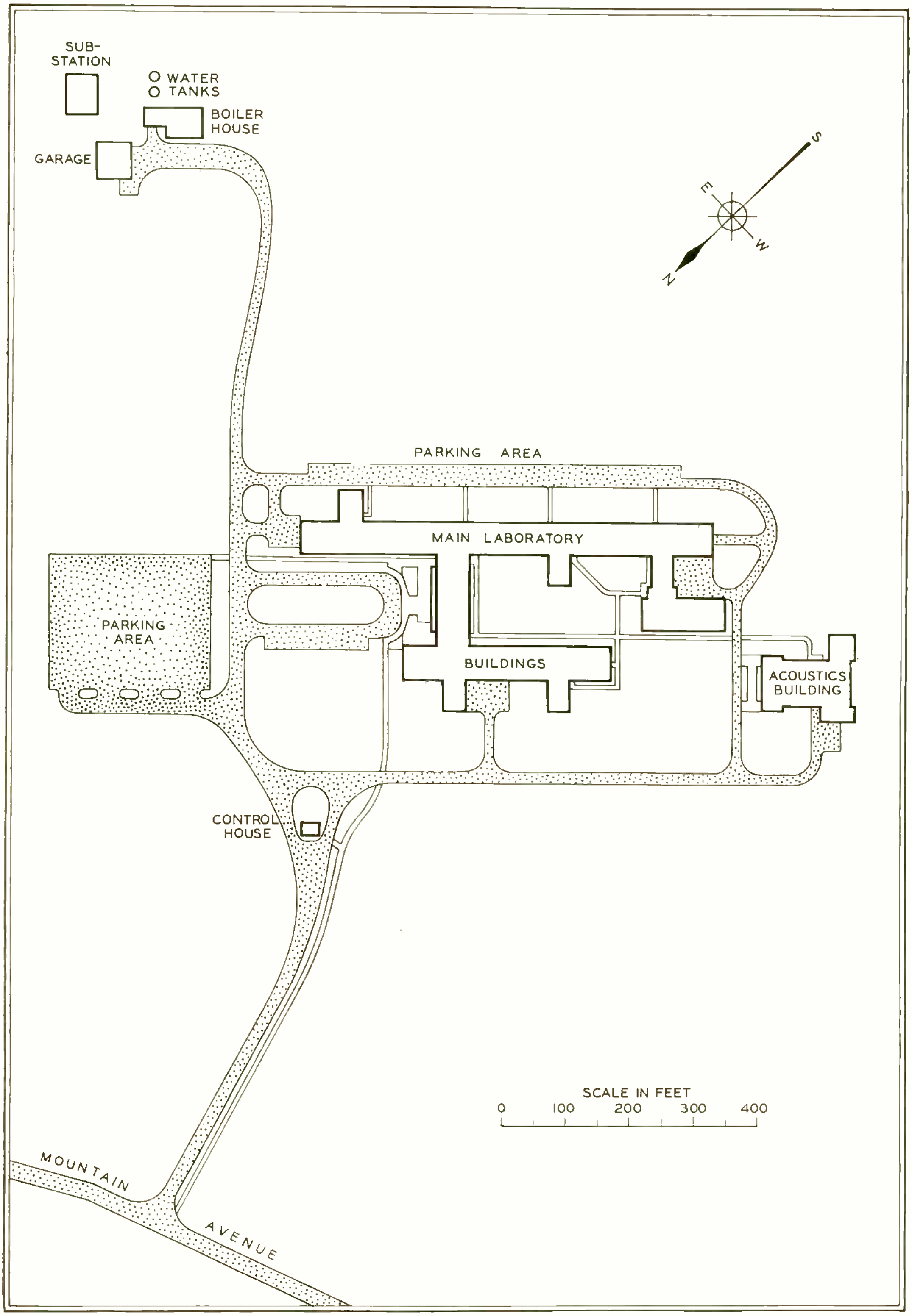


Simplified floor plan of the acoustics laboratory at Murray Hill

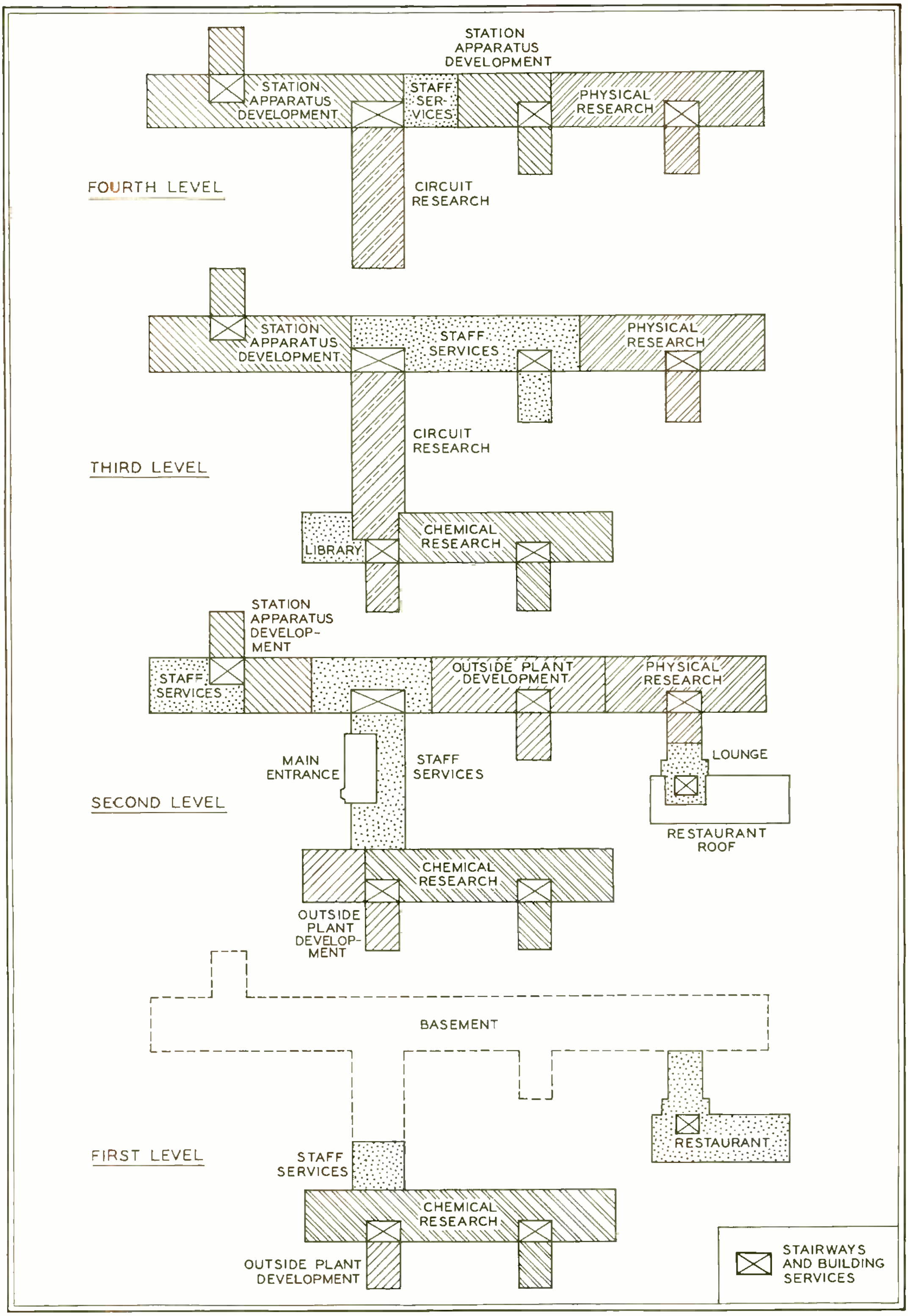
square in shape. The work of providing and installing the repeaters and balancing equipment in these buildings is being handled for the Long Lines by the Western Electric Company. This work, now under way in over twenty of the completed buildings in this area, began at the end of April and should be completed and the equipment tested by the fall, when the Plant Department starts placing the through circuits in service.

No construction has been started on the section of the cable west of Laramie but plans call for building over twenty-five more repeater stations to Wendover, Utah; and, counting those to be built by the Pacific Company, there should eventually be from ninety to a hundred buildings in all.

The new cable will supplement several existing "open wire" transcontinental lines, and, according to present plans, from fifty to seventy telephone circuits will be put in service over the completed sections between Laramie and Omaha by some time in December. When the rest of the cable is completed in December of 1942, there will be about one hundred circuits in the cable all the way from Omaha to Sacramento, plus about twenty or more to take care of traffic between the east and Denver. This will represent an increase of about fifty per cent over the present number of transconti-



General layout of the grounds and buildings at Murray Hill



Approximate locations of the principal types of work that will be located at Murray Hill nental circuits. Eventually Long Lines expects to have some 600 telephone channels working through the cable, or about triple the present number of transcontinental circuits, as well as several radio network circuits. A few of the telephone channels in the cable are being provided for telegraph purposes. For each telephone channel so used, up to 18 telegraph or teletypewriter circuits can be made available.

One of the problems encountered in laying the buried cable is due to conditions caused by the corrosive nature of the soil in certain sections. This has necessitated a special protective covering over the cable, known as "thermoplastic," composed of rubber, asphalt and inert filler.

The Medical Department

The care of accidents constitutes an important function of the Medical Department. Fortunately, most of these are minor in character. In volume the number of accidents cared for range between 200 and 250 a month, not including foreign bodies of the eye which number over 100 a month. Only about 40 per cent of the accidents in general occur on the job and only from 25 per cent to 30 of the foreign bodies of the eye are received while at work. Of all the injuries sustained by workers in industry those to the eyes are entirely preventable. It is estimated that 15 per cent of the blind in America have lost sight because of occupational trauma and about 10 per cent of all industrial accidents in the United States concern the eye.

Dr. O'Malley making an ophthalmoscopic examination of S. P. Shackleton's eyes

Approximately 2000 eyes are lost in industrial accidents each year, and $50,000,000 is lost to employees and employers of American industry as a result of preventable eye injuries. Goggles are provided by the Laboratories for all employees in shop areas where they may be required and should be used more frequently.

Flying Boat Passengers Saved by Marine Radio Telephone

A Western Electric 226-type marine radio telephone foiled Davey Jones recently when, as the central figure in a struggle

Miss Adams dressing a minor injury of one of W. T. Wichman's fingers

with the sea, it saved the lives of twenty-four people aboard the *Arthur B*, a chartered fishing boat which foundered off Long Island's south shore near Fire Island.

Out for a day's fishing, the yacht *Commander* came upon the *Arthur B* sinking rapidly in a heavy sea. The *Commander* called the U. S. Coast Guard station at

Built in 1914, *the bandstand in Abington Square has become a landmark to West Street people. Now the City is having the top removed, since no concerts have been given there for many years. The lower floor, refitted for its humbler purpose, will remain. Columns and lintels are for sale to anyone who wants a pergola*

Fire Island, notifying them of the plight of the stricken vessel, with the promise that they would stand by until the rescue ships arrived.

The *Commander* then took the *Arthur B* in tow and continued to tow the boat for about five miles before two Coast Guard boats appeared on the scene. By this time the *Commander* had been forced to cease towing and stand by while the *Arthur B* sank lower and lower in the water despite the frantic bailing of the crew.

The Coast Guard removed twenty-two of the twenty-four people from the sinking boat, leaving the captain and the mate to handle the *Arthur B* while it was being towed back to port by the Coast Guard. However, twenty minutes after the passengers had been removed, the Captain and the mate also had to be taken off; the *Arthur B* sank while in tow two miles from shore.

Bancroft Gherardi, 1873-1941

Bancroft Gherardi, dean of telephone engineers and a former Director of the Laboratories, died on August 14, 1941. Entering the New York Telephone Company in 1895, he transferred to the American Telephone and Telegraph Company in 1907, and rose to become Vice President and Chief Engineer and a Director of that company. An account of his career appeared in the Record for May, 1938, on the occasion of his retirement from active service.

National Defense, Military and Naval Items

R. L. Jones has been appointed official Investigator for the newly organized National Defense Research Committee.

Members of the Laboratories who have been granted leaves of absence recently are:

Charles A. Hebert, Ambrose Section,

Lieut. Frank A. Parsons instructing selectees in the use of a 45-caliber automatic pistol at the Aberdeen Proving Ground in Maryland

Inshore Patrol, Section Base, Tompkinsville, Staten Island.

ROBERT J. KOECHLIN, Company A, 34th Infantry Training Battalion, Camp Croft, South Carolina.

H. B. ELY has been commissioned a Lieutenant Colonel in the Ordnance Department to serve as a member of the Industrial Service in the Office of the Chief of Ordnance at Washington. A graduate of the United States Military Academy, Col. Ely served in the Army for fifteen years and was at one time in charge of the Fire Control Section at Frankford Arsenal. His son, H. B. Ely, Jr., who left Columbia to enter the 207th Coast Artillery, has been appointed a cadet at West Point.

L. J. SIVIAN, W. B. SNOW and R. G. WATLING have been granted leaves of absence to engage in National Defense Research Committee work. Mr. Sivian is located at the U. S. Navy Radio and Sound Laboratory, Point Loma, Calif. Mr. Snow and Mr. Watling are at the National Defense Laboratories, Fort Trumbull, New London, Connecticut.

ANDREW W. CLEMENT has been advanced to the rank of Major in the Coast Artillery Board and is located at Fortress Monroe, Va. He says:

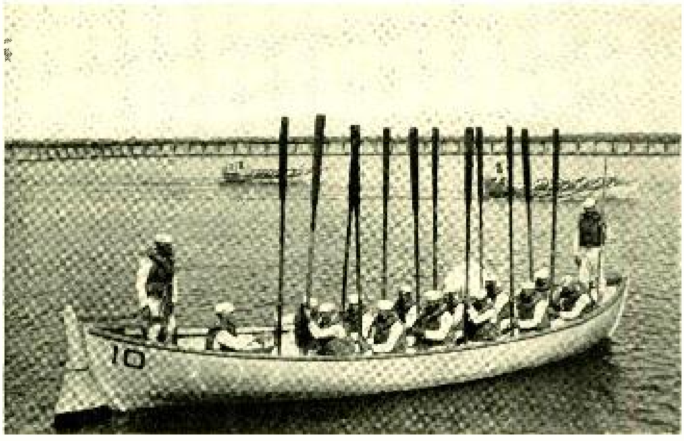
I am still assigned as a member of the Coast Artillery Board, and am engaged in experimental and general engineering work on Coast Artillery material. I see some of my old associates of the Laboratories frequently in the course of this work, particularly Dr. Fry. . . . I should count it a catastrophe if the RECORD failed to arrive for even one issue. It contains more news than a dozen letters from home."

ALBERT J. LEIMER is a seaman Second Class at the Naval Training Station, Norfolk. Mr. Leimer writes:

Our training includes boat drills afloat, skirmishes and bayonet drills on land. We also have gas drills here so that we can get used to gas masks. In classes we take up parts of a gun and how to repair it. We have gun drills and firing every day.

LIEUT. FRANK A. PARSONS has been assigned as Director of Military Training Office, Ordnance Replacement Center, Aberdeen (Md.) Proving Ground. In a recent letter he says:

Here the selectees are brought in from the various Reception Centers and are given their basic military training before being sent into the field. I have charge of the pistol marksman-



A boat drill in which Seaman A. J. Leimer took part ship course. In this the men are given basic instruction in the use and care of the pistol and then taken out to the range to fire a practice course and a record qualification course. I have another officer and about 40 enlisted regular army men, sergeants and corporals helping with this work. We take a training company of 250 men each week. Since the first of April, over 6000 men have been put through this course and about a half million rounds of ammunition have been used.

Collegiate Degrees

Additional members of the Laboratories to whom collegiate degrees have been awarded recently are:

V. R. Gabson	B.E.E.	N.Y.U.
H. C. Hey	B.E.E.	N.Y.U.
F. A. Janiszewski, Jr.	B.E.E.	N.Y.U.
C. V. Lundberg	B.Ch.E.	N.Y.U.
B. McWhan	M.E.E.	Brooklyn Poly.
J. P. Messana	M.E.E.	Brooklyn Poly.
R. H. Ricker	B.E.E.	Brooklyn Poly.
G. J. Schaible	B.E.E.	N.Y.U.
W. Senitoritch	B.E.E.	N.Y.U.
R. O. Soffel	B.A.	N.Y.U.

Advanced Mathematics at Brown

Because of the immediate need of such experts in national defense, a summer session was organized at the Graduate School in Applied Mechanics at Brown University to train graduate engineers, mathematicians, and other specialists in the application of higher mathematics to industry. Courses were offered in differential equations, elasticity and fluid dynamics and seminar meetings were also held.

R. M. Foster of the Laboratories was one of the visiting lecturers. He discussed *Electrical Networks and Their Analogue in the General Dynamical Problem*. The mathematical equations used to determine the free electrical oscillations of such networks are identical in form with those required to evaluate the small mechanical oscillations of material structures. Inductances, in the electrical network, correspond to masses in dynamics; resistance to friction and capacitances to springs. Most of these problems, particularly in the mechanical field, have in the past been concerned with analyzing the resultant vibrations of such systems into their components. Mr. Foster described in his lectures how to solve the reverse problem of prescribing the required frequency response and determining the electrical system which will give that response.

A. B. Clark
Director of Systems Development, completed thirty years of service on August 1

T. C. Fry, at a picnic gathering of the students and staff on August 8, gave a brief and informal talk on the rôle played by mathematics in industry and defense.

News Notes

H. S. Sheppard has been appointed Apparatus Staff Engineer, reporting to the Director of Apparatus Development, temporarily replacing H. B. Ely, who at the request of the War Department is leaving to enter Military Service as noted on the previous page. Mr. Sheppard will continue also to perform his present duties as Commercial Engineer in the General Staff Department.

G. T. Kohman and W. E. Campbell spent several days in Pittsburgh in connection with electrical contact studies in progress in the Homestead and Brandywine offices. Mr. Campbell later attended the A.S.T.M. meeting in Chicago as a member of Committee B-3 concerned with corrosion.

William Frees
of the Development Shop completed thirty years of service in the Bell System on the twenty-sixth of August

J. W. Foley
of the Transmission Engineering Department completed thirty years of Bell System service on August 7

R. E. Drake
of the Quality Assurance Department completed thirty years of service in the Bell System on August 1

C. S. Fuller, L. H. Germer, F. E. Haworth, J. J. Lander, D. A. McLean and K. H. Storks attended a meeting of the American Society for X-Ray and Electron Diffraction at Gibson Island, Maryland. Mr. Fuller presented a paper on *X-Ray Investigation of Synthetic Plastic Compounds*.

A L. Robinson checking the frequency swing of a frequency-modulation transmitter

A. H. White presented a paper, *Electron Diffraction Studies of Surface Corrosion*, at the University of Pittsburgh.

The technical paper *Measurement of the Delay and Direction of Arrival of Echoes from Near-By Short-Wave Transmitters* by C. F. Edwards and K. G. Jansky, presented before the I.R.E. in New York last January, was published in the June *Proceedings* of the Institute.

F. R. Bies was in Springfield from June 20 to July 5 on type-K carrier work.

H. H. Glenn and C. A. Webber, at Kearny, discussed wire insulation problems. Mr. Webber also visited Baltimore on cord development problems.

H. H. Glenn at the Rockbestos Products Company in New Haven discussed insulated wire. He also visited the Brooklyn Navy Yard to confer on the same subject.

N. Botsford visited Fort Monmouth on problems relating to the design of coils.

E. T. Hoch was at the Hawthorne plant consulting Western Electric engineers on the manufacture of induction coils.

F. Hardy was in New Haven and Schenectady to investigate the lubrication of step-by-step apparatus.

THE "TELEPHONE HOUR" which goes on the air every Monday at 8:00 P.M. (E.D.S.T.) will be repeated each week at midnight beginning with the broadcast of September 29. This broadcast will go only to the stations in the territories of The Mountain States Telephone and Telegraph Company and The Pacific Telephone and Telegraph Company and will be received by them at 10:00 P.M. and 9:00 P.M. respectively. The broadcast for the two Western companies will be a "live" performance with the complete cast, exactly duplicating the performance which is given at 8:00 o'clock.

D. B. Penick testing cable-carrier program equipment with a frequency analyzer

O. L. WALTER visited the Veeder-Root Company in Hartford to discuss the manufacture of dials.

C. ERLAND NELSON was in Pittsburgh in connection with panel-bank contact studies.

W. H. S. YOURY, R. J. NOSSAMAN and V. B. PIKE were in Akron recently in connection with rubber tape developments.

S. C. CAWTHON from Kearny was in Point Breeze for experimental work on coverings for buried cables.

J. W. KENNARD from Point Breeze was in New York to discuss toll cable development problems.

F. R. MCMURRY visited the Teletype Corporation plant in Chicago in connection with the development of teletypewriter appa-

H. G. W. BROWN
of the Switching Development Department completed thirty-five years of service in the Bell System on August 1

R. B. HILL
of the Commercial Engineer's Staff completed thirty years of service in the Bell System on the fourteenth of August

J. W. GOODERHAM
of the Switching Development Department completed thirty years of service in the Bell System on August 27

J. B. Draper
of the Switching Development Department completed thirty-five years of service in the Bell System on August 10

S. C. Cawthon
of the Outside Plant Development Department completed thirty years of service in the Bell System on August 14

E. Vroom
of the Switching Development Department completed thirty years of service in the Bell System on August 1

ratus, especially reperforator-transmitters.

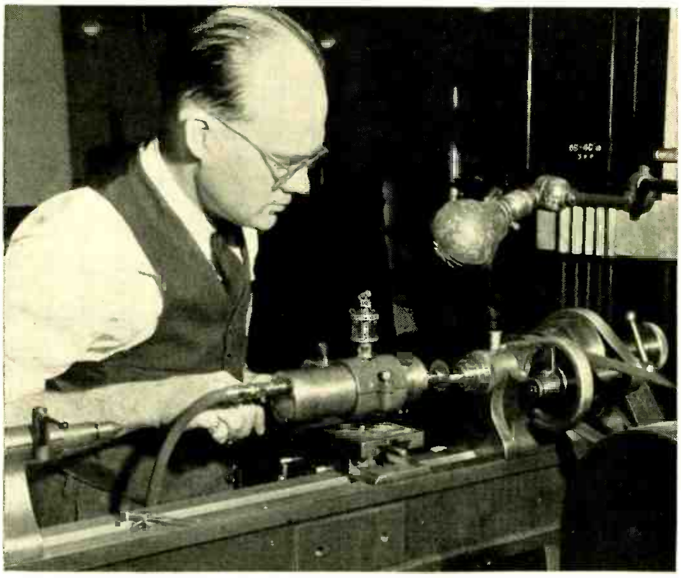
W. R. Young was in Cleveland from July 14 to 25 to coöperate with Long Lines and O & E people in conducting a school for Ohio Bell Company and Long Lines supervisors and maintenance men on the theory of operation of an automatic teletypewriter switching system to be installed for the Republic Steel Company. T. L. Corwin assisted the following two weeks in covering maintenance and adjustment matters.

H. W. Heimbach and J. E. Greene, Jr., attended the crossbar cutover of the central office in Union City, New Jersey.

J. G. Ferguson and A. Burkett visited community dial offices in Cincinnati and Suburban and Southern Bell Company territories.

R. H. Miller visited Cleveland, Columbus, Detroit, Michigan, Chicago and Indianapolis, and J. W. Woodard, Philadelphia and Pittsburgh, to discuss current orders for telephone switchboards.

To investigate conditions surrounding the furnishing of power to unattended repeater stations on the projected toll cable from Omaha to San Francisco, C. H. Achenbach visited Kansas City, Wichita, Omaha and Denver, driving over the entire route of the cable. He also discussed power problems with Telephone



William Patterson using a pneumatic grinding attachment on a lathe in the Precision Room to cut glass brushes

Patents Issued to Members of the Laboratories During the Month of July

W. P. Albert
S. W. Allison
H. L. Barney (2)
W. M. Beaumont
W. M. Bishop
H. W. Bode
W. L. Bond
H. T. Budenbom
R. Burns
A. J. Busch
C. C. Cash
I. E. Cole
F. S. Corso
K. H. Davis
C. J. Davisson
R. C. Dehmel
W. B. Ellwood
B. A. Fairweather
L. Ferguson
C. S. Fuller
F. Gray (5)
H. C. Harrison
E. Hartmann
R. B. Hearn
F. A. Hubbard (3)
S. B. Ingram
J. R. Irwin
J. B. Johnson
F. S. Kinkead
L. E. Krebs
E. Lakatos
M. B. Long
K. L. Maurer
J. H. McConnell
J. B. McKim
J. L. Merrill, Jr.
S. E. Michaels
D. Mitchell
J. F. Morrison
R. A. Morrison
E. E. Mott (2)
S. F. Nelson
R. C. Newhouse
H. G. Och
R. S. Ohl
R. L. Peek
E. Peterson
G. S. Phipps
C. E. Pollard
R. K. Potter
T. C. Rehm
T. D. Robb
E. E. Schumacher
O. A. Shann
R. A. Sykes
G. K. Teal
D. M. Terry
R. V. Terry
E. M. Tolman
P. W. Wadsworth
S. B. Williams
I. G. Wilson

Company engineers in San Francisco, Los Angeles and Seattle.

F. T. Forster studied the operation of the trial installation batteries at West Hartford.

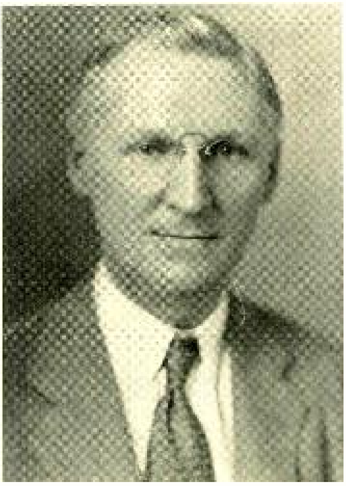
M. A. Froberg was at the Bull Dog Electric Products Company in Detroit in connection with power service equipment. He also visited the Power Equipment Company in Detroit, manufacturers of power rectifiers.

H. T. Langabeer visited Elmira and Hartford to make tests on aluminum bus-bar connections. He also went to Storrs and New Canaan, Connecticut, to observe the operation of 110 A power plants.

J. H. Sole visited Fort Wayne to discuss the design of power plant equipment.

F. T. Meyer visited the Eastman Kodak Company plant at Rochester on July 2 to discuss the photo sensitizing of metal blanks for template purposes. He was accompanied by A. C. De Lorme of the Western Electric Manufacturing Department at Kearny.

W. B. Prince
of the Switching Development Department completed thirty-five years of service in the Bell System on August 3

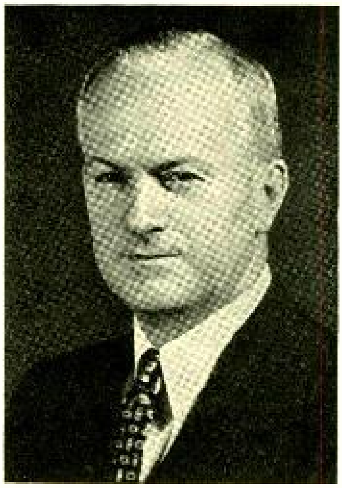


C. D. Lindridge
of the Equipment Development Department completed thirty-five years of service in the Bell System on August 22

George Rupp
of the Building Shop completed thirty-five years of service in the Bell System on the twenty-ninth of August

R. G. McCurdy

W. C. Beach



O. H. Loynes

Twenty-Five-Year Service Anniversaries

Ralph G. McCurdy embarked on his career in inductive coördination soon after his graduation from the University of California, as Engineering Assistant to the California Joint Committee on Inductive Interference, an organization sponsored by the power and railroad interests of the state and the Bell System. Three years later he joined the A. T. and T. Co., but for another year was assigned to the California investigation. He then entered the Engineering Department in New York and continued, in a broader field, his work on noise induction from power and railway systems. Under his direction rapid advances were made in the design of basic measuring instruments and techniques as well as in the development of measures for mitigating noise interference. Seventeen patents record some of his personal contributions to the art; among the more important are arrangements for measuring impedance unbalance and for analyzing complex electrical waves.

Since 1924, Mr. McCurdy has been closely identified with the work of the Joint Subcommittee on Development and Research of the National Electric Light Association, now the Edison Electric Institute, and the Bell System. The coöperative work which his organization carried on with engineers of the power and electrical manufacturing companies furnished the basic technical data needed for the development of construction and operating practices now generally employed by the power and telephone companies to prevent interference.

Mr. McCurdy transferred to the Laboratories with his department in 1934, becoming Noise Prevention Engineer. Three years later he assumed broader responsibilities as Assistant Director of Transmission Development and then, on February 1, 1940, he became Director of Transmission Engineering.

Mr. McCurdy is a Fellow of the A.I.E.E. and of the Acoustical Society and is chairman or member of a number of technical committees. The McCurdys' home is in Englewood, New Jersey, where four of their six children now live with them. For a number of years he has been a member of the Governing Board of his church.

* * * * *

When William C. Beach entered the Laboratories in 1916 the country was verging toward war, and soon he was editing orders and assembling train dispatching and telephone systems for shipment to the A.E.F. in France. In 1918 he was in the Navy, in charge of radio supplies for commercial vessels. The war over, he resumed his work in development and testing of ringing systems, mainly studying the characteristics of apparatus on low-frequency a-c. In 1926 he transferred to laboratory work on circuits to connect manual and dial offices, notably key-indicator and cordless B boards. Among his contributions in that period was a method of generating pulses by the operation of relays. From 1933 on he has been engaged in the laboratory testing of the crossbar system, giving most of his attention to marker circuits.

Mr. Beach was graduated by Purdue in 1916 with a bachelor's degree in electrical engineering. Two sons are now in college; a daughter is studying commercial art. In Bloomfield, where the Beach family live, he is active in the Boy Scout movement, having held a number of offices in the local council. He enjoys studying birds, collecting coins and is a member of the Telephone Pioneers.

* * * * *

MOST OF O. H. LOYNES' service in the Bell System has been concerned with the design and development of carrier telephone systems. After he had been graduated by the University of Wisconsin with an E.E. degree in 1916 he joined the Engineering Department of the A T & T and for the first three years was engaged in the development of toll switchboard circuits. With the formation of the Department of Development and Research in 1919 he became associated with the equipment phases of carrier telephone systems. He also spent short periods on voice-frequency repeaters and toll signaling systems.

Mr. Loynes came to the Laboratories at the time of the 1934 consolidation and beginning in 1935 was in the carrier group of the Transmission Engineering Department concerned with field trials and the preparation of descriptive information concerning carrier systems for use by the Operating Companies. Early in 1941 he transferred to the Transmission Development Department on similar work. In 1939 when some type-K carrier systems were sold to the International Standard Electric Corporation for installation in Sweden and Finland, Mr. Loynes was assigned to the project to assist in placing the systems in service. After he arrived in England en route for Finland, World War II broke out, the carrier projects were held up and he returned to America.

During the early 1930's Mr. Loynes carried on out-of-hour studies in law and in 1934 obtained an LL.B. degree. He has been active in the affairs of Eta Kappa Nu and has served, since 1936, on its Award Organization Committee which sponsors each year a recognition of America's outstanding young electrical engineers.

* * * * *

AFTER P. A. JEANNE received his B.S. in E.E. degree from Colorado College in 1915 he immediately joined the student course of the Western Electric Company at Hawthorne. Four months later he came to West Street where he made transmission development studies, particularly on the design of

J. A. Boyce and W. F. Besemer assembling and wiring experimental amplifiers in the shop of the transmission development laboratory induction coils. In 1917 Mr. Jeanne enlisted in the Signal Corps and for nearly two years was in France, serving with the Research and Inspection division of the Signal Corps, A.E.F., and later as officer in charge of the inspection section of the Signal Corps Depot at Gievres, France. Shortly after his return to this country he joined The Mountain States Telephone and Telegraph Company where he was concerned with the mitigation of interference between power and communication circuits. This work included field measurements of the magnitude of noise and low-frequency induced voltage; design of transposition systems to reduce noise; electrolysis surveys and the design of electrolysis drainage systems; and negotiations with power companies relating to the prevention or removal of conditions hazardous to telephone plant and the application of measures to reduce inductive interference.

In 1922 Mr. Jeanne was given a year's leave of absence for study at M.I.T. from which he received his M.E.E. degree in 1923. He then joined the Department of Development and Research of the A T & T and since then has been continuously associated with investigations relating to the inductive coördination of communication and power facilities, including electrified railways.

He has been in charge of a group of engineers assigned to study low-frequency interference from power systems and means for its prevention. Among the developments that have come out of this work may be mentioned the application of neutral impedances for limiting power system fault currents, including the reactions of such impedances on power system operation; the statistical determination by observations over a period of years, using automatic oscillographs, of the characteristics of power transmission line ground faults as they occur under operating conditions; the determination by a similar oscillographic survey of certain characteristics of power distribution circuits which are important in connection with the joint occupancy of poles by such circuits and by communication circuits; and a number of developments in the application to the telephone plant of specific measures of interference prevention, such as relay protectors and neutralizing transformers. For a number of years he has been a member of the Protective Devices Committee of the AIEE and has a wide acquaintance among power engineers and engineers of the operating telephone companies. Mr. Jeanne came to the Laboratories at the time of the 1934 consolidation and is now in the Protection Development Department.

Mr. and Mrs. Jeanne are residents of Mount Vernon and have a daughter who is a junior in high school and a son in junior high. Mr. Jeanne is a Telephone Pioneer.

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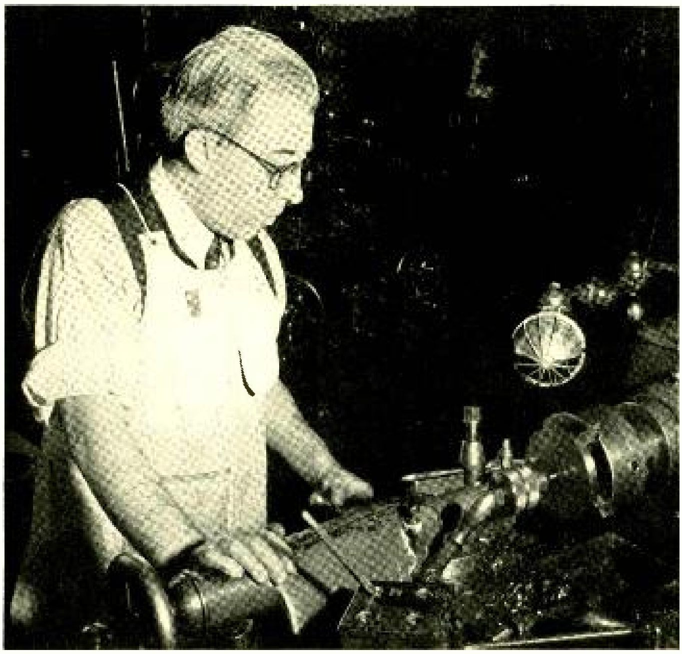

David Anderson machining a permalloy disc on an engine lathe in the Development Shop

STANLY TERRY'S first work with the Bell System was with the Line Material Inspection Department of the Western Electric Company. Following this he was in the circuit laboratory of the systems group and then became a junior draftsman. In 1918 when a new group was formed for the purpose of engineering the

P. A. Jeanne

Stanly Terry

R. E. Curran

Metropolitan toll office he joined this group. During the next few years he also was concerned with the development of automatic private-branch exchanges for government uses; with the preparation of methods for drafting procedure; with the development of circuit charts for personnel training; and with local-cable, cable-rack and circuit layouts.

In 1924 Mr. Terry transferred to the Patent Department where he has since been associated with the production of patent drawings covering all types of communication apparatus and systems.

The Terrys, who live in Freeport, Long Island, have three children, a boy in junior high and two girls, ages eleven and seven. Mr. Terry is active in fraternal organizations and is a member of the Edward J. Hall chapter of the Telephone Pioneers of America. He is interested in carpentry and cabinet making and in golf and swimming.

* * * * *

Robert E. Curran entered the Building Department of the Western Electric Company at 463 West Street in 1916 as an electrician. A few years later he became a laboratory mechanic in what is now the Switching Development Department working on step-by-step switches and later on panel apparatus. He lives in Brooklyn in the winter and in Sayville in the summer.

* * * * *

Transmission development problems, chiefly relating to telegraph systems and transmission measuring methods, have been S. I. Cory's work during his twenty-five years with the Bell System. In 1916, when he joined the Engineering Department of A T & T, the possibility of using small-gauge conductors and the then newly developed vacuum-tube repeater for long distance toll cables was being studied intensively. Mr. Cory's first work was in the development of a telegraph system for use with these new cable facilities. In this connection he spent several years at Kingston, N. Y., in design and experiment on composite sets, noise killers, telegraph relays and circuits. This work resulted in the standardization of the d-c metallic telegraph system for small-gauge cables. Subsequently he was actively concerned with the development of the voice-frequency carrier telegraph system.

The work on telegraph transmission measuring methods and means, which was begun at Kingston, has assumed more and more importance as a part of Mr. Cory's work as the telegraph systems have become more and more complex and the service more exacting. His experience has also included the transmission aspects of all types of d-c grounded telegraph, problems arising from the operation of teletypewriters over telegraph systems, and of switched teletypewriter service. That he has contributed largely in this connection is evidenced by nineteen issued patents with several pending and by published articles dealing with tele-

O. J. Zobel

S. I. Cory

H. L. Walter

graph transmission measuring methods and means. An important phase of this work consisted in the development of a method for producing transmission coefficients. These are ratings for telegraph circuits which indicate their performance capabilities. Without transmission coefficients present-day circuit layout problems would be difficult to handle.

Mr. Cory attended Wittenberg College for two years and after a year's outside work in meter testing and inspection transferred to Ohio State University for two years, receiving his B.E.E. degree in 1916. He immediately joined the A T & T Engineering Department. In 1919 upon the formation of the D & R, Mr. Cory transferred to this department and in 1934 when the D & R was merged with the Laboratories, he continued his work on telegraph transmission, at first in the Telegraph Transmission Development Department and more recently in the telegraph development group of the Switching Engineering Department.

The Corys have one son, Sam Jr., who is now a senior in chemistry at Lehigh. They live on a two-acre plot in Towaco, N. J., much of which is landscaped. Gardening is one of Mr. Cory's hobbies; although this and photography take much of his spare time, he manages to take part in civic activities.

* * * * *

Filters are now so basic a part of the telephone plant that newcomers to the Bell System are scarcely aware of the time when such networks were not readily available. But in 1916, when Otto J. Zobel entered the Engineering Department of A T & T, filters were novelties, and almost his first assignment was to study them from a theoretical standpoint. Some of the early filters for carrier systems were of his design. As time went on the possibilities of networks for the correction of distortion were realized and Dr. Zobel became one of the recognized specialists in the field.

A number of fundamental patents and five theoretical papers record his contributions to the art, each having its individual transmission function. One such contribution was the concept of image parameters, and a mathematical analysis which showed that a network can be built up of a series of sections into a composite structure. By designing the different sections to the same image impedance at junction points as many sections as necessary could be connected to secure the overall characteristics desired. Another concept useful for distortion correction was that of a constant-resistance network whose loss and phase shift can be designed at will without affecting the energy or phase relationship of the line which the network terminates.

Dr. Zobel received his bachelor degree from Ripon College in 1909 and his Ph.D. from Wisconsin in 1914. With his associates in D & R he joined the Laboratories in 1934.

He is now a member of the Mathematical Research Department where he has been recently concerned with line temperature-compensating networks that are used in feedback amplifiers.

Dr. Zobel's sports are trout fishing and riding; he records his trips into the Rockies in motion and still pictures. Concerts and reading occupy his leisure in Manhattan during the winter.

* * * * *

H. L. WALTER joined the Engineering Department of the Western Electric Company in 1916 as a draftsman and spent the next four years principally on communication and signaling equipment for the U. S. Navy and Signal Corps. In 1920 he entered the specifications group where he prepared manufacturing and testing information on telephone apparatus, particularly amplifying equipment, testing and maintenance apparatus, public address and speech input units and repeater equipment for both telephone and telegraph. During this time he attended C.C.N.Y. for a year and then continued his education at Cooper Union from which he received a B.S. in E.E. degree in 1924 and an E.E. degree in 1928.

In 1922, when what is now the Commercial Products Development Department was organized, Mr. Walter transferred to this group and for the next fifteen years was concerned with the mechanical design and development of apparatus and systems for public address, speech input, sound picture recording and reproduction, music reproducing and distribution, and audiometers for measurements of hearing loss. He was also intimately associated with much of the development work done for the Navy and Signal Corps. This work included fire-control and ships' service telephone switchboards; general announcing equipment for the U. S. Navy; sound-ranging equipment for submarine and Signal Corps use; and portable camp telephone sets.

In 1939 Mr. Walter transferred to the specifications group of the Transmission Development Department where he engaged in preparing specifications covering varistors and other central-office equipment. In October, 1940, he went to the Commercial Products Development Department on a temporary basis to set up special testing facilities at Kearny for naval announcing equipment. Soon after the completion of this work he joined the department permanently and has since been on the mechanical design of a glide-path radio receiver to facilitate the landing of aircraft.

The Walters live in Riverdale, New York. Mrs. Walters is the former Augusta G. White who was a member of the Western Electric Engineering Department from 1918 to 1924. They have two boys, one in high school and the other in junior high. Mr. Walter's main recreations are tennis and 16-mm movies. He is a member of the Telephone Pioneers.

* * * * *

DURING THE MONTH of August the following members of the Laboratories completed twenty years of service in the Bell System:

Research Department

C. N. Anderson — B. F. Lewis

Apparatus Development Department

W. T. Pritchard — W. E. Stephens

Systems Development Department

G. H. Downes — E. R. Taylor

General Service Department

Alice Kavanagh

Personnel

M. S. Mason

Plant

Andrew Scaglione

* * * * *

P. B. MURPHY spent a week in Cleveland in connection with a demonstration of Ship-to-Shore SOS signals.

H. W. EVANS of the Transmission Development Department is shown in the main frontispiece on page 1 and A. E. JOEL, JR., of the Switching Development Department, in the photograph on page i of the News Notes.

A. E. BACHELET's article *Remote Control for Reversible Program Circuits* published in the June RECORD was abstracted in the June 28 issue of *Nature* (London).

A. H. SCHIRMER visited Eau Claire and Joplin to observe lightning tests being carried on at these locations.

R. P. BOOTH was in Cheyenne, Wyo., in connection with the wave-tilt and cable-static noise tests being made there by J. MALLETT and J. L. LINDNER.

J. H. SHUHART and C. H. GORMAN, JR., are about to start measurements near Kansas

City on a forty-mile section of open-wire line. This section has just been retransposed to an arrangement designed to permit sixteen type-C carrier systems on a four-crossarm phantomed line.

C. E. Clutts and C. M. Hebbert have been in Greensboro and Charlotte making tests on type-K carrier telephone systems.

N. Monk, J. F. Nuner, D. T. Osgood and E. C. Thompson were at La Plata, Md., where they made tests in coöperation with engineers of the Rural Electrification Administration.

K. C. Black interviewed the Long Lines people along the coaxial cable route from Stevens Point to Minneapolis about the operation of the system. M. M. Jones was in Minneapolis studying detailed operating procedures for the system in connection with the preparation of *Bell System Practices*. K. D. Smith checked the testing equipment for the coaxial cable installation in Minneapolis.

H. A. Wenk and L. B. Hochgraf of the Laboratories and G. J. Goetz, H. J. Talley and E. H. Davis of the Long Lines Department carried out tests at Lewistown, Pa., of a circuit for switching working pairs of a type-K carrier system. C. C. Cash and L. C. Roberts of the Laboratories observed at New York.

J. F. Polhemus and B. C. Bellows, Jr., visited the repeater stations at Princeton and Philadelphia in connection with the trial of 3-megacycle coaxial equipment.

C. S. Yeutter was at Chicago making preliminary tests in connection with a field trial of the automatic deviation regulator for type-K1 systems between Chicago, St. Louis and Joplin.

J. E. Cassidy was at the Patent Office in Washington relative to patent matters.

* * *

J. J. Fennelly, 1889-1941

J. J. Fennelly of the General Service Department with over thirty-two years of service with the Western Electric Company and the Laboratories died on July 26 following an illness of several months. Mr. Fennelly joined the Western Electric Company in 1906 as a shop clerk in the manufacturing department. He left the company in 1908 and returned two years later to the same work. Later he transferred to the Accounting Department where he remained until 1917 when he was placed in charge of laboratory order service of the old Transmission Department. Shortly after the combination of this department with the Research Department he was placed in charge of the same type of work for the combined organizations. From 1936 to 1939 he handled orders placed upon the Development Shop by the research group. He then transferred to the local service group of the General Service Department and in 1940 took over the supervision of a group handling special cleaning and battery service.

* * * * *

A. J. Wier has just returned from a trip over the Chicago-Joplin cable route on which type-K carrier has been installed and over the Central Transcontinental Route between Omaha and Denver on which type-K carrier equipment is being installed.

Stock Records and Control

By R. H. WILSON
General Service Manager

FOR many years a scientific system of stock control has been under development by the Laboratories. New methods and records have been introduced and special machines have been devised for posting drawout records, determining the most economical amount of stock to order, and finding the minimum quantity at which stock should be reordered so that the out-of-stock conditions can be controlled economically.

If only one stockroom were concerned, the problem of keeping a record of its operation would be an easy one. There are fifteen at the Laboratories, however, with 12,300 items and it would require keeping about 92,000 stock cards, if every item had a separate card for each stockroom and was carried in one-half of them. This would be an enormous file to contend with; in some cases it would mean handling as many as a dozen cards when the reorder of a stock item was considered.

Until last year this difficulty was met by using only one card for each item and posting the records in as many separate sections on this card as there were stockrooms carrying the item. This posting was done by hand and was necessarily laborious; it was done in that way only because until recently there had been no suitable machine.

At the beginning of 1940 the Stock Control Group, the Methods Department and the Office Equipment and Development Department of the Western Electric Company, working with the National Cash Register Company on the design of features required by us, finally obtained the machine shown in the headpiece.

The first step in the operation involving these machines occurs when an engineer obtains material from a

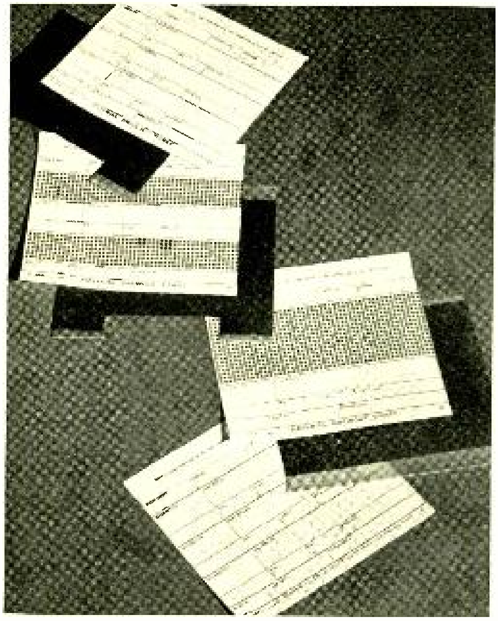

Fig. 1—A pull-apart arrangement permits the easy separation of this new drawout ticket into the original and three copies, for stockroom control. Cross-hatching makes the second item readable on the second copy only and the third item on the third copy

stockroom and fills out a drawout ticket. In the recently designed form shown in Figure 1, the ticket permits the withdrawal of as many as three distinct items. It is easily separated into the original and three copies; the first two copies are cross-hatched so that only the second item is readable on one and the third on the other. The stock control group is thus provided with three separate tickets which can be sorted according to the stock number of each item. The remaining copy is returned to the person making the withdrawal.

Each stock item has a number, and stock record cards are filled in accordance with that number. These tickets are sorted, using the equipment shown in Figure 2, according to the first two figures of the stock number. The tickets in each section of the sorter are then placed in final numerical order. All the tickets of the same number—that is, for one stock item—are totaled day by day and entered on the record card.

Transfers of material between stockrooms are also recorded. If one stockroom is low, stock is transferred to it from the one which the record card indicates can most easily spare it. Reorders are placed when the total stock has reached the minimum stock or ordering point. Entries, of course, are made when fresh supplies are received. A typical card, as shown in Figure 3, carries in its left margin a continuous day-to-day inventory, which shows the total stock on hand in all stockrooms, distributed as indicated in the various stockrooms.

Fig. 2—Drawout tickets are sorted in accordance with the number of the stock item. Withdrawals from each stockroom are summarized daily

While posting each card the stock-control clerk watches to see if stock should be transferred between stockrooms or if the ordering point is being reached. If so, the card is kept out of the file for action. Withdrawals are in red, receivals indicated in black, and stock transferred marked TR. A separate roll accumulates all entries and gives a sound method of checking the accuracy of all postings.

Each line gives date, the number of withdrawals and the total of units withdrawn. This information is essential in determining minimum stock or ordering points because the two factors required are the average number of withdrawals during the restocking time and the size of the average withdrawal.

Associated with the record card is a stock purchase card of recent design, shown in Figure 4. When an item reaches the ordering point this card is removed from file. The information at the foot of the card shows the number of drawout tickets and the total amount drawn out by months as obtained from the stock record card. This is used to determine the rate at which the item will move in the next few months. Once this is known the most economical amount to order can be found from the ordering tables discussed later. Approvals for the purchase are then obtained and the card is forwarded to the Purchasing Department for action. The advantages of this card are that it eliminates the use of a separate purchasing requisition for each reorder of stock and it is also of service to the stock-control group because it carries a complete record of purchasing for seventeen reorders of stock.

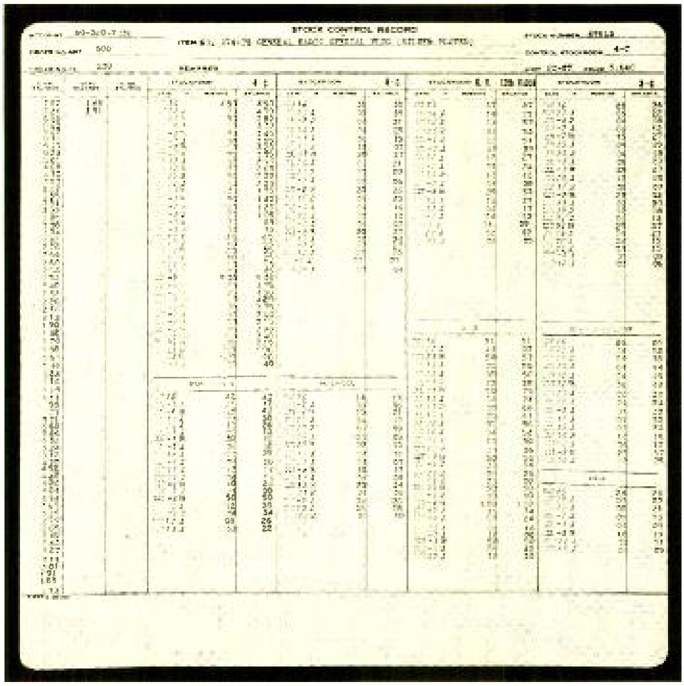

Fig. 3—A continuous daily inventory is kept for each item on record cards. The total amount on hand is shown in the column at the left and the distribution by stockroom in the other columns

Management is concerned with the economical operation of stockrooms but engineers are primarily interested in obtaining items promptly and in the desired amount. Consequently for each item there must be carried the most economical amount of stock comparable with its demand. The "out-of-stock" condition must be kept at a reasonable minimum. Since most of the items are staples and not subject to the vagaries of style and season, it has been found possible by mathematical studies to meet these conditions in a routine way.

For most items only the operating factors of the stockroom have to be taken into consideration. These are the interest rate on money invested in stock, insurance, depreciation, obsolescence and the cost of placing stock orders. Rent does not have to be considered because our stockrooms do not change in size. Under these conditions a simple table is all that is required since the most economical amount of stock to order is proportional to the rate at which the item moves. There are occasions, however, when other factors have to be taken into account provided none of these is in conflict with current governmental regulation. These are increasing discounts for larger lot purchases; various periods within which payment may be made; lower transportation rates on larger lot shipments; increase in the risk of obsolescence and depreciation as the amount purchased increases; the advisability of purchasing more than the normal amount when prices are rising and less when they are falling; whether an actual saving is made by grouping orders on a supplier to get a better price or save on transportation rates.

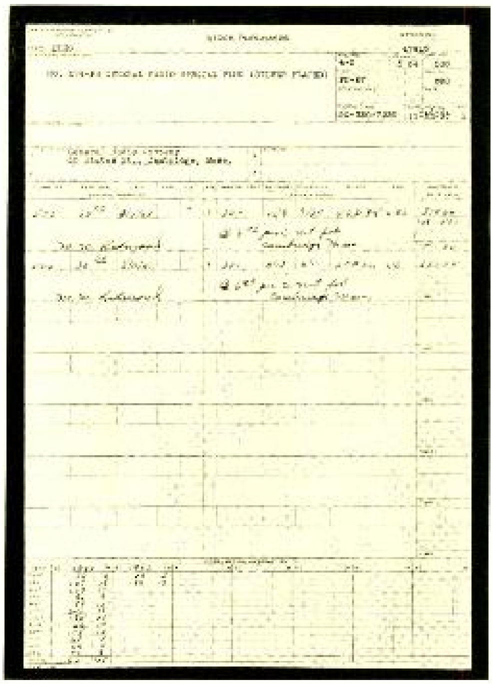

Fig. 4—The ordering point and the quantity to be ordered are shown in the upper right-hand corner of this stock purchase card. The number of drawouts and the total amount withdrawn by months are given at the foot of the card

A table is required for each condition and some of them are too large to handle easily. They also soon become dog-eared and dirty. To overcome these handicaps and speed up their use the stock-ordering machine shown in Figure 5 was devised. The tables are prepared on one long scroll which is mounted in the machine on

Fig. 5—The most economical amount of each stock item to carry is found from tables mounted on rollers in this stock-control machine or on the panels

rollers so that it can be spun rapidly to bring the columns on the table selected adjacent to the associated information on the face of the machine. Strips of different colors at the top of the columns help to identify the tables quickly as the scroll is rolled. Other tables which are small and in continuous use are mounted on the cover panels of the machine.

To avoid exhaustion of the old supply before the new arrives it is necessary to determine the amount of stock which should be on hand when fresh stock is ordered. This is called the ordering point; it depends on the probable number and size of the withdrawals which will be made during the restocking time, and variations in the restocking time. On the basis of a mathematical study of these factors tables were made several years ago to determine the correct ordering points. One very important fact was immediately obvious from the study. On the average it costs approximately twice as much to protect completely an item from running out of stock as to protect it against running out once in five years. For many items it would not cause serious inconvenience if an out-of-stock condition occurred with that frequency, and that in general is the amount of protection in the Laboratories at present.

A machine to determine the ordering point is shown in Figure 6. It carries tables on a roll about thirty feet long and has different color markings at the top of the columns like those on the stock-ordering machine, so that any table can be compared readily with the associated column on the front of the machine. The tables show ordering-points against running-out-of-stock from once a year to complete protection. Because only the desired amount of protection is given to each stock item, inventory is maintained at an economical minimum.

At present, of course, stock control has been decidedly complicated by general business conditions. Many items are difficult to get; the time of delivery is lengthening; and price changes are occurring all the time. Ordering amounts and ordering points are being adjusted to meet these conditions and the stock-control machines are proving helpful in that work.

Fig. 6—The point at which new stock should be ordered is computed from tables on rollers in this machine

V1 Telephone Repeater Arrangements

By P. G. EDWARDS
Transmission Development Department

OVER a quarter of a century has now passed since the 22 type repeater was introduced into the telephone plant. That the most widely applied of these repeaters—the 22A1 and 22A2—have endured for more than half this period is an indication of the basic soundness of the design. During the periods of rapid increase in the number of two-wire circuits, these repeaters were installed literally by the tens of thousands. Now, however, this well-established and effective unit is yielding to technological progress, and is stepping aside for a newcomer—the V1 telephone repeater.

Basically, a repeater consists of two amplifiers, each compensating the losses suffered by the speech currents in passing over the line in one direction. At the point of amplification, therefore, the repeater is essentially a four-wire circuit—two wires and one amplifier being used for each direction of speech flow. To match the impedance of the repeater to that of the line, to transform from the two-wire line circuit to the four-wire amplifying circuit, to compensate for unequal attenuation at different frequencies, to by-pass low-frequency or d-c signaling, and to derive separately the phantom channels, however, certain other equipment is required that becomes to a greater or less extent a part of the repeater itself. These various elements have already been discussed in the RECORD.* The major pieces of equipment closely associated with the 22A1 repeater or actually forming a part of it are: two line repeating coils, two balancing repeating coils, two hybrid coils, two balancing networks, two equalizers, two filters, two amplifiers, and in some cases regulating networks, signaling equipment, and composite balancing equipment. A typical layout is shown in the upper part of Figure 1.

A brief analysis shows that the selection of most of this apparatus is governed more by the line to which it is assigned than by the amplifier with which it is used. It may, therefore, be regarded as more closely associated with the line than with the amplifier. The repeaters are all made of 600 ohms impedance, but the repeating coil ratios vary because of different line impedances. The hybrid coil, of course, pertains to one as much as the other, but the balancing network and the balancing repeating coil must fit the line rather than the amplifier. Regulating network, equalizer, and filter are also primarily determined by the line rather than by the amplifier. The low-frequency ringing does not pass through the amplifier at all, and the phantom channel has its separate amplifier; the means for deriving both phantom and signaling circuits are thus controlled to a greater extent by the line than they are by the amplifier.

The new V1 design recognizes this fact by grouping all of the accessory equipment with and as part of the line equipment, thus reducing the repeater

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proper to two amplifiers. This rearrangement is indicated in the lower part of Figure 1. In this way all V1 repeaters become essentially identical, and may be changed freely from one circuit to another as maintenance requires. This was not possible with the 22A1 repeater because of the line equipment associated with it. Because of this rearrangement of functions the V1 repeater, while designed primarily as a two-wire repeater, is applicable also as a four-wire repeater, and will be used as such within the limits of its gain. Another advantage of the new arrangement is that the repeater is smaller, and thus more of them may be placed on a single bay. This groups the equipment requiring frequent attention more closely together, and tends to reduce the maintenance effort. These differences in equipment arrangements and their advantages will be discussed in a forthcoming RECORD article.

Another important change, and one of considerable interest, is the use of a different method for interconnecting two-wire and four-wire circuits, an improved arrangement of which has recently been developed by N. Botsford. With this new method, two repeating coils replace the hybrid coil and the repeating coils for both line and network of the previous arrangement. Moreover the two repeating coils with the new arrangement do not need to be matched as do those with the 22A1 repeater. Each of these repeating coils has three pairs of windings, which are marked A1, A2, A3 and B1, B2 and B3 at the left of

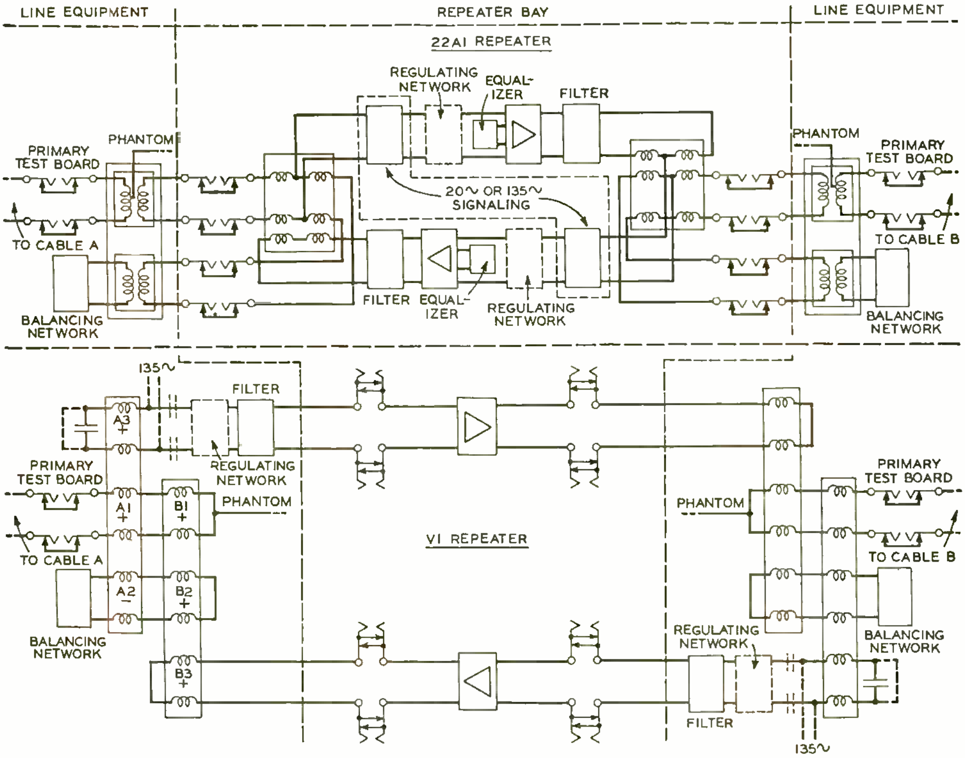


Fig. 1—Block schematic for an intermediate 22A1 repeater, above, and for a V1 repeater, below

Figure 1. Signs + or − are also given to indicate the relative poling of the three windings of each repeating coil. With the help of these designations and signs, the hybrid-coil action of this pair of repeating coils can readily be followed.

Speech coming in over the line from the left induces equal fluxes in the cores of both coils through windings A1 and B1. The flux in the A core induces voltages in windings A2 and A3, and that in the B core induces equal voltages in the B2 and B3 windings. Since A2 and B2 are of opposite sign, however, there is complete cancellation in the network circuit, and no current flows in the network if the impedances connected to the A3 and B3 windings are equal. The energy coming in over the line thus divides equally between the input to the upper branch, where it is amplified and passed to the line at the right, and the output of the lower amplifier, where it is dissipated.

Amplified speech from the lower amplifier induces a flux in the B core through winding B3. This flux, through the B1 and B2 windings, induces currents in the circuit to the line west and in the network. These two currents, through windings A1 and A2, attempt to induce flux in the A core, but since these windings are oppositely poled, the net flux is zero if the line and network impedances are equal. As a result no current is induced in the upper branch through the A3 winding. The energy from the lower amplifier, in other words, divides equally between the line and the network, and none goes to the upper amplifier.

Besides providing hybrid-coil action these coils act as repeating coils to match the impedances of line and repeater. The turns ratios of the three windings of each coil may be made such as to do this without affecting the hybrid-coil action. The coils also permit ready derivation of phantom circuits. Another advantage of this new repeater is that return-loss measurements* are greatly facilitated, since the ready access to the

*RECORD, *July*, 1938, *p.* 375.

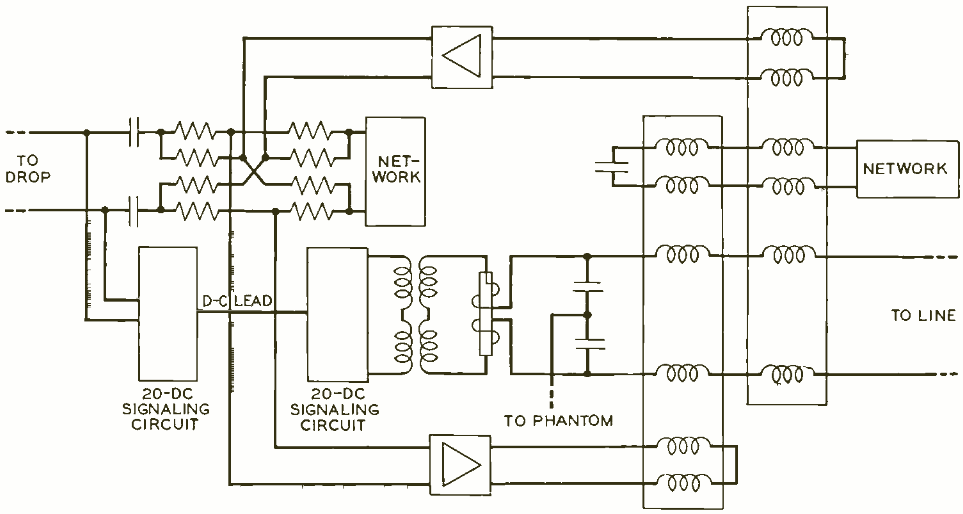


Fig. 2—Block schematic for a V1 terminal repeater showing arrangements for deriving a phantom and by-passing 20-cycle d-c signaling

four-wire circuit permits direct measurement of the trans-hybrid loss under working conditions.

The method of deriving the phantom and of by-passing 20-cycle signaling is indicated in Figure 2, which shows the arrangement of the repeater as used at a terminal. This method of handling the signaling permits lower inductance and thus less expensive repeating coils to be used, and further reduces the cost of the repeater. At the same time it gives a greater signaling range than the method that was used with the earlier repeater.

Still another advantage is in the method of associating a composite set with the repeater for the derivation of d-c telegraph and signaling channels. In the past, composite sets have been included in the line, and carefully balanced in the network circuit. With the V1 repeater, however, the composite set will be connected across a condenser bridge in a manner similar to that of 20-cycle signaling. Such an arrangement affects the impedance at voice frequencies relatively little, and little or no special balancing will be required. Because their characteristics need not remain fixed to the same degree, less expensive composite coils can be employed. Since 20-cycle signaling and telegraph circuits are obtained in a similar manner, the new repeater can be easily converted from one form to another when required.

At the line side of the terminal repeater, two repeating coils are used to secure hybrid-coil action as in Figure 1, but at the office side, a new type of terminating set is used which consists of a resistance network. The loss in such a hybrid is nearly 11 db

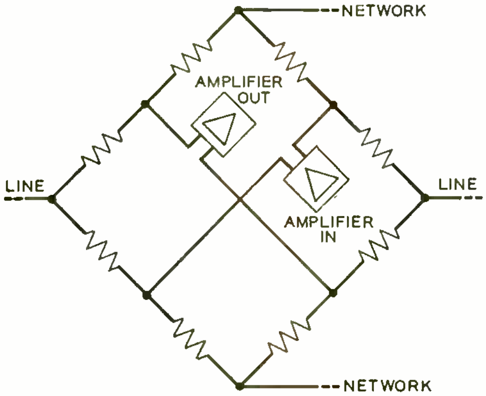


Fig. 3—Diagrammatic representation of the new resistance hybrid coil used at the office side of terminal repeaters

instead of the nominal 3 db of the usual hybrid, but this added loss is of little consequence at the circuit terminal. This resistance hybrid is essentially a double Wheatstone bridge with connections as shown in Figure 3. Here it will be noticed that the line and network are conjugate as are also the amplifiers. Such a resistance hybrid is not only more economical than the coil type, but furnishes a very good terminating impedance.

Designing the V1 Repeater and Associated Equipment

By R. L. CASE
Transmission Development Department

THE V1 repeater applications represent not merely a modification of the 22 and 44 type repeaters,* but a fundamental change in repeater design. The basic changes from the 22 type repeater design were the use of a combination hybrid-repeating coil and the association of the equalizer, filter, and regulating network with the line equipment instead of with the amplifier. Some of the advantages of the combination hybrid-repeating coil have already been discussed.† Others arise from the association of the filter, regulating network, and equalizer with the line equipment, since with this change the amplifier is required to provide only a flat gain, and thus can be the same regardless of the type of line with which it is used. This has permitted a number of simplifications, not only in the amplifier but in the regulating network, equalizer, and filter, and should result in marked economy in original cost and in maintenance. Since the V1 repeater consists essentially of two one-way amplifiers, the basic changes from the 44 type repeater design are not so striking. They consist principally in the association of the regulating networks and high-frequency equalization—formerly a part of the repeater proper—with the line equipment.

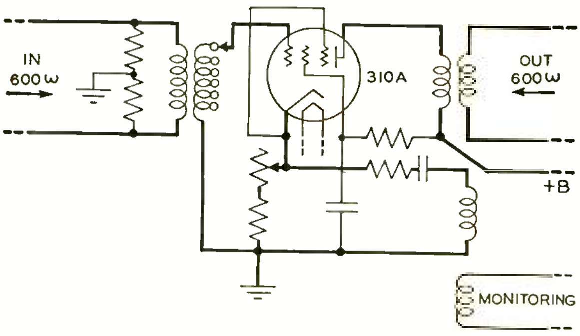


Fig. 1—Schematic of the amplifier circuit employed for the V1 repeater

A heater-type tube is employed for the first time in voice-frequency repeaters, and a small amount of feedback provided in the circuit reduces the variations in gain due to battery fluctuations to about one-third those of the 22A1 repeater. The feedback, as shown in Figure 1, is derived from an extra winding on the output transformer in conjunction with the cathode circuit, which includes a potentiometer. This potentiometer in conjunction with taps on the input transformer serves to control the gain. The five taps on the transformer each give a change in gain of 4 db, while the potentiometer gives continuous control over a range of 5 db. In this way the gain may be controlled over a continuous range of 25 db, with a maximum gain of 35 db.

*RECORD, *August*, 1931, *p.* 579.
†Page 20 of this issue.

In the 22A1 repeater, gain was controlled by a more expensive potentiometer in the input circuit, and a grid battery—common to a number of repeaters—was required to supply the grid bias. With the V1 repeater, however, grid bias is obtained from the voltage drop of the plate and screen current through the potentiometer and fixed resistance, and thus no separate grid supply is needed. Besides serving a dual purpose—to control gain, and furnish grid bias—this potentiometer is a very simple and inexpensive one, and has materially simplified the circuit as well as reduced its cost. Moreover the voltage drop across one unit of the resistance in series with the potentiometer permits the activity of the tube to be checked with the 1R tube-test set* without taking the amplifier out of service. The gain-frequency characteristic of the amplifier is approximately flat over the major part of the voice band, being down only 0.5 db at 250 and 4000 cycles. The load characteristic is slightly better for some gain settings than that for the 22A1 repeater as shown in Figure 2.

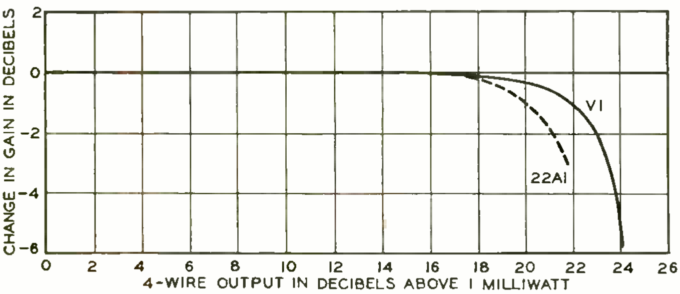


Fig. 2—Gain-load characteristic of the amplifier

Transmission through the repeating-coil hybrids and the amplifier is thus essentially flat with frequency, and the equalization formerly included in the repeater to compensate for the loss-frequency characteristic of the line is now included in the line equipment itself. This correction is made in the equalizer filter circuit. In designing for the degree of equalization correction, a compromise was made by basing the degree of correction on an ideal two-repeater section line for two-wire circuits, and six repeater sections for four-wire circuits. For longer lines and more tandem repeaters, the equalization provided still gives a satisfactory overall characteristic. In matching line and equalizer characteristics for two-wire circuits, the critical frequency ranges for circuits with H88 loading are from 100 to 200 cycles and from 3,000 to 3,500 cycles, where the cut-off of the line loading begins to have a large effect. This is evident from the curve of Figure 3, which shows the bare-line frequency-transmission characteristic. By placing the filter next to the repeater so that the distributed capacitance of the windings of the input transformer could serve as part of the filter, the desired characteristics over the upper end of

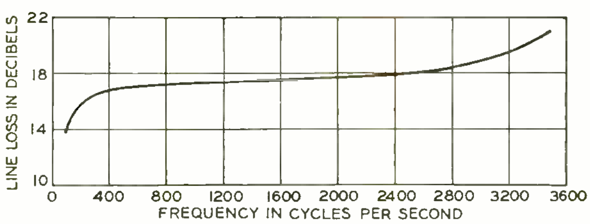


Fig. 3—Line-loss characteristic of 50 miles of 19 H-88-50 side circuit

*Record, *June*, 1939, *p.* 316.

the frequency range were obtained. Then by using only a single condenser in the tip and ring conductors to serve as an equalizer, the characteristics were met sufficiently well at the low end. These equalizing condensers also serve as blocking condensers for 135-cycle signaling. Thus for two-wire H-88-50 circuits which are expected to constitute the major part of the future demand for new facilities a very simple equalizing arrangement has been effected. For some of the other types of two-wire circuits and for four-wire circuits the equalizer arrangements are not quite so simple as here indicated.

On long cable circuits, variations of temperature produce sufficient variation in wire resistance and corresponding attenuation to require an adjustment of the gain. This is done by arranging the repeaters at approximately 100-mile intervals to provide the required regulation. The new V1 repeater is also an improvement over the older 22 and 44 type repeaters in being readily adapted to use at regulating points. With both the old and new repeaters, regulation is secured by resistance pads whose elements are changed by relays. Different pads are required for different types of cable circuits, depending on gauge, loading, and whether side or phantom. The relays, in turn, are controlled by a pilot-wire regulator which is responsive to temperature changes on the line. With the older 22A1 and 44A1 repeaters, the variable network is connected as an integral part of the repeater proper. With the V1 repeater, on the other hand, the regulating networks are part of the line equipment. The V1 repeaters may be shifted indiscriminately, without regard to the line with which they are associated, in contrast to the absence of similar flexibility with the older 22 and 44 type repeaters. This new arrangement also permits the provision of a common control to adjust the regulating networks of a phantom group.

The regulating pad control network for the V1 repeater is made up of four resistance pads, which can be cut into the circuit by relays in various combinations. For a typical H88 loaded cable, these pads individually produce losses of 1.5, 2.75, 4.25, and 5.50 db. A total loss variation of from 0 to 14 db is obtained in steps of between 1.25 and 1.50 db. One relay is used for each pad, and by using "U" type relays, which carry a large number of springs, each relay is able to control two other circuits; four relays thus control the three one-way channels of a phantom group. This corresponds to the use of fifteen relays which do the same work in the older 22A1 repeater.

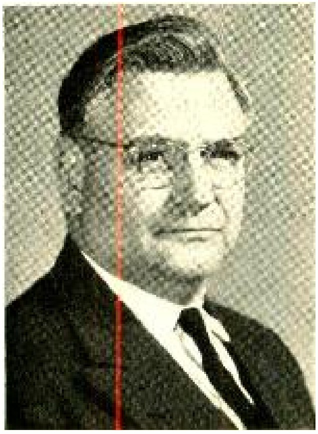
Contributors to this Issue

T. C. M. Woodbury graduated from Wentworth Institute, Boston, in 1916. In 1931 he received the LL.B. degree from St. Johns College and the LL.M. from St. Lawrence University in 1933. Mr. Woodbury joined the Apparatus Drafting Department of the Laboratories in 1924, after spending several years with the B. F. Sturtevant Company and the Holtzer-Cabot Electric Company. From 1931 until a year ago he was in charge of Apparatus Standards books. Since then he has been engaged in laboratory work on standardization problems. He was admitted to the bar in 1934.

R. H. Wilson received the B.Sc. degree from Victoria University, Manchester, England, in 1913 and the M.Sc. in 1923 from the same institution. He was instructor in the University of Toronto, Canada, for a year and then joined the Western Electric Company in 1914 to develop radio receiving equipment. In this connection he was intimately associated with the experimental work which culminated in radio transmission between Arlington, Va., and Paris, France, in 1915. During the next three years he designed and developed vacuum tubes, particularly for military use. In 1919 Mr. Wilson transferred to research service and the following year took charge of this work. As Research Staff Engineer, he became responsible for all service functions of the Research Department. During this time he introduced new methods of stock control which reduced the cost and increased the efficiency of operations.

Since 1939 Mr. Wilson has been General Service Manager in charge of transcription service, correspondence files, central stores, order and laboratory service; also traffic and office service such as mail, messenger, telegraph, photographic and the print facilities.

Henry Hovland joined the Western Electric Company after an extensive experience in the independent field. Leaving the University of Minnesota, he worked for a time with an electric lighting plant, and then spent eight years with



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R. H. Wilson

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the Automatic Electric Company. Following this, he was with the Lincoln Telephone Company for four years. With the Western Electric Company he worked on the trial installations of panel equipment at Newark and Wilmington, and since then has been engaged in design pertaining to the step-by-step system.

P. G. Edwards graduated from Ohio State University in 1924 with the B.E.E. degree, and in 1929 received the E.E. degree by thesis. In 1918 he was granted a commercial first-class radio operator's license, and from 1919 to 1922 was Morse operator and repeater attendant for the Western Union Telegraph Company. He then joined the Long Lines Department of the American Telephone and Telegraph Company and in 1924 transferred to the D and R Department. There he was concerned with toll test boards and fault location, and later with toll signaling and carrier facilities. He continued this work with the Laboratories after the 1934 consolidation. Later he was associated in turn with the local and toll transmission engineering groups in connection with problems involving voice-repeatered circuits. At present he is engaged in the development of voice-frequency, radio-connecting, and single-channel carrier systems.

R. L. Case received the A.B. and B.S. degrees from Denison University in 1921, and joined the Laboratories in July of that year. In 1926 he received his M.A. degree from Columbia, having taken advantage of the Laboratories' part-time graduate study program. During his early connection with the Laboratories, he engaged in the transmission design of two- and four-wire telephone repeaters, echo suppressors, and the terminal equipment for the first transatlantic radio circuits. His interest in telephone repeaters has continued, and since 1929 he has been in charge of a group responsible for their design. More recently he has also been responsible for the transmission design of amplifiers and associated equipment for voice-frequency program broadcasting facilities.

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