BELL LABORATORIES RECORD

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September 1925 to
September 1926

BELL TELEPHONE LABORATORIES
INCORPORATED

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BELL LABORATORIES RECORD

Volume one SEPTEMBER, 1925 *Number one*

FIFTY years ago there was no telephone. But there was a telephone laboratory. In a corner of a Boston workshop Alexander Graham Bell was investigating speech and hearing and was devising apparatus and methods for the electrical communication of intelligence.

During the fifty ensuing years the American Telephone and Telegraph Company, or its predecessors, has maintained for the Bell System a telephone laboratory. From two men its personnel has grown to thousands; from a small space to a large building; from simple tools to the complete equipment which modern scientific progress has made possible. And beyond the walls of the laboratories other groups of men are carrying investigations into the field.

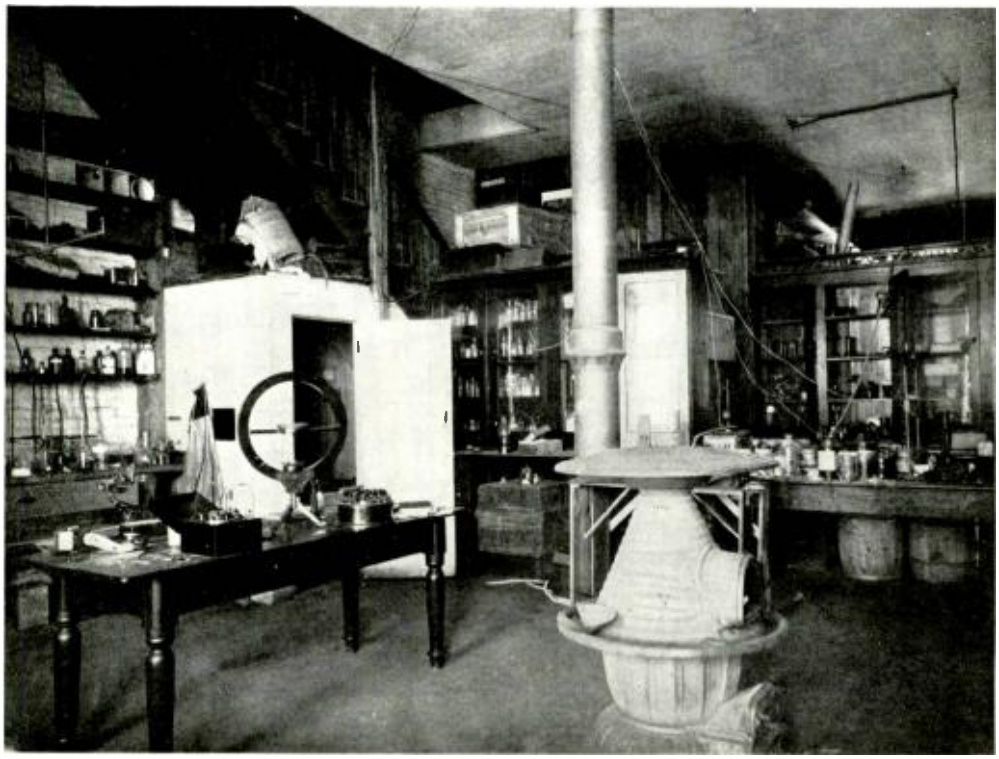
Today we justly prize the pictures and written records and models of Bell's early work. They occupy the places of honor in our historical collection and in our museum. We welcome each addition to our knowledge of the original laboratories and of its successors. We are interested in knowing of the pioneers whose work we carry on, of their point of view and methods. We who uphold, as we are able, their tradition of research and human service and bring to bear on similar problems our more modern scientific methods—we are interested in our predecessors for their achievements and for themselves.

Theirs were the contributions of history. Ours are the contributions of today and of tomorrow. Our interest does not stop with the deeds of yesterday but grows with time and feeds on propinquity. We wish to know more of each other, to learn from each other's methods, to enjoy our group achievement, to have a record and a medium for our information. And hence this magazine.

Our editorial policy is to provide for ourselves that information of a personal, scientific, or organization character which will be of interest and

value to us as members of Bell Telephone Laboratories. And because we are of the Bell System and our researches, laboratory developments, and investigations are for the American Telephone and Telegraph Company, we shall find particular interest in news items and articles relating to that Company and to our colleagues in its Department of Development and Research. We shall report to our readers also the progress and achievements of the Western Electric Company with the members of whose various departments we have had and are maintaining through our work close personal relationships.

With this expression of policy we present Volume one, Number one of BELL LABORATORIES RECORD.

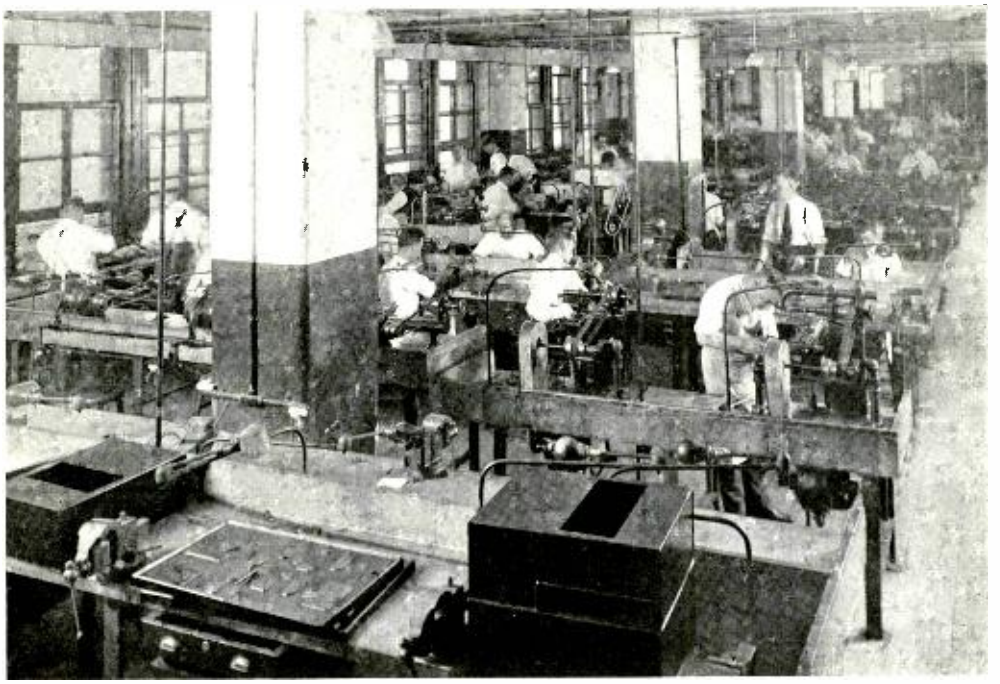


A Bell Telephone Laboratory of 1886
A corner in the laboratory maintained by the American Bell Telephone Company at 141 Pearl Street, Boston

The Model Shop

On the fourth floor of our building is a place where ideas are made into facts. Before the Western Electric Company can sell a new piece of equipment, we usually must show it in actual operation. If the design involves only slight departures from standard practice the Western Electric Company usually builds the first specimen. When, however, something must be built which incorporates untried improvements, or when the demand is too small to permit customary production methods, it is our own Model Shop which does the work.

Our present shop does not date back to the earlier days of the organization, although it is a logical outgrowth of the old shops. It was formed in 1907, under the direction of John W. Upton, the man who for all the ensuing eighteen years has guided its destiny. It was then officially known as the Model Shop; and as such it is still popularly known, although its official name has for some years been the Engineering Shop in recognition of the true character of the work. From the original twelve men, drawn from the then existent shops here, in Chicago, and in Boston, it has grown steadily and evenly to a department of 230 men, with Adolph H. Sass as assistant to Mr. Upton, and eleven supervisors under them. An interesting fact is that Mr. Sass and every one



A view of the bench work section of the Model Shop

of the supervisors has been promoted from the ranks of the Model Shop workers.

No less interesting is the long record of many of the men. Mr. Upton himself will have been with the company twenty-five years next April, having been located at Clinton St., Chicago, until the formation of the Model Shop. Charles A. Grant, in charge of orders, has a record of twenty years to his credit, all of it in the shop here at West Street.

There are much longer records even than these. Edward Boland has been with the company forty years, the last twelve in the Model Shop. Edward Buttner lacks only a year of equalling this, for he joined the company in 1886. Miss Addie Knoeller and John Kunze have both seen thirty-five years of service. Otto Muller, the grand old man of the Model Shop, who has spent thirty-three of his more than three score years and ten with our company, is still vigorously looking forward to the opportunity of breaking the service records of men younger than himself. Carl E. Forsberg, who came with us in the same year, 1892; Conrad Schaul, whose record runs from 1893; Edward F. Gordon and Alfred E. Kopetz who date their service from 1894; and Charles Sauerbrey, who started work with us in 1895, all can boast of thirty years or more with the company.

In the year of the Spanish War Edward J. Harrington and Goodwin Rosenblum joined our organization. The next year came Albert E. Waight, runner up to Otto Muller for the Shop

The Old Guard: Veterans of twenty-five years service with the company, who are the backbone of the Model Shop. From left to right they are: Back row, E. Buttner, A. E. Kopetz, C. Sauerbrey, C. E. Forsberg, E. Boland, C. Schaul, J. Kunze. Middle row, A. E. Waight, E. F. Gordon, J. J. Hughes, E. J. Harrington, N. F. Schoen. Front row, O. Muller, Miss A. Knoeller, G. Rosenblum

Future Model Shop experts: Some apprentices at work

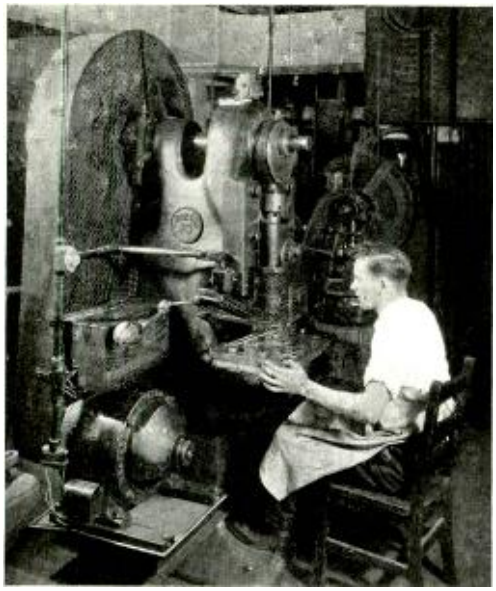
age record, who in defiance of his seventy years has one of the most remarkable records on the company list: for twenty-seven years he has never been late a single day. (Any youngster of fifty years or less who thinks he can't keep up the pace, please notice.) In the same year as Waight, there came with us John J. Hughes and Nicholas F. Schoen. Finally, in 1900, Charles E. Wenzel joined the company.

These are some of the men who have built up the reputation which our Model Shop enjoys. That it may not suffer in the years to come, an apprenticeship system has been adopted to provide the experts of the future.

This apprentice course was organized on January 2, 1919, by George Johnson and Archibald E. Kidd, under the direction of George B. Thomas, and with the cordial assistance of Mr. Upton and Mr. Sass of the Model Shop. Bench work, machine work, and technical instruction in elementary subjects constitute most of the course, which lasts three and one-half years. It started with only one man, Harry J. Battaglia, but has grown until there are now twenty apprentices in it. Nineteen have finished the course since it was started; and of them, thirteen are still with the company.

That the course is accomplishing its purpose is indicated by the fact that, although only six years old, it already has one graduate, Carl W. Maurer, who is Assistant Shop Instructor, and three who are now classroom instructors in the apprentice course.

Needless to say, the accuracy required on the large majority of the work done by the Model Shop is of a higher order than for usual commercial manufacture. Experimental radio sets, picture transmission sets, the mechanical parts for the vacuum tubes built by our Tube Shop at 395 Hudson



Hawthorne has no monopoly on heavy machinery: One of the Model Shop punch presses in operation by D. Moffat

Street, new devices of all kinds, call for expert workmanship. The steady recurrence of such jobs has built up the present large, well equipped department.

Recently a need has been felt for even higher accuracy of workmanship than a model shop handling such varied classes of work could furnish. When machines are expected to grind, mill, bore, or cut to two ten-thousandths of an inch, they cannot be used for miscellaneous work.

As a result, some months ago Room 428 was set aside for a high-precision shop. In it have been installed special machines of the finest quality and in the most perfect condition. Two bench millers and two bench lathes form the smaller regular equipment. There is also a Rivett screw cutting bench lathe, a drill press, and the heavier equipment, consisting of a universal milling machine, a big Brown and Sharpe cylindrical grinder (for grinding heat treated shafts and other parts to accurate dimensions), and a superb Pratt and Whitney screw cutting engine lathe.

Good machinery is of little use, however, unless it can cut to a mark; and something must determine the mark. For flat work, therefore, the dimensions are laid out on a specially imported Société Genevoise jig-boring machine, which acts both as a high-precision drilling or boring machine and, more frequently, as a dividing engine for making accurate measurements.

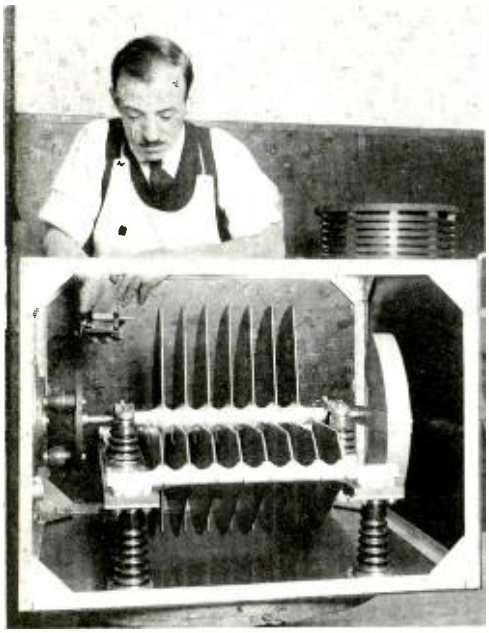
For measurements of circular arc, laying out centers for gear teeth, and similar exacting work, no machine was available which would meet the incredibly small limits of accuracy which

High Precision Shop Specialties: J. L. Agterperg assembling condenser type transmitters in a dust proof case, while C. W. Maurer, in the background, uses the Société Genevoise drilling and boring machine to measure a jig layout

we require. Finally, after a study of the apparatus used by the Bausch and Lomb Optical Company of Rochester, New York, and the United States Naval Observatory at Washington, George F. Atwood of the Apparatus Development Department designed a new precision dividing head possessing the accuracy needed.

Most commercial circular indexing machines involve gears, each having its own error; and since the error for one gear is multiplied by every gear beyond it, no great precision is possible. The new dividing head, which is mounted on a milling machine when in operation, has no gears and can be relied on for as close limits as the eye, aided by a microscope, can detect.

After the dividing head has indexed a new gear, the tool which cuts the gear teeth must preserve the accuracy. Therefore a special fly cutter is used.



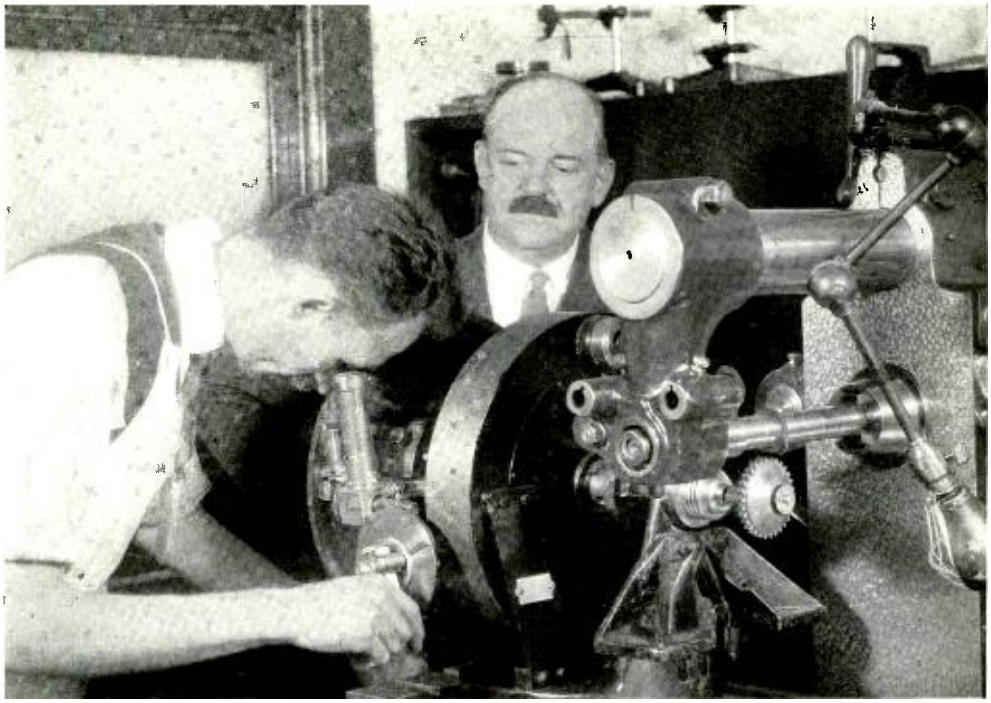
The large and the small of it: J. P. Ferrigni of the Model Shop compares a standard condenser with the giant from the Leviathan's radio telegraph set

A fly cutter has only one cutting tooth, so that there can be no eccentricity between cutting teeth which would cause them to cut in slightly different arcs. That single tooth, and the individual teeth of the gear which it makes, are checked for accuracy in an interesting way. A large scale drawing of the correct contour, made very accurately by an expert draftsman, is hung on the wall of the room. Then the tooth is held in front of a Bausch and Lomb projecting lantern, and its shadow cast on the drawing. Thus the minutest error becomes readily apparent.

A snap-shot photograph of A. H. Sass

Interesting things have come from our Model Shop with its unusual machinery. Machine switching was there transformed from thoughts on paper to apparatus almost able to do thinking by itself. The first experimental equipment and the trial installation of the panel system both came into existence in the shop. So, too, with the experimental apparatus and trial installation of the first printing telegraph, which for a year afterward was produced in quantity in the shop.

Radio sets of all kinds have been made there, some to form units in big land installations, some to travel the high seas, and some to entertain famous men and women. The *Leviathan's* telegraph messages to shore stations are sent by equipment which came



R. Slovenz of the High Precision Shop adjusts the dividing head on a milling machine, under the supervision of Mr. Upton

from the Model Shop. When the great combined fleet of the United States Navy sealed its radio transmitting equipment (to simulate war conditions) and sailed to Hawaii this year on manoeuvres, some Model Shop radio sets had what was probably the longest rest in their history; for the model TL telegraph transmitting sets on Uncle Sam's battleships came from the fourth floor of our own building. Another Model Shop job is the 5 kw. transmitting equipment at the great central United States Army radio station at Fort Leavenworth, one of the Army's radio centres for the whole country. The news, music, and speeches of the world from which he is barred by precedent are brought to His Holiness, Pope Pius XI, thanks to the splendid workmanship on the radio set built for him by our Model Shop.

High quality radio broadcasting was first achieved by apparatus built in the Shop. The first models of the 50, 100, 500, 1000, 2500, and 5000 watt Western Electric sets, each of which has constituted a recognized standard of comparison for broadcasting sets of similar power, were produced here. The first 5 kilowatt set for the Navy (the TL type), the special transmitters for use on small Coast Guard vessels, and many other types, came into being here.

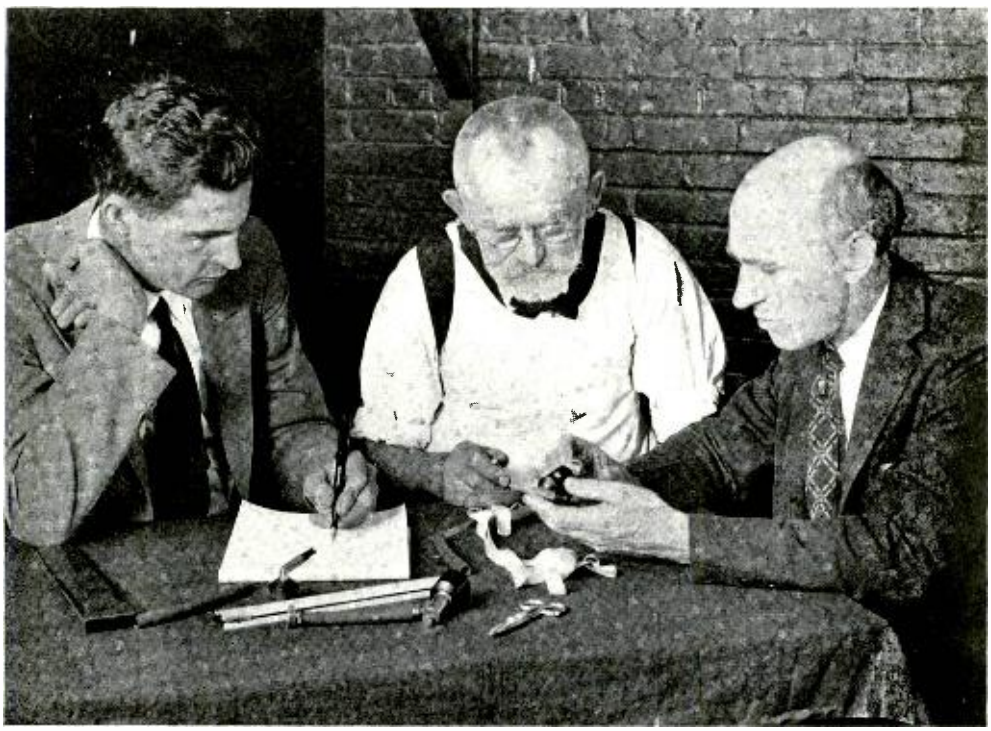
Special equipment for public address systems is in the regular course of Model Shop business. Some of the most typical, though less familiar achievements in this line were the special transmitter mountings, horns, and signalling equipment in the cars used by candidates Dawes and Davis in the last presidential campaign; the grouping panels in the New York Hippodrome, permitting for the first

time a successful use of transmitters in parallel, combined with individual volume control for each transmitter; the radio installation of Hudson View Gardens, where each of 360 apartments has access to any one of four different radio programs at any moment; the quick shift device for transferring from one transmitter to another which was installed in the United States House of Representatives and the St. Louis Municipal Theatre; and the first mobile public address system, installed in a truck.

The original models of the electric stethoscope were built in our own shop; so too were the audiometer and the audiphone, which measure deafness and aid the deaf to hear; and also the artificial larynx. The tiny moulded ear-pieces for the audiphones, which hold the inconspicuous small-type receiver in the ear, are still produced to order by the shop.

One of the most interesting and notable machines which has appeared from the Model Shop is the picture transmission set. The design of a 100-pitch lead screw of extreme accuracy, and of a special light valve of most delicate construction, presented difficulties which taxed even the Model Shop.

The pictures are reproduced in strips 0.01 inch wide. A beam of light of varying intensity moves across the film at the receiving end, duplicating the gradations of light and shadow in the original. Obviously the slightest overlapping or spreading will ruin a reproduction. Therefore the 0.01 inch strips must fall in their

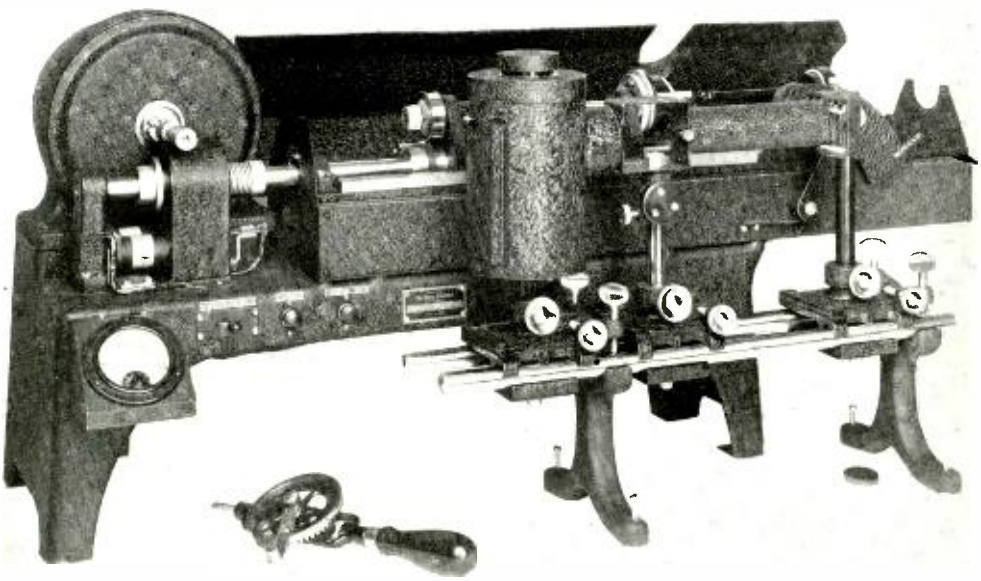


Otto Muller helps to preserve the Model Shop's reputation for co-operation
A conference with C. E Lane and G. R. Lum: on the manufacturing problems involved in the production of the artificial larynx

allotted place to the minutest degree of accuracy. Their edges must be knife-sharp in delineation. No ordinary screw thread can approach such exactness. So, too, with the light valve, which must operate with the utmost regularity, and produce the sharpest of images. Only the superb workmanship of experts can achieve such results as these.

While its radio sets send messages through the ether, and its picture transmission sets send photographs and signatures over land by wire, the Model Shop can point to its terminal equipment for the New York-Azores cable as proof that it does not discriminate against the sea. At each end of this remarkable permalloy-loaded cable is automatic equipment for recording the messages which almost tumble over each other in their rapidity of departure and arrival. Vacuum tube amplifiers, multiplex printing telegraph machines, and such equipment, make a sharp contrast to the old way of cable communication, where slow, faint telegraph impulses were barely caught and identified.

For communication by sea, by land, by air,—wherever something new and exactingly accurate is needed to transmit human speech and all related to it—the Model Shop is ready to build the apparatus which fills our need.



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An example of fine Model Shop work: The transmitter of the picture transmission set, with the remarkable lead screw visible in the left center

The Semi-Remote Control Power Board

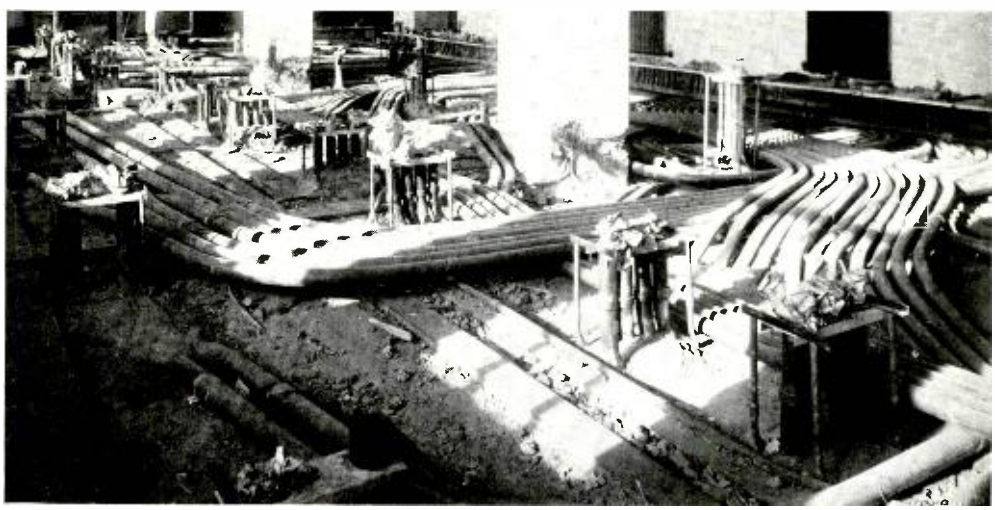
THOSE familiar with the construction of power rooms in telephone offices know that the smooth floor about the power machines and power board has concealed a world of trouble for engineers and builders alike.

Underneath that surface usually lies a network of crossing and interlacing conduits, supported, surrounded, and covered by a cinder fill. Because the layout of these conduits depended on facts not ascertainable when the building was erected, it has been understood that the power room floor was inevitably to be laid after all other construction around it had long since been finished.

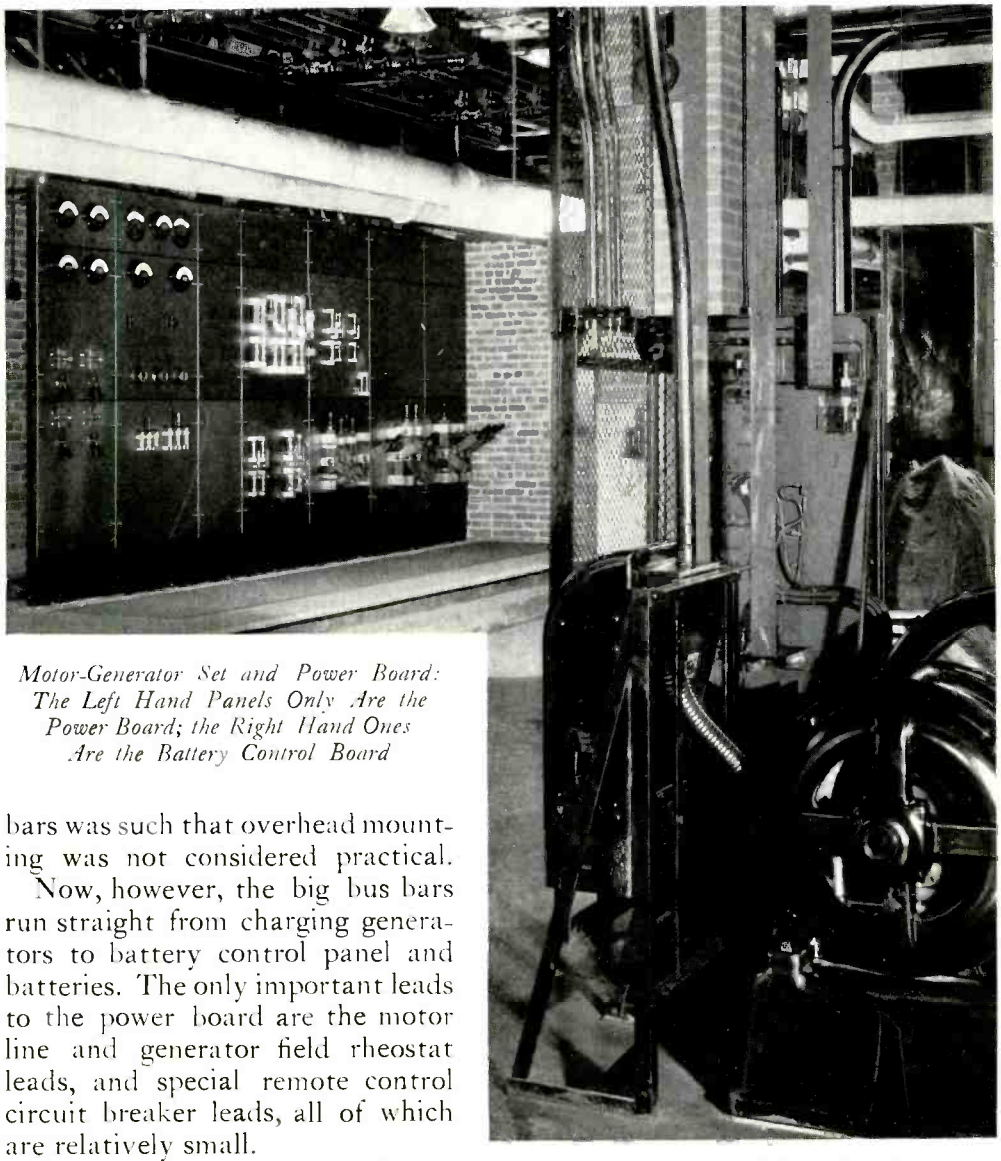
Not alone was the power room floor a troublesome addition at a later date, but because of that hard concrete surface all the conduits and ducts for the ultimate office capacity had to be put in before it was laid. This was necessary because the big charging generators were connected to the office batteries by heavy leads running to the power board and by bus bars or leads thence by way of the battery control panel. Every motor, every generator, had these heavy leads running through conduits in the floor fill.

Now all this annoyance has been eliminated. A semi-remote control power board, and a system of overhead bus bars and conduits, have been adopted as standard after successful trials at several offices. Strangely enough, it is the semi-remote control feature which has made the change possible.

So long as every lead had to come to the power board, a complex of big, clumsy bus bars had to be designed in minutest detail for the rear of the board. The multiplicity of the bus



A Typical Old Type Conduit Layout in a Cinder Floor Fill



Motor-Generator Set and Power Board: The Left Hand Panels Only Are the Power Board; the Right Hand Ones Are the Battery Control Board

bars was such that overhead mounting was not considered practical.

Now, however, the big bus bars run straight from charging generators to battery control panel and batteries. The only important leads to the power board are the motor line and generator field rheostat leads, and special remote control circuit breaker leads, all of which are relatively small.

Instead of elaborate bus bar and conduit systems which required detail engineering of a high grade, the new system is built up by the installer from standard parts furnished for all jobs. Bus bars now come in straight sections of stock lengths, in flat turns of 90° and 45°, in quarter twists, etc. By combining these parts, almost any combination can be obtained. The bus bars, being of simple, straightforward construction, can now be carried on commercial bus bar hangers; while the few conduits needed are also supported from the ceiling.

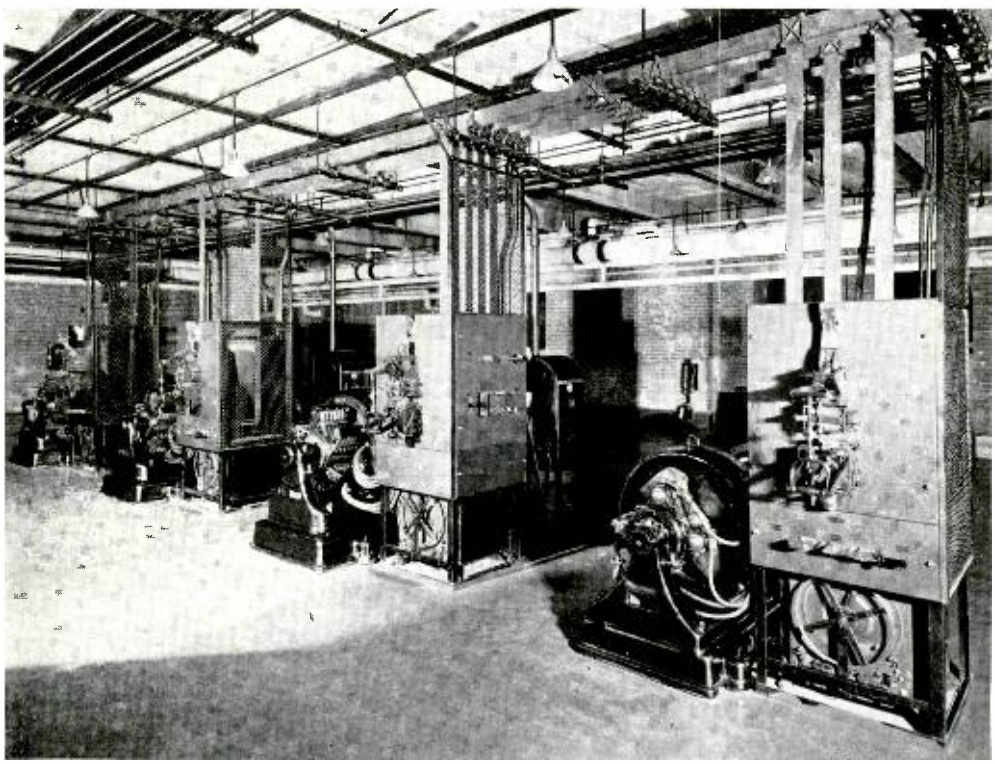
Aside from the resultant saving in building construction, bus bar design, and labor of installation, there is the further advantage that only such leads as are required at the time need be installed. Additions mean no more than the installation of a few hangers and the connecting up of the new bus bars. Thus there is an appreciable

saving in carrying charges, as compared with the old system.

Moreover, the new power board is compact to a degree impossible in the old arrangement. The motor starting compensator or starter and the generator control switches are now mounted on standardized panels located at the set itself. As a result, only the essential pieces of apparatus—remote control switches, motor and generator rheostats, and meters—are mounted on the power board. Three or four sections now do the work of a former line of board stretching the length of a room.

The special circuit breaker which makes all this possible consists essentially of contacts controlled by three coils and a solenoid, the whole being merely a big multiple relay. It combines the functions of safety device and switch. One winding is in series with the line, and serves to open the breaker automatically under an overload. Two shunt coils are arranged to give differential operation and to open the circuit in case of current reversal. A pair of coils (the solenoid), located in the circuit of a remote control push button switch, opens or closes the circuit breaker. The remote control switch may, of course, be placed at any convenient point, the standard location being at the power board.

Under the new system the power man starts the motor-generator set by means of the compensator or starter and connects the generator to the desired battery leads, these operations being performed at the set. He then goes to the power board, adjusts the



Charging Motor-Generator Sets, Showing Overhead Conduits and Charging Bus Bars: New Semi-Remote Control System

generator voltage to the proper value for charging the batteries, and operates the remote control switch to close the circuit from generator to batteries. Generator voltage is controlled by the generator field rheostat. Current and voltage for the generator can be read on the meters at the power board. Lamps indicate which generators are in use, and to which batteries they are connected. Best of all, the controls for all sets are within sight and within reach from the front of the board.

It is estimated that the new system will decrease the initial outlay for an average office, and result in appreciable savings in the annual charges for new offices. In case unforeseen changes in an office must be made, the saving will be very large, since it will no longer be necessary to tear up floors, rip out both wiring and conduit systems, and reconstruct the whole power room.

In the Eye of the Public

Visit of the A. I. E. E.

An inspection trip to 463 West Street has been part of the New York Convention of the A. I. E. E. for the last five years. Covering as it does so many phases of electrical science, the work of the Laboratories has something of interest to every member of the Institute; and there are always new developments to hold the interest of men who return year after year.

Some hundred and fifty members and guests were in the 1925 visiting party. They were divided into groups of about a dozen each and guided by engineers familiar with the work of the various laboratories. Starting at the museum the groups visited the exhibits of chemical work, telephone repeaters, the binaural effect, transmitter standards, transmitter life tests, high quality transmission, loud speakers, cathode ray oscillograph, evacuation of vacuum tubes, Piezo-electric effect, machine switching, remote control system, vacuum thermocouples, and materials testing.

President Jewett Receives Degrees

The honorary degree of Doctor of Science was conferred by both New York University and Dartmouth College on Frank B. Jewett, president of Bell Telephone Laboratories and vice-president of the American Telephone and Telegraph Company, during the 1925 Commencement ceremonies, in recognition of his services in the advancement of the science of electrical communication.

Bell Laboratories Exhibit At Industrial Motion Picture Exhibition

A one-reel film, "The Electrical Transmission of Speech," was presented by Bell Telephone Laboratories as a feature of the annual exhibition given by the Motion Picture Chamber of Commerce at Town Hall on April ninth. The showing of the film was preceded by a short talk by John Mills, Director of Publication, outlining the work of the Laboratories.

Mathematical Research

IN educational circles from time to time the question arises as to what must be taught to produce the engineer and scientist of the future. The answer is invariably "first, the fundamentals of mathematics, physics and chemistry"; and in our research organization each of these fundamentals has its place and its specialists in the different fields of physics and chemistry and mathematics. But the end of our research is not mathematical conclusions; it is physical and chemical concepts and data which enlarge the base of scientific knowledge from which useful applications may be made to our communication art. And mathematics is a tool for these physical and chemical investigations, rather than an end in itself. However, the modern problems of physics and chemistry are expressed and analyzed mathematically, and frequently for such work new mathematical relationships and processes must be originated.

Our Mathematical Research Department is therefore primarily a consulting organization, its chief function being to furnish expert advice regarding the mathematical phases of the investigations carried on in the laboratories. As part of the research organization, it is available to other branches of the company as well, and a considerable portion of its activities is devoted to the mathematical phases of development problems such as filter design, circuit theory, and the apportionment of apparatus in automatic telephone installations.

Mathematical researches are directed or carried out by Thornton C. Fry with the immediate assistance of Miss Clara Froelich, who received her training at Barnard; Miss Jessie Smith of St. Lawrence; and Miss Florence Metz, who came from Mt. Holyoke. Dr. Fry, who is a graduate of Findlay College, Ohio, came to the research department in 1916 from the University of Wisconsin, where for the previous four years he had been instructor in mathematics and where he received his Ph.D. His researches have appeared in some dozen papers in the technical journals on various subjects in mathematics, physics, and astronomy.

Although this mathematical department does not regularly supply computing service to other departments (that function usually being performed by special groups of calculators in the departments where their services are required), it is fully equipped with modern electrical calculating machines, so that it can efficiently handle complicated computations when they arise in connection with its regular activities.

Perhaps the most interesting of these machines is the Millionaire, which operates on a totally different mechanical principle from all other computing devices. The ordinary computing machine, in multiplying a number by three, actually *adds* the number three times. This requires three rotations of the counting mechanism. The Millionaire requires only one rotation, no matter what the multiplier may be. In other words, the ordinary calculating machine does not really multiply, but performs multiple addition; while, as Dr. Fry puts it, the

The Millionaire Calculating Machine in use by Miss Rose Araneo

Millionaire "knows the multiplication table, and saves itself a lot of work."

There are also two Mercedes calculating machines, which perform entirely automatic division, requiring only that the operator set up the divisor and dividend in the proper registers, but not requiring any further supervision. These machines are of the ordinary type, doing multiple addition in place of multiplication, and multiple subtraction instead of division. The principle by which they determine when they have reached a remainder less than the divisor, and should therefore discontinue the process of subtracting, is interesting. For this purpose, they divide one time too many, thus getting a *negative* result, which is detected by the fact that the machine attempts to "carry over" beyond the limits of the recording dials. Since they have exceeded the correct answer by something less than ten tenths of the divisor, they shift to the next decimal place and start to add these tenths in. At the first addition, the last figure shown in the answer (which was one too great) is reduced by 1, and a 9 appears in the next decimal place. Then appear, successively, 8, 7, 6, etc., until the machine again attempts to carry over beyond the limits of the counting mechanism. By this means a positive remainder is again obtained. The machine now reverses again; and it repeats this shifting back and forth until an eight-place answer is found.

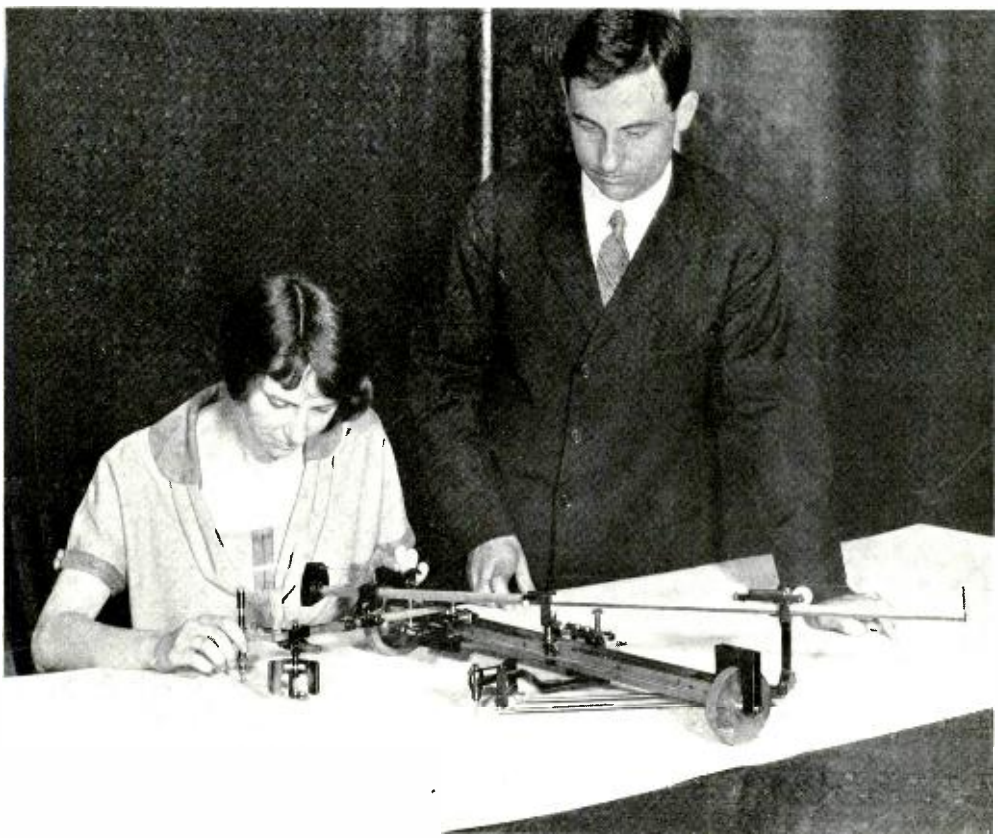
Both the Millionaire and the Mercedes machines will also function as adding machines, though they are less often put to such uses.

Another mechanical aid which is of a less familiar character is the Coradi Integraph. This device is so constructed that when a pointer is passed over the graph representing any mathematical function, a pen associated with the machine draws the graph of the integral of that function. If the pointer traced "y = sin x," for instance, the pen would draw the integral of sin x, which is cos x. Its operation makes use of the principle that the *slope* of the integral curve is proportional to the *ordinate* of the curve integrated. A bar is supported by two pivots, the horizontal distance between which never varies; one of these is carried by the tracing point, while the other remains on the axis of

abscissae. The slope of the bar is therefore always proportional to the ordinate upon which the tracing point rests. Hence, if a pen is mounted so as always to move parallel to the pointer, that pen will trace the integral curve. This is accomplished by having the pen carried by a wheel the axis of which is perpendicular to the rod. This wheel can roll freely, but is sharp at the edge so that it will not slip sideways. It therefore always travels parallel to the pivoted bar.

Examples which would give a clear idea of the product of the Mathematical Research Department are difficult to find, since most of its work is of a consulting character and deals with fragmentary phases of the subjects involved. Occasionally, however, the Department is actively concerned with an investigation from beginning to end. One such case was the study of binaural hearing; that is, the study of how we derive our sense of the direction and distance of the source from which a sound proceeds. According to a theory developed by Lord Rayleigh and extended by Messrs. Fry and R. V. L. Hartley, the source is fixed by noting the differences in intensity and phase of the sounds heard by the two ears.

To check this theory, it is desirable to perform experiments in which the intensity and phase at each ear is controlled



A Scientific Instrument in Action
Miss Jessie Smith operates the Coradi Integraph, while Dr. Fry watches the resulting integral curve appear

independently of the other ear. The position of the source from which the sound appears to come may then be compared with the position predicted by the theory, and the reliability of the predictions determined. But to do this the experimenter must know what the phase and intensity differences would be for actual sources in various positions. The determination of these is a labor of some magnitude, and was part of the work which Dr. Fry's department did on this subject.

Moreover, there are many combinations of phase and intensity which could not arise from any source whatever; yet when these are applied to the ears in the laboratory, the sound often appears to come from a definite place. This also requires explanation. It was especially in the field of "impossible stimuli" and in that of complex tones, that the work of Messrs. Fry and Hartley lay. An equation was developed which made it possible to investigate the conditions existing at each ear at any instant when a complex tone was sounded.

The Prime Incentive

Furnishing ever better and more comprehensive telephone service is the prime incentive to our every-day work. More truly, I think, than people outside realize or would credit, we are actuated by the same spirit of enthusiasm in discovering better methods, in rendering a service which will give public satisfaction, and in doing a job well, which animates those working in colleges or scientific institutions. . . .

It is our ambition to go on improving the telephone service. It is our ambition to go on lessening the cost of telephone service. It is our ambition to have the respect and confidence of the public and of all the different members and sections of the public. We carry on scientific research on a scale that is probably not equaled by any organization in the country, or in the world. We take as much joy out of discovering new methods and being able to lessen the cost of telephone service as we would in being able to earn a little more money than our competitor, if we were running the ordinary type of competitive business.

We are, in fact, a large, democratic American institution, owned by 340,000 men and women, with 340,000 employees, and $2,500,000,000 of property, all directed toward better and cheaper telephone service for the people of the United States.

—Walter S. Gifford

On The Basis Of Experience

An article recording the Bell System experience and present relationships of the Directors of the Laboratories

THE words "experience" and "experiment" are closely related. An experiment is merely an experience under some artificial conditions which have been arranged and controlled in order to determine what are the relationships of the various factors. Experience, on the other hand, implies a reality—the conditions are not so readily controlled; they represent life as it is.

It is the function of the Laboratories to make experimental investigations and from these to derive correct conclusions as to the relations of the various physical factors. And it is the function of the Directors of the Laboratories, with broad oversight and with proper financial control, to give executive approval to expenditures of time and money along lines of investigation which will be of proper commercial value to the Bell System in its task of rendering a universal communication service. Adequately to direct to such an end the general activities of a group of thirty-six hundred people and an expenditure of several millions of dollars a year, requires that the directors themselves shall have had experience in experiment and in the application of experimentally derived conclusions to commercial ventures. Since the experiments of our Laboratories either are undertaken for a specific development in communication or are broadly basic to future developments, there is required, in addition, for adequate direction a wide experience in the communication art and an up-to-date knowledge of the problems and needs of the companies which the Laboratories are to serve.

A few notes as to the Bell System careers of the individual members of the Board of Directors will show a broad basis of experience and company relationships. Owned, as they are, jointly by the American Telephone and Telegraph Company and the Western Electric Company, the Laboratories are directed by John J. Carty, Bancroft Gherardi, and Frank B. Jewett of the American Telephone and Telegraph Company; Charles G. DuBois, James L. Kilpatrick, and Jay B. Odell of the Western Electric Company; and Edward B. Craft, Executive Vice-President of the Laboratories.

To John J. Carty is due in a large measure the present day research attitude of the Bell System. Starting himself as an experimenter, and rapidly gaining a reputation as an organizer of scientific work and a selector and developer of men, it was General Carty who first directed the combined research of the Bell System. After early experiences in which he had been Chief Engineer of the New York and New Jersey Telephone Companies he became, shortly after the headquarters and staff organizations were established in New York in 1907, Chief Engineer of the American Telephone

and Telegraph Company. His Engineer of Plant, under whose immediate direction came the departments concerned with transmission and communication apparatus, was Bancroft Gherardi. And under Mr. Gherardi, as head of the group concerned with transmission, was Frank Baldwin Jewett, one of the first Ph.D's in Physics to be attracted by the possibilities of industrial research.

This was the organization when those advances were made which today we think of as early, such as the application of coil loading to phantom lines and the extension of long distance service from New York to Denver. This was the organization, also, which was responsible for the researches on cable which led to the installation of loaded duplex cable over the route from Boston to Washington.

By April, 1911, a laboratory research group had been formed in the Engineering Department of the Western Electric Company to bring the most recent point of view of electronic physics to bear on the solution for the American Telephone and Telegraph Company of the problem of the development of telephone repeaters and of similar problems. By the combination of the work of these research laboratories with investigations in the field and with corresponding developments, such as that of the air-gap loading coil, in other laboratories of the Engineering Department, there was brought about under the organization and stimulating oversight of Mr. Carty the then wonderful achievement of a transcontinental telephone line.

Prior to the completion of the research and development work necessary for the transcontinental line Mr. Jewett had been transferred to the Western Electric Company, where, as Assistant Chief Engineer, he assumed the general direction of the research laboratories which were under the immediate charge of E. H. Colpitts. In the subsequent rapid advances which led to the trans-atlantic radio demonstration, carrier-current systems, machine switching, and the like, there were many individual suggestions and contributions, which were made by every department of the System from the Long Lines of the American Telephone and Telegraph Company to the Manufacturing Department of the Western Electric Company at Hawthorne; but throughout them all one sees the guiding hand of General Carty leading the research activities, with Mr. Gherardi directing the work in the field and Mr. Jewett the work in the laboratories.

Between a research accomplishment and its ultimate commercial utilization lie all the problems of apparatus development, combination into complete systems, selection of standards for apparatus or systems, and economical manufacture. The development of suitable apparatus and its combination into suitable systems was the task of the Apparatus Development and Systems Development Branches of the Engineering Department of the Western Electric Company. Among Mr. Gherardi's duties as Engineer of Plant for the American Telephone and Telegraph Company and later as Vice-President in charge of the Department of Operation and Engineering, were the proper selection from the means made available by research and development activities, and the adoption and maintenance of standards for operation. To the Manufacturing Department of the Western Electric Company fell the problem of the development of the method of manufacture and the economical production in any desired amount of such

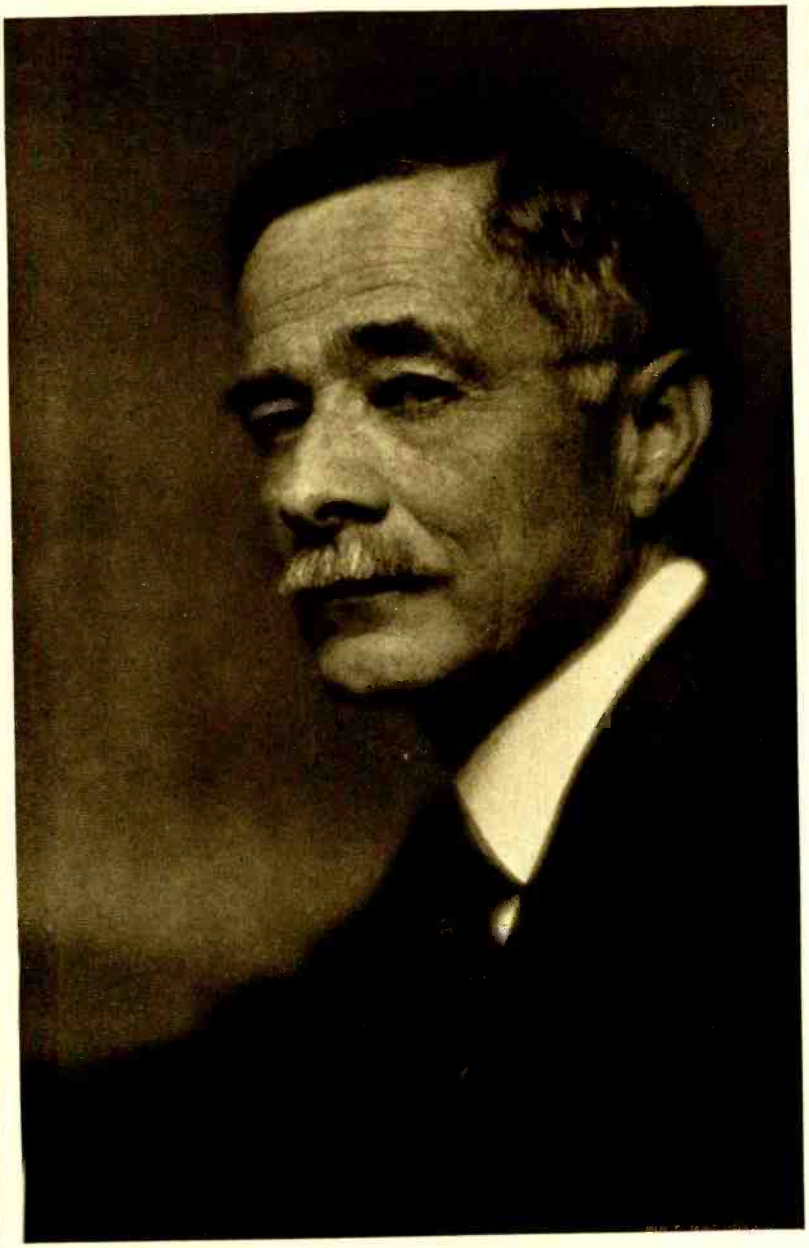
DIRECTORS

of

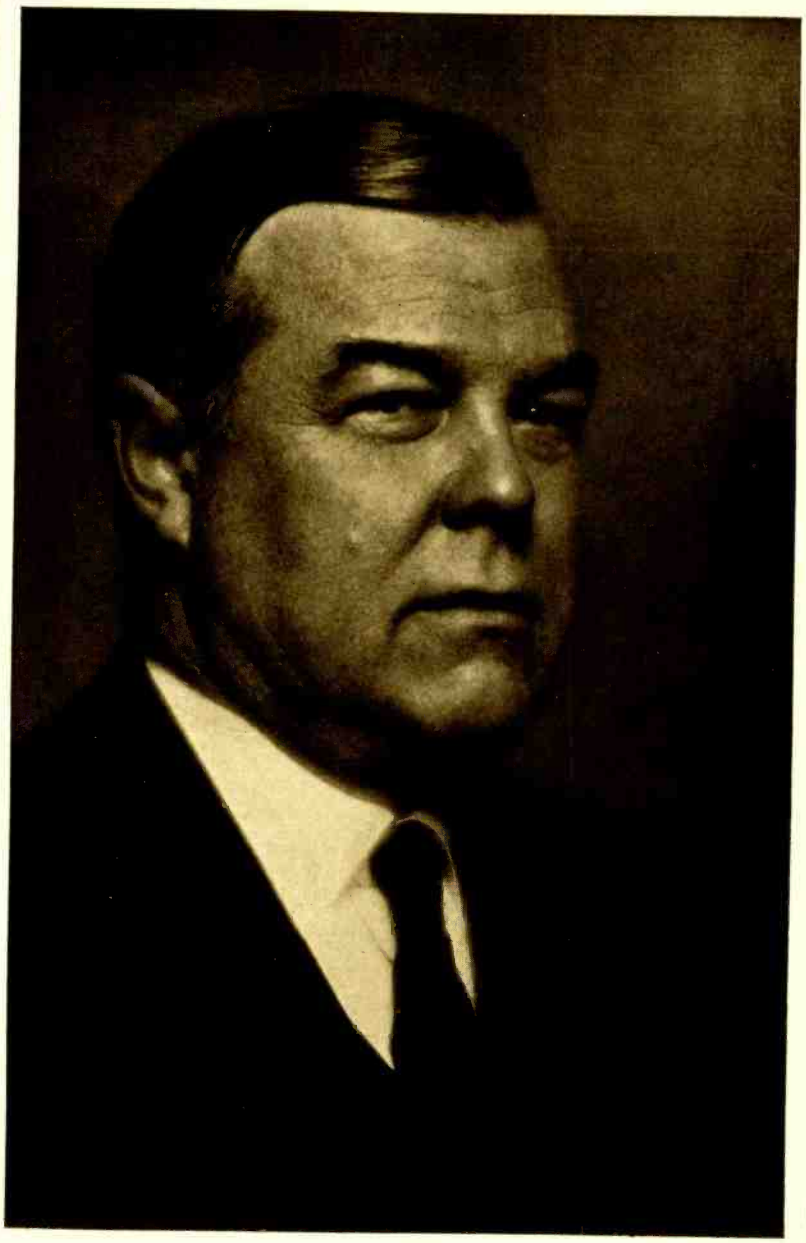
BELL

TELEPHONE

LABORATORIES



JOHN J. CARTY
Vice-President, American Telephone and Telegraph Company
Chairman of the Board of Directors, Bell Telephone Laboratories, Incorporated



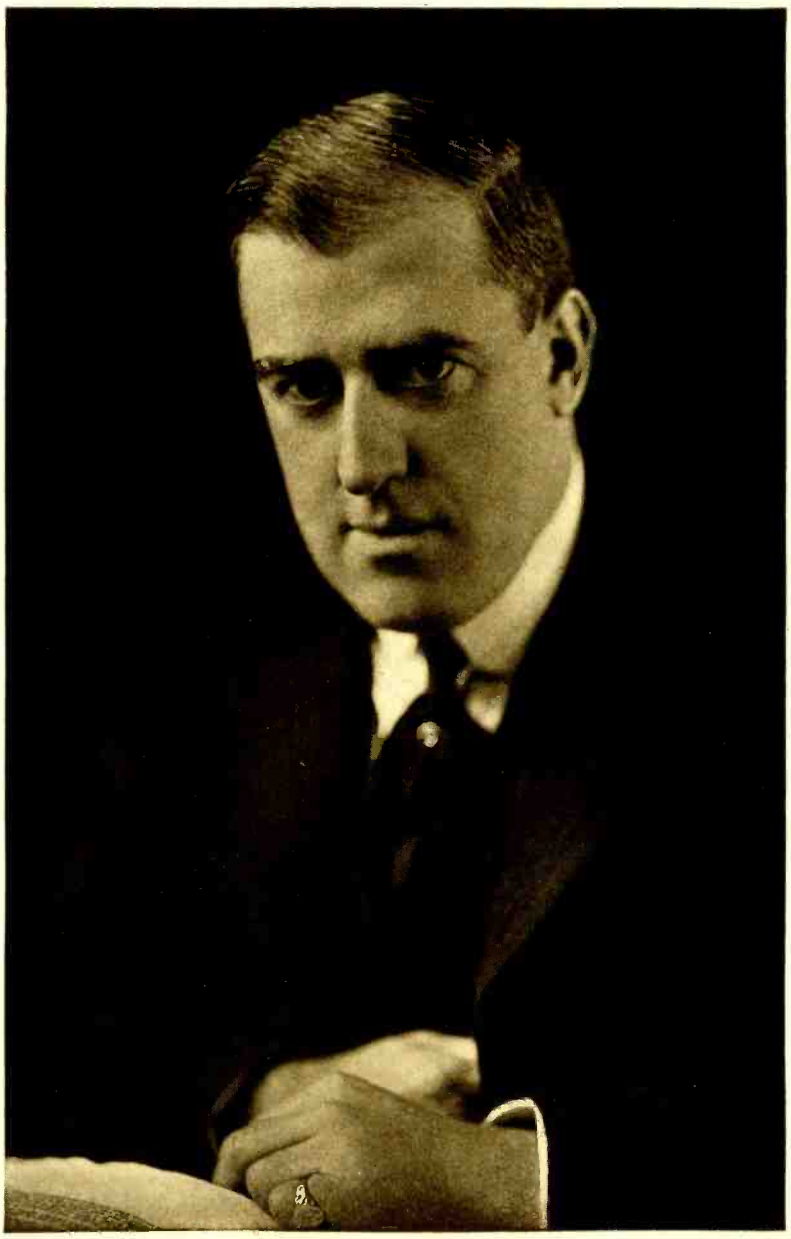
CHARLES G. DUBOIS
President, Western Electric Company, Incorporated

BANCROFT GHERARDI

Vice-President, American Telephone and Telegraph Company

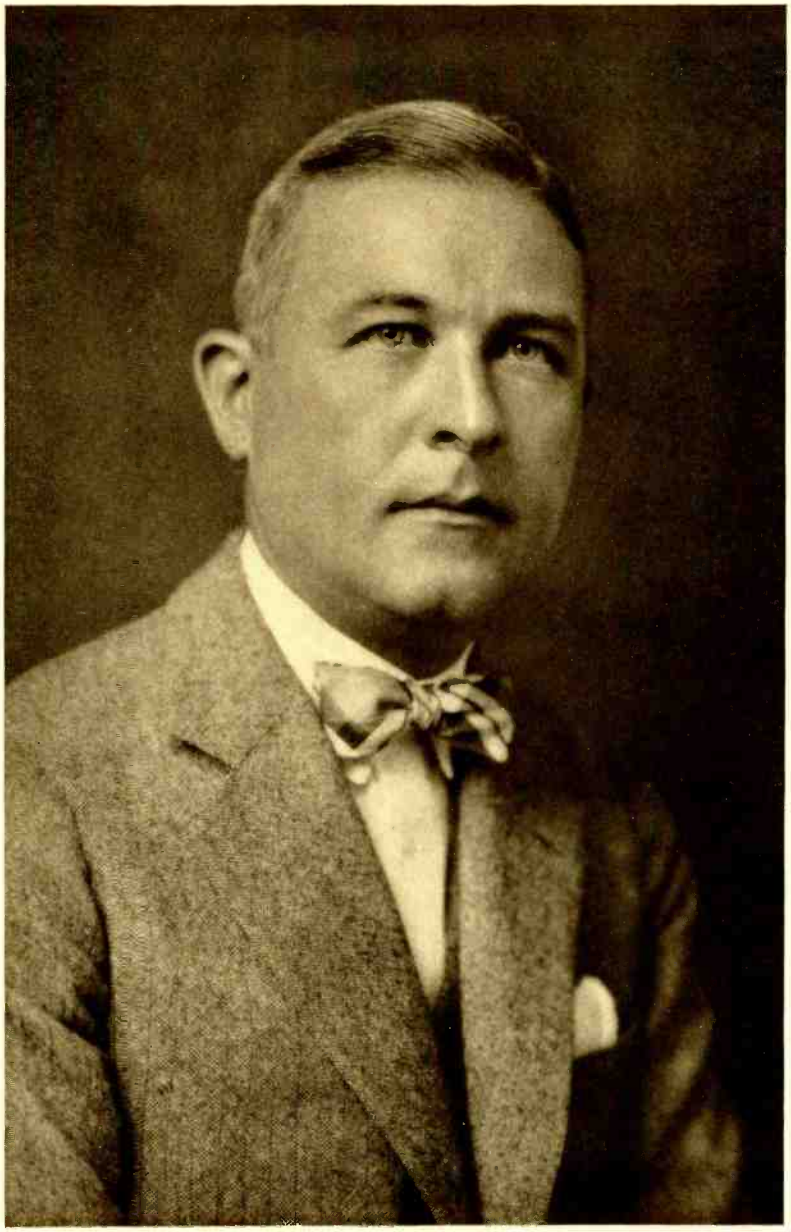
FRANK B. JEWETT

Vice-President, American Telephone and Telegraph Company
President, Bell Telephone Laboratories, Incorporated



JAMES L. KILPATRICK
Vice-President, Western Electric Company, Incorporated

JAY B. ODELL
Assistant to the President, Western Electric Company, Incorporated



EDWARD B. CRAFT

Executive Vice-President, Bell Telephone Laboratories, Incorporated

newly developed apparatus as had been approved and standardized for telephone use.

As the manufacturer of telephone equipment the Western Electric Company had also numerous problems requiring laboratory research and development studies. These it presented to its Engineering Department, which performed such services for it in addition to operating the Research Laboratories for the Bell System. All those services, which its Engineering Department performed for it, are today performed for the Western Electric Company by Bell Telephone Laboratories.

By the presence upon its Board of Charles G. DuBois, President, James L. Kilpatrick, Vice-President, and Jay B. Odell, Assistant to President, of the Western Electric Company, the Laboratories brings to bear upon the control of its problems the experience which these directors have derived through Western Electric service and their knowledge of the problems of manufacture, distribution, and installation of supplies and equipment. In Charles G. DuBois the board has a representative familiar not only with manufacturing problems but particularly with those of finance and business. Mr. DuBois' experience not only includes several years as supervisor of the Branch Houses of the Western Electric Company but ten years, prior to the War, as comptroller of the American Telephone and Telegraph Company. It was during the War that he brought his financial ability to the American Red Cross, which he served as comptroller. Through James L. Kilpatrick, who is in charge of the telephone operations of the Western Electric Company, the Laboratories have the advantage of the point of view of manufacture, installation, and telephone sales, and also the experience of a former operating telephone man. With the products of the development and design engineers, as manufactured and installed by the Western Electric Company, Mr. Kilpatrick has for years had familiarity and experience as Superintendent of Plant of the Bell Telephone Company of Pennsylvania. More recently he has been superintendent in charge of the Installation Department of the Western Electric Company and concerned with its enormous program of central-office extension and machine-switching installation. In this work he brought to bear his operating company experience while acquiring a Western Electric point of view. Through Jay B. Odell the Laboratories derive the advantage of business experience in the sale to operating telephone companies of the apparatus for the design of which the Laboratories are responsible. For years Mr. Odell was in charge of the New York House of the Telephone Sales Department, and there he was responsible for the distribution within the territory of the New York Telephone Company of millions of dollars' worth of equipment each year. Mr. Odell's present position as assistant to President DuBois assures to the Laboratories an added and intimate contact with the Western Electric Company.

In Edward Beech Craft, Executive Vice-President, the Laboratories have a representative who has had unique experience as a designer and developer of communication apparatus and a wide experience in the direction of such development. In 1902 he started his telephone career with the Western Electric Company at Chicago in the field of apparatus development. In 1907, when the various laboratories of the Bell System were consolidated

into a laboratory operated in New York by the Western's Engineering Department, Mr. Craft was transferred to this newly organized department. During the five years at Chicago he had individually made a number of interesting developments and for the greater part of the time had also been in charge of the group engaged in apparatus design. Of his early inventions perhaps the basic design of the flat type relay has been the most far reaching. Another illustration, an ingeniously simple device which has given service for twenty years, is the No. 35 type fuse. Starting in 1907 in charge of the apparatus development work of the Western's Engineering Department, Mr. Craft was successively Assistant Chief Engineer in charge of all development activities, and Chief Engineer.

The first of our Directors to enter the telephone industry was General Carty, who started his career in 1879, entering the Telephone Dispatch Company of Boston three years after Dr. Bell's invention opened that field of opportunity which each succeeding invention has only served to enlarge. In 1891 Mr. DuBois entered the New York office of the Western Electric Company as a clerk, becoming Chief Clerk five years later. Mr. Gherardi started in 1895 as engineering assistant in the New York Company and four years later became its Traffic Engineer. The same year Mr. Kilpatrick entered the Switchboard Installation Department of the Pennsylvania Company where he shortly became test operator, and a year later special inspector in charge of station inspection. Mr. Craft, in 1902, was attracted from a superintendency in an Ohio manufacturing company by Western Electric opportunities for inventive genius, and over seventy patents tell part of the story of his acceptance of that opportunity. In 1904 in the same company, but at West Street, Mr. Odell started with a year's work in warehouse and shops before entering upon a clerical position. In the same year Dr. Jewett started with the parent company in Boston as Transmission Engineer.

Such, in brief, have been their Bell System experiences. Varied and individual as they are—and in these variations is the necessary element of breadth—there are at least four common elements. First to be recognized, but not necessarily first in importance, is the fact that each has made individual contributions to the progress of the communication art and its corporate advance. Each has been at some time a specialist of recognized standing in his particular field of activity. The second obvious similarity is the ability to lay out and direct large-scale operations, involving plans and activities over a long period of time. Third, and related to the second but not inherently so, is the ability to develop human material. Throughout the Bell System are to be found men who look to one or another of these seven directors as the man to whom they owe an external stimulus and guidance which was basic to their own careers. It has been this ability and interest in the making of men which has won for each of the directors a widespread personal loyalty that exists throughout all the various Bell System units. And last to be mentioned, but probably first in importance, is the attitude which they brought to their work—a consciousness of the life mission of the Bell Telephone System as an exponent of human service through a universal system of communication.

Our Far-Flung Outposts

ALTHOUGH Bell Telephone Laboratories is a compactly organized company, its activities are not confined to the West Street building. Its outposts cover practically all of the United States, and through its contact with the International Western Electric Company occasionally reach to foreign lands.

Our outposts are of two classes—fixed and mobile. In the former may be grouped our several radio stations in New Jersey, our resident inspectors at various factories, and a group at Hawthorne engaged in development studies of lead covered cable. In the mobile patrols are included travelling inspectors, specialists who are away for long or short trips on special installation or similar projects, engineers who go abroad on special missions, and engineers who co-operate with the International Company.

Our radio activities in New Jersey are the nearest outposts. We have three radio stations located respectively at Cliffwood, near the town of Matawan, and at Deal Beach and Elberon, both near Asbury Park.

The station at Cliffwood, situated on a forty-acre plot which is the property of the Company, is a receiving station. A resident staff of six engineers is there engaged in experimental and research work in field measurements, ship-to-shore transmission, directional sending, and methods of reducing the effect of static. This staff consists of Carl R. Englund, Harold T. Friis, Harold C. Baumann, Edmond Bruce, Apel G. Jensen, and Horace E. Overacker, engineering; Adolph Sultzman, mechanic; and Earle M. Hagaman, carpenter.

Deal Beach is a transmitting station. It is also on land owned by the Company and it is one of the pioneer stations in broadcasting work. It is one of the first stations in the world to broadcast a musical program for entertainment. A staff of eight engineers is on duty conducting experimental work in antenna systems, shore-to-ship transmission, directional sending, and other important work. The Deal Beach staff consists of C. R. Burrows, George M. Eberhard, Enoch B. Ferrell, John C. Gabriel, Gerald McTernan, Charles F. P. Rose, Ernest J. Sterba, Albert F. Toth, engineering; John L. Smith, mechanic; and Mr. and Mrs. Sherman, caretakers.

Our largest outpost is the lead-covered cable development group at Hawthorne, a unit of about twenty-five men under the leadership of L. S. Ford. This group is concerned with the manufacture and testing of lead-covered cable, including submarine cables.

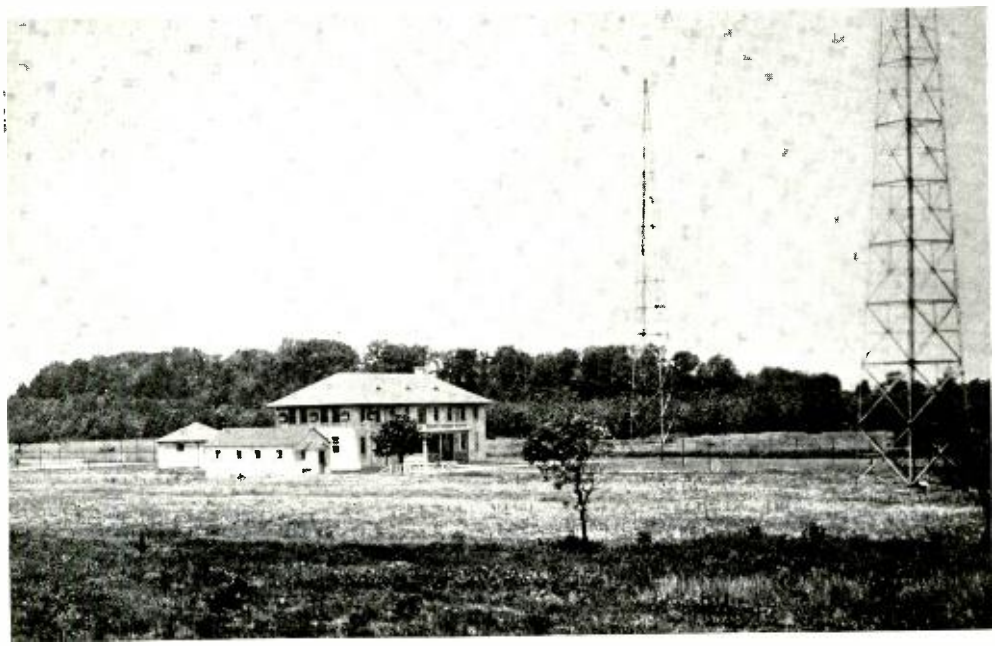
The other permanent outposts and many of the mobile ones are from our Inspection Department. Those high standards for which the Western Electric Company has been noted from its early beginning are maintained scrupulously by a rigid inspection of all the products that the Company distributes, those manufactured by other firms as well as those manufactured at Hawthorne and Kearny.

R. L. Jones as the head of the Inspection Department has organized two divisions for his department: an In-

spection Engineering Department and an Inspection Operations Department. The former performs various functions and forms a connecting link between our Company and the Western Electric distributing houses, and also with the operating Telephone Companies. Its field representatives throughout the United States keep the Laboratories informed of how its designs are performing in service. The West Street personnel co-operates closely with the Systems and Apparatus Development Departments by a sympathetic criticism of designs based on inspection results and on field reports. Its experts are available at all times for co-operation with outside manufacturers in the production of apparatus of the required standards.

The duties of Inspection Operations relate principally to the detailed inspection of materials and apparatus purchased for the operating telephone companies but not manufactured by the Company. All such materials are manufactured in accordance with specifications furnished by the Company, and it is the duty of Inspection Operations to determine if all the products meet these specifications in every respect. In order to perform this duty satisfactorily the United States is divided into seven districts with a group of representatives in each. Also there are resident inspectors at factories where equipment is purchased regularly in such quantities as to justify the continual presence of one or more representatives. These forces are reinforced by a number of travelling representatives who visit the district houses and shops at frequent intervals. Complaints relating to the quality of materials furnished to operating companies are investigated by the Operations Department and the responsibility fixed. In cases in which there are defects in manufacture it negotiates the proper adjustment with the manufacturer.

Thus the work of the Inspection



This Attractive Building Houses the Laboratories and the Staff at Deal Beach

Department places its outposts in both the fixed and travelling divisions.

The work of inspection is of a permanent nature while the work of the other departments at distant places may be irregular. Still there is rarely a period during which there are not several engineers away on very important work. These jobs may range from a day or so in a nearby city to a year or more in a foreign country. During the current year there have been many such instances.

Jacob S. Jammer of the Systems Development Department has been in Australia since early in January in connection with the testing of a type "B" carrier telephone system on the circuit between Melbourne and Sydney.

Several engineers have been to the west coast on various missions. William C. Redding was in Los Angeles on cable work. Joseph Juley and Marby D. Kennedy have been in Seattle for long periods in connection with trial installations of toll-dialing circuits; and Rezin B. Steele was in San Francisco for several months working in co-operation with engineers of the American Telephone and Telegraph Company on the Inauguration Day demonstration of the telephone transmission of pictures.

Ermin P. Bancroft and John C. Burkholder, Jr., at Chicago and Washington respectively, also co-operated with the American Telephone and Telegraph Company engineers in that demonstration of country-wide transmission of pictures.

The cities of the middle west are well-known to our engineers. Practically at all times there are several engineers at Hawthorne for various jobs of long and short duration. Leslie R. Porter and R. G. Koontz spent some time in Lansing, Michigan, on the installation of a No. 3 toll switchboard.

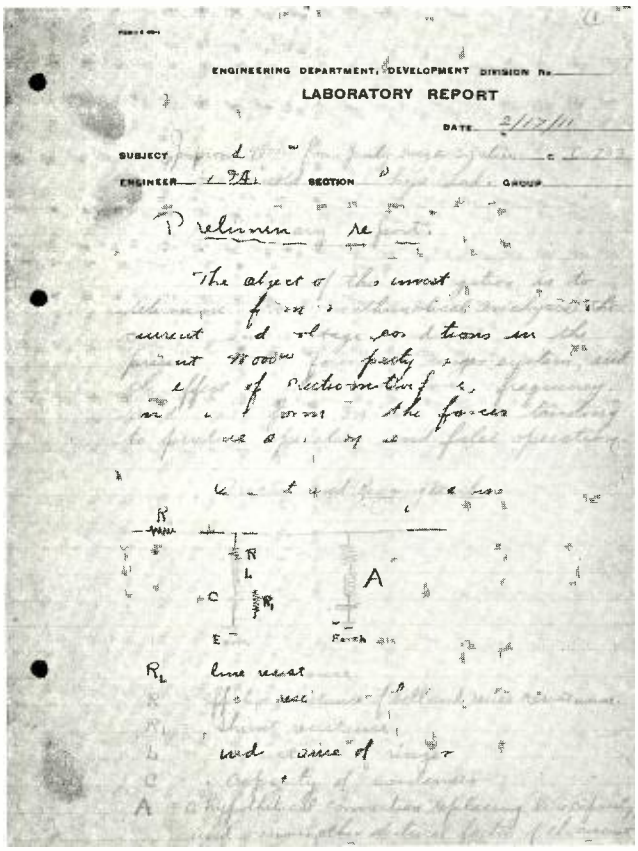
The list could be extended indefinitely. Our engineers co-operate closely with the Western Electric branch houses and its Installation Department, with the engineers of the American Telephone and Telegraph Company; and the operating telephone companies, and on occasion the services of one or more engineers have been required in practically every city of the United States. Thus, while each trip is of comparatively short duration, there are always a number of engineers away on special jobs, and we have constant contact with the Bell System operating forces in the field.

Because of our close co-operation with the International Western Electric Company, particularly by the work of the cable development group, the services of our engineers are furnished frequently for its work in various foreign countries.

His First Job

In successive issues of the Record there will be described the first work assignments in the Laboratories, or in the Bell System in general, of some of the men who are responsible for the present direction of our investigations and developments.

H. D. Arnold's first job in the Laboratories was really three different problems, but the first on which he reported was a mathematical investigation of four-party selective ringing, where he set up a differential equation for the current through the circuit and calculated its value at successive instants of time. Upon such a ringer circuit is impressed alternate half-waves of an alternating electro-motive force; and so the solution cannot be obtained by the ordinary alternating current method where both halves of the wave are successively applied. His analysis is also interesting because of his adoption of a "hypothetical connection replacing line capacity and various other electrical factors of the circuit," that is, his introduction of a lumped artificial line to simulate the actual line for the frequencies with which his investigation was concerned.


ENGINEERING DEPARTMENT, DEVELOPMENT DIVISION No.

LABORATORY REPORT

DATE 2/17/11

SUBJECT

ENGINEER L. A. SECTION GROUP

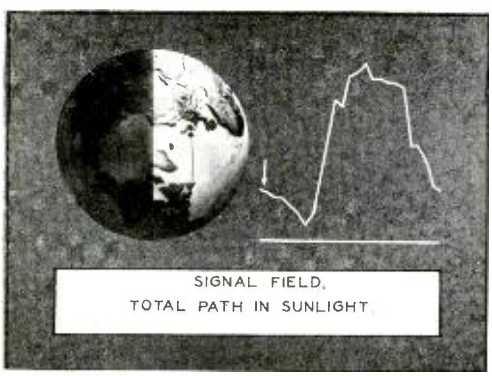
The first page of this first report of our Director of Research is shown in the accompanying illustration. The whole report is an interesting example of the scientific method.

[Dr. Arnold graduated from Wesleyan University in 1906 and obtained his M. S. degree at the same institution a year later. Then as Fellow in Physics at the University of Chicago he worked under Dr. R. A. Millikan, and received his Ph. D. degree in 1909. After a year of teaching physics he entered the Engineering Department of the Western Electric Company as a research physicist.]

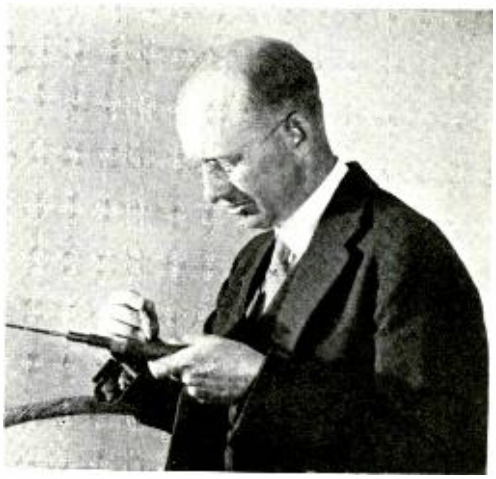
Bell System Researches As Recorded In Articles Published Since January 1, 1925

Oliver E. Buckley discussed the development of permalloy-loaded cable in the July issue of the *Bell System Technical Journal*. Principal problems encountered were first the calculation of signal transmission over cable; second, practical problems of design, manufacture and installation. Among the latter were protection of the copper conductor from damage by the heat treatment necessary for the permalloy, and protection of the strain-sensitive permalloy tape from damage by the pressure on it at great depth. Third, new terminal apparatus and operating methods suitable for much higher signal speeds had to be worked out. Success of these developments appears in the speed of 1900 letters per minute one way, compared with 250 letters in each direction with the older type of cables. The substance of this paper was presented by Dr. Buckley before the A. I. E. E. at Saratoga Springs in June.

In the same issue of the *Journal* is



An illustration from the Espenschied-Anderson-Bailey paper



Dr. Buckley shows the structure of permalloy-loaded cable

a report by Lloyd Espenschied, Clifford N. Anderson and Austin Bailey* on measurements of transmission and noise for transatlantic radio telephony. Solar radiation is shown to be the cause of daily and seasonal variations in signal strength. A pronounced dip occurs at sunset and sunrise. Definite correlation exists between abnormal radio transmission, and disturbances in the earth's magnetic field. A tropical origin is indicated for long-wave static. Static noise is lower at higher frequencies. Directional receiving antennas of the "wave" type show an average improvement over loop antennas of about five to one in signal-to-static ratio.

Of particular interest is the authors' ability to make their lucidly written article attractive to the eye by the development of diagrammatic photo-

*All of the American Telephone and Telegraph Company.

graphs. Reproduced here is one of a series showing how the signal strength varies as the earth's rotation carries the transmission path into and out of the daylight zone.

POWER LINE APPLICATIONS OF TELEPHONE AND TELEGRAPH APPARATUS—A system of remote supervision and control of power sub-stations is described by Joseph C. Field. The use of carrier currents to telephone over power lines, permitting a close supervision over extensive power systems from a central point, is covered by Nugent H. Slaughter and Wallace V. Wolfe.

TELEPHONE TRANSMISSION—A paper by Leon J. Sivian discusses the function and design of a physical reference system for telephone transmission, and the requirements that it should meet.

PHOTOMICROGRAPHY—A description of the micro-structure of austenite and martensite—crystalline structures of steel at different stages of its treatment—with splendid illustrations, is given in a paper by Francis F. Lucas.

ELECTRONIC PHYSICS—Various phases of this subject are treated by Herbert E. Ives and Alfred L. Johnsrud in "Normal and Selective Photoelectric Effects in Alkali Metals and Alloys"; by Clinton Davisson and Lester H. Germer in "Thermionic Work Function of Oxide-Coated Platinum"; by Herbert E. Ives in "Photoelectric Effect of Thin Films of Alkali Metals"; and by Thornton C. Fry in "The Theory of the Schroteffekt."

WAVE FILTERS—Kenneth S. Johnson and Timothy E. Shea discuss the general principles of wave filter design and the theory of wave filters using mutual inductance.

PICTURE TRANSMISSION—Herbert E. Ives, Joseph W. Horton, Ralzemond D. Parker,* and Alva B. Clark* are joint authors of a paper which marks an epoch in the development of Bell System service. It treats in a comprehensive and readable manner the general scheme of picture transmission, the adaptation of the scheme to telephone line transmission, synchronization of the sending and receiving elements, the apparatus and circuits involved, and the characteristics of the received pictures.

RADIO—Harold W. Nichols' and John C. Schelleng's "Propagation of Electric Waves Over the Earth" is an important contribution to present-day theories of the effect of the earth's magnetic field on electric waves travelling through the atmosphere. They develop the mathematical theory of the phenomena encountered, and give formulas for various effects to be expected.

Short wave transmission and transoceanic radio telephony are discussed in papers by Sidney E. Anderson, Lewis M. Clement, and Gustave C. DeCoutouly; Arthur A. Oswald and John C. Schelleng; and Raymond A. Heising.

H. T. Friis recently presented his able and original paper on a "New Directional Receiving System," before the Institute of Radio Engineers. The possibilities of the use of the Friis two-loop system in the reduction of the effects of static has created considerable interest in radio circles and has been described in several radio magazines.

APPARATUS—Telegraph apparatus in particular, is the subject of papers by Jacob R. Fry and Leland A. Gardner*; John A. Bell, Roy B. Schanck,* and David E. Branson*; Baxter P. Hamilton,* Harry Nyquist,* Maurice B. Long, and Walter A. Phelps.

MATERIALS-TESTING—An excellent discussion of the methods developed

*Of the American Telephone and Telegraph Company.

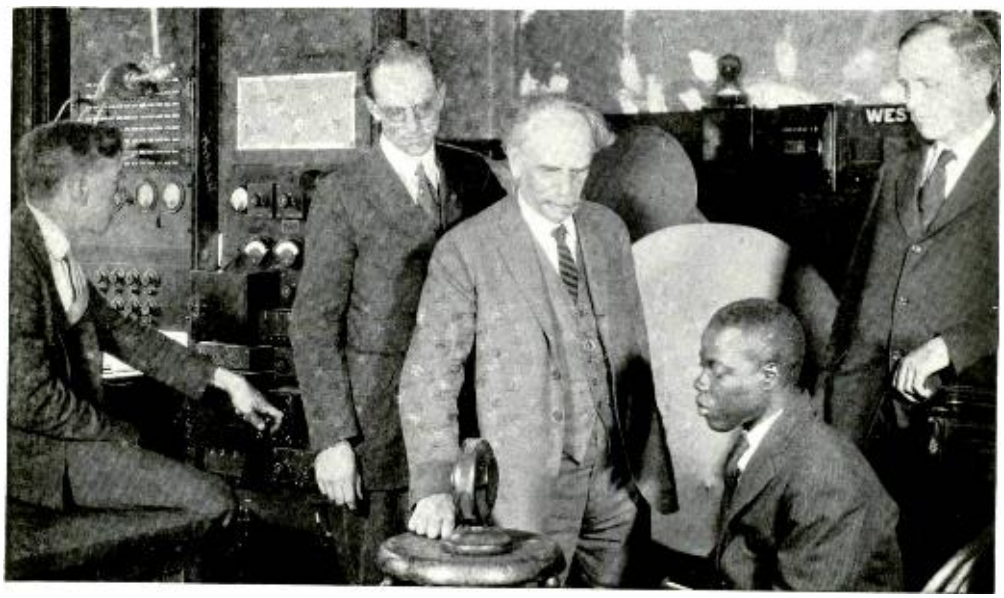
by our Laboratories for testing the very thin strips of metal used in telephone apparatus is contained in Harvey A. Anderson's "Tension Tests of Thin Gage Metals and Alloys."

CONTEMPORARY ADVANCES IN PHYSICS—"Electricity in Solids," "Electricity in Gases," and "Waves and Quanta" are the fifth, sixth and seventh papers of a series by Dr. Karl K. Darrow appearing in the *Bell System Technical Journal*. Of the last named paper, one scientific editor said, "It is by far the best presentation of the subject that I have ever seen."

Lack of space has prevented giving more than a bare list of the articles published by our engineers since January first. In the future, however, somewhat fuller reviews of technical papers published during the preceding month will appear in each issue.

AFRICAN SPEECH ELECTRICALLY RECORDED

THE Laboratories have been privileged recently to co-operate with Professor Franz Boaz of Columbia University in his studies of African speech. In June, Dr. Boaz brought to the Laboratories Mr. M. E. Ansah, a member of the Akwamu tribe, who is a student at Columbia. Using a new type of harmonic analyzer developed by Raymond L. Wegel, Dr. Boaz then made a number of observations of energy distribution in Mr. Ansah's native speech. Electrically-cut phonograph records were also made, first of isolated words and then of connected speech. Dr. Boaz will use these records, with translations of their words, in studying the language and comparing it with others.



A. C. Millard, J. P. Maxfield, Dr. Boaz, Mr. Ansah, H. C. Harrison

DURING the past six or seven years there have been carried out in our Laboratories, on a fairly large scale, four educational experiments; and now a fifth is being planned. Of the four original experiments the results have so far been favorable and all of them are being continued.

One experiment was the introduction in 1918 of a program of employment and training known originally as the "Technical Assistant Course" but more recently as the "Student Assistant Course." Each year in June or February the Personnel Department, which conducts this course, selects from graduates of neighboring high schools a number of promising young men who could make a success in the course of study of a four year engineering school, but are at the time unable to attend college. The successful applicants are employed under a plan of work and class-room training which will help them to compete on a more equal footing with college men of their own age. A part of their working time is spent in class-room instruction in mathematics, physics, electrical engineering subjects, and in the theory of their application to communication engineering. The remainder of the usual number of working hours is spent on productive work in our engineering drafting-rooms and in various laboratories, on jobs of increasing difficulty as the individual progress of each student warrants.

This course of training involves three years of class work. To be eligible for the successive yearly units of instruction in the course each Student Assistant must not only have made satisfactory progress on the job, but must be in sufficient health to warrant outside study and must have satisfactorily completed the previous units of instruction. Up to the present date sixty-four men have satisfactorily completed this three year course of training. Fifty-eight of this number are still with us and of the remaining six, four are away at colleges for further education.

Another experiment, starting about the same time, was the organization of the program of Out-of-Hour Courses to be conducted by members of the staff. These courses, however, are so well known and have been so widely attended that they require no comment.

Another scheme of education in conjunction with employment is that of the Instrument-maker Apprentice Course whereby young men are trained as journeymen instrument makers This course includes training in the principles of the machinists' and tool- and die-makers' trades. It extends through three and one-half years and includes 2496 working hours a year. Apprentices progress under a carefully organized instruction program through the various types of work of our Model Shop. Starting with experience in elementary bench-work and progressively operating bench and engine lathes, screw-machines, milling-machines, grinders, and shapers, they finally acquire experience in heat treatment, the operation of winding machines, a large variety of bench work, and the regular run of work of our Model Shop. During these three

and one-half years they receive on company time six hours a week of instruction in shop arithmetic, mechanical drawing, algebra, geometry, trigonometry, chemistry, practical mechanics, tool design, and some ideas of civics and economics.

Each apprentice enters into a regular apprentice agreement, is indentured, and receives upon the successful completion of his course of training a certificate as a journeyman and the customary cash bonus. After the completion of his first year of employment as a journeyman instrument-maker he receives an additional bonus. Much of the expert work which comes from our Model Shop is put out by men who have received their apprentice training in our shop or by the older apprentices who are getting their experience in the regular run of work which passes through the shop.

The instrument-makers in the Model Shop who have completed this training are:

1922

HARRY J. BATTAGLIA
GEORGE J. WOLFE

1923

CARL W. MAURER
JOHN J. GALLAGHER
ROBERT P. L. PILTAN

1924

CARL E. OSTLUND
WALTER R. SCHERB
HERBERT N. MICKLEY
JOHN A. BRADBURY
JOHN W. SWOLFS
EMIL DICKTEN
CHARLES ENGLEHART

The fourth experiment in education was the inauguration in September, 1920, of a plan for part-time post-graduate study at Columbia University, enrollment in which is open to selected employees. Candidates for this opportunity for part-time study are limited to graduates of a four-year course of college study who are interested in and qualified for graduate work in mathematics, physics, or chemistry. It has not been the practice to grant applications of men whose service with the company has been less than one year, or who have received their undergraduate degrees within the current year, because of the excellent opportunities for study and training which the out-of-hour courses offer.

In his relations with the University an approved applicant proceeds without regard to his company connection and selects the courses he desires and pays the usual tuition. In order to attend the necessary class hours, however, a reduction in working hours is made for each man, but without a reduction in pay. His study is, of course, carried on entirely outside of regular working hours. While under this plan many men have taken special courses at Columbia without continuing for a degree, several have continued and obtained higher degrees. Those who have obtained Master of Arts degrees:

1922

LESTER H. GERMER

1923

FRANKLIN MOHR
EUGENE PETERSON
JESSE F. WENTZ
JAMES R. WILSON

1924

PAUL P. CIOFFI
HOMER W. DUDLEY
WARREN P. MASON

1925

CLYDE R. KEITH
LEROY A. MACCOLL
EDWARD L. NORTON
ANTHONY C. ZACHLIN
JAMES J. WYLY
PAUL S. DARNELL

In addition to the above men, R. L. Case and F. X. Rettenmeyer have completed all the work for a degree but

have not taken the final examination.

The fifth and proposed educational experiment is a scheme of co-operative instruction in electrical engineering with Massachusetts Institute of Technology. Under the auspices of the American Telephone and Telegraph Company a co-operative program of training is being arranged with the Institute whereby selected students, during the third, fourth, and fifth years of the Institute course, will spend alternate terms at the Institute and with the Bell System. The last two terms of such industrial experience will be with the Laboratories, the earlier terms being divided between the New York Telephone Company and the Western Electric Company. The present plan calls for starting this course in February, 1926, so it will be 1928 before any of these co-operative students reach the laboratories.

Two Bell System Prizemen

The John Scott Medal with premium of $1000 was awarded by the City of Philadelphia to William G. Houskeeper of the Laboratories for "a method of sealing through glass metals having widely different expansion coefficients. It is popularly known as 'the copper-glass' seal and is gas-tight." The process is very valuable in the construction of high power electron tubes and other similar devices used in engineering in recent years.

* * *

The Morris Liebmann Prize with premium of $500 was awarded to John R. Carson of the American Telephone and Telegraph Company for his discovery of the "single-sideband" method of carrier transmission by wire and radio.

The John Scott Medal awarded to William G. Houskeeper

Public Addresses By Laboratories Engineers

Herbert E. Ives delivered lectures on the transmission of pictures over telephone lines before the Sigma Xi Fraternity (Purdue and Cornell chapters), the Detroit Engineering Society, the New York Electrical Society, the City Club of Rochester, the Accountants' Theories and Talk Club, the American Philosophical Society, the Rochester Academy of Science and Rochester Section of the Optical Society of America, the American Institute of the City of New York, and the Harvard Engineers Club of New York.

Nugent H. Slaughter spoke on the use of carrier current telephony on high voltage power lines before the Western Society of Engineers at Chicago.

John Mills spoke to the Accountants' Theories and Talks Club on the work of the Laboratories. He also delivered an after-dinner talk at the annual banquet of the Kappa chapter of Sigma Xi Fraternity at Columbia on electrical communication.

Kenneth S. Johnson and Frederick J. Given delivered informal talks on various phases of electrical communication to the Woburn Club at the Hotel Biltmore. Mr. Johnson also spoke on wave filters, at Yale University.

J. Warren Horton described some recent developments in telephony, in an address given before the Engineers' Club of Hartford, Connecticut.

Paul B. Findley delivered a talk on the Western Electric public address systems before the Men's Club of the Cathedral of St. John the Divine. He also described the work of the Bell Laboratories in addresses before the Engineers' Club of Bridgeport, Connecticut, and the Men's Clubs of Murray Hill, L. I., and Pelham, N. Y.

R. L. Jones' talk, "Some Bread and Butter Developments," given at one of the Friday luncheons of Western Electric executives, described some of the economic advantages to the Bell System of research work done in the Laboratories.

Lester H. Germer's paper, "Initial Velocity Distribution of Thermionic Electrons," was read before the American Physical Society.

Paul C. Hoernel spoke to the senior class of Brooklyn Polytechnic Institute on carrier current telephony and telegraphy and to the Physics Club of New York on the fundamentals of radio broadcasting.

Karl K. Darrow delivered a series of lectures at Carnegie Institute of Technology, Pittsburgh, on "Atoms and Radiation."

Frank B. Jewett delivered a talk on the influence of science upon modern civilization, as part of the science course of the forum of the Unity Church, Montclair, N. J. He also spoke at the A. I. E. E. convention at St. Louis, on present aspects of electrical communication; and at the tenth anniversary of the Engineering Foundation, at the Union League Club, on permalloy.

Edward B. Craft spoke on the organization, structure, and work of Bell Telephone Laboratories at a luncheon of the Financial Society of the American Telephone and Tele-

graph Company, a group of supervisors which includes members of the Treasury Departments of the Western Electric, New York Telephone, and Bell Securities Companies as well as American Telephone and Telegraph Company men.

At the Educational Conference of Mechanical Engineers held by the Bell System in Chicago during the latter part of June, Mr. Craft addressed the mechanical engineering professors, pointing out the rapid growth in opportunity for the solution of mechanical engineering problems by analytical methods somewhat analogous to those applied to electrical engineering problems, and describing some of the mechanical problems encountered in the design of communication apparatus.

SERGIUS P. GRACE, in an address given at Detroit to the National Purchasing Agent's Association, told how telephone engineers are turning the results of their discoveries to serve the public in quite different fields. He spoke particularly of the artificial larynx, the audiometer, the Western Electric stethoscope, the use of permalloy in submarine cables and in telephone receivers for the deaf, and the transmission of pictures over telephone lines.

Mr. Grace also addressed the radio audience over Station W X C, the Detroit Free Press, and W C C O, the Gold Medal Station at Minneapolis, mentioning as contributions to human welfare the audiometer, the audiphone, the stethoscope, the public address system, and the artificial larynx, and demonstrating the latter. A dramatic incident in Mr. Grace's stay in Minneapolis occurred when H. P. Storkerson of the Northwestern Bell Telephone Co. brought in one of their best construction foremen, a man who for fourteen years had been unable to speak. After a few minutes' practice with the artificial larynx he was able to talk. His company is now arranging to supply him with one of these instruments.

H. CLYDE SNOOK, at the Society of Automotive Engineers' convention at White Sulphur Springs, Virginia, discussed the application of noise measuring and analyzing devices developed by Bell Telephone Laboratories to the study of the noise output of various parts of an automobile.

Using an audiometer, extra amplifier, and cone loud speaker, Mr. Snook gave his large audience a rough test of their own hearing. He first caused the tone from the audiometer to vary continuously from a volume easily audible to one completely inaudible to the normal ear. As each of his listeners reached the limit of his own hearing he raised his hand to indicate that fact; and the way in which hands shot up in the audience, first one and then another, was a striking demonstration of the variations between individuals of acuity of hearing. He also used simultaneously two cone-type loud speakers to demonstrate the masking effect of a tone or noise and how it could obscure another tone which it was desired to hear. After giving his audience such fundamental ideas as to hearing and the measurement of musical tones and noises, Mr. Snook applied these principles to the problems of reducing noise in an automobile.

Student Assistants Dinner

ONE of the last acts of the Laboratories under its former incorporation as the Engineering Department of the Western Electric Company was the granting of certificates to the sixty-four men who have successfully completed the Student Assistant Course. These certificates of hard work, well accomplished, were presented at a complimentary dinner given to the graduates at Keen's Chop House on the evening of December 18, 1924. In addition to the members of the Personnel Department and a considerable number of supervisors there were present the following graduates:

Baarens, H. C.
Baumfalk, J.
Brower, N. C.
Brymer, S. J.
Chegwidden, R. A.
Conover, M. S.
Cooke, L. B.
Dalton, J. F.
Dean, C. P.
Dehn, J. W.
DeMonte, R. W.
Downing, H. H.
Drake, W. A.
Elbert, E. F.
Engel, T. J.
Fairlamb, P. B.
Farkas, S. F.
Firth, B. G.
Gerner, J.
Giroud, H. A.
Goehner, W. R.
Harazim, S. J.
Hartman, C. D.
Heuerman, G. F.
Huber, G. H.
Husta, P.
Hopkins, H. F.
Journeay, J. S.
Kahl, W. E.
Knapp, J. G.
Korn, F. A.
Kuhlman, H.
Kuhn, W.
Lang, A.
Lee, F. F.
Manthorne, W. H.
Melick, J. M.
Michal, O. L.
Miller, A. S.
Peterson, R. R.
Pfarrer, R. C.
Procopiadi, S.
Pullis, G. A.
Rahn, E. W.
Rose, C. F. P.
Schmidt, G. F.
Sloane, L. E.
Sohnle, G. F.
Stilwell, G. R.
Subrizi, V.
Trottlere, W. P.
Tassi, V.
Voelker, F.
Wean, M. J.
Williams, R. C.
Williford, O. H.
Young, T. J.

Short and informal talks were made by George B. Thomas as toastmaster, John Mills, Martin K. Kruger, William Fondiller, and by William A. Drake, R. R. Peterson, Jr., and Victor Subrizi for the graduates. It turned out to be somewhat of an experience meeting, as each of the graduates traced his own experiences in the work of the company and William Fondiller followed their example by telling some of his own earlier experiences in connection with the development of loading coils. A bit of advice which he gave to the graduates excited enthusiastic applause. He said:

> Now I want to put in a word for the supervisors. I was at a meeting of the Franklin Institute in Philadelphia a few weeks ago and just before the meeting Mr. Chesterman, the Chief Engineer of the Bell Telephone Company of Pennsylvania, and I were talking with Professor Alleman, the chairman of the Franklin Institute. Professor Alleman is a professor at Swarthmore College, I believe. Mr. Chesterton said to the Professor: You ought to talk with your young men and tell them about some of the problems of the Bell Systems and get them acquainted with the diversity of the opportunities which we have. You know something about our work from the papers that have been read by Bell System engineers before the Franklin Institute. The elderly professor replied: I can't tell these young men anything; they know more than I do.
>
> This illustrates one phase of self-determination. Some of you young men perhaps know more than your supervisors. You analyze them, you criticize them, perhaps justly, perhaps unjustly. Give your supervisor credit, at least, for trying to do the job, trying to cope with the problem. I grant you, you may know more about it than he does, but give him a chance. Encourage him to show his initiative. Don't dismiss his suggestions too harshly. You might break his spirit!

Club Notes

David D. Hagerty, Secretary-Treasurer
Bell Laboratories Club

The growth and popularity of basket-ball made the 1924-25 season the best in the history of West Street. The Club league, composed of eight teams representing the various departments of the Laboratories, met for games in the gymnasium of the Telephone Club on 17th Street. As the teams were more evenly matched than in former seasons the championship was in doubt until the last game of the season. This was played between Shops and Equipment, neither of which had lost up to that time, and was attended by three hundred loyal rooters. The Equipment team won and was awarded the gold basket-balls which had been donated by the Club.

Champions of the Girls' League: The Correspondence Files Team
Standing: Miss Cruger, Catherine Kelley, Thelma Rifflard, Pete Krumenaker, Gladys Nettleship, Miss Hence. Sitting: Anne Marie Wallenberg, Alice Pease, Ethlyn Boyer, Dorothy Wheeler.

This Basket-Ball Team Carried B.L.C. Colors to Victory Over Kearny
Standing: Jack Waldron, "Tip" O'Niel, Harold Cahill, Tommy Curley, Alex. Turner.
Sitting: "Mike" Michal, Bill Trottere, Charlie Gittenberger, "Dutch" Maurer, "Lew" Dunkard.

Late in January the Bell Laboratories club challenged the team representing the West Side Shops of the Kearny works, a team which had beaten many of the best teams around New York and New Jersey. The challenge was accepted and we won by a score of 20 to 14. While no title went with the winning of this game, bringing home to West Street the silver bowl which had been donated by Kearny and our Club meant that our team had conquered one of the fastest teams in New York and Jersey. Bell Laboratories Club gave a dinner before the game to the players and managers of both teams; and after the game all those who attended enjoyed the dancing. The officers of the B. L. C. were pleased to have as their guests Mr. F. L. Gilman, Kearny Works Manager, and his staff.

During the winter months the "women's interests" of Bell Laboratories Club startled the athletic world —at West Street—by placing in the competitive field not one or two basket-ball stars, but five all-star basket-ball teams. Over one hundred girls played basket-ball each week, in the gymnasium at Washington Irving High School. We feel confident that the winning team—McCormack's "Correspondence Files"—could conquer with ease an aggregation of any other commercial organization in the Metropolitan district. If you had seen them muss up Bollinger's "Angels" on March 4, you'd know this is not exaggerated.

Baseball

The 1924 baseball season was a "home-run" and the 1925 series is now on at Friends Field! In addition to all the features which made last year so successful, we have Frank Graham as our umpire—and what gives a

baseball fan more joy than a new umpire to pick on! There is a new Spalding trophy to compete for; and the entry of the Tube Shops team, as the dark horse, has us all guessing.

Track

On March 25, 1925, the Club entered men in two events in the Kearny Works Track Meet. The 300 yard dash was won by the B. L. C. with our H. M. Yates, Jr., first and T. P. Ingram second. The other event, in which we were entered, was the half mile relay, and our team, with Yates running anchor, finished second.

Our track meet of September, 1924, was a success and the Club is anxious to repeat. Last year the events for women were limited, but the success of our girls' basket-ball season shows that we must plan more events for the girls.

Swimming

If you enjoy a day at the beach try Brighton Beach Baths some Saturday or Sunday and we are sure you will become a "regular." Although many people think the bathing season ends with Labor Day, Brighton is at its best in September. The water is quite warm, the summer crowds are gone, and the air is cool. Brighton Beach is more than a bathing beach; it is an athletic center. It offers without any extra charge the use of the pool, handball courts, running track, and baseball field.

Hiking

Hiking activities were discontinued during the winter, but with the arrival of the mild weather the "call of the wild" has been heard by our hikers; and they have tramped through New Jersey and Long Island, and around Westchester County.

Riding

The equestrians, who have been riding indoors all winter, have taken to the "great open spaces." A. D. Soper, Captain, has led the "troop" on long rides through beautiful Westchester County.

New members are always welcome. The troop starts from Van Cortlandt Park every Saturday at 3 o'clock.

Bowling

The Club Bowling League closed the season with a dinner at the Telephone Club on April 28th at which the season prizes were presented to the winners by Vice-President Craft. This was followed by a theater party to see "Hells Bells," one of Broadway's hits.

Our Riders Sally Forth Into Westchester

Sewing

Two classes in dressmaking were held every Tuesday and Thursday evening during March, April, and May. Along with elementary work the instruction included advanced dressmaking and designing.

The classes will be resumed in October under the direction of Miss Bowman of the School of Domestic Arts, Pratt Institute.

Golf

Since April 15 the practice cages on the roof of section G have been available to club members from 8 to 9 a.m., 12 to 2, and 5 to 6 p.m. every day. The Club also hopes to make suitable arrangements later for a tournament at Briarcliff or over some similar course.

Chess

Although our chess team lost the telegraph chess match to the Hawthorne Club, it won for the second time the Potter Trophy, and with it the championship of the Commercial Chess League of New York. Our team has gone through two complete seasons without losing a league match; this is a record which had not been accomplished before our entry into the League two years ago. The Potter Trophy was presented to Bell Laboratories Club at a dinner given in our honor in the rooms of the Manhattan Chess Club on April 6, 1925. The acceptance speech was made by our Club President, Burton W. Kendall.

Cards

One of the more recently instigated activities of the Club, which has proven to be very popular, is auction bridge. Card parties were held during March, April, and May at 6 o'clock, in room 411. They have been discontinued during the summer but the committee in charge plans to start again in October.

Rifle Club

Another new sport at West Street is shooting (not the kind which is featured on the first page of the New York dailies). We mean a regular organized rifle club which engages in informal competitions every Tuesday evening on the rifle range of the Signal Corps in Dean Street, Brooklyn.

The Club has joined the N. R. A. and expects to enter teams in some of the important rifle matches of the coming year.

Music

The music group of B. L. C. is composed of the Glee Club, the Dance Orchestra, and the Symphony Orchestra.

The Glee Club under Mr. Goetze's leadership, on June 15th, gave an informal recital to the officers and guests of the B. L. C. after which they discontinued until the fall season.

The Dance Orchestra and the Symphony Orchestra are under the direction of Mr. Zammataro.

AN ODDITY OF SCIENCE

Would one ever expect that the same piece of steel could on successive days, at the same temperature, have different lengths? This phenomenon was discovered by W. G. Houskeeper some years ago while he was working on high-powered vacuum tubes, but because of other work Mr. Houskeeper carried his investigation no further than the authentication of the fact. A five inch piece of seamless tubing used to support the filament was heated to about 600 degrees centigrade. The sagging of the filament called his attention to a contraction, and careful measurement showed an actual shrinkage in the length of the tube. One steel tube exposed successively four times to such temperature treatment in a vacuum contracted seven-sixteenths of an inch. There are conditions, therefore, when steel shrinks almost as badly as an all-wool garment.

A PATENT A DAY

During the five months, January to May inclusive, since the incorporation of the Laboratories the records show the issuance at Washington of about 135 patents to members of the Laboratories. Statistically this is at the rate of something more than one patented invention per working day. Ninety-five different men are included in the list of inventors; and these are almost equally divided between the Research, Apparatus Development, and Systems Development Branches with the subjects of the patents correspondingly distributed. All these patents were, of course, applied for some time before their issuance, and all are assigned to the Western Electric Company.

THE printed form in which BELL LABORATORIES RECORD *greets you has been arrived at through the advice of several experts, all members of the American Institute of Graphic Arts. Irving B. Crandall of our Laboratories, Frank Fleming of Rogers & Company, Inc., which has done the press-work, and T. M. Cleland, who designed the cover page, are members of this Society which is the highest court of appeal in standards and tastes. Herbert E. Ives of the Laboratories is also a member of the Society and will be our advisor on questions of color and photography. The thanks of the Bureau of Publication are expressed to these gentlemen for their advice and assistance.*