The Hardening of Lead

By E. E. SCHUMACHER

THE Western Electric Company began using lead-sheathed cable in 1880, and at first employed a commercially pure grade of lead. But this material is so soft as to be deformed under comparatively small loads. The increasing size of cables imposed severe strains on the sheath in the operations of drawing into underground ducts and of placing them overhead; to secure greater strength, an alloy containing three per cent of tin was adopted in 1894. This was found to be much stronger than the pure lead, and incidentally it was more resistant to corrosion.

Fig. 1—Lead antimony alloy (99% lead —1% antimony) which had been annealed at 230° C. for one hour, quenched and photographed immediately. Magnification 200 times

Tin is expensive, and it was found desirable to replace it by a cheaper metal. Research led to the adoption in 1912 of an alloy of lead with one per cent antimony. This alloy, which is still the Bell System standard, has all the good qualities of its more costly predecessor; notably, it is several times as strong as commercially pure lead. That such an improvement may be obtained by such a small change in the composition of the metal is at first sight surprising: it is only in recent years that enough knowledge of the structure of metals has been gained to permit even a partial explanation of such behavior.

Lead-antimony alloys are known commercially as hard lead, and we say that the addition of antimony hardens lead. "Hardness" is an excellent descriptive noun, but in technical use it has an uncertain significance. As applied to lead alloys it refers rather to the stiffness of the metal, its resistance to bending, or more generally to deformation of any sort. To relate this property to the composition and condition of the material would require a complete knowledge of metal structure, which we do not possess. A qualitative understanding, however, is given by our present knowledge which of recent years has been greatly extended, particularly by means of X-ray studies.

Metals, we know now, are made

up of crystals, and these crystals are made up of atoms. The atoms are arranged in the crystals in very definite ways, spaced always in some geometric pattern. The crystals, on the other hand, are generally arranged within the metal in a perfectly haphazard fashion, and may be of very different sizes. Mechanical and thermal treatment, such as the extrusion process, tends to give the crystals a more uniform orientation, but there is always some slight change in orientation at the boundaries of the crystals.

In an alloy of two metals we distinguish three typical cases. There may be present but one kind of crystal, containing atoms of one metal held in solid solution with atoms of the other. Or, if neither metal is soluble in the other, there may be two kinds of crystals each made up of atoms of only one metal. But in the most common structure, there are two kinds of crystals, each containing atoms of both metals, but in different proportions. In one kind of crystal, atoms of one metal will predominate, and vice versa. This is the case in lead-antimony alloys of high lead content; these are made up of crystals consisting mostly of lead, among which are interspersed a few crystals consisting mostly of antimony. These facts we know from microscopic and other observations.

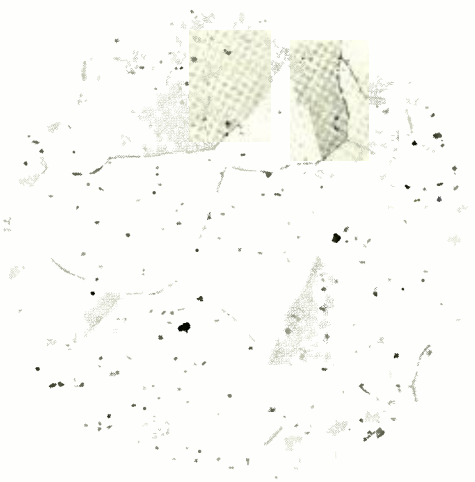


Fig. 2—Lead antimony alloy (99% lead —1% antimony) which had been annealed at 230° C. for one hour and then aged at 20° C. for five days. Magnification 200 times

Now in general, the amount of one metal that another will hold in solid solution varies with the temperature. Thus at 247° C. an alloy of lead containing up to 2.45 per cent. antimony will consist only of crystals of lead containing antimony in solid solution. Any greater proportion of antimony will be present as separate antimony-rich crystals. But at room temperature only about 0.25 per cent of antimony can be in solid solution at equilibrium. Hence as an alloy of one per cent antimony is cooled from 250° C. to room temperature most of the antimony will separate out of the lead-rich crystals and will form small new crystals consisting of nearly pure antimony.

The crystals in a metal, as was noted above, may be of different sizes—the average is dependent on the conditions under which the metal crystalized. If the metal is rapidly frozen, they are apt to be small—if it is cooled slowly from the liquid state they will be large. Now it is generally true that the smaller the average size of the crystals the greater is the resistance of the metal to deformation. This we can understand in a way, because the regular arrangement of the atoms in a crystal results in the existance of planes having a minimum resistance to shear; adjacent crystals

will have these planes inclined to each other, and therefore two crystals have a greater resistance than one of the same size. The effect is similar to that of a pile of bricks; if the bricks are neatly piled we can slide the upper half of the pile off the lower half fairly easily, which we could not do if the bricks were simply heaped up at all angles to each other.

The same explanation may be used to account for the hardening of lead by the addition of antimony. In sheathing a cable the metal is extruded through a die at a temperature of about 250° C. and is then cooled in the air. The alloy contains about one per cent antimony, and therefore at this temperature is composed only of crystals of lead with antimony in solid solution. As the sheath cools, some of the antimony atoms separate to form new crystals which occur within and at the boundaries of the lead-rich crystals. Although constituting only a small portion of the total volume they are very small and hence numerous. In consequence, they very materially increase the resistance of the metal to deformation. Hardening produced in this way is known as dispersion hardness, and is obtained in other alloys of commercial importance. Duralumin, the aluminum alloy of great strength which is used in airplanes and motor parts, gains its strength from a similar precipitation of silicides of copper and magnesium, which are present in the alloy in small amounts.

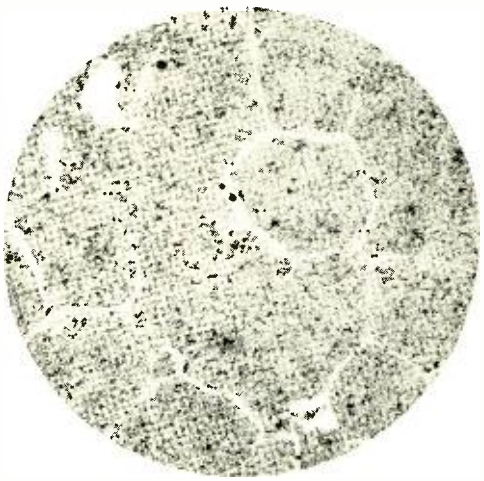


Fig. 3—Lead antimony cable sheath alloy (99% lead—1% antimony) which had aged in service for eight years. Magnification 200 times

This explanation of the hardening action is only partial; the actual increase in strength is too great in proportion to the increase in inter-crystalline surface to be entirely accounted for in this way. One interesting and easily-grasped theory to account for the additional strength postulates that the tiny precipitated crystals act as keys, which break up the regularities of the larger crystals, and prevent these from slipping on their planes of weakness. Other theories have been advanced, but these are too complicated to be touched on here, and are of greater value as suggesting lines of research than as means of forming a picture of the actual behavior of alloys.

Whatever the way in which the dispersed crystals serve to strengthen the metal, there can be no doubt that there is a definite relation between the number and size of these small crystals and the hardness of the alloy. Without attempting to explain the process, we can determine this relation experimentally, and thus find the requirements for greatest hardness. If there is too much antimony present the particles will be too large,

and the best hardening will not be obtained. An excessive amount of antimony will also cause brittleness. In this connection it must be remembered that equilibrium at room temperature is only reached very slowly, so that the precipitation of antimony and the increase in hardness and brittleness go on for months, or even years, after the sheath has been manufactured.

If we could give an explanation of this hardening process more adequate than that roughly outlined above, we could perhaps devise new ways of treating metals which would give even greater hardness. For this reason, and to fulfill the more disinterested aims of pure science, such a more adequate explanation is greatly to be desired, and it is in many places being sought. From the discussion given here it is perhaps hard to see why it is so difficult to find. One reason is that the atoms, which we have regarded as the ultimate components of the metals, are themselves highly complex structures, possessing many properties not yet clearly defined or understood.

Physicists today are concentrating their studies on the structure of the atom. Their researches have taught us that it is made up of electric charges acting on each other and throughout the immediate vicinity in highly complicated ways. Throughout a crystal the atoms are regularly arranged, and their forces will combine to give regularity to the properties of a crystal along any given line, but at the crystal surface there is a discontinuity in the atomic arrangement that may well give rise to abnormalities in the internal forces resisting deformation. It was for some time thought that crystal interfaces must contain an amorphous phase: that is, a mass of metal in which the atoms were irregularly arranged, as in a liquid. Without entering into further discussion of such speculation, it is evident that we cannot understand the behavior of metals until we know more of the properties of their structural elements, the atoms. For this the metallurgist must wait upon the physicist. If, on the other hand, the metallurgist can simplify his observations of the way in which atoms act in crystals into general laws, he may furnish the physicist with knowledge as to the properties of atoms from which may be derived further knowledge as to their necessary structure.

Acknowledgment is made to Miss A. K. Marshall of the General Apparatus and Physical Laboratory, who made the photomicrographs shown in this article.

Retired from Active Service

By A. F. WEBER

ON the Laboratories' list of retired veterans there are now eight names—seven men and one woman. The best years of their lives have been given to the telephone industry. Their skill has made a definite contribution to the excellence of our product; and beyond that, their loyalty has added to our traditions of service something intangible but lasting. Under the provisions of the Plan for Employees' Pensions, Disability Benefits and Death Benefits, which has been adopted by these Laboratories in common with other companies of the Bell System, these eight have retired from active service among us.

Oldest of these veterans, in point of service, is Alfred E. Kopetz, who joined the New York Shop of Western Electric in February, 1894. He was born in Germany of Austrian parents, and like so many of his countrymen, he had a natural aptitude for things mechanical; as an instrument maker and later as a foreman he was extremely valuable to our Shop. Mr. Kopetz now lives on his farm at Halcott Center, Greene County, New York. The outdoor life has rebuilt his health, promising that he will enjoy many more years of usefulness to his family and community.

Frank Forestiere, another veteran of the Shop—in this case the woodworking department—was with the Bell System for over thirty years, starting in June, 1896, and was one of our most expert woodworkers. Mr. Forestiere is an Italian by birth. Failing health forced his retirement. He is now living in Bay Ridge; and like Mr. Kopetz, has found that an outdoor life and lightened work have greatly improved his health.

Albert E. Waight, who had twenty-eight years' continuous service, is a veteran of the Civil War. He started with Western Electric as a tool and gauge maker in the old Manufacturing Department at New York and was transferred to the Model Shop when manufacturing was moved to Hawthorne. He is now living in Newark, New Jersey.

Up to the time of his retirement in November, 1926, Joseph Kearns had been at West Street for twenty-three years. For many years he had charge of the maintenance of the elevators; more recently he was connected with the Power Service Department, where he handled the apparatus for making liquid air. Mr. Kearns now makes his home in Belle Harbor, Long Island.

Mrs. Elizabeth Lorenzer is the only woman among our retired veterans. She started in at West Street twenty years ago, as a lacquerer, and in this position she continued until the removal of the Manufacturing Department; at the time of her retirement she was acting as matron in the Building Department. Mrs. Lorenzer is a real New Yorker; she was born on Eleventh Avenue, and is now living on Ninth Avenue near Twenty-fourth Street.

Frank Forestiere

Michael O'Donovan

Joseph Kearns

Elizabeth Lorenzer

Alfred E. Kopetz

Albert E. Waight

Eugene L. Ruymen

Benjamin F. Merritt

Another born New Yorker is Eugene L. Ruymen, the youngest of our old-timers. Although he has had eighteen years of continuous service, he is still in early middle age; his retirement from work in the Systems Department, where he was engaged in wiring and maintenance, was forced by ill health.

From Ireland Michael O'Donovan emigrated to the United States and to the Western Electric Company. Mr. O'Donovan's ability in the Shop resulted in his advancement from mechanic to assistant foreman. Illness brought about his retirement in July, 1925, after eighteen years of service. From his home in Jersey City, an O'Donovan still comes to the Laboratories; his son Edmond, a candidate for the Shop Apprentice Course.

Benjamin F. Merritt entered the New York Telephone Company in 1896, where he became Superintendent of the repair shops. In 1907 he resigned to take up other employment; he returned, to the Western Electric Company, in 1912. At the time of his retirement in March, 1927, he was Assistant Curator of the Laboratories' Historical Museum. Mr. Merritt's home is in Towaco, New Jersey.

Although these men and women have retired from active service in the Laboratories, their useful careers are by no means ended. One man is operating his own little farm, and in addition is supervising the county's road-building equipment. Another is acting as treasurer of a building concern in which he is a partner; a third has turned his interest in mechanical things into the practical channel of clock repairing. Their savings have been put to work in home-ownership or in other productive investments which are helping to educate the coming generation as well as to provide its elders with the comforts of life. The failing health which with most of them was the precedent to retirement, has generally been improved by quiet and leisure: we may confidently expect all these old friends to enjoy many more years of usefulness.

Measuring Dial Speeds

By O. F. FORSBERG

A LITTLE instrument, known as the dial, has in recent years become a valuable adjunct to the modern facilities of communication; yet many of us have placidly accepted it as a mere convenience without giving much thought to its importance or to the wonders it performs. In the realm of wired communication it opens paths of conversation for thousands of people; and, mounted on a desk-stand or other telephone, it unerringly directs the intricate machine-switching mechanisms which, without the aid of operators, make possible a myriad of speech highways.

The dial has a rotating wheel with ten finger holes to each of which a number is assigned. This wheel controls a set of interrupter contacts at the subscriber's end of the telephone line. To dial, a finger is inserted and the wheel rotated to the stop. For any telephone call the dialing operation must be performed a number of times corresponding to the number of digits and letters in the telephone designation of the called subscriber. When the dial is released it returns to the normal position under the control of a speed governor, and produces in the signalling current on the line, interruptions which correspond to the number of the hole in which the finger was inserted. The successive opening and closing of the telephone circuit results in the transmission to the central office of electrical impulses, and there these operate electro-magnetic switching apparatus which sets up the desired connections.

To insure satisfactory operation of this central-office equipment, which is controlled by the dials, the electrical impulses must, within certain limits, be regularly transmitted and of equal duration. Some accurate and convenient means of checking this impulse rate or "dial speed" must therefore be provided. Several methods have been used in the Bell System since the inception of machine switching. These range from a simple stroboscopic method, using a tuning fork to time the impulses, to that of the new instrument, in which a pendulum measures the dial speed.

With this new instrument, the repairman at the subscriber's station first dials the test-desk man, who in turn connects him to the dial tester. The repairman then dials 0, and tones

automatically put on the line by the instrument indicate whether the dial is too fast, too slow, or is operating at normal speed.

The timing element of the new tester is the pendulum, the use of which, as a means of measuring time intervals, dates back to Galileo in the sixteenth century. In the tester it measures the time taken by the nine impulses which the repairman dials. At the beginning of the first impulse the pendulum is released and allowed to swing. At the end of the ninth impulse a contact is closed which records the position of the pendulum at that instant. After the ninth, if the impulses had the proper duration, the pendulum will be in one position; but if they occurred in too long or too short a time it will either be beyond or not up to this position. Corresponding to these three positions are three separate contacts and for each a distinctive tone is transmitted to the repairman.

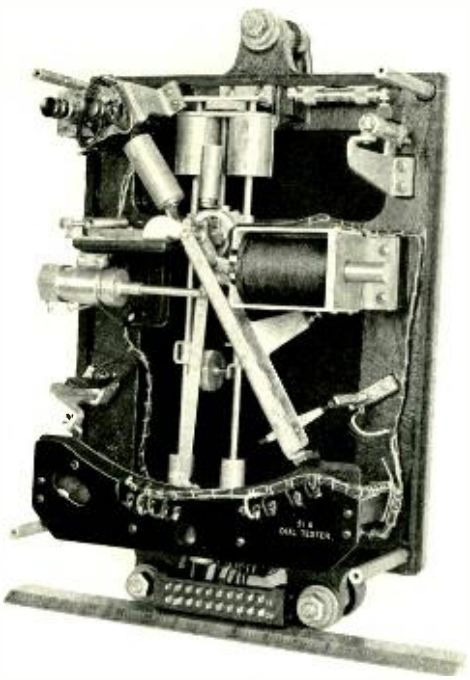


Figure One

The pendulum is mounted on knife-edge bearings, as shown in Figure 1, and can swing through an angle of approximately sixty degrees. A magnet holds it in the starting position, thirty degrees to the left of the vertical. The contacting device involves a vane attached to the pendulum. When the pendulum is started the vane is pulled toward it by a magnet. When this magnet is de-energized at the end of the ninth impulse the vane springs away and makes contact with a metal strip which is divided into nine segments separated by narrow gaps. In line with the gap between each two segments is a small projection which acts as a stop to the vane and prevents it from sliding along to the adjacent segment. These segments and stops are shown in Figure 2, in which the plate on which they are mounted has been removed from the dial tester. Contact between the vane and a segment closes a circuit which sends over the line a tone characteristic to that segment.

Associated with the pendulum are a number of other devices necessary for completely automatic operation of the tester. For example, to return the pendulum to its starting position there is an electromagnet formed by a solenoid and a plunger. The plunger is linked to a pivoted arm which engages and moves the pendulum and the vane. A dash-pot regulates the speed of the plunger, preventing injury to the fine knife edges due to the pendulum being moved too quickly. After the pendulum has been engaged

by the magnet which holds it in the starting position, the solenoid is automatically de-energized and the arm withdrawn under the action of a coiled spring. This resetting mechanism is automatically controlled by means of an associated electrical circuit.

The development of this dial tester involved a number of interesting problems. In the first place, it was necessary to demonstrate that the pendulum could be adapted for use in an instrument of this kind. The tester is required to check both subscribers' dials, which should send from eight to eleven impulses a second and also operators' dials, which should send twenty impulses a second. In order to meet these conditions, the time required for the pendulum to swing its entire arc must be slightly greater than nine-eighths of a second.

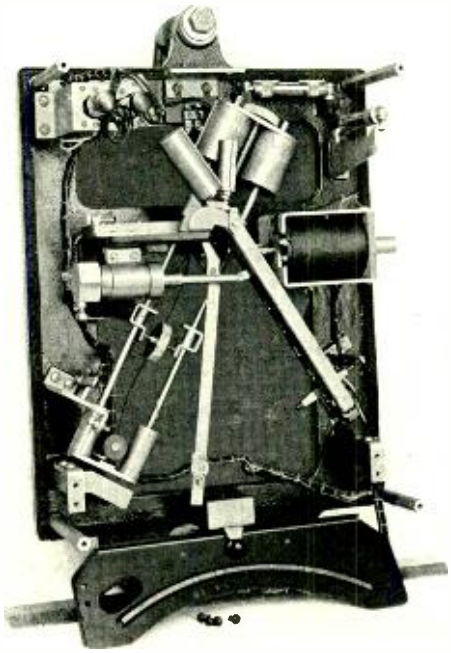


Figure Two

A theoretical study, therefore, was made of the pendulum motion and a time-displacement curve plotted showing the time for the pendulum to swing from its start position to various points in its arc. The curve shown in Figure 3 was computed from the fundamental pendulum equation which had to be completely solved with the aid of elliptic integrals.

A laboratory set-up was then made and oscillograph measurements were taken of the time required for the pendulum to swing through measured arcs. A stiff wire projecting from the lower part of the pendulum was arranged to make contact, as the pendulum swung, with another wire which could be fixed in position corresponding to any desired angle of pendulum swing. A magnet released the pendulum from its position thirty degrees from the vertical, and oscillograms were taken of the times between the release and the contact with the "protractor wire" as set at various angles. The results of this investigation indicated that consistent performance might be expected and that further development was warranted.

Another problem was adjusting the pendulum to the proper period. To vary the period it is necessary to change the position of a pair of cylindrical weights which may be moved up or down on the pendulum bars. The stop watch was selected as the most practicable means for timing the period. Tests were made to determine the relation between the time of fifty swings and the time of the first swing which is used for checking dial speeds. The results of this study, showing a definite and consistent rela-

tion between these two factors, permitted the time adjustment to be made with the watch.

The next step in the development of the complete design was the layout of the segments of the commutator which should indicate whether or not dial speeds were within the limits specified for proper functioning. Computations were made on the basis of the theoretical curve to determine the arcs through which the pendulum would swing during the time intervals represented by nine dial impulses at the various standard rates. In determining the location of the projecting edges or stops of the commutator segments, it was necessary to modify somewhat the theoretical time-displacement values to allow for factors introduced by the associated apparatus for starting and stopping the pendulum.

Based on data collected through these studies and on preliminary experiments, complete models were then built. These were calibrated under conditions closely simulating field conditions. This calibration and tests on the models bore out the forecast of the preliminary studies that the apparatus was entirely satisfactory as a timing element. The pendulum dial-tester, therefore, is now a part of the equipment of several metropolitan telephone exchanges.

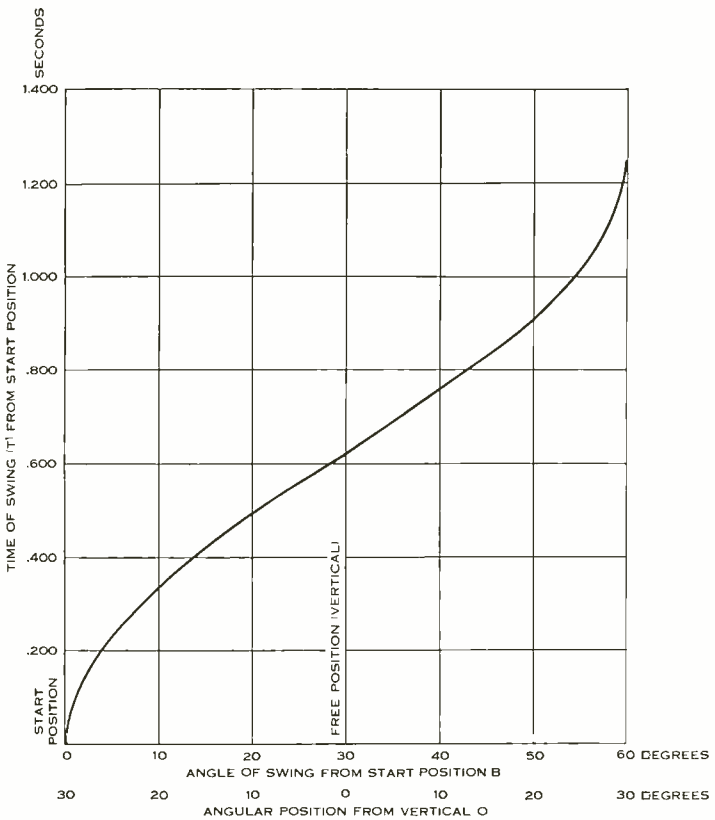


Figure Three

Items of Interest

THE FIFTY KILOWATT radio broadcasting transmitter, on which development has been in progress in the Laboratories for several months, is now being tested "on the air." Gratifying reports of reception of programs have come in from almost all parts of the United States and Canada, from Havana, from Montevideo, and even from Victoria, Australia.

* * * *

OF THE A. I. E. E. CONVENTION at Detroit, quite the outstanding feature was television. Mr. Craft opened a symposium on this subject, and introduced H. E. Ives, who described and demonstrated the general principles. Technical papers on various problems of television systems were presented by Frank Gray, J. W. Horton and R. C. Mathes; H. M. Stoller and E. R. Morton; and E. L. Nelson, all of these Laboratories; and by D. K. Gannett and E. I. Green of A. T. & T. Set up in space provided through the courtesy of the Book-Cadillac Hotel management, television sending and and receiving outfits were operated under the supervision of E. F. Kingsbury by A. L. Johnsrud, J. R. Hefele and C. R. Keith. Demonstrations were given during two days to members of the Institute and their guests; a third day was devoted exclusively to employees of the Telephone Company; and two more days to demonstrations to the public by invitation. More than five thousand persons saw the system in operation.

At a preliminary demonstration for the press, much interest was shown, and all the newspapers accorded generous amounts of space to the event. Many persons prominent in civic and business circles were brought to the demonstrations through the invitations of Michigan Bell officials.

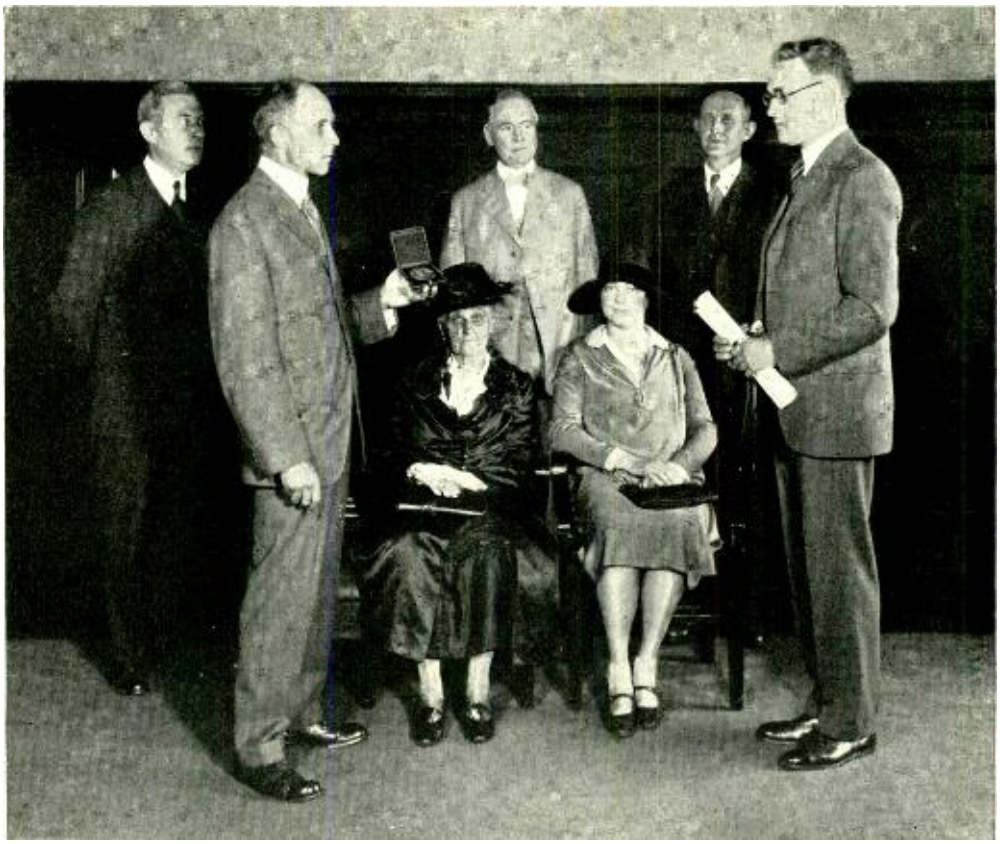
* * * *

HARVEY FLETCHER attended the latter part of the A. I. E. E. Conventon at Detroit, and then went to the annual meeting of the American Federation of Organizations for the Hard of Hearing held at Chautaqua, New York. The opening day he spoke to the Board of Managers on considerations in rating audiphones, and the following day presented a report on "The Method of Finding the Deafened Child and of Assisting Him Both Educationally and Medically," initiated at the Laboratories and prepared for the United States Commissioner of Education. As Chairman of the Committee on Scientific Research he read reports on results of testing school children, on a booklet being prepared for publication and on an outline for testing audiphone sets by the local organizations. After consultation for teachers present on the fundamentals of speech and hearing, he discussed a paper on hearing aids presented by Dr. Douglas Macfarlan. From Chautaqua, Dr. Fletcher went to the National Convention of Instructors for the Deaf, held at Columbus, Ohio, where he presented a paper on "The Possibility of Using Small Amounts of Residual Hearing in the Education of the Deafened."

"For Noteworthy Public Service"

FOR noteworthy public service a Theodore N. Vail Medal has been awarded to Edward J. Reilly of the Research Department. This was formally presented to him on July first by President Jewett in the presence of other executives of the Laboratories.

As a lieutenant of the Seventy-first Infantry, New York National Guard, Mr. Reilly attended the annual encampment in 1926; on August 20, he was Officer of the Guard. Nine or ten men of the company, off duty at the time, were resting in the guard-house. One of them, a sergeant, having found in the guard house an apparently empty bomb, showed it to Lieutenant Reilly, asking him what it was. Lieut. Reilly explained the device, cautioning the sergeant on no account to pull out the cotter pin. This would release the firing mechanism, and in four seconds the bomb would explode. By an unaccountable impulse, the sergeant immediately pulled out the pin; sparks flew from the bomb, showing that its time fuse had been ignited. Instinctively the sergeant dropped the bomb and tried to jump away; equally by instinct Lieutenant Reilly reached for the bomb, to try to throw it out of the guard-house. He had almost reached it when it exploded, showering him with burning phosphorus and wounding him with flying fragments.



President Jewett presents to Edward J. Reilly the Vail medal for noteworthy public service. In the photograph, seated, are Mr. Reilly's mother and his sister-in-law, Mrs. Joseph Reilly. Standing, are Vice-President Craft; President Jewett; Captain Macfarlane, Lieutenant Reilly's commanding officer in the New York National Guard; Joseph Reilly; and Edward J. Reilly

The men, although some were badly hurt, escaped through door and windows. Lieutenant Reilly, however, remembered that a prisoner was confined in a cell inside. In spite of his own injuries and the remonstrances of the men, Reilly insisted on returning to the gas-filled room to release and bring out this man. He then commandeered a passing automobile in which the several wounded men were placed, and rode with them to the hospital. The medical officer on duty there, noting that Lieutenant Reilly was bleeding and burned, proposed to treat his injuries at once, but Reilly insisted that all the others be cared for first. Fortunately, although his hurts were exceedingly painful, he recovered and returned to the Laboratories in a few weeks.

Courageous devotion to the public is one of the Bell System's finest traditions. Every day, service is carried beyond the line of duty, but frequently there occurs an incident so noteworthy as to deserve more than passing recognition. The purpose of the Theodore N. Vail Memorial Fund is to recognize appropriately such unusual

acts, which conspicuously illustrate the high ideals governing the policy of Mr. Vail.

A Vail Medal is a recognition of good judgment, of initiative, resourcefulness, courage, and endurance; with something at stake to justify the effort. Every one of these qualities was indicated in Mr. Reilly's action.

Knowing that there was a brief interval between the ignition of the bomb and its explosion, he used good judgment in taking the chance of hurling it through the open door. As officer in charge, he was responsible for his men—for their immediate safety, and for the speedy treatment of their wounds. Even though his attempt to throw the bomb outside might be considered instinctive, only deliberate courage could send him back into the choking fumes. Painfully injured, he retained control of the situation until his men had been made comfortable.

In an official report, his captain has spoken of Lieutenant Reilly's conduct as meriting the highest commendation for exceptional bravery and quick action. To this, the Laboratories have added recognition in the form of the Vail Medal.

The Progress We Are Making

Mr. Gifford's statement mailed with the July dividend checks of the A. T. & T. Co. is reproduced because, in few words, it gives very concrete evidence of the steady progress the Bell System is making toward better telephone service.

"TO THE STOCKHOLDERS:

The Bell System has made substantial progress in the extent and quality of telephone service during the past six months.

425,000 telephones have been added, making a total of 18,000,000 telephones interconnected in and with the System.

The percentage of calls completed on the first attempt has increased nearly 1% or 500,000 calls per day—this in spite of the fact that uncompleted calls are due largely to reasons beyond the control of the operators, such as busy wires, do not answer, etc.

The average time for the completion of (or definite report on) toll calls was two minutes for the year 1926. During the first six months of 1927, the time was reduced to one and eight-tenths minutes.

While improvements in methods, training and management have contributed largely to these gains, an increasing permanence in the operating force has resulted in its having the highest average of experience in the history of the System, and this has helped effect these and other improvements in service.

The expenditures for plant additions, betterments and replacements for the year 1927 will exceed $380,000,000, or approximately the same as in 1926. These expenditures will take care of the growth of the business and enable the furnishing of a still higher grade of telephone service.

An enlarging and improving service is the foundation of good relations with the public, the employees, and, we hope, with the stockholders.

WALTER S. GIFFORD
President."

Eleven Miles of Wire

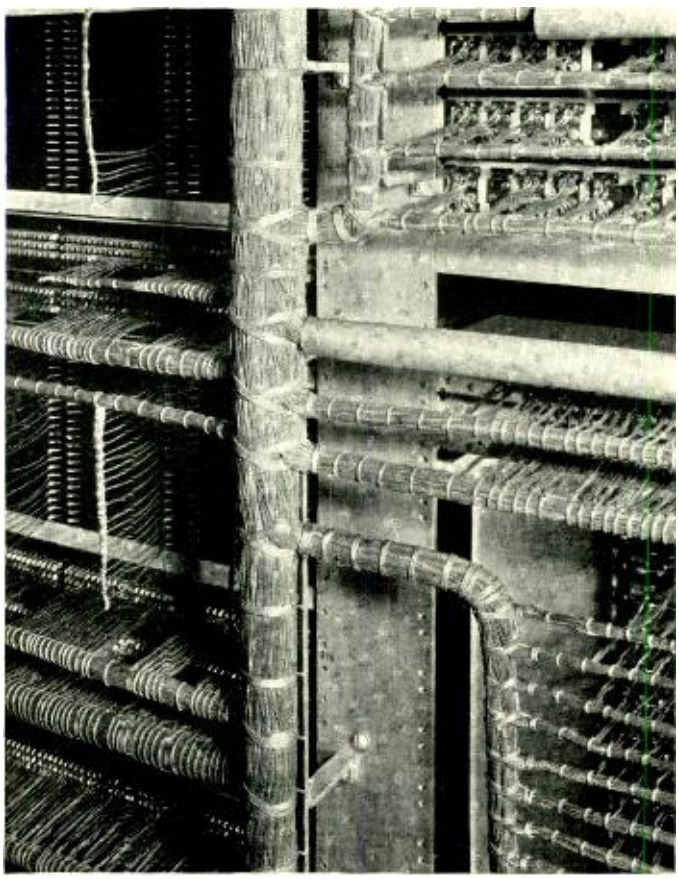
By P. D. HANCE, Jr.

ELEVEN miles is not a stupendous amount of wire in these days of long-distance cables. But when a single machine-switching frame, four feet wide, can absorb a mile of wire for every foot of its height, the story seems worth telling.

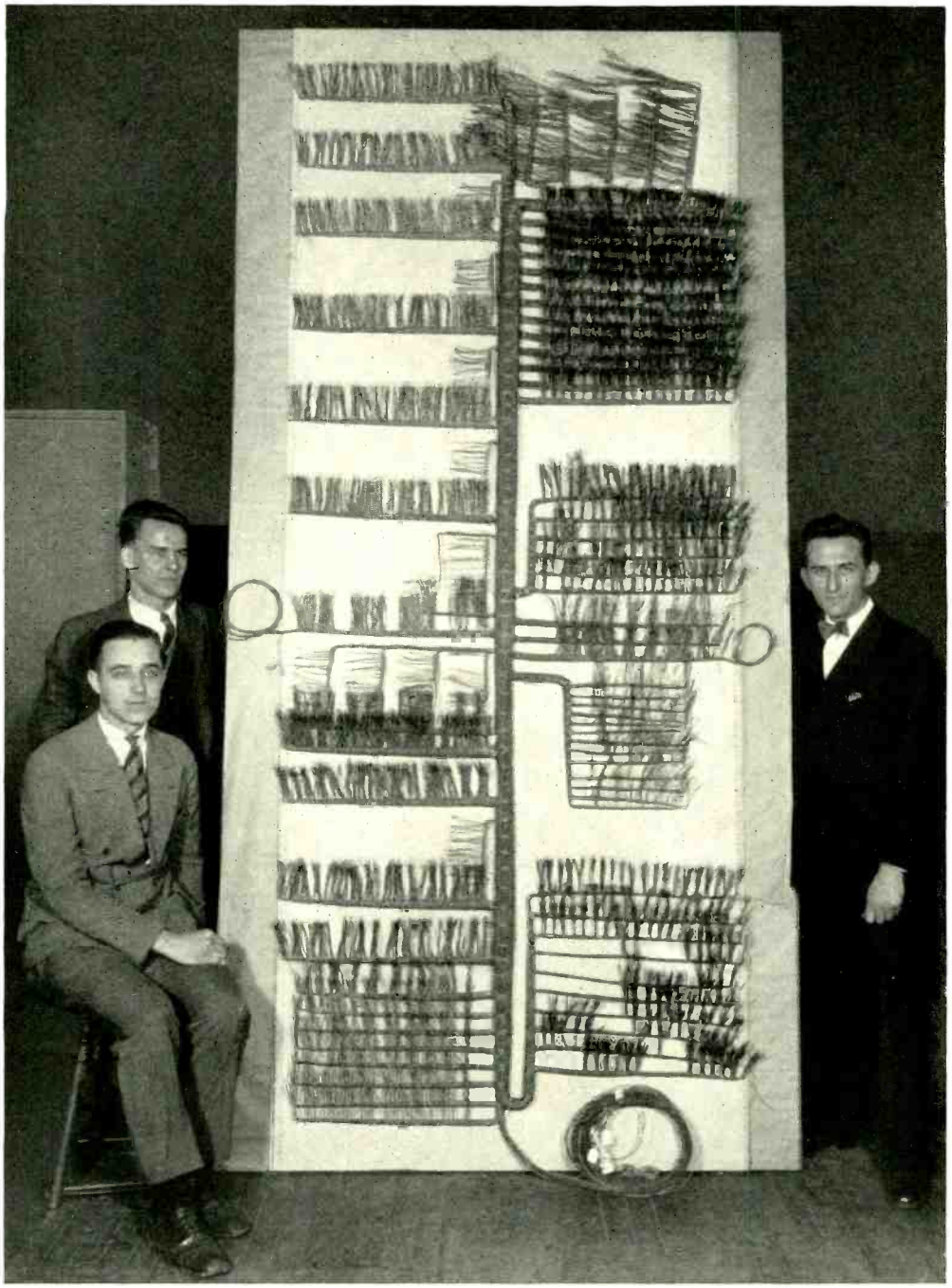
In the Machine-Switching Laboratory there is now under test a circuit of so complex a character that it requires wire densities of very considerable magnitude.

One way to interconnect apparatus is illustrated by some home-made radio receivers—run each wire in a straight line from terminal to terminal. Result: chaos—a mat of wires criss-crossing in every direction and effectively blocking access to the apparatus for test and adjustment. To avoid this, telephone practice is to group the wires into a "local" cable, whose making is an art developed to a high degree both here and at Hawthorne. The cable for this particular circuit is one of the largest ever constructed in our Laboratories. A total of eleven miles of wire were cut into 6,854 pieces, to interconnect the coils and contacts of over four hundred relays, together with more than two hundred lamps and the necessary terminal blocks.

In making such a cable, the first step is to design it so that the various



As thick as a man's wrist is the central stem of this cable with its 1778 *wires. In the background are a few of the* 13,000 *soldered connections*



Frank Kuchas, Hollis Van Damme, and Warren Mischler with the local cable of their making

arms fit onto the steel frame, which supports the circuit, neatly and in such a manner that the wiring and the rear of all the apparatus are always easily accessible. What is more difficult, and more important, each of the 13,708 ends of wire to be soldered must emerge from the cable exactly opposite the terminal to which it must connect. After the design is complete, the layout is sketched in pencil, full size, of course, on an immense board. Large nails are driven into the board at all corners and branching points, and smaller ones at each point where wires emerge from the form. The individual wires are looped around these nails, sewed into a tight cable with a series of what a sailor knows as half-hitches; and, finally, the ends are trimmed to their proper length, skinned and shellacked in order to keep the insulation from raveling.

Since some of the nails are on one side of a branch, while others are along the opposite side, the thickness of each arm of the cable must be known in advance, so that the centers of the nails will be in just the right position and so that each wire emerging from an arm will be exactly opposite its soldering terminal. The diameters of the arms at various points are all computed from the circuit drawings. This local cable was designed by F. H. Graham of the Equipment Development Department and was laid out and built by J. E. Devaney and A. Risser of the Systems Development Laboratory.

In order that the wires in a group emerging from one stitch may be identified and soldered to the right terminals, various colors of insulation are used in the cable. The color of each wire is shown on the circuit drawing, at the terminal to which the wire connects. In case of any doubt there is a buzzer set at hand, by means of which the man on the job can readily determine the identity of each wire.

Stock Subscriptions

The following data give a summary of employee subscriptions from our Laboratories to stock of the American Telephone and Telegraph Company. The figures are as of June 30.

Employees	
Number of employees eligible to subscribe	3364
Number of employees subscribing	2132
Per cent employees subscribing	63%
Shares	
Total number of shares for which employees are eligible	31063
Number of shares subscribed for	19607
Per cent shares subscribed for	63%
Payments	
Total subscription value of shares under subscription	$2,457,912.00
Total paid-in value of shares including interest credited at 7% per annum compounded quarterly	$ 868,969.45

News of the Month

THE AMERICAN ENGINEERING STANDARDS COMMITTEE, in its current Year Book, shows that the Bell System is the largest industrial organization cooperating with the Committee as a sustaining member. C. H. Amadon, S. P. Grace, C. D. Hocker, R. L. Jones, A. E. Petrie, and E. B. Wheeler of the Bell Telephone Laboratories are acting on sectional or working committees, in addition to eighteen other representatives from various parts of the Bell System.

Of the twenty standardization projects under the procedure of the A. E. S. C. in which the Bell System is interested, some of the more important are methods of testing wood, manhole frames and covers, specifications for copper wire, and for zinc coating of iron and steel, and specifications for low-voltage line-insulators.

* * * *

MR. CRAFT advised against any compulsory adoption of the metric system in a brief article which appeared in the July number of *Weight and Measure,* a quarterly circulated by the American Institute of Weights and Measures. He called attention to the transition years of confusion and expense which such a change would bring to the communication industry.

In part Mr. Craft wrote: "At present there are involved in the telephone plant over 13,000 different forms of apparatus and these require for their construction over 110,000 separate varieties of piece parts. The specifications for these have all been and are being expressed in the English units.

"In addition to the confusion which would be caused by unnaturally changing by law the names and sizes of the units of measurement, there are the added effects which would result in confusing decimal fractions of the new units. To change the specifications by designing to convenient multiples or submultiples of new units would result in apparatus differing in size and shape from the existing apparatus which is so extensively employed throughout the country. The new and the old would not fit together. Replacements and extensions of plant equipment would be very difficult and expensive. Even if all new designs were made on a basis of metric units, it would still be necessary to maintain for years a duplicate manufacturing system for producing spare parts, which are exact reproductions of the original and early designs, and a duplicate system for maintenance and extension of existing plants."

* * * *

R. R. WILLIAMS spent July 13 in Washington in consultation on wood preservation tests being conducted by the Department of Agriculture. The next day F. F. Farnsworth and W. G. Knox joined him for a visit to the Institute of Paint and Varnish Research of the H. A. Gardner Laboratory.

As in other Bell System departments, the General Health Course for Women was given at the Laboratories. The first class opened October 22, 1926, with a registration of twenty-three; the second, which was in two sections, on March 1, 1927, with a registration of fifty-five. The course was taught by Statira Crawford of the Medical Department, assisted by Gratia L. Prouty of the Employee Service Department. Fifty-seven girls completed the requirements for certificates which were distributed on July 7 by George B. Thomas, our Personnel Director.

Graduates of the General Health Course: back row: the Misses Bliss, Mallard, Fitzgerald, Johnson, Snyder, Muller, Brodie, Briegs, Smyth, Bliss, Barbour, Radtke, Branagan, Grosso, Kirk, Nodzak, Mains; middle row: the Misses Baran, Heinl, De Shanse, Ludlow, Blauvelt, Nylander, Barioni, Larkin, O'Donnell, O'Connor, Wissmann, Pughe, Scherr, Clare, Kohlsdorf, O'Donnell, Molloy, White; seated: the Misses Nettleship, Haege, Johnston, O'Brien, Finate, Meyers, Smith, Crawford, Prouty, Salis, Banta, Cuervo, Yach, Maxwell, West

The following, not shown in the photograph, also qualified for certificates:

Helen Cruger
Elizabeth R. Fox
Kathryn E. Joyce
Addie E. Knoeller
Margaret J. McMillan
Ina K. Myrick
Patience B. Penney
Edith Repetti
Muriel W. Wille

* * * *

The Vermont Telephone Association, of which the Independent Connecting Companies of that State are members, as well as the New England Telephone and Telegraph Company, was addressed by S. P. Grace on June 15 at Burlington. Mr. Grace described the work of the Laboratories which has led to recent notable advances in telephony. Equipment for a Vitaphone demonstration, under auspices of Western Electric, was installed and operated by R. E. Kuebler of the Laboratories.

* * * *

The Laboratories participated in the Nassau County welcome to Colonel Lindbergh held at Roosevelt Field near Mineola on June 16 by providing a Public Address System at the request of the New York Telephone Company. At the corners of the platform were eighteen loud-speaking telephones, directed to various parts of the audience, and beneath was a booth housing the apparatus and the batteries. The system used was a Number 2, with an extra 9-A amplifier, installed and operated by G. C. Porter and C. F. Stephan.

Departmental Notes

Apparatus Development

H. S. Price inspected broadcasting stations of the Crosley Manufacturing Company at Cincinnati, of Gimbel Brothers at Philadelphia and of Larus and Brother Company at Richmond, Virginia.

W. L. Tierney visited Milwaukee, Yankton, South Dakota, and Beatrice, Nebraska, to make surveys for one-kilowatt installations for the Milwaukee Journal, the Gurney Seed Company, and the Dempster Mill Manufacturing Company, respectively. Then he went to St. Louis, where he tested and put into operation the new one-kilowatt station of Concordia Seminary, and inspected the five-kilowatt station of the Voice of St. Louis, Incorporated.

D. H. Newman, who left New York about six months ago to supervise installation of broadcasting equipment at Montevideo and Buenos Aires informed the Laboratories that regular broadcasting of operatic programs from the Colon Theater in Buenos Aires began on May 23, and that the Montevideo station was completed in June. At the request of those in charge at Buenos Aires Mr. Newman has postponed his return to New York for several months to train the operating staff and to supervise technical activities of the organization.

H. S. Price recently inspected radio station WMAF in preparation for its active season. This station, located on the estate of Colonel E. H. R. Green at South Dartmouth, Massachusetts, is ordinarily operated during the summer only.

H. S. Price and W. L. Tierney were recently in Buffalo, supervisng modification of a broadcasting station operated by the Churchhill Evangelistic Association to comply with the new requirements of the Federal Radio Commission. Mr. Tierney, after leaving Buffalo, went to San Francisco to supervise installation of a one-kilowatt broadcasting station for Don Lee, Incorporated.

R. D. Gibson spent several days in Huntsville, Alabama, modifying the power-line carrier-telephone system of the Alabama Power Company.

Research

D. G. Blattner was in Montreal from June 27 to July 2, to assist in a tie-in of broadcasting stations and long lines for broadcasting the Diamond Jubilee Celebration of the Dominion of Canada. This occasion was the first time that a united program was presented to the people of the Dominion from the Atlantic to the Pacific.

L. H. Germer gave a group of five lectures on thermionics at the Institute of Chemistry conducted by the American Chemical Society during the month of July at Pennsylvania State College. Dr. Germer's lectures, which started July 18, were part of a series entitled "Advanced Electron

Theory as Applied to Thermionic and Photoelectric Emission and Allied Subjects."

C. J. DAVISSON has been appointed a member of the National Research Council, Division of Physical Scientists.

D. G. BLATTNER conferred with Dr. Cabot in Boston on June 18 on recording and reproducing heart beats to facilitate the study of heart sounds.

R. M. BOZORTH, R. M. BURNS AND L. W. MCKEEHAN attended the Institute of Chemistry at Pennsylvania State College. Mr. Burns contributed to a discussion on "The Control of Corrosion—Protective Coatings" and Mr. McKeehan to a discussion on "Modern X-Ray Research on the Structure of Metals."

C. C. HIPKINS spent the past month in the laboratories of the New Jersey Zinc Company at Palmerton, Pennsylvania, to obtain information on paint testing methods and equipment.

A. W. HAYES was at Hawthorne June 30 to July 14 in connecton with carbon testing for the handset transmitter.

COMMERCIAL

G. F. FOWLER has been appointed to the Papers and Meetings Committee of the New York Electrical Society for the coming year.

W. F. JOHNSON was elected second vice-president of the Purchasing Agents' Association of New York at the annual meeting held July 8.

SYSTEMS DEVELOPMENT

E. VROOM AND G. F. SHULZE spent several days in Washington in connection with the application of an improved vacuum tube to toll equipment.

IMPROVEMENTS in the wiring arrangements of type "C" carrier telephone equipment were tested out at St. Louis by F. A. Brooks.

ONE OF THE FIRST automatic power plants installed in connection with a No. 9 switchboard was placed in service at Pitcairn, near Pittsburg, recently. This installation, which is in successful operation, was visited by R. L. Lunsford and W. S. Ross during the past month.

L. A. LEATHERMAN discussed our central office questionnaire with Chesapeake and Potomac engineers at Washington.

SEVERAL recent improvements in the method of supporting equipment structures have been installed in the new step-by-step office at Utica, New York, and in a toll office at Erie. These improvements were inspected during the past month by R. E. Noble and E. K. Eberhardt.

L. D. PLOTNER has been investigating tests on the new step-by-step installations at Springfield, Massachusetts, and Battle Creek, Michigan.

C. G. SPENCER visited Cleveland to discuss several features of the adoption of straightforward trunking equipment in that city.

INSPECTION AND OUTSIDE PLANT DEVELOPMENT

DURING JUNE W. A. Boyd, H. F. Kortheuer, O. S. Markuson, W. C. Miller and P. S. Olmstead attended Inspection Survey Conferences at Hawthorne. R. M. Moody attended a similar conference at Kearny.

J. A. St. Clair, Local Field Engineer for the Inspection Department at Atlanta, visited Jacksonville, Daytona, West Palm Beach, Lake Worth and Miami during the second week in June in connection with field work in his territory.

J. M. Schaefer, Local Field Engineer for the Inspection Department at Omaha, went to Helena and Missoula, Montana, during the latter part of June to investigate engineering complaints.

C. H. Amadon conducted timber preservation experiments in Denver during July.

W. H. S. Youry was in Boston June 16 to observe tests on pole reenforcements conducted by engineers of the New England Telephone and Telegraph Company.

L. V. Lodge spent the early part of July in Newcastle, New Brunswick, investigating northern pine poles.

F. D. Powers was in Providence July 6 for information concerning development studies on rubber gloves.

In Boston, on July 5, J. A. Carr investigated development studies on body belts and safety straps.

E. M. Honan and B. A. Merrick conducted experiments on copper wire splicing methods with engineers of the American Telephone and Telegraph Company and of the New York Telephone Company at Linden, New Jersey.

C. D. Hocker attended the annual convention of the American Society for Testing Materials held at French Lick, Indiana. C. S. Gordon attended the early sessions of the convention and then went to Chicago for the remainder of the week to visit suppliers of outside plant materials.

R. C. Kamphausen, Local Field Engineer for the Inspection Department at St. Louis, visited Dallas, Fort Worth, Houston and San Antonio during the latter part of June.

D & R News Notes

THREE new members of the Department are M. T. Dow, John M. Barstow and K. E. Gould. Their work will be on transmission and inductive interference problems. Mr. Dow, who has been with us for two summers on temporary work, has been an instructor in physics at Harvard for the past year. He received his Bachelor's degree at Ottawa, Kansas, in 1917, and in 1921 received the degree of M.A. from the University of Pennsylvania. From 1921 to 1923, he was a part-time instructor at M. I. T., the balance of his time being taken up with research work. Mr. Barstow, until recently an instructor in physics at Kansas State Agricultural College, obtained his B.S. degree from Washburn College in 1923 and received a Master's degree from the University of Kansas in 1924. He was employed by the Southwestern Bell Telephone Company during the summer of 1926 on transmission problems. Mr. Gould recently received the degree of Doctor of Science from M. I. T. He graduated from Oklahoma A. & M. College in 1924 and in 1925 received a Master's degree in E. E. from M. I. T. and during the past two years has been an assistant instructor at that institution, while pursuing his graduate studies. Mr. Gould spent last summer in this Department on work connected with inductive interference problems.

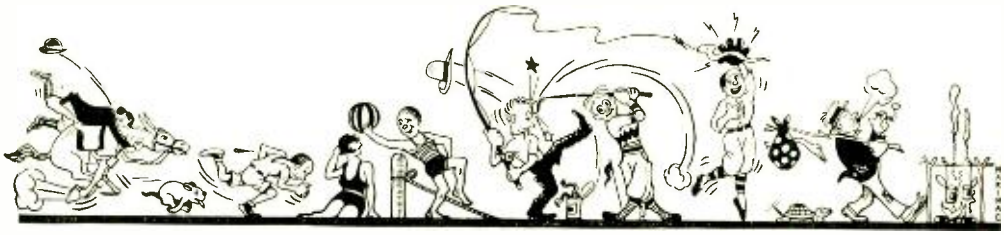
RECENT ENGINEERING GRADUATES who have been employed in this Department and assigned to work on transmission and inductive interferance, are as follows:

E. D. Guernsey, University of Michigan.
O. D. Grismore, Purdue University.
V. A. Douglas, Purdue University.
R. W. Gutshall, University of Colorado.

G. K. THOMPSON visited Baltimore early last week to make the preliminary arrangements for an historical exhibit to be made by the American Telephone and Telegraph Company at the Baltimore and Ohio Railway Company's Centennial Exhibit which will take place at Halethorpe, just outside of Baltimore, September 24 to October 8.

J. L. ALLISON of the Power Section spent a few days in the Pittsburgh district, inspecting the first automatic power plants installed for small offices. The Westinghouse factory at East Pittsburgh was also visited.

L. T. WILSON, L. A. KELLEY and R. H. CLAPP are at Denver participating in tests in connection with lightning interference in carrier telegraph circuits.



Bell Laboratories Club

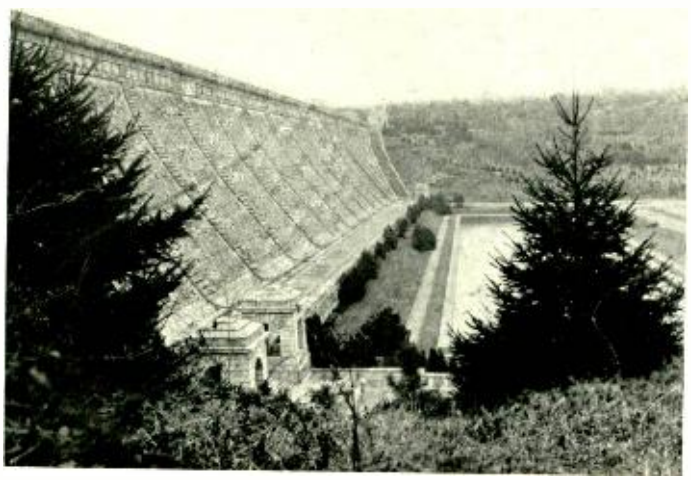
ONE hundred and forty of the Club's track and field athletes took part in the 1927 Club championships at Erasmus Field on June 18. The number of entries in this meet gives a good idea of the growth of our interest in track; in our first meet only seventy-six took part.

H. M. Yates remains supreme in the short dashes. In the hundred his victory was easily won, but in the two-twenty he had to fight off a desperate challenge by W. E. Whidden, also of the Research Department, finishing with advantage of inches only.

The hardest fought event of the day was the final heat in the sixty-yard dash for women. The finish of the race was absolutely brilliant, the Misses Hanley, Boman, and Rooney finishing almost simultaneously.

In the 440-yard dash, Kaler got away to a good start but had to be content with third place when he was passed by Quinn and Pasanen in the home stretch. However, he evened matters by winning the eight-eighty. Twenty-four runners faced the starter in this event. Moffit dashed to the front and held the lead until the last hundred yards, when Kaler passed him and held a two-yard lead to the tape.

The quarter-mile relay for women was both interesting and exciting. Five teams faced the starter in this race, which was won by Telephone Systems. It was a fight to the finish between Miss Wall of Telephone Systems and Miss Boman of Commercial. The mile relay for men was also won by Telephone Systems, the Model Shop taking second place. Gray of



From a hiker's photo album—the huge dam at Kensico Reservoir

HUNDRED-YARD DASH

First: Yates, Research.
Second: Whidden, Research.
Third: Ingram, Telephone Systems.

220-YARD DASH

First: Yates, Research.
Second: Whidden, Research.
Third: Sanchez, Research.

440-YARD DASH

First: Quinn, Telephone Systems.
Second: Pasanen, Model Shop.
Third: Kaler, Research.

HALF-MILE RUN

First: Kaler, Research.
Second: Moffit, Model Shop.
Third: Healy, Research.

60-YARD DASH FOR WOMEN

First: Eleanor Hanley, Research.
Second: Marie Boman, Commercial.
Third: May Rooney, Research.

QUARTER-MILE RELAY FOR WOMEN

First: Telephone Systems Department.
Second: Commercial Department.
Third: Research Department.

ONE-MILE RELAY FOR MEN

First: Telephone Systems Department.
Second: Plant Department.
Third: Commercial Department.

SHOT PUT

First: Dickenson, Research.
Second: Cronin, Telephone Systems.
Third: Kaler, Research.

HIGH JUMP

First: Kontis, Tube Shop.
Second: Cook, Inspection.
Third: Kaler, Research.

BROAD JUMP

First: Pasanen, Model Shop.
Second: Whidden, Research.
Third: Thorn, Telephone Systems.

BASKETBALL THROW

First: Josephine Fowler, Telephone Systems.
Second: Natalie Skinner, Inspection.
Third: Eleanor Hanley, Research.

SCORE FOR POINT TROPHY FOR MEN

Research: 34 points.
Telephone Systems: 15 points.
Plant Department: 14 points.
Tube Shop: 5 points.
Patent Department: 3 points.
Commercial Department: 1 point.

SCORES FOR POINT TROPHY FOR WOMEN

Telephone Systems Department: 10 points.
Research Department: 8 points.
Commercial Department: 6 points.
Patent-Inspection Departments: 3 points.

Summary of results of the Club's track and field meet

Telephone Systems and Pasanen of the Shop team were the stars in this event.

A jump of 19 feet 4 inches won the broad jump for Pasanen of the Model Shop, with Whidden's jump of 18 feet 10 inches second, and Thorn's of 18 feet 1 inch third. Dickenson of the Research Department won the shot put with a throw of 42 feet, and Kontis of the Tube Shop carried off first place in the high jump without difficulty.

One of the most interesting events of the day was the tug of war between two teams from the Model Shop and two from the B & M Department. In the trials both of the B & M teams defeated the Model Shop teams, making the finals between teams from the same department. The closeness of this event in trials and the finals is brought out by the fact that none of the teams competing won by more than two inches. All of the men who took part in this tug-of-war went through rigid training in preparing for the event.

The Western Electric Post of the American Legion staged a very interesting and amusing novelty race. Pipes were placed on first base, sacks of tobacco on second base, and matches on third base; the prize was given to the first three men who reached home plate smoking their pipes. W. A. Bollinger, Past-Commander of the post and Vice-Commander of the American Legion of New York County, was the winner.

Some Snapshots Taken at the

At the crack of the gun in the 440-yard dash

Finish of the sixty-yard dash: the Misses Rooney, Boman and Hanle (winner)

Leaders in the basketball throw: the Misses Hanle, Fowler (winner) and Skinner

Winning tug-of-war team, coached by W. C. Calmar: J. Marshall, P. Healey, P. Casey, F. Pracknaik, M. Cassalli

Club's Track and Field Meet

Yates leads the field across the line in the two-twenty

Pasanen hits the dirt in his winning broad jump

Kontis, high-jump winner, clears the bar

Snappy action in the tug-of-war—the rope almost moved

Hiking

A trip to Indian Point Park has been scheduled for Saturday, August 13. The trip up the river will be made on a Hudson Day Liner; then there will be a hike over the trails of the park. Bring some food to eat on the boat coming home—or you can buy some at the cafeteria on the boat. Other important data: the cost will be about $1.25; meet at the entrance of the new building at twelve-thirty; the hostess will be Miss Barton.

Hiking emblems have been awarded to fourteen hikers: the seventy-five mile emblem to Phyllis Barton and R. W. Bogumil; the forty-mile emblem to R. B. Blackburn, J. A. Bradbury, Evelyn Brisbane, Margaret Brisbane, W. C. Buckland, F. P. Faas, F. B. Hilton, Elizabeth M. Mains, Emma Nylander, F. R. Stansil, Ruth Twist, and Emma W. Wilson.

Some of our hikers catch a buggy ride