Bell Laboratories Record

Volume Three | October, 1926 | Number Two

The Evolution of the Input Transformer

By F. E. FIELD

INPUT transformers started their history but not their present characteristic name with the commercial installation in 1904 of telephone repeaters of the electromagnetic type. Transformers of various kinds and for different purposes had been in use in the telephone system for some years. In general their function was to insulate one portion of a telephone circuit from another. Thus, a toll line would be terminated by one winding of a transformer, the other winding of which could be connected to the local circuit. The local and long distance portions were thus insulated, but the speech currents in either portion were, by induction, repeated in the other, and hence, the name of "repeating coil" for such a transformer. The ratio of the turns in the two sets of windings was, of course, chosen with reference to the impedances of the lines between which the coil was to repeat.

When the mechanical repeater was inserted in a stretch of long distance circuit, a transformer called a repeating coil was used between the line and the input side: i.e., the receiving element of the repeater. Its function was to connect line and repeater without excessive transmission loss of voice currents due to unmatched impedances, and to prevent transmission of low frequencies incident to the use of the repeater on composited lines carrying telegraph signals. This repeating coil had a low ratio and a low impedance.

When a vacuum tube, suitable as an amplifier of voice frequencies, had been developed a need arose for a repeating coil with ratios and impedances previously not required in the telephone plant. And with this need there was a new emphasis upon the word "input" and the introduction of the term "input transformer" to describe the coil used to connect the line and the receiving side of the repeater element.

The input impedance of a vacuum tube—that is, the impedance between the grid and the filament—is very high, approaching infinity under certain conditions; and a transformer was required to transform—i.e., "step up"—the low impedance of the line

to match the high impedance of the tube. Development work by E. O. Scriven was started in February, 1913, toward the production of one with as high a step-up ratio as could be obtained with satisfactory transmission of voice frequencies. The design then developed had a straight

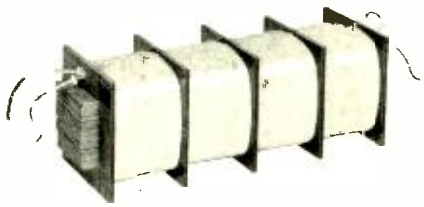


Fig. 1—Design of 1913; size 9 by 3 inches

silicon-steel core and was wound in a number of sections to minimize the distributed capacity, as shown in Figure 1. Before assembly in the repeater equipment it was mounted in a wooden box filled with moisture-proofing compound. Its voltage-amplification — frequency characteristic is shown in Figure 2, and indicates a range of transmitted frequencies wide enough for intelligible speech.

This type of transformer had a very large external magnetic field which proved troublesome in the operation of the repeater. An entirely different type, therefore, was designed by R. L. Jones in the early part of 1914. That transformer, shown in Figure 3, was of the shell type. It had less distributed capacity than the straight-core type and there was some improvement in the range of transmitted frequencies, as is shown in Figure 2 by the characteristic dated 1914. This type of transformer was used in the first demonstration of the Transcontinental Telephone Line.

A considerable number of transformers of this type were built for use in the early vacuum-tube repeaters. Difficulty was experienced, however, in their manufacture, particularly in the winding. With the increasing demand for input transformers it was soon desirable to redesign for commercial production. The type of structure shown in Figure 4 was, therefore, evolved by W. L. Casper, and the first model of a transformer of this design was built in March, 1915. It was later known as the 203-type input transformer. Its construction is well suited to commercial production; the spools and windings are readily made and the assembly of the core with the spool involves very much less labor than the assembly of the earlier design.

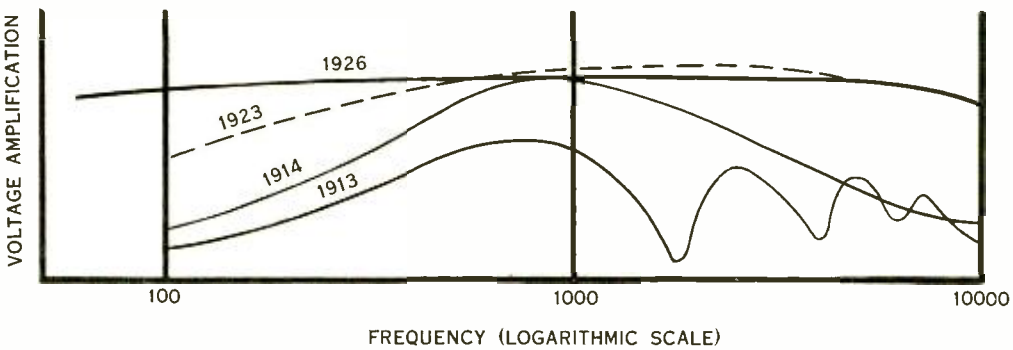


Fig. 2—How the voltage-amplification characteristics of our transformers have been improved in thirteen years

From an electrical standpoint the new transformer was practically the equivalent of the preceding design and was entirely satisfactory for the transmission of speech.

The 203-type transformer, however, was large, heavy and expensive. To obtain the desired transmission for voice frequencies a very high impedance was required and that meant many thousands of turns of fine insulated wire. Since the Manufacturing Department had not at that time developed the technique of winding No. 40 black-enamel insulated wire it was necessary to use much larger wire insulated with enamel and silk. The amount and kind of wire required, therefore, were directly responsible for the size and weight and much of the cost.

In 1916 the problem of designing smaller and cheaper repeater equipment placed upon the coil development group the necessity of developing corresponding transformers. In this development the use of standard

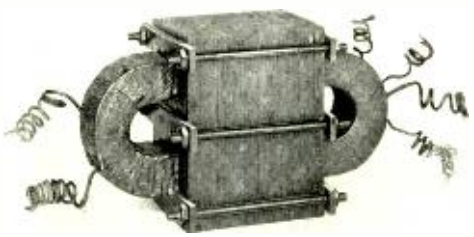


Fig. 3—Shell-type design of 1914; size 6⅝ by 4 inches

parts and standard methods of construction were adhered to as far as possible in order to secure a low cost. The toroidal construction of Figure 5 was selected. The number of turns of wire, however, which could be wound on the core was limited by the size of the shuttle on the winding machine. Also, the inertia of the moving parts of the winding machines then in use was so large that wire smaller than No. 31 could not be used without an excessive number of breakages. Due to these limitations on the

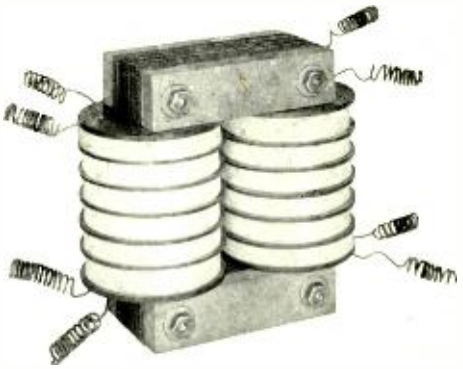


Fig. 4—Design of 1915; size 6¾ by 4⅝ inches

windings, an amplification as large as was desired could be obtained only at a sacrifice of the low frequencies. It was not desirable, however, to impair the quality of the repeater operation in this manner.

Up to that time (1916) the use for input transformers had been confined practically to telephone repeaters. In these, the amplification of frequencies below 135 cycles and above 2300 cycles was not desirable; in fact, it was decidedly objectionable, and means were provided elsewhere in the repeater to reduce the amplification of these frequencies. The band of frequencies which the transformer was required to transmit was therefore defined at about 200 cycles to 2300 cycles and the trend of the development had been along the lines of producing smaller and cheaper transformers rather than in attempting to extend the range of transmitted frequencies.

Furthermore, since it was desirable

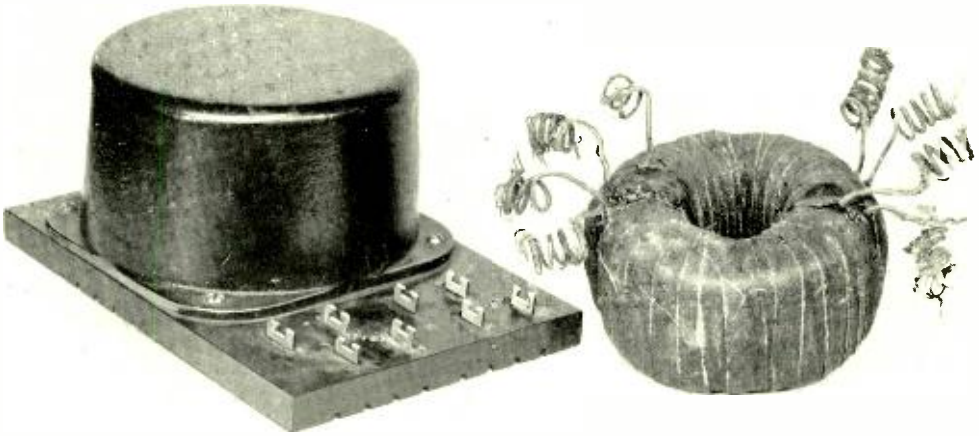


Fig. 5—Toroidal transformer, mounted on a block 6 x 4⅝ inches

to maintain the input impedance of telephone repeaters approximately constant over the transmitted frequency-range, each of the transformers so far mentioned was designed to be used with a non-inductive resistance shunt across its windings and the characteristics shown were taken under that condition. The resistance also served to flatten out the amplification characteristic, producing a more uniform amplification over the frequency range.

Soon after the United States entered the World War the demand for amplifiers of various kinds added a great stimulus to the development of input transformers, especially of the smaller and lighter types. Their development required not only the solution of many theoretical problems of design but also the development in the Manufacturing Department of the technique of winding small sizes of insulated wires. This accomplishment at Hawthorne was one of the principal contributions to the realization of small, highly-efficient input-transformers.

A number of designs were produced in the years 1916-1918, but only two of them combined advantages of cheapness and efficiency which enabled them to survive. They are the 201 and 213 types shown in Figure 6. Many of the amplifiers transmitted frequencies below and above the previously adopted range of 200 to 2300 cycles, for considerable progress was made in extending the frequency range.

The progress in amplifier design made during these years led to the decision in 1918 to improve the quality of the repeaters on the transcontinental telephone circuit. Since the quality of the transmission of the voice frequencies depended largely on the input transformer, that part of the repeater was selected as affording the greatest possibility of improvement. Naturally the types of transformer which were investigated were those recently developed for small amplifiers. Of these the 201 type was selected, since it was small, inexpensive and readily adaptable to quantity production. Furthermore, the Manu-

facturing Department had had experience in making this type and had developed methods of winding.

It was next evident that very little more could be done in reducing the size of the input transformer and that any further improvement would have to be in extending the frequency range or reducing the cost. Attention was given to the amplification of the higher frequencies and means were found whereby the amplification of the frequencies from 3000 to 5000 cycles, and even higher if necessary, could be controlled by the use of certain methods of constructing the windings. By these means it is possible to produce, in the frequency range above 1000 cycles, an amplification characteristic of practically any shape desired and hence to obtain the approximately flat characteristic necessary for faithful and accurate reproduction. An input transformer with such a characteristic is the 234-type shown in Figure 7. It has a silicon-steel core and an improved mechanical structure; and it is highly efficient as well as inexpensive. Its amplification characteristic is shown in Figure 2 under the date, 1923. This transformer, as well as those mentioned later, is designed to be used without any shunt resistance and the characteristics shown for it were taken under that condition.

Further development in the design of transformers, with the object of improving the amplification at the lower frequencies, led to the use of permalloy as a core material. Also, a further study of methods of winding resulted in the extension of the high-frequency range considerably above 5000 cycles. These developments have resulted in transformers with almost uniform amplification over a wide band of frequencies. This characteristic, very necessary in the high-quality amplifiers of the present day, is shown under date of 1926 in Figure 2. A transformer of this type is the 226-type, which is mechanically similar to the 234-type shown in Figure 7, except that it has a permalloy core.

Our progress of approximately thirteen years in the development of input transformers is well symbolized by Figure 2, to which reference has previously been made. There has been a steady improvement in trans-

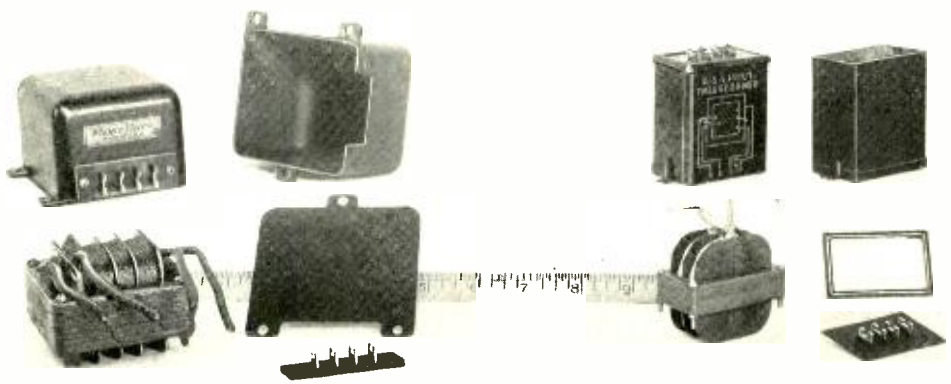


Fig. 6—"War babies"; 201-type on the left and 213-type on the right

mission characteristic, both in frequency range and in voltage-amplification ratio. Commensurate improvements in cost, in reliability, and in reduction of size have accompanied the gains in transmission. Of the engineers concerned with coil development whose studies and designs have been responsible for these advances many names ought to be mentioned, particularly H. Whittle and E. L. Schwartz, but space limitations preclude telling the complete history.

The developments have resulted in input transformers which are about as small as can easily be handled for manufacturing purposes, with a range of transmitted frequencies adequate to present-day requirements, and producible at relatively low cost. Further progress will demand attention particularly to extending the range and further reducing the cost. The method and technique which has been evolved will prove of value also in other related developments.

Fig. 7—234-type input transformer; an example of present-day small, economical, and efficient design

The Silent Drama of Telephony

By JOHN MILLS

WHEN a motion-picture film gets across to its audience its photography has carried an emotional stimulus. Of this fact *The Gold Rush, The Big Parade, Grass, The Last Laugh, Don Q,* and *He Who Gets Slapped,* were excellent illustrations. Their realism excited and strained the observer's emotions; they presented concrete human situations, not cold abstractions.

Of motion pictures, however, there is another and more limited type which strives, not for the emotions, but for the intellect; and deliberately deals with abstractions. This type is in the class of educational and so-called "non-theatrical" pictures.

Into this field Bell Telephone Laboratories entered in 1921 with the production of the remarkably successful film *The Audion.* The scenario was written by the late Dr. H. W. Nichols with the assistance of J. C. Schelleng and others. The film received a wide distribution through the Motion Picture Bureau of the Western Electric Company and more than forty prints of it have been made at various times.

All previous products of non-theatrical films, as far as the writer can learn, had been limited to the portrayal of actions which could be photographed. But how can one photograph the operation of a vacuum tube as an oscillator, a modulator, a detector, or an amplifier? The instinctive answer is "it can't be done." An illusion had to be created; and an essentially new technique had to be developed to accomplish it.

Dr. Nichols first simplified the physical processes which were involved and then symbolized them. In the development of suitable pictorial symbols and in the production of the picture in which these symbols vary, change, and move with an illusion of the physical operation of the tube itself, he was ably assisted and advised as to motion-picture technique by two motion-picture engineers, Messrs. Arthur W. Carpenter and F. Lyle Goldman. These experts were at that time on the staff of the Bray Pictures Corporation, but later became the active members of the Carpenter-Goldman Laboratories, Incorporated.

In the next entry of our Laboratories into this educational field these two experts acted as consultants and their newly organized company performed the photographic work of producing *The Electrical Transmission of Speech* and *The Nature of Speech and Audition.* The first of these films shows the physical principles of speech production and its electrical conversion by telephone transmitter and receiver. The second records graphically some of the fundamental facts, derived by investigations in our Laboratories, as to the pitch and energy content of speech, as to the sensitivity of the ear, and as to the intelligibility of the various syllabic sounds of the English language.

These two films were produced

with the advice of Messrs. Snook, Fletcher, Maxfield, Frederick, Moore, Wegel, and other specialists in the material which they portrayed, and the scenarios followed outlines prepared by John Mills. They were carried through production by P. C. Hoernel who contributed several ingenious methods of presentation and was responsible for coordinating the technical comments of the various engineers whose work they recorded.

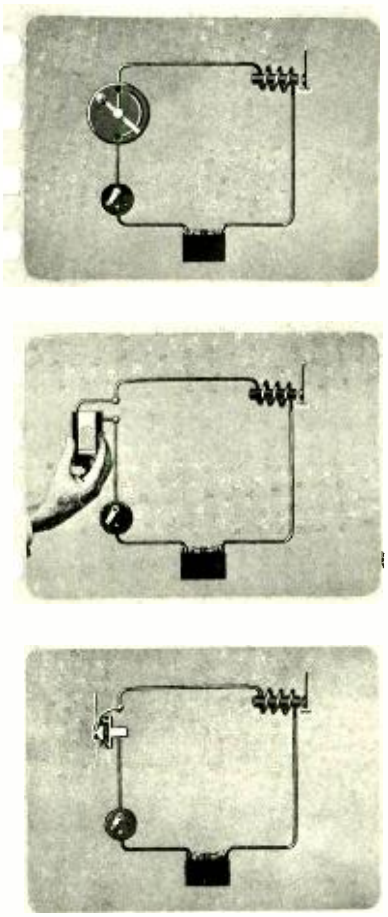


Figure 1

Both films were widely used in lectures before colleges and engineering societies by G. B. Thomas and others and have since formed a part of the introductory survey of our work which is presented to recruits from the colleges. Of the second film, which is limited in appeal because of its technical content, only a few prints have been made, but of *The Electrical Transmission of Speech* over forty prints have been made. Some of these have been purchased by telephone companies and the rest are kept in circulation by the Motion Picture Bureau of the Western Electric Company.

The film on speech transmission was an experiment in visual education and differs from other films in the following way. An educational film is usually constructed by writing a logical series of titles and then illustrating these titles in any way whatever which will be effective. The logical outline, therefore, inheres in the titles rather than in the pictures themselves. In *The Electrical Transmission of Speech,* on the contrary, the logical arrangement inheres in the pictures and the titles are incidental.

This idea was the outgrowth of a lecture which the writer of the scenario had given before various college classes. In that lecture a simple telegraph circuit consisting of a battery, a key, a sounder, and the connecting wires was sketched on the blackboard. For the telegraph key would then be substituted a variable resistance, which did not alter the physical relationships but meant that the modulation of the current, instead of being from no current to full current, was from some current to a higher value. By successive substitutions of this character the diagram was developed into a carrier-current system and finally a radio-telephone system, emphasizing thereby the fundamental unity of all forms of electrical communication.

The more elementary of these steps were embodied in *The Electrical Transmission of Speech*. Figure 1 shows three frames of this picture where the variable resistance is replaced successively by a carbon cell

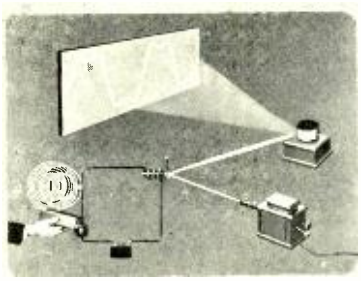


Figure 2

and by the button of a telephone transmitter. The current indicator in the circuit, consisting of an electromagnet with a spring armature, became by the addition of a mirror the moving element of an oscillograph. And this oscillograph pictured on a screen, as shown in Figure 2, sound waves of single frequency as produced by tuning forks. The oscillograph next showed complex waves, formed by the superposition of the waves from two tuning forks, and how the characteristic of a complex wave is altered by resonating one or another of its components. A basis was thus laid for the appreciation of complex waves, the speech significance of which is due to the resonating chambers of the mouth. For the exposition of this idea Mr. Hoernel placed his own head at the disposal of the photographic experts with the result shown in Figure 3. Finally, by the transition indicated in Figure 4, the simple current-detecting device became an ordinary telephone receiver and the source of the sound waves delivered to the ear in Figure 5.

The next film production of the Laboratories came two years later, in 1925, in a group of pictures dealing with the switching operations of a telephone central-office. This production was engineered by P. C. Hoernel and the scenario was by John Mills. Technical advice as to circuit features

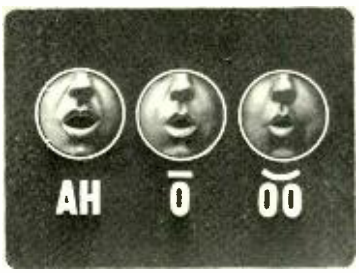


Figure 3

and methods employed by operators, and expert assistance in arranging apparatus for photographic presentation, were contributed by W. H. Bendernagel.

The purpose of that picture was to show the electrical, mechanical, and human operations which are per-

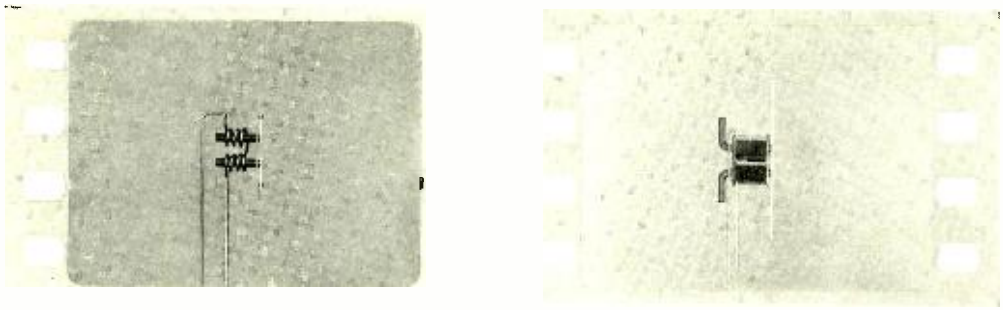


Figure 4

formed in setting up a telephone connection between two subscribers. A portion of it, therefore, was obtained by direct photography of apparatus in operation and of the actions of subscribers and operator. The remainder consisted of animated diagrams showing the circuits and operations of the relays, lamps, and keys in the sequence in which they occurred. The direct photography was made in the P. B. X. of the Laboratories on the tenth floor and in two of the offices.

Figure 5

The actors in this film drama were J. S. Hartnett, W. F. Johnson, and Dorothy Amrell, who rehearsed and posed for their respective parts with all the usual surroundings of grease paint, powder, and high-powered electric lights which accompany a commercial production.

The film thus made was *Through the Switchboard,* and from it, by cuttings and the addition of titles, and some photographic material not incorporated in the original edition, two other films were produced known as *A Telephone Call* and *A Circuit Study of a Telephone Call.* These later editions were arranged by A. K. Aster. Of the complete and original film some twelve prints are already in circulation and the demand is increasing.

In *Through the Switchboard* the opening scene shows Mr. Hartnett initiating a call by lifting the receiver of his telephone; and then it cuts to a view of our P. B. X. where his line-lamp lights and Miss Amrell plugs in and answers. After the number has been given it shows her operations in completing the connection and in ringing; and then cuts to a view of Mr. Johnson receiving the call. When the conversation terminates, scenes show the two men hanging up the receivers; the supervisory lamps light, and the operator disconnects.

The film then takes up these operations in detail. For example, the original signalling operation is shown by dissolving the desk stand to show the switchhook within it. The conventional symbol for the switchhook is then introduced and the circuit diagram of the subscribers' line is built up. In detail thereafter the various

features of the cord circuit are "animated in" and their function and operation indicated and related by cutting back to views of the actual switchboard.

After showing in this way all the circuits and operations there follows a review in which the entire circuit diagram appears. The calling subscriber's receiver is lifted off its hook, the switch closes, the lines in the diagram which indicate the subscriber's line are emphasized by greater brightness; the diagram of the line relay is animated, its contact closes and the diagrammatic line lamp brightens. Diagrammatically also the answering cord tip then moves to engage with the jack. The supervisory and line-cut-off relays are animated in proper sequence, and the portions of the circuit then carrying current appear brighter. On the other hand the line-relay circuit reverts to its normal brilliancy as current in it ceases, the relay opens, and its diagrammatic lamp fades out. In this way the successive steps in the operation are followed on the diagram by animation and illumination. Figure 7 is a frame from this portion of the film showing conditions after the subscriber has been called and while conversation is taking place. The complete presentation occupies two reels.

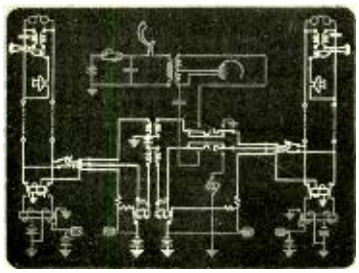
In 1926 two new films, as was previously mentioned, were made from this material. Of these, *A Telephone Call* omits practically all circuit detail and electrical operations, picturing only the mechanical and human operations. This film is now being distributed by the Motion Picture Bureau of the Western Electric Company for showings in clubs, schools, and Y. M. C. A's. The other film confines itself almost entirely to the development of the circuit and its sequence of operations.

How some of these operations are treated is shown in Figure 8. The switchhook, line relay and subscriber's lamp are there paralleled by an elementary diagram at the right to emphasize the separate circuits and the relay operation.

The most recent production of the Laboratories is a portrayal of the operation of the vacuum tube as a telephone repeater. In the original

Fig. 6—Actors in "Through the Switchboard": J. S. Hartnett, Dorothy Amrell, and W. F. Johnson

vacuum-tube film, *The Audion,* the emphasis was more on radio than on voice-frequency operations. The present film for its scenario follows a booklet, issued some time ago by the American Telephone and Telegraph Company and entitled *The Magic of*



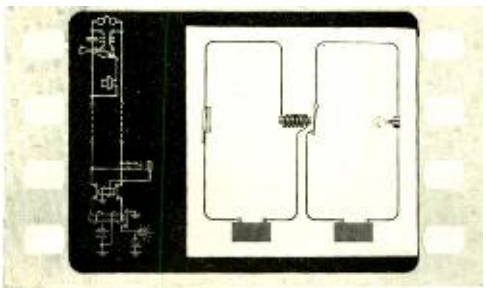


Fig. 7 above and 8 below

Communication, selecting those portions which have to do with long-distance transmission by repeaters. It takes its name from that booklet with a sub-title *The Telephone Repeater.*

This picture starts by developing a conception of wave motion of air molecules; and this is symbolized by thousands of tiny circles which move back and forth on the projection screen, each with simple harmonic motion about its normal position and in such phase relations to the others that waves sweep across the screen. For the transmission of one wave across the screen forty-eight frames are required. Each frame has 1600 dots carefully laid out by scale to the required position as in Figure 9.

Many technical details of this character, which enhance the illusion and contribute to the accuracy of presentation, were contributed by Joseph W. Coffman and A. K. Aster. The former is an educator and motion-picture expert who recently joined the Carpenter-Goldman Laboratories. The latter, as a member of the Bureau of Publication of our Laboratories, was technically responsible for the production of this picture.

From the idea of wave motion of air molecules the film progresses rapidly to a corresponding wave motion of electrons in wires, and its translation by a receiver into air waves. The idea of an attenuation of the electronic motions in long wire-circuits is then developed and hence the necessity of a telephone repeater. At the transmitting end of the line the moving dots representing electrons are most numerous and decrease exponentially to the receiving end. These dots, which are animated and have different positions in successive frames, are illustrated in one position by Figure 10.

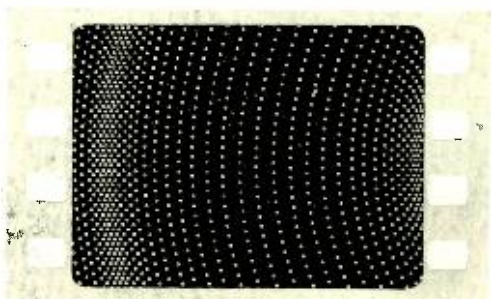


Figure 9

The operation of the vacuum tube as an element is then developed and finally it is shown as a telephone re-

Figure 10

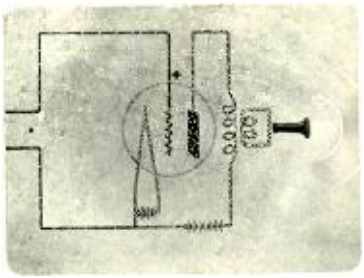


Figure 11

peater. First there is built up the idea of emission of electrons from the filament, then their passage to a charged plate, and finally their control by a grid. Successive frames in which the electrons in the connecting wires and the tube have different positions show a periodic variation in the stream through the plate circuit corresponding to the surging in and out of the grid circuit of a much smaller number of electrons; while in the secondary winding of the output transformer a very much larger number surge back and forth with the same period as those in the grid circuit. A frame from this portion of the film is shown in Figure 11.

The film ends with a map of the United States into which are animated by bright lines the enormous network of wires through which the American Telephone and Telegraph Company and its Associated Operating Companies make possible its nation-wide telephone service.

Our New Radio Laboratory at Whippany

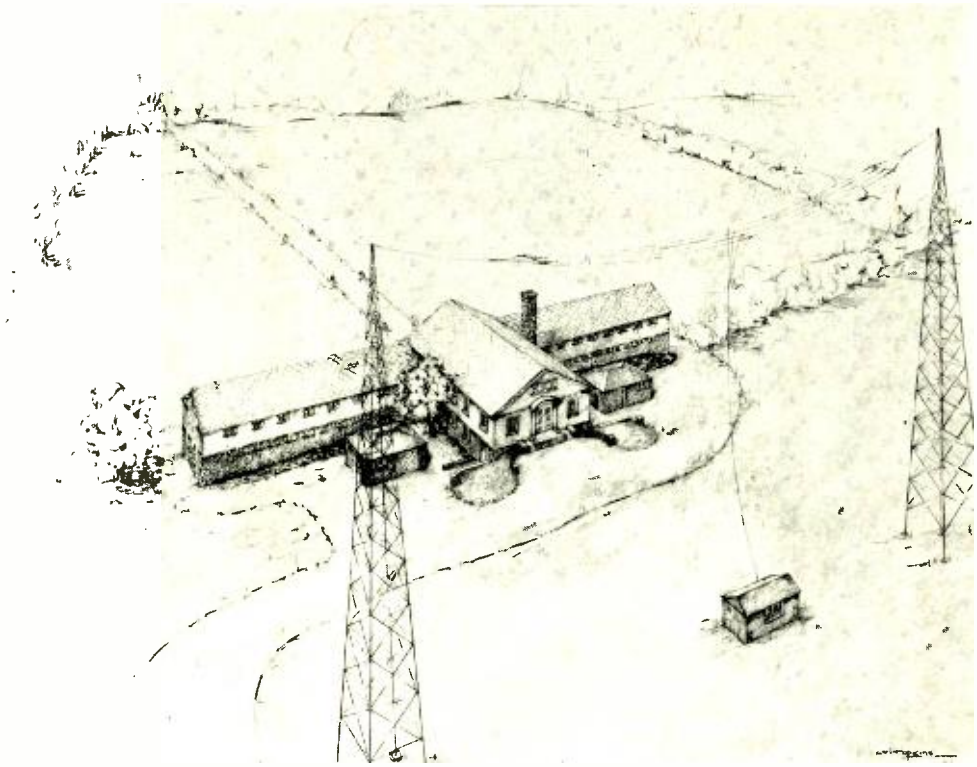
By EDWARD L. NELSON

A RECENT noteworthy addition to the facilities of the Laboratories is an experimental radio station at Whippany, New Jersey, for broadcasting development.

Up to the present, the test-program activities essential to the development of Western Electric broadcasting equipment have centered in our West Street Building. Many readers, no doubt, have had occasion to listen to these "2XB" tests, which had their beginning in the autumn of 1921. Phonograph selections, the usual offerings of the handful of stations then "on the air," constituted the first tests. Attention was then directed to the transmission of music—vocal, instrumental, orchestral and organ—as originally played. The extensive acoustic and telephone experience of the Laboratories aided in the gratifying progress made, and a standard of transmission was soon achieved which has been difficult to improve. This work afforded a firm foundation upon which to build, and subsequent broadcasting equipments have conformed to its general lines. As a result, it is possible after an interval of less than five years, to point to some 150 Western Electric-equipped stations in regular operation, most of them recognized leaders in the industry; and the number is on the increase.

Growth in the number of transmitting stations, remarkable as it may appear, has, however, been completely overshadowed by the corresponding expansion in the receiver field, a condition which has made it undesirable to have a test station in the heart of the metropolitan area. Even when testing is restricted to the hours after midnight, in conformity with government regulations, there are protests from confirmed "DX" enthusiasts; and no doubt many who do not take the trouble to forward complaints experience a feeling of impatience and ill will toward the strong test stations. Further, the present tendency, for reasons similar to those just mentioned, is toward the installation of regular-program stations on plots outside the densely populated districts. This necessitates a thorough study of the conditions surrounding the operation of this new type of installation. These considerations and the fact that a high-power radio transmitter is a rather undesirable neighbor in our Laboratory where delicate measurements are a part of the ordinary day's work, led to the search for a more suitable location which has culminated in the purchase of the Whippany property.

Whippany, a small industrial community, is approximately four miles east of Morristown and on the Mount Pleasant Road, one of the principal highways connecting with the Oranges and Newark. Since it is some fourteen miles from the latter, and twenty-two miles from Manhattan, abnormally strong signals will not be projected into these areas. The plot includes nearly fifty acres of



A "bird's-eye sketch" of the Whippany radio laboratory as it will look when completed

grass-covered elevated land with a gentle slope to the east, and is but a few hundred feet from the highway. Railway transportation is afforded by the Lackawanna Railroad with a station at Morristown, from which hourly service to Hoboken is maintained. The Whippany River Railroad, a short line connecting with both the Lackawanna and the Erie, passes through Whippany and a switch track adjoins the property. On the neighboring highway, with frequent service to Morristown, the Oranges, and Newark, is a bus line which will render the station nearly as accessible as the Laboratories in so far as a large portion of the New Jersey commuting zone is concerned. The advantage of this feature from the standpoint of the engineer with a family is evident. An adequate supply of water from the mains of the local company is already on the property. The power required has been contracted for with the New Jersey Central Power and Light Company, which serves this section of the country, and is now erecting an additional 20,000 kv-a plant on the Passaic River approximately one mile from the station. Considering these factors, the location is ideally suited to our purpose.

In order that the station may be available in the shortest possible time, a building already on the property is to be remodeled. This was originally a dairy; it consists of a central portion approximately 45 feet by 80 feet including two stories and a basement, together with two two-story wings approximately 25 feet by 100 feet. For the present, active use will be made only of the central sec-

tion. The upper floor will be modified to provide for a large operating room and a laboratory approximately 40 feet by 45 feet, together with a suitable studio and control room, a private office, and a general office. The lower floor will be devoted to a power room, a storeroom, a shop, and a locker room. Provision for the heating plant, fuel storage bins, and possibly some additional dead storage space will be made in the basement. The lower portion of the building is of field stone; the second story is sheathed with shingles. Two small detached buildings to the right and left of the main structure will be used as garages. When the contemplated changes are completed, it is expected that the space will be quite satisfactory for laboratory purposes, and that the structure will present a handsome appearance.

The initial antenna system will be supported by two 250-foot steel towers now under construction. These are set well out in front so that the building will be away from the denser portion of the antenna field, and that ample space may be provided for the installation of an adequate ground system.

As has been indicated, this station is intended to provide facilities for development work in radio broadcasting. The first use of the plant will be in connection with transmission tests on the 50 kw. set which will be our next production in this field. In the Laboratories, work on the units for this transmitter is proceeding rapidly and, as soon as the building is modified, a large portion of the activity will be transferred to Whippany with the object of beginning the tests "on the air" early in the autumn. All tests will, of course, be made after midnight as the station is not intended for broadcasting purposes in the accepted sense. However, since they will constitute the trial runs on one of the latest developments in the art, they probably will be of interest to all radio enthusiasts. The Department of Commerce has assigned the station call letters "2XN".

In addition to these tests it is expected that study of transmitting antenna-systems for use in the broadcasting frequency-band will constitute an important phase of the work. There is a rather remarkable shortage of detailed design information in the literature upon this important subject. Although our experience in the past few years has added considerably to our store of knowledge, nevertheless it is not complete and further work should produce worthwhile results.

Other important problems will immediately occur to the engineer who has given serious thought to broadcasting matters. Remarkable as the progress of the past few years has been, the solution of many pertinent questions still lies in the future, and opportunity to make suitable contact with the medium involved, that is, the ether, is obviously a prerequisite to success. This opportunity the new station is expected to afford, and there can be little doubt that it will contribute materially to the maintenance of Western Electric's eminent position in the industry.

EDGAR SELDEN BLOOM

Director, Bell Telephone Laboratories

Recently elected President of Western Electric Company, Mr. Bloom now becomes a Director of our Laboratories. A graduate of the University of Pennsylvania, from Bell System service in several operating companies and most recently as Vice-President of American Telephone and Telegraph Company, he brings wide experience in engineering, construction, commercial and executive functions.

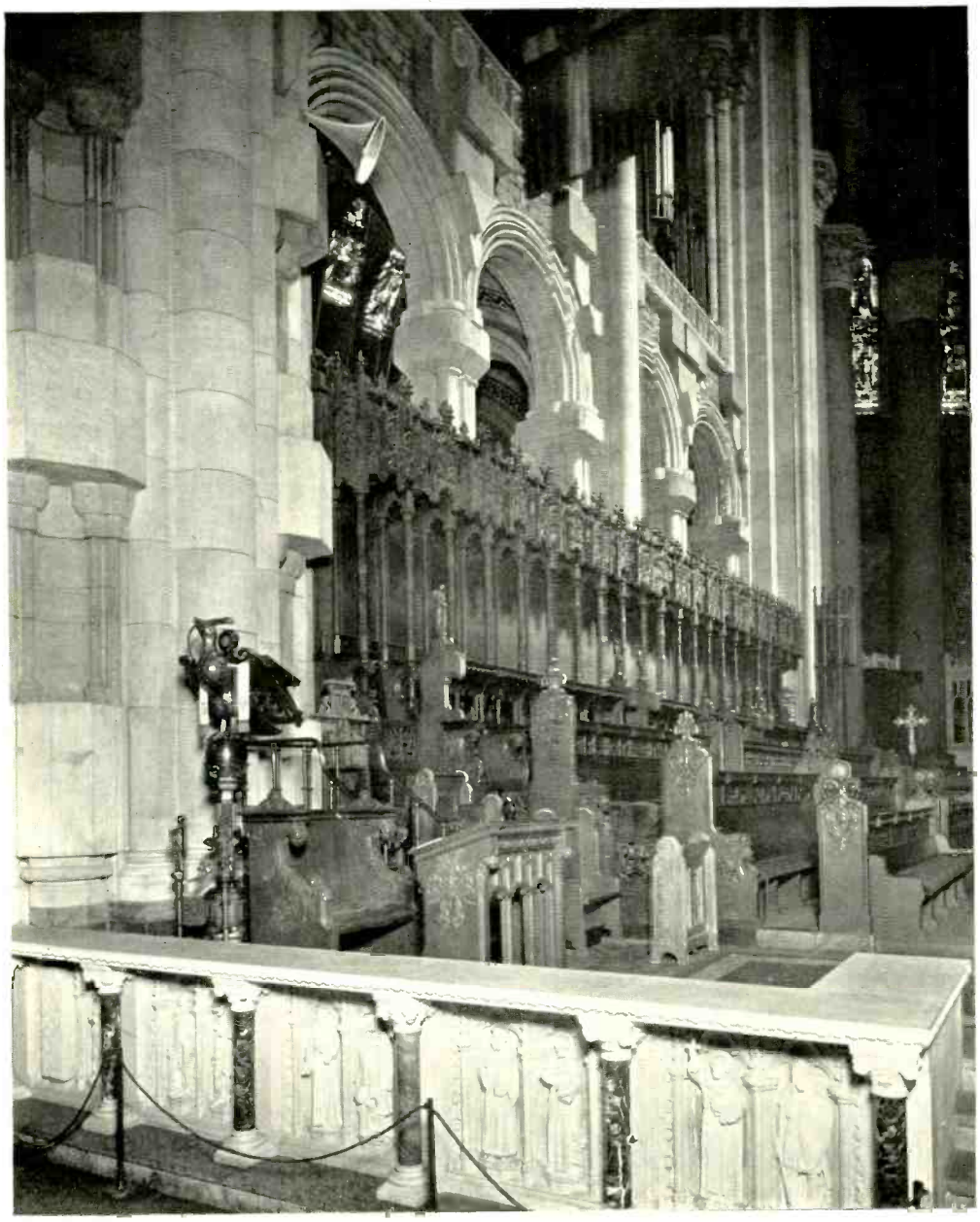
Public-Address Systems

By T. L. DOWEY

PROBABLY all of us have at some time had the irritating experience of straining our ears in an effort, often unsuccessful, to catch the words of a speaker addressing some audience of which we formed a part. Such occasions remind us that in most gatherings of any size the limitations of the unaided human voice render it difficult or impossible for a speaker to make himself clearly understood by all his hearers. One of the chief functions of our public address systems is to overcome this obstacle, which must have intervened between speakers and audiences since men first began to gather in assemblies. In case the speaker has difficulty in making his voice loud enough to carry as far as the more remote listeners, all that is required is that the public address system shall reinforce his voice sufficiently. Broadly speaking, the public address system thus used would have three essential parts: its transmitter, the amplifier, and the loud-speaking telephones. The function of the transmitter or "microphone" is to "pick up" the voice of the speaker—that is, the transmitter creates electrical fluctuations when acted on by sound waves. The more closely these fluctuations correspond to the sound waves causing them, the less "distortion" the transmitter is said to produce. The type of transmitter employed for such work is similar in its fundamental principle to the ordinary telephone transmitter which we use every day, but instead of the customary single granular carbon button, it has two such buttons, one on each side of the diaphragm. Also the diaphragm is very thin, is tightly stretched, and arrangements are made to damp it. These special features make the transmitter comparatively free from distortion. Since this microphone is also employed with our broadcasting equipment many illustrations of it in the press have made widely familiar its appearance, and the screened mounting in which it is suspended on springs to isolate it from vibration.

The electrical fluctuations which constitute the output of the transmitter are much too weak to operate the loud-speaking telephones, and amplification is, therefore, necessary. The transmitter output is brought through shielded conductors to amplifiers which are practically free from distortion over the frequency range met with in speech and music. These amplifiers, together with the auxiliary apparatus used for supplying power to the system and for other purposes, are usually installed in a room known as the "control room," although in small installations this apparatus is often set up at some inconspicuous location in the auditorium itself.

The power output of the amplifiers is used to operate the loud-speaking telephones. In the example we have chosen, these would be of the horn type, consisting of a receiver unit combined with a large straight horn. The

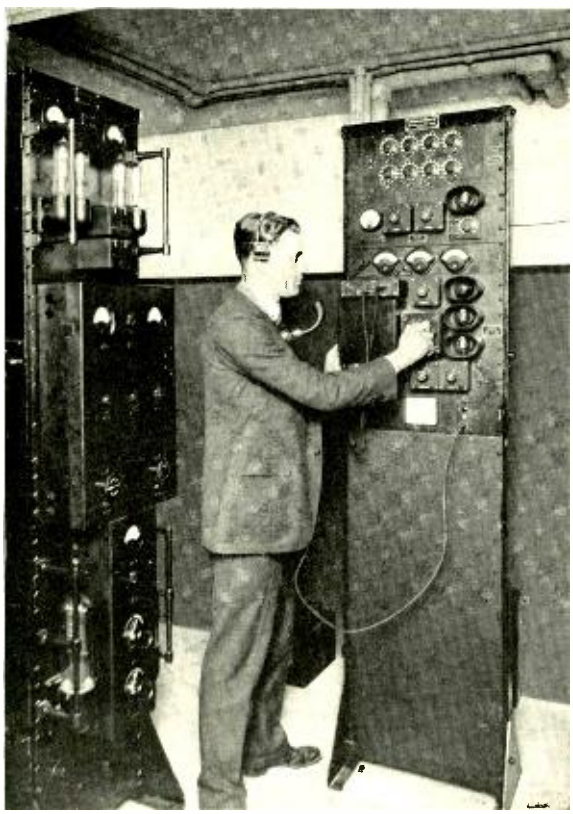


One microphone and horn of the public-address installation in the Cathedral of Saint John the Divine, New York

horns are mounted in a group approximately vertically above the speaker, at a height of about twenty-five feet, tilting downwards slightly from the horizontal, and pointing out radially in such directions as to cover the whole area occupied by the audience. When the system operates, the audience will not, so far as its ears inform it, be conscious that any artifi-

cial means is being used to reinforce the speaker's voice. The transmission is of sufficiently high quality for the reproduced sound to appear natural, and the effect of placing the horns in a cluster above the speaker creates the illusion that all the sound is proceeding from him. There would be danger of losing this illusion if the loud-speaking telephones were scattered about the auditorium, as there would tend to be an appreciable time interval between hearing a sound from the speaker and hearing it from the different horns. This would produce an effect like echo, and there would also be a disagreeable and confusing impression that the sound was coming from a multiplicity of sources.

There is a limit to the amount of amplification which can be applied in the case we have described. This arises from the fact that part of the sound energy from the horns travels back through the air to the transmitter, through which it again passes into the system. If the amplification is high enough, this will lead to oscillations being set up in the system, and a sustained singing noise will be heard from the loud-speaking telephones. Just before this stage is reached the output of the system will begin to deteriorate in quality. With most gatherings sufficient amplification can be obtained before this limit is reached.



Control room of a typical 1-A public-address installation

In many auditoriums the speaker's voice is heard loudly enough, but there is difficulty in understanding because the words sound indistinct and appear to run into each other. This is generally due to the auditorium being excessively reverberant, which happens when most of the interior surfaces are of hard materials, such as plaster or stone. The duration of sounds in such an interior is unduly prolonged, because the waves undergo many successive reflections from the various hard surfaces, instead of being quickly absorbed, as they are on striking soft surfaces, such as drapery or carpets. This prolongation causes each syllable to be confused with the next, and so tends to make speech unintelligible. A simple public address system of the type just described often overcomes this condition, because if the speaker uses a low tone, the reverberation caused by his own voice

*Philadelphia celebrates the Sesquicentennial of American Independence. The huge stadium is equipped with one of our public-address systems**

can be greatly diminished; and since the horns are directed so as to throw their sound on the audience, where it is largely absorbed, the total amount of sound which reaches the hard reflecting surfaces of the interior is reduced enough to make the reverberation unobjectionable. In many auditoriums, inaudibility due to their large size and unintelligibility due to reverberation have both to be contended with.

What has been said about voice reinforcement applies equally well to music produced by a soloist or an orchestra.

The various other applications of public address systems can be viewed as developments from the typical layout which has been described. Instead of there being only one transmitter position, several may be provided, in the same room or in separate rooms, for use on different occasions. Besides coming from a transmitter, the input of the system may be taken from a radio receiver, from a telephone line, or by means of an electrical reproducer from a phonograph record. Where there are several transmitters or other sources of input, a transmitter control panel is used to select the proper source on each occasion when the system is used. This is accomplished by means of a dial switch having several positions, a different source of input being connected at each position. If it is necessary to

* Bell Laboratories Record, *July*, 1926, *page* 219.

pick up sound from several scattered sources at once, as with several performers taking part in a theatrical production, or a large orchestra, it may be necessary to employ several transmitters simultaneously. This is accomplished by means of transmitter grouping panels which provide means for combining but separately controlling the output of the different transmitters. This is of great value in obtaining the proper balance between different parts of an orchestra or between a singer and an orchestra.

Besides reproducing sound at a point where it originates, for the purpose of local reinforcement, a public address system can be used to reproduce sound at as many other points as required. Usually these are in the same building, but if necessary some of the output can be delivered to a telephone line for this purpose. For controlling the various output circuits of the system, a volume-control panel is used. This consists of an auto-transformer with a large number of taps, which are multiplied to dial switches. Each dial switch is connected through a cut-off key to a circuit in which one or more of the sound reproducers are connected. By this means the proper volume level can be obtained in each circuit.

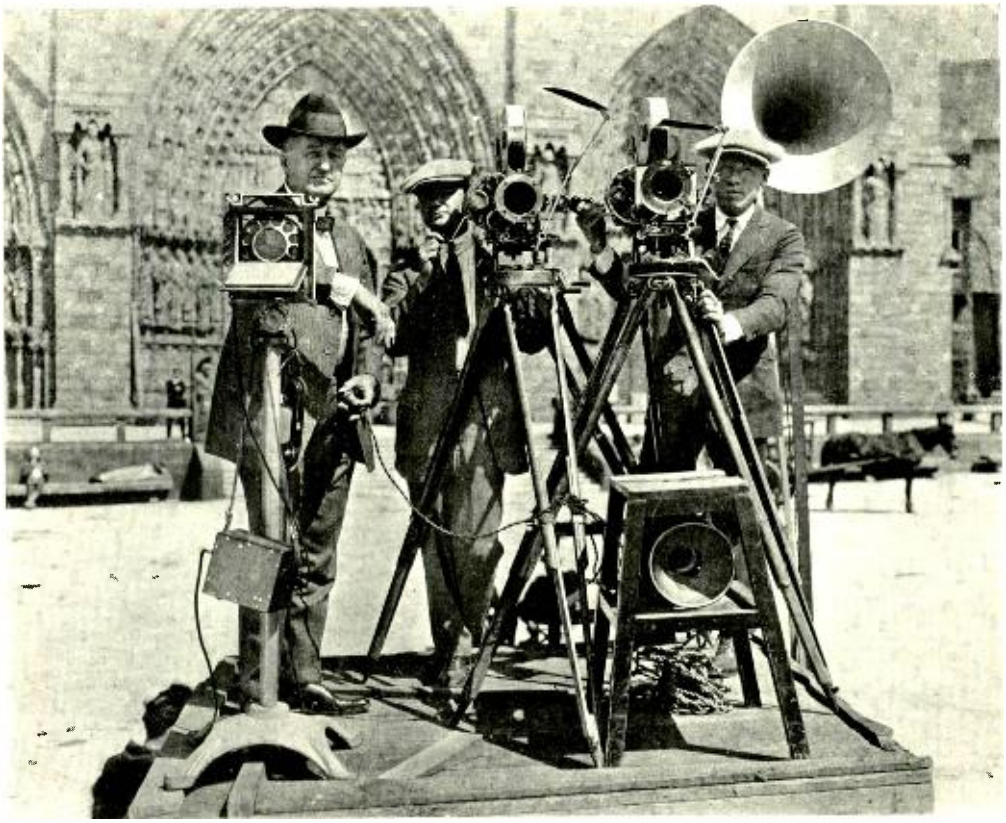
In addition to the horn-type loud-speaking telephones which have been mentioned, head receivers and cone-type loud-speaking telephones are also utilized with public-address systems. It may be remarked here that the purpose of the larger sizes of cones and horns is not necessarily to produce a greater volume of sound, as is often supposed by the public, but to secure better reproduction of the low frequencies which are an important element in musical quality. From the standpoint of public-address system work, there is a difference between horn and cone type loud-speaking telephones which is worth noting: namely, that the cone type distributes the sound much more broadly. For this reason, we generally use only horns for local reinforcement; if cones were used, so much sound would be carried back to the transmitter that the oscillating condition previously mentioned would set in before sufficient amplification had been obtained.

It sometimes happens that speech or music has to be reproduced over some area like a park, which is too large to be covered according to our preferred practice by a single group of loud-speaking telephones. Supplementary loud-speaking telephones must then be used, and great care has to be exercised, when laying out and installing the system, to avoid objectionable acoustic effects of the kind which were previously mentioned as likely to occur when a listener hears the same sound coming from two or more sources some distance apart.

Headsets are used with a public address system in such places as hospital wards or hotel rooms, where loud-speaking telephones would be unsuitable. Headsets operated at more than normal volume are used to aid members of an audience who are partly deaf.

The use of public-address apparatus in electrical phonograph recording was dealt with in the January issue of the RECORD.

One of the most recent developments in connection with public-address systems is remote control. This is so arranged that in a school, for example, the principal, by means of a set of keys mounted on a panel in his office, can start the system, or in case



Directing "The Hunchback of Notre Dame" with the aid of a public-address system.

of emergency appropriate it from any other use to which it is being put, and then talk through a transmitter on his desk to any parts of the building which he may select.

As already mentioned, in many installations the amplifying equipment is located in a separate room, which may be so situated that the operator of the equipment has no direct means of observing conditions at the points where the transmitters and sound reproducers are being operated. However, three indirect means are available, any or all of which may be used to enable him to keep in close touch with the operation of the system. One of these consists in monitoring the output of the system by listening to it with a headset or loud-speaking telephone located in the control room. The operator can make a rough check on quality and volume by this means and can also follow the program. Another means is the use of what is called a volume-indicator panel. The volume indicator consists of a sensitive galvanometer operated by means of a rectifying tube from the output of the system. By adjusting the amount of power supplied to this galvanometer until it gives a standard deflection, it is possible to measure accurately the power output of the system. The third means by which the operator is enabled to keep in touch with conditions is through the use of an intercommunicating system, in cooperation with one or more observers who remain at the points

where the audience is located and report to the operator whenever it is necessary to make changes in the volume or balance, or when it is necessary to switch from one transmitter to another. Each observer is provided with a handset, while the operator uses a breast transmitter and head receiver.

We have at present three sizes of public-address equipment. The most powerful is known as the No. 1 Public-Address System, and is intended for dealing with outdoor gatherings and large buildings. The No. 2 system is intended to deal with small outdoor gatherings and interiors of moderate size. It is generally similar to the No. 1 system, except that a less powerful output amplifier is employed. The No. 3 system is intended for use in small installations. It is much simpler than the No. 1 and No. 2 systems and does not include the various control panels used with the former.

A considerable part of the apparatus used with public address systems is also used with radio broadcasting systems. In this connection it is interesting to note that such apparatus may be developed by two entirely different methods. One plan is to so design it that the distortion introduced by one part, for example, a transmitter, is cancelled by equal and opposite distortion in another part, such as its associated amplifier. The other method of development is to make each part of the equipment as nearly as possible perfect and free from distortion. The former method may sometimes permit more rapid commercialization of one particular type of system, but it makes it difficult to use any apparatus interchangeably. Our public-address equipment, like Bell System apparatus in general, is designed according to the second method, which gives maximum flexibility and ultimate economy.

As might be expected of apparatus offering so many different possibilities, our public-address systems are being used for a remarkable variety of purposes in a field so wide as to include practically every kind of large building or place of assembly, and confidence in the results obtainable has begun to reach the stage where large projects are under consideration whose commercial success will be largely dependent on service rendered by equipment of this type.

A considerable amount of engineering is required in connection with work of such diversity, where no two problems are exactly alike and fresh combinations are constantly occurring. Engineering recommendations for proposed installations are prepared on the basis of information obtained from the prospective purchaser, or, if the nature of the problem demands it, from a physical survey on the spot. The recommendations include the plan which is to be followed in making the installation, and give sufficient information to enable the customer to complete the necessary wiring. The installation is carried out by the customer, but in most cases it is done under our engineering supervision.

In The Month's News

TELEPHONE PIONEERS to the number of more than seven hundred visited our building on August 27, as one of the events of their Thirteenth Annual Meeting. In the Auditorium they were formally welcomed by John Mills, who described the Laboratories, their work for the Bell System and how the fundamental studies had been applied in the phonograph and motion-picture field. A special showing of some of the Vitaphone specialties was made under the supervision of G. E. Mather and his staff. Many of the Pioneers visited our Historical Museum, where they were received by W. L. Richards, W. C. F. Farnell, A. K. Aster, C. D. Hanscom, Miss Boman and Mrs. Hadfield. The arrangements for the visit were made by S. P. Grace, who represented the Laboratories on the headquarters committee for this convention of Pioneers and by L. S. O'Roark who is responsible for the scheduling and utilization of our new auditorium.

THE CELEBRATION OF THE FIFTIETH anniversary of the American Chemical Society held in Philadelphia from September 6th-11th was attended by the following men of the Laboratories: R. R. Williams, J. E. Harris, E. E. Schumacher, H. T. Reeve, C. L. Hippensteel, R. E. Waterman, G. T. Kohman, J. A. Lee, A. R. Kemp and J. T. Acker. In the exposition section of the convention the Laboratories was represented by a permalloy exhibit. This included a device for showing the magnetic properties of permalloy,* and several groups of photos showing various stages in permalloy manufacture and in cable laying. The remainder of the display showed the sequence followed in the making of permalloy wire and tape, and also exhibited several samples of cables including the first successful transatlantic and the first permalloy cable.

THE AZORES EARTHQUAKE which occurred on August 31st was the cause of considerable inconvenience to two of our engineers, G. A. Locke and A. Melhose, who for several months have been working on the New York-Azores cable. Practically every building in the town of Horta on the Island of Fayal, where they were staying, was damaged, many were destroyed, and all water and electric light service was interrupted. Both the office and station equipment of Western Union suffered slightly. The storage battery plant is now being replaced, and only a slight delay will be experienced. After the disaster the Laboratories' engineers assisted Western Union in every way possible to restore its service and equipment to normal. These men have now taken up temporary lodgings in two incompleted houses with fifty members of the Western Union staff until the tents supplied by that company can be set up. It might be interesting to know that Mr. Locke reported that the rumors of a bubonic plague in the Azores are unfounded.

H. E. IVES attended a meeting of

* BELL LABORATORIES RECORD, *November*, 1925.

the American Astronomical Society in Nantucket during the week of September 5th, and also visited the Woods Hole Biological Laboratory.

D. H. NEWMAN has returned from Port-au-Prince, Haiti, where he was supervising the installation of a No. 106 Radio Telephone Broadcasting Equipment.

F. S. BERNHARD is now located at Santiago, Chile, where he is making a preliminary survey for a point-to-point radio-telephone system near Santiago, and testing a power-line carrier-telephone system between Santiago and Valparaiso.

P. H. BETTS has just returned from Gibson, Indiana, where he supervised the installation of a radio system* to permit telephone communication between the yard master and the engineer of switching locomotives in the Gravity Classification Freight Yards of the Indiana Harbor Belt Railway, (a subsidiary of the New York Central Railroad).

H. W. DIPPEL, of the Purchasing Department, D. W. Mathison of Apparatus Development, and J. Alden of the Commercial Department of Western Electric, recently visited the Henry L. Scott Company of Providence in connection with the design and manufacture of a new machine for the precision testing of wire insulation. This is a recent development of the Laboratories.

J. W. MCCAW, buyer of chemicals in our Purchasing Department, attended the convention of the American Chemical Society at Philadelphia.

J. S. HARTNETT has been named as representative of the Laboratories on the New York Junior Board of Trade and Transportation, an organization devoted to commercial and civic welfare.

W. V. WOLFE attended the Pacific Coast Convention of the A. I. E. E. held in Salt Lake City the early part of September. He later visited San Francisco and Los Angeles to study the power-line carrier situation on the Pacific coast and spoke on transmission problems before the electrical students of California Institute.

J. B. KELLY attended a meeting at Colorado Springs of the American Academy of Ophthalmology and Otolaryngology.

R. M. BURNS, accompanied by H. T. Byck, and Dr. J. J. Johnston, left at the end of August for Seattle, San Francisco and Los Angeles to study in the field the effect of corrosion on cable sheathing.

W. C. JONES visited the Hawthorne Works early in September in connection with the manufacture of the No. 555 loud speaking receivers which are being used in the Vitaphone equipment.

E. L. NORTON of the Research Department, accompanied by H. T. Martin of the Apparatus Development Department, spent a week at the Hawthorne Works in connection with the production of an electromagnetic reproducer.

T. C. FRY and W. A. SHEWHART were in Columbus, Ohio, during the week of September sixth attending the meeting of the American Mathematical Society.

J. J. GILBERT returned on September seventh from a three months' stay in Newfoundland, where he was doing work on the Bay Roberts-Penzance permalloy cable.

D. G. BLATTNER was in Philadelphia from September first to fourth to introduce a number of improve-

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* *The experimental system was described in an article by Mr. Betts on page 79 of the* RECORD *for April,* 1926.

ments in the Bell System exhibit of talking moving-picture equipment at the Sesqui-Centennial Exposition. He also spent two days in Atlantic City in connection with the introduction of the Vitaphone in that city.

KARL K. DARROW attended the international conference on magnetism held at the Technische Hochschule of Zurich from June 21 to June 26, and the meeting of the British Association for the Advancement of Science at Oxford from August 4 to August 10.

H. A. FREDERICK returned on July 15th from Cleveland, where he spent three days attending the tri-monthly conference of the American Telephone and Telegraph Repair Committee.

T. L. DOWEY, whose article on public-address systems appears in this issue of the RECORD, is now engaged in sales engineering of such systems with the Graybar Company, to which he has been transferred.

J. P. MAXFIELD visited the Victor Talking Machine Company at Camden on August 17 to discuss the policies regarding future development work to be undertaken by the Laboratories in connection with the contract existing between the Victor Company and Western Electric.

DURING AUGUST, R. M. Moody, C. J. Hendrickson, W. A. Boyd and H. F. Kortheuer were in Hawthorne in connection with regular Survey Conference Work. R. H. Hart and S. C. Miller visited Pittsburgh and Lebanon, Pennsylvania, in connection with Survey Conferences with steel manufacturers. In company with W. A. Shewhart, Mr. Miller also visited the pole plant of the American Forest Products Company, which is located at Yarmouth, Maine.

R. L. JONES and S. C. MILLER were recently in Boston discussing with New England Company engineers the quality of supply materials being furnished to that company.

THE PITTSBURGH SECTION, A. I. E. E., was addressed on September 14 by P. B. Findley of the Bureau of Publication. Under the general title, "Landmarks in Communication," he described some of the outstanding developments of the Laboratories.

AMONG CONTRIBUTIONS of Bell Laboratories men to the literature of technical progress may be noted:

"Complex Magnetism," by Eugene Peterson, *Physical Review*, March, 1926.

"Some Photographic Problems Encountered in the Transmission of Pictures by Electricity," by Herbert E. Ives, *Journal of the Optical Society*, March, 1926.

"A Radio Field-Strength Measuring System for Frequencies up to Forty Megacycles," by H. T. Friis and E. Bruce, presented at a meeting of the Institute of Radio Engineers, May, 1926.

"A New Mechanical Test for Rubber Insulation," by C. L. Hippensteel, *Industrial and Engineering Chemistry*, April, 1926.

"The Balanced Sea Earth for Cables," by J. J. Gilbert, *The Electrician*, August 6, 1926.

WILLIAM FONDILLER'S contributions to the development of loading have been recognized by the publication in the Italian journal, "Telegraphi e Telefoni" and in the German paper, "Physikalische Berichte" of extensive abstracts of some of his recent papers.

J. B. ODELL has resigned as Director of Bell Telephone Laboratories, and is succeeded by E. S. Bloom.

Introducing the 1926 College Graduate

By MAURICE B. LONG, *Educational Director*

DURING the summer a number of recent graduates of engineering schools and colleges have become members of our Laboratories. In an introductory survey, essentially that described in the RECORD a year ago, they have been told the organization of our System and the Laboratories, before starting work in particular departments.

Like its predecessors, the group has been recruited from institutions spread over the entire country and includes also men with degrees from foreign universities. Sixty educational institutions are represented and the territories of fourteen Bell companies. From any single institution the largest number is seven, that from Massachusetts Institute; others contributing more than two are Harvard, Yale, Union, Columbia, New York, Brooklyn Polytechnic and the University of Iowa.

The assembly of this widely representative group, chosen in accordance with the ideals of the Laboratories, is another illustration of cooperation and coordination within the Bell System. In advising suitably-qualified men in universities about the work and opportunities which our Labora-

Top Row: A. B. Bailey, M. I. T.; L. E. Krohn, U. of London; H. B. Deal, M. I. T.; H. Lathrop, Vermont; C. F. Maylott, Worcester Poly.; J. T. Wilmarth, Colgate; H. W. Bode, Ohio State; W. R. Steeneck, N. Y. U.; J. W. Tate, N. Y. U.; W. E. Campbell, Witwaters Rand U.; H. A. Henning, Penn State. Bottom Row: R. G. Watling, Occidental; A. G. Russell, Brown; H. A. Weber, N. Y. U.; H. L. B. Gould, Acadia; S. J. Lambert, U. of Iowa; C. P. Stocker, Ohio U.; T. Slonczewski, Cooper Union; G. W. Burr, Yale; P. W. Prindle, Columbia; E. H. Joyner, V. M. I.

tories offer, the Operating Companies not only have given great assistance to our Personnel Department but also have taken an important part in insuring the technical progress of the communication art which is essential to their own welfare. Theories and inventions, laboratory investigations and designs, of the telephone equipment of the future will be the task and creative opportunity offered to these young men.

For this important work the Laboratories has sought, and believes that it has found in them, certain characteristics. It requires technical training in the engineering sciences usually, but occasionally in accounting, business, or law. It has looked for trained brains, in vigorous bodies, with pleasing but dynamic personalities; for men who will bring sound and fundamental technical training to their tasks, and give promise of making engineering contributions and of developing, as occasion requires, into supervisors of similar tasks.

It expects that they will approach their work with intellectual curiosity, and with an ability for and a habit of study, which will respond to the facilities offered by the work itself and by our "out-of-hour courses." It trusts that they will learn from the rest of us by association and will cooperate with us and thus avail themselves of

Top Row: H. H. Holland, Columbia; N. H. Thorn, Bucknell; W. N. Mellor, Gettysburg Col.; G. C. Peterson, Iowa State; L. B. Hilton, M. I. T.; A. Grendon, Columbia; E. B. Stallman, M. I. T.; I. V. Williams, Penn. State; J. E. Nielsen, Royal Tech. Col., Copenhagen, Den.; M. S. Glass, U. of Chicago; D. W. Eitner, Maryville; F. E. Nimmcke, Brooklyn Poly.; H. O. Wood, J. H. Rohrbaugh, Wooster. Center Row: A. N. Holden, Harvard; A. S. Worfolk, Stevens; F. W. Winters, Harvard; J. W. Brown, U. of Wash.; H. A. Lewis, Cornell; F. F. Stoner, Harvard; L. E. Krebs, Carnegie Tech.; G. T. Wood, Union; W. B. Snow, Stanford; C. P. Thomson, Princeton; K. M. Weeks, N. Y. U.; B. E. DeMaré, Jr., U. of Penn.; E. Swanson, Lund's U., Sweden. Bottom Row: D. E. Trucksess, Penn State; F. A. Hinshaw, Kansas State; T. L. Dimond, U. of Iowa; A. E. Kerwien, Union; B. F. Runyon, Illinois; A. Rivenes, Montana State; J. R. Reeves, U. of Oklahoma; L. A. Lebaut, U. of Paris; W. A. Ock, Brooklyn Poly.; F. R. Stansel, Union.

opportunities for advancement in our industry. Their first evidence of ability to do so will be the quickness with which they learn and produce: upon the basis of the trust engendered by their technical production and by their cooperation will depend their opportunities for broader responsibilities.

They have come to our Laboratories, so far as we know, not "oversold" on its opportunities; but because they expect to find in it the character of work in which they are most competent and will be most satisfied. To them it offers work of engineering importance and of social value, under conditions which will stimulate the greatest team play and assure those pleasant human relationships without which one's professional life would be incomplete. They know that on the average our executive positions are held about fifty-fifty by men of college training and men whose education has been less formally acquired. For them, as college graduates, opportunities for study and introductory courses are not uniquely provided, but are merely part of the general scheme, within our organization, illustrated by out-of-hour courses, to establish facilities to individual growth and advancement fitted to the training or experience of its various members. Their success with us and our development of their abilities are matters which will be individual and are of the future; but the association has been formed on the basis of a frank and mutual understanding.

Top Row: T. G. Gastner, Drexel Inst.; H. Morrison, Worcester Poly.; C. B. Sutliff, U. of Iowa; H. Baillard, Columbia; A. E. Thiessen, Hopkins; W. A. Hyde, Stanford; E. S. Pennell, Bowdoin; C. B. Mullett, Michigan; C. N. Nebel, Missouri; F. B. Anderson, U. of Penn. Center Row: F. L. Crutchfield, No. Carolina State; A. L. Beach, Pratt; G. W. Wilson, Middlebury; J. G. McIvor, Royal College of Science, Dublin; E. W. Conger, No. Dakota; R. C. Koernig, U. of Colorado; H. N. Wagar, Harvard; H. G. Romig, California; G. Garbacz, Milwaukee College of Engineering; W. W. Perkins, Maine; G. E. Atkins, Roanoke. Bottom Row: D. S. Bender, Rensselaer; H. R. Kimball, M. I. T.; F. J. Beck, B. P. I.; B. H. Carmer, Rensselaer; F. S. Kinkead, Ohio State; C. E. Germantown, Lafayette; C. O. Wells, U. of Oregon; M. H. A. Lindsay, M. I. T.; N. Bishop, Yale; C. P. Carlson, Michigan.

What Is Service?

By J. S. HARTNETT

IN these days of prevailing slogans, we naturally hear much about service—in business, in the public prints, on the air. Being thus a lively topic, it is idealized and, controversially, ridiculed. There are those who consider it an essential of business and those who would insist that it acts only to cloy. What is it then, this common denominator of all of our slogans?

Basically, if bromidically, behind every such word is a collective idea. As a word, "service" is a little one grown big. The idea it conveys has expanded apace. Time was when the word was used principally as an occupational classification. It inferred unskilled labor. The phrase "service organization," if used at all, would have had reference to the laundry, the dairy, or other agency of the household. Its implication was more or less menial. Servility or servitude were its connotations. Truly a word of inhibition.

Decades pass and values change—even in words. The meaning of "service" is now broadly reversed. We talk of it as the spirit of service. We call our Bell System, assuredly a unit of mobilized skill, a service organization—"one system, universal service." We find service staffs within almost every business, and similarly each advertises its service at large. It thus evolves that this word, which in one sense came out of the kitchen, is used to symbolize the coordination of management, the promotion of industrial and human relations, the assisting of a business within itself and of trade in general, inter-relatedly. Do we stray then in saying that service is necessarily a guiding spirit to an actual end?

The answer to any question is best found in experience. Within our Laboratories we have established Service, centrally and in our various departments. Does it help us achieve our end? In movie technique, I give my conclusion first. It must and does. It is inherently part of everything that we do, from the manufacture of an individual audiphone to the eventual laying of a cable to the shores of the Azores. Service is our sub-structure, tested daily in its solidity.

Flash back through the factors contributing to this conclusion. Fundamentally, in the case of the cable, we have research in permalloy and cable loading, problems of insulation and transmission measuring, apparatus development of terminal facilities—all studies of infinite detail. These will require that materials be purchased, received, tested, manufactured, tested again as finished products, and finally delivered to ships. There will intervene the preparation of laboratory reports, the transmittal of working data, the despatch of telegrams, the provision of funds for our engineers to travel to Hawthorne and Lisbon. Figures of estimated costs will be prepared, expenditures accounted for as incurred, and final costs made statistical as we finish. The whole roster

of our personnel, from the Director of Research and the Apparatus Development Engineer to the decoder of cablegrams in our Telegraph Department and the instrument maker in our Engineering Shop will in some way at some time bend efforts to produce this newest Atlantic cable.

In such a large and diverse organization, it may be asked if service can always be effectively coordinated. Can it be a pervading spirit? Yes and yes.

Flash back again, in closer detail. In our merchandise service we have entailed, for instance, the matter of our material requirements in the operation of the Laboratories. These requirements are legion: thumb tacks, a motor-generator — what not? If the materials be such as are used with regularity, we must store them in quantities consistent with their consumption. We have thus set up our merchandise assets and we must control these assets in such a way that we provide the requisite quantities for normal use and yet keep these quantities within bounds so that they are represented on our balance sheet as a liquid asset rather than one which is stagnant or frozen. There must be here then in the service of keeping stores the application of broad knowledge of material uses, the study of trends of consumption and the intelligent handling of the whole to guard against surplusage—in a phrase, coordination of effort and cost.

Similarly the other phases of this merchandise service must operate from day to day in active concert. Deep as some of us may be in our engineering or research work, we are all, however engaged, none-the-less kindred. There are people of whom we rarely see and seeing, do not know individually, who will be serving the interests of all of us. A shipment will need to be made: upstairs the engineer will have attended to assembling the apparatus to be shipped; some place in the lower floors of the building there will follow the preparation of the necessary shipping instructions, the packing and crating of the material to be shipped, the arrangements for its transportation. In all of which is involved from the administrative or service standpoint, the entire gamut from the maintenance of the necessary quantity and kinds of shipping forms to the legal execution of a trucking contract—unitized steps in unified action.

We find also in the course of our work the occasion for much utilization of office service. Look into our Transcription Department and see there what is the nearest approach to perpetual human motion among us: the concentration of a large staff of stenographers, typists, duplicator operators, all constantly at work in turning out correspondence, specifications, bulletins, instructions and all the natural flow of written material that must go forth on the sea of business. The dictation of a specification by an engineer will engage at the other end of a telephone one of these typists who remains to him only a voice but whose efforts in the joint completion of this piece of work are yet of importance. From the end of another telephone, messengers are despatched to appointed rounds. Down in the fantastic glare of our photograph room, someone else, expertly trained, will be photographing some device in which the engineer will be interested, having previously on another occasion even photographed the engineer himself. From an adjoining room,

blueprints roll out by the hundreds. For correspondence between departments, a travelling post office hastens distribution. And when some of us have reached dessert at dinner, others are clicking away on the printer telegraph our messages to Hawthorne. So again, in our so-called office service, multiple efforts individually exerted will grease the ways.

Similarly, in every department of service. Our plant must be adequate. Elevators must be run up and down, lights lit. Someone must schedule our orders for work: in and out of the Shop, to our customers. A carpenter, a physicist need medical attention: a nurse, a doctor, are at hand. We seek reference to published material; be it "Who's Who" or a Danish engineer's latest conception of repeater operation, library service is available: to secure our reading for us, to anglicize, to compile. Even recreation is serviced.

From these foci I think it can be seen how "service" fits into our day's work. It *is* the coordination of utilities and the spirit of aid. It is the aspect of our organization which might be termed one of the two almost inseparable elements by which our results are produced. Those elements are *personnel* and *matériel*.

Our personnel must provide the human elements—the brains and ideas whether technical or administrative, while our systems of service merged therewith and guided thereby provide the material phases.

Such then is the so-termed spirit of service as we carry it out. Granted that we may be too indulgent in the use of this word or phrase, there is apparently none better for it. It is something of what the French call *esprit de corps*. Our smartest writers ridicule it as an evidence of American enthusiasm. They minimize it by saying it is Rotarian, one of the fetiches of a go-getting nation. Our smarter writers are sometimes over-enthusiastic in their self-effulgence. Notwithstanding these gentlemen, service remains more necessary than it is evil. Within our Laboratories, within any business, between businesses, the fact is realized, I think, that service is the available, assisting element; that those responsible for it must continue to apply to capacity their efforts to make it always such.

A famous man once said that we cannot all be deluded all of the time. A whole people could not misconceive the idea of service. It must be something more than the fatuous god of the Babbitts. It is. It serves.

Club Notes

THE Bell Laboratories Orchestra is about to start its 1926-27 season, the third since its organization. It invites the attention and cooperation of all musicians in the Laboratories. The purpose of this organization is to furnish musical recreation. It is evident to all whose tastes lie along these lines that the enjoyment of each individual in an organization of this kind is heightened by the cooperation of every other individual, and for that reason every musician in the building should identify himself or herself with the orchestra and work for its success this season. While the details of the season's program have not been worked out it is assured that plenty of musical work both in rehearsal and public appearance will be forthcoming.

The first rehearsal will be held on Monday, September 21, in the Rest Room. Anyone wishing to discuss the activities of the orchestra in more detail is urged to get into touch with any one of the following officers of the organization: Conductor, L. E. Melhuish; Business Mgr., W. A. Krueger; Librarian, R. J. Podeyn.

Chess

The knights of the chess board will be seen in action again this month with the opening of the season.

Again this year we have entered a team in the Commercial Chess League of New York City, and as all the teams have added some very strong players to their respective organizations, many extremely close and hot fights are expected in the tournament. The Potter trophy has become the permanent possession of this Club, and we have donated a new trophy. This year our old enemies at 195 Broadway have entered a team and we know that beating West Street will mean more to them than the trophy. Broadway is very lucky in having this year D. G. Grimley and J. M. Stahr, who last season were the No. 1 men on the West Street and Hawthorne Club chess teams.

A Bell System Chess League is now being discussed, and if a sufficient number of the branches of the Bell System are interested, plans will be started as soon as possible for the organization of such a league.

All interested in chess are cordially invited to attend games; Captain Voos will always welcome new players.

Basketball

The Inter-departmental League League for men will open the 1926-27 season in November with eight teams competing for the individual prizes and the Department Trophy. All league games will be played on Tuesday and Thursday evenings, starting November 2nd, at Labor Temple, 14th Street and 2nd Avenue, New York City. Two games will be played every evening, the first starting promptly at 5:30 P.M. Club members and their friends who may be interested are always welcome at

these games. No admission is charged.

The departments which will be represented in the league are Commercial, Research, Equipment, Toll and Circuit, Tube Shop, Apparatus Development, Patent, Inspection, and Junior Assistants.

In addition to the inter-departmental games plans are now being made for the organization of a Bell Systems Basketball League in which will be represented the various branches of the Bell System located in and around New York. Any club member who has not played in the club league before this season should consult at once with D. D. Haggerty.

Handicap Golf Tournament

Contestants in the Club's Golf Tournament assembled at Salisbury for the qualifying round on Saturday, September 11th. Sixty entries were received, among which were some of the Club sharpshooters such as J. Hiller, G. Kellogg, G. Lewis, E. H. Clark and J. A. Burwell. Full details of the tournament will be published in the November Record.

Bowling

On the evening of September 24, C. W. Lowe, Chairman of the Bowling Committee, gave the signal which opened the season and started 120 men in the Club Tournament, which will consist of 84 games bowled over a period of 28 weeks. This season the Club Tournament is being held at Dyer's Manhattan Alleys, located at 1680 Broadway, instead of Recreation Alleys located at 368 Fulton Street, Brooklyn, where our matches for the past five years have been held. The attendance on the opening night has proven to the Bowling Committee that there is no let-up this year in the enthusiasm.

Applications were received from 133 men desiring to take part as regulars throughout the season, but the Committee was obliged to place 13 of these names on the substitute list. It is the desire of the officers that more men signify their intention of becoming part time bowlers and serving as substitutes during the coming season. A careful study of the organization of the Bowling League will show that the substitutes play just as important a part in the League's activities and success as the regulars. No League could exist without an active substitute list and a hard-working substitute committee.

The officers of the Bowling Club for the 1926-27 season are:

C. W. Lowe, General Chairman.
E. D. Johnson, General Secretary-Treasurer.
R. J. Miller, Chairman, Group "A."
A. R. Thompson, Sec.-Treas., Group "A."
W. B. Prince, Chairman, Group "B."
G. A. Brown, Sec.-Treas., Group "B."
W. A. Bollinger, Chairman, Group "C."
F. Broome, Secretary-Treasurer, Group "C."

Bowling is an activity which affords both recreation and healthful exercise and it is hoped that many new faces as well as the old ones will be seen on the alleys this coming season.

Women's Activities

Arrangements have been made for the women's swimming class at the Carroll Club at 5:30 Wednesday evenings, starting October 6, 1926. Miss Bolan is taking care of the registrations and can answer any of your questions regarding this activity.

There were several other activities proposed in the September Record which will be announced on the bulletin board as the plans are completed. Any one of the women's committee or the Club secretary will be glad to

hear from you if you have suggestions about any of the present activities, or any new ones in which you feel that a fair number of the women would be interested.

Although some sports may come, and some may go, the bridge enthusiasts go on forever. At least they did not give up during the summer. The regular games, however, did begin Monday, September 20th, with May Murtaugh again planning the games and generally looking after the players' enjoyment. The women are playing in the Rest Room from five to seven o'clock every Monday, and since they are planning more equipment they will welcome you if you are interested in this favorite indoor sport. There is a tournament ahead and plans for mixed games.

Fall Dance

The Fall Dance of the Club will be held in the Grand Ballroom of the Hotel Pennsylvania on Wednesday evening, November 10. The music will be furnished by Ben Bernie, and tables will be provided for those desiring to play bridge. Special features are being planned by Chairman McCormack and will be announced.

Swimming

One of the finest pools in the Metropolitan District is in the Shelton Hotel, 49th Street and Lexington Avenue, and the Club has secured special privileges which are available to its members.

The hotel charge for the use of the pool is $1.50 for either afternoon or evening session, but if tickets are purchased through the Club Secretary, Room 164, the price is $1.00. The pool is open until 11 P.M. on week days and 9 P.M. on Sundays.

Riding

Riding will be continued at Unity Riding Academy although the classes at Van Cortlandt Park will be discontinued. Arrangements for lessons, either in groups or individually, may be made with the Academy at the rate of two dollars and fifty cents for two hours. Miss Gilmartin will be glad to let you have tickets at any time you may wish to join the class.

Hiking

The weather is going to be real hiking weather now. There is just enough of the frost in the air to make walking a joy. All this being true, glance through this program and you will find several interesting trips for you to take: Tuesday, October 12, Mianus River; Saturday, October 16, Orange Reservation; Sunday, October 24, Little and High Tor; Saturday, October 30, Inwood Reservation.