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MR. BELL INVENTS THE TELEPHONE

One day back in the eighteen-seventies, a pair of serious young men were tinkering with a new sort of telegraph set which they hoped would make their fame and fortune. They had some little steel springs, like the reeds of a parlor organ, hooked up to telegraph keys at one end of a wire; and a second set of reeds at the other end. They were trying to adjust the reeds at the far end to the same pitches as those at the transmitting end; this scheme would let them send a number of code messages over the same wire at the same time.

But the tuning was a difficult job; and because he was a trained musician, Graham Bell was doing this part of the work himself—holding a reed to his ear and adjusting its length so it would vibrate in tune to Tom Watson's reed.

In the meantime Watson was having his own troubles. Bell had to make his reeds

These scenes from the new A T & T sound picture "Mr. Bell" illustrate episodes in the invention of the telephone. Here Mr. Bell (Raymond E. Johnson) shows how he tuned a harmonic telegraph receiver

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Needing more energy to transmit speech, Mr. Bell made his "liquid transmitter," whose diaphragm had a platinum wire dipping into a small cup of acid

light and stiff, so they would vibrate fast enough to give the tones he wanted. For that reason, when the reeds were closely adjusted they would stick to the poles of the transmitter electromagnets and Watson would flip the reeds, with his finger, to set them in motion. On this particular day one reed was stuck to the adjusting screw, and Watson gave it a snap to get it loose. Bell heard his own reed respond with a distinct "twang" far different from the steady "buzz" he was expecting. He recognized it for what it was—an honest-to-goodness transmission of *sound;* and with a shout of excitement he dashed out to see what his partner had done.

This incident has been described again and again as the critical episode in the story of the telephone's invention. Perhaps it was. But the vital point in the episode is not the transmitted sound itself but Bell's interpretation of its meaning. As Sherlock Holmes was so fond of pointing out, we all have eyes to see and ears to hear, but we don't all use them to the same degree.

Holmes would have loved the story of Bell's invention of the telephone, for Bell was trained to track down the secrets of sound just as Holmes was trained to recognize a criminal by the cut of his beard. It was his inheritance from the two great Scottish scholars who were his father and grandfather, and it was the reward of his own energetic study. He was brought up to be a teacher of speech, or as his father put it, a "corrector of defective utterance!" He was a trained and talented musician. And like a thorough Scotsman, he studied not only the surface of his subject but its innards as well: he was just as much interested in the physiology of the organs of speech and hearing as he was in careful articulation, dramatic expression and graceful gestures.

There are all sorts of significant stories about Bell's early days in Edinburgh. He taught his dog to growl while he pushed the patient creature's jaws open and shut in an attempt to form words; with his brother, he built a "talking machine" in the form of the human vocal organs; and he learned his father's system of "visible speech" so well that he could read foreign languages aloud with a good native accent. Some time during these early years, perhaps while he was studying music in Edinburgh, Bell discovered that he could make a piano string sound its note by holding

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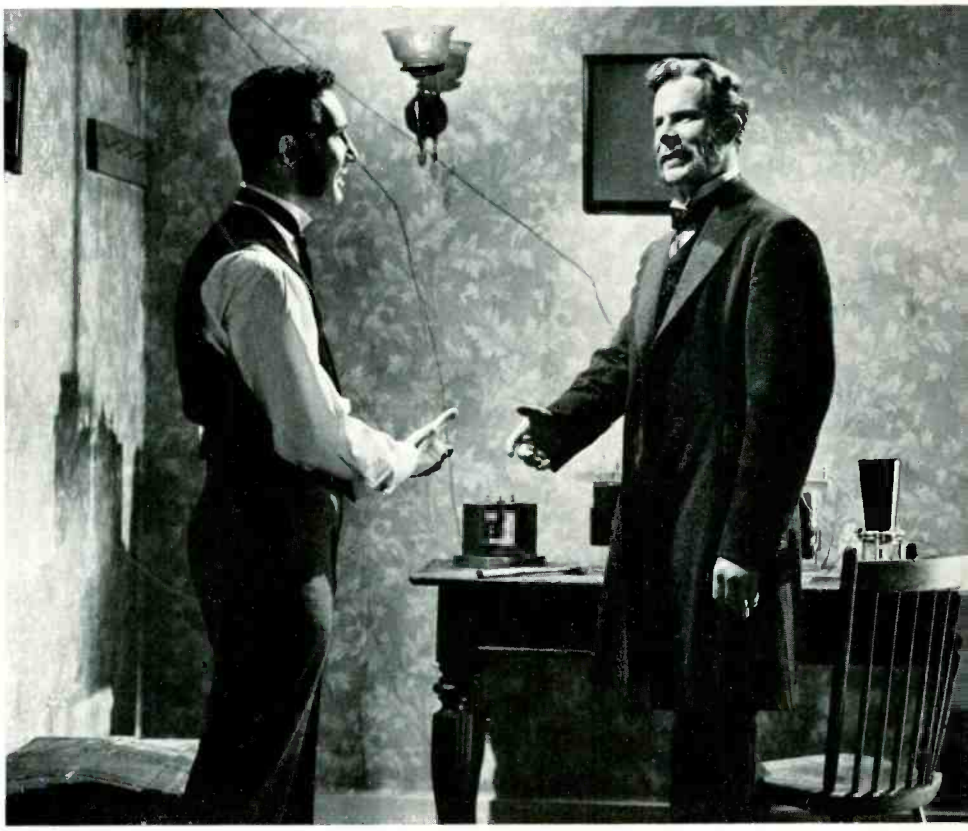
down the "sostenuto" pedal and singing close to the instrument. This amusing trick was never forgotten. It became the inspiration, later on, of the "harmonic telegraph" which he built with the help of his skillful assistant, Thomas Watson.

Another thing he discovered for himself (though others had observed it before him) was that any vowel sound is largely a combination of two tones, and these two tones are formed by the two cavities in the mouth—one in front of the tongue, and the other in back of it. He proved this by tapping his throat and cheek to get the air inside the cavities to moving, and then noting the pitches of the two tones. Melville Bell—Graham's father—told a friend about his son's discovery; and the friend, in turn, told Graham about some of the acoustical work of Helmholtz, the great German scientist.

One thing Helmholtz had done was to form synthetic vowel sounds by combining the tones of two tuning forks driven by electromagnets. But Bell, who did not read German and had to get his information second-hand, thought that Helmholtz had gone further and actually *telegraphed* vowel sounds. This set him to thinking furiously. One of the things he thought was that he had better start learning something about electricity, which he did. Another idea that followed was that he ought to be able to use these resonance phenomena, that interested him so much, to make a new kind of telegraph which would carry more than one message at a time through a single line. And, most important of all, he thought that somehow or other he might possibly be able to work out a machine that would send spoken words out over a wire. This last thought was pretty nebulous; but it was there, just the same, and it never went away.

It was at this time, while Graham was trying to repeat the Helmholtz experiments with electrically driven tuning forks, that



"Mr. Bell, I heard every word you said, distinctly!" says Watson (Mason Adams), rushing in from the other room

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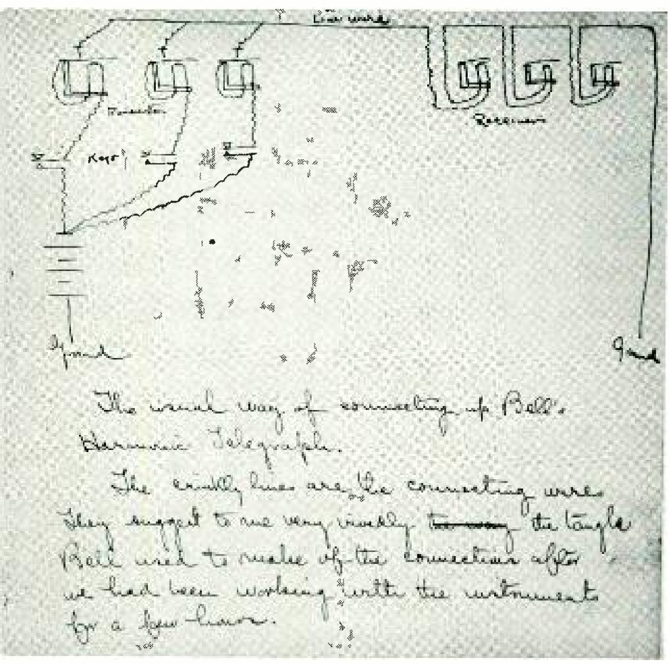
the Bell family moved to Canada. A year later, in 1871, he went to Boston to accept a teaching engagement his father was forced to refuse. There he presently opened a "school of vocal physiology" for deaf mutes, persons with defective speech, and teachers of the deaf and dumb. Later still he was appointed Professor of Vocal Physiology at Boston University.

During his year in Canada, Bell had been doing very little experimenting but a great deal of thinking. Now, settled down in Boston with a place of his own where he could work to his heart's content, he was ready for a fresh attack on the problem of the harmonic telegraph.

This harmonic telegraph of Bell's deserves some careful attention, because it was the direct ancestor of the "electric speaking telephone." In the light of our present knowledge, the device seems very simple, but in 1870 it was a bold and original idea. It is easiest to describe as a sort of primitive carrier system, with the carrier currents generated by tuned steel springs or reeds driven by electromagnets, and with telegraph keys serving as modulators.



Drawn many years later by Thomas A. Watson himself, this diagram shows how Bell proposed to make a harmonic telegraph system

Bell's idea was derived from his experiments with piano strings, and it was reinforced by his mistaken understanding of Helmholtz' work with tuning forks. Remembering that any piano string would respond to only one fundamental musical tone, he reasoned that a tuned reed at the far end of a telegraph line would vibrate in response to a make-and-break current sent out by the vibrations of a reed tuned to the same pitch at the near end *and to that frequency only*. He might, then, have three transmitting reeds, T-1, T-2, and T-3; and three receiving reeds, R-1, R-2, and R-3. Reeds T-1 and R-1 might be tuned to the note C, T-2 and R-2 to F, and T-3 and R-3 to A. With this arrangement, Bell reasoned, R-1 would vibrate only in response to a current from T-1, R-2 only to T-2, and R-3 only to T-3. The same reasoning would apply to a larger number of pairs of instruments. And Bell thought that several currents of different frequencies could travel over the same line simultaneously without interfering with one another; in other words, that a line was capable of carrying a complex current without serious distortion. To complete the system, a telegraph key in circuit with each of the tuned-reed transmitters might be made to interrupt the current in a series of dots and dashes which could be read by an operator using the properly tuned receiver at the other end of the line.

That was Bell's theory of the harmonic telegraph, and it was sound enough in principle. But what he found in practice was that the apparatus was far from easy to operate. At the frequencies he was using, the amplitude of the reeds was very small, and the adjustment of the make-and-break contacts was exceedingly critical. Frequently the reed would stick to a contact instead of vibrating as it should. Furthermore, he found that his receiving reeds left a great deal to be desired: their sound was so weak that they had to be held close to the ear to be heard at all; they were very hard to tune to the correct pitch to correspond with the transmitters; and they were not nearly so selective as he had hoped—in technical terms, their "Q" was much too low.

This simple explanation of the harmonic

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telegraph will clarify the story told in our opening paragraphs. The transmitting reed stuck to its contact, and Watson plucked it to get it started. But it stayed glued fast to the contact, and instead of generating the steady make-and-break current that he wanted, it did something far more important and exciting. It induced in the magnet a current varying in frequency and amplitude precisely with the characteristic sound of the twanging reed. The current was picked up by Bell's receiver, because he was holding the reed against his ear, damping its free end and thus helping it respond to a current of varying pitch. Bell heard the sound, as anyone might have done. But we can believe the inventor was unique in this: he could understand exactly what it meant. It meant that the telephone had ceased to be a dream, and was ready to become a reality.

At the Centennial Exposition held in 1876, Mr. Bell demonstrated this membrane-type transmitter to Dom Pedro, Emperor of Brazil

It was now June of 1875; Bell had been in Boston for four years, teaching and studying, experimenting with his telegraph, and groping his way slowly toward the invention that was to make him famous. Bit by bit he was filling in his mental picture of what the telephone must be: the sort of electric current that was needed, the kind of instruments that might be required. In 1874 one of his friends at Massachusetts Tech introduced him to two new scientific toys, the Phonautograph and the Manometric Capsule, each of which would draw a picture of a voice wave very much like the modern oscillogram with which we are all familiar.

When he saw these voice-pictures, Bell thought first of his deaf pupils: If they saw pictures of normal speech, they might work with their own voices till they could copy the patterns. He experimented with the Phonautograph and Capsule, but found their patterns too complicated to be helpful to the deaf. Fascinated none the less by their possibilities, he recalled his studies at the University of London, of the human ear, with its sensitive diaphragm, called an ear-drum, and its incredibly delicate system of recording levers. From his friend, Dr. Blake, in Boston, he obtained a specimen of an ear; and with it he made oscillograms like those of the Phonautograph.

Then he considered the pictures as reflections of the voice waves themselves. They were complex, pulsating waves. If the voice were to be carried by electricity, it would have to be by the same sort of complex, pulsating electric current—not the steady make-and-break current familiar to everyone at the time, the sort of current he was trying to use in his harmonic telegraph. *Was it possible to translate sound waves into such currents, transmit the currents over a wire, and then translate them again into sound?*

The conception of a complex voice wave was not new to Bell; it had been in his mind for some time, perhaps since the Canadian days. Now the pictures traced by the Phonautograph, the Manometric Capsule and the ear brought the whole idea into sharp focus.

In casting about for a device that would translate the voice wave into a corresponding electric current, it was natural that Bell should turn first to an elaboration of the

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harmonic telegraph. The word "elaboration" is carefully chosen: the mechanism he conceived was so complicated that he never tried to build it.

Let's suppose (as Bell did) that we have before us a whole series of harmonic transmitting reeds, tuned like the strings of a piano to the chromatic scale and covering a compass of three or four octaves. Add a transmission line and at the other end a corresponding set of receiving reeds. For four octaves we will need 48 reeds at each end, each with its own electromagnet; the transmitters responding to vocal tones instead of telegraph keys.

Now if you spoke a word at the transmitting end, wouldn't the word set the proper reeds to vibrating, generating make-and-break currents that would operate the corresponding reeds at the far end; and wouldn't those reeds in turn produce a complex of buzzing sounds that would at least form a reasonable imitation of your original utterance?

At a lecture demonstration that was held in New York City, music and speech transmitted from New Brunswick were heard by the audience. Pictured is the identical "box telephone," now in our Bell System Historical Museum at West Street

No one knows if the machine would work, for no one has ever tried it. Bell called it his "Harp Telegraph" and there he stopped, for he realized its impossible complications. But it was a milestone none the less, for it set him to thinking about possible simplifications, and those simplifications ended in the telephone.

Step No. 1—the magnets.

If it were possible for a single wire to carry a constantly varying complex current, why couldn't the same sort of current be set up in a single electromagnet instead of requiring a whole series of electromagnets?

Step No. 2—the reed.

Why do we need a whole series of tuned reeds to pick up all the frequencies of speech? Remember the ear-drum, that marvelous instrument that can pick up every *nuance* of the human voice and translate it into nerve-currents for the brain. Why not a single *diaphragm?*

Step No. 3—the current.

We need an induced current, not a make-and-break current. We need a "continuously variable, pulsating current" such as no tuned reed with its opening and closing of a line can ever generate. Bell knew this, though just when he was conscious of it we can't say. And he knew that the generation of such a current was theoretically possible by moving a piece of metal back and forth in the neighborhood of an electromagnet. But, he thought, would not any induced current be too weak to be of any practical use? That question was answered when he heard the twang of Watson's reed.

The two young men working in a Boston attic in the late spring of 1875 had not perfected their harmonic telegraph, but they had done something much more important. They had transmitted sound—and a practical telephone was just around the corner. Watson's reed had served as a diaphragm, actuated in this case by the tip of his finger rather than his voice. It had

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set up in an electromagnet a pulsating, complex current. And that induced current, traveling through a wire, had been strong enough to control the reed at the inventor's ear.

Bell saw at once what had happened. And he saw, too, that a drumhead diaphragm attached to the reed would make it vibrate with the sound of the human voice. That same night he gave Watson directions for building the famous "Gallows-frame" model. The next day it was finished; and it transmitted recognizable voice sounds, although it was not sensitive enough to handle articulate words. Months of heart-breaking labor were required before the instrument was built that carried the first complete sentence. But the corner had been turned. The principle of the telephone had been established.

THE AUTHOR: A graduate of Hamilton College in 1920, ARTHUR THOMPSON immediately joined the Laboratories. In the ensuing years he made an intensive study of typography and printing methods, fields in which his authority was recognized by election to the presidency of the American Institute of Graphic Arts. During World War II he was concerned exclusively with the editing and production of instruction manuals for the Army and Navy. In January, 1946, Mr. Thompson was made Publication Production Manager—his responsibilities covering books, booklets and monographs; illustrations and printing; and displays, demonstrations, and motion pictures.

J. R. PIERCE HONORED BY I. R. E.

The 1947 Morris Liebmann Memorial Prize of the Institute of Radio Engineers has been awarded to J. R. Pierce for his development of a traveling-wave amplifier tube having both high gain and very great band width. Members of the Laboratories who have received this prize are R. A. Heising, J. R. Carson, Ralph Bown, Edmond Bruce, F. B. Llewellyn, W. H. Doherty, G. C. Southworth, H. T. Friis, and S. A. Schelkunoff.

The I. R. E. has also elected as Fellows: K. G. Jansky for his researches in the realm of cosmic and circuit noise affecting radio communication; and J. W. McRae for his outstanding work in the planning of research development programs in radar and countermeasures and for his researches in radio transmitting methods.

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MEASURING MICROHARDNESS BY INDENTATION TESTS

E. S. GREINER
Chemical
Laboratories

One of the most commonly measured characteristics of metallic materials, hardness, is often determined by pressing a ball, cone, or pyramidal-shaped indenter against the specimen with a known weight and observing the penetration obtained. In its usual form the apparatus is not suitable, however, for measuring the hardness of plating on metals, thin sheets, or the structural constituents in metals which are microscopic in size.

To determine the microhardness of metallic materials it is necessary to indent them with a specially ground diamond. The size of the indentation is measured under a microscope. A polished specimen is placed on a movable stage, Figure 1, and an area for test is selected. Then the specimen is moved to a fixed position under an indenter by sliding the table along a machined track. This locates the indentation so that it can be seen for measure-

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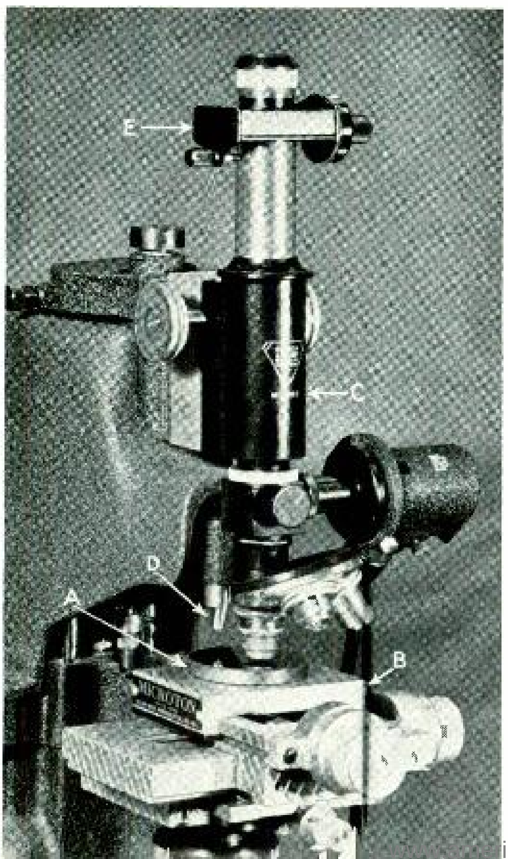
ment by returning the specimen to its initial position under the microscope.

The specimen is indented by slowly driving it upward with a motor-operated screw until it contacts the indenter. At the moment contact is made, a part of the load is applied to the indenter and the rest immediately after the upward motion of the specimen has been stopped by breaking an electrical contact. The total load, which may be from 25 to 3,600 grams, acts for approximately 20 seconds while an electric timer operates, after which the indenter is raised and the specimen lowered, thus completing the process. These operations are carried out automatically by electrical relays and the timer. The dimensions of the indentation, which are frequently from 0.001 to 0.004 inch, are measured with a micrometer eyepiece.

Diamond indenters for microhardness tests are generally of two types—Vickers* and Knoop. They differ in form as is shown in Figures 2 and 3. The hardness value for the Vickers instrument is the load in kilograms per square millimeter of indented surface; while that for the Knoop is the load in kilograms per square millimeter of the indentation at the surface of the specimen. With the Vickers instrument the hardness is computed by the formula $H_v = 1.854 \frac{P}{D^2}$ where P is the load in kilograms applied to the indenter, and D is the length in millimeters of the surface diagonal of the indentation, as shown in Figure 2. Similarly for the Knoop indenter, the hardness $H_k = 14.23 \frac{P}{L^2}$ where P is the load in kilograms and L is the length in millimeters of the indentation, Figure 3. The numerical constants in each of these equations are for ideally perfect indenters and relate the measured dimensions to the areas used to calculate the hardness. The Vickers and Knoop hardness values of specimens determined by these methods are of the same order of magnitude.

Fig. 1—Microhardness tester developed by the Wilson Mechanical Instrument Company. The specimen A is mounted on a stage B, which slides back so that the position on the surface selected by the microscope C can be brought under the indenter D. The indentation is measured with the micrometer eyepiece E



An application of the microhardness test for determining the Vickers hardness of specific areas in a specimen of low carbon steel impregnated with aluminum is shown in the photomicrograph of Figure 4. The diffusion layer, at the top, is an iron-aluminum alloy and has a Vickers hardness value of 200. The low carbon steel, at the bottom, has a value of 120 and is therefore softer than the diffusion layer. Both of these measurements were made with a 200-gram load on the indenter, and the difference in size of the indentations is visual evidence of the difference in hardness.

Similarly, the use of the Knoop indenter for determining the hardness of structural areas in a lead-antimony alloy is shown in Figure 5. The light-colored area consists of nearly pure lead and large precipitated particles of antimony, Knoop hardness 5; the darker area is a solid solution of antimony in lead and very small particles of antimony, Knoop hardness 10, when measured with 25 grams on the indenter. A comparison of the indentations shows the latter are areas of substantially greater hardness than the former.

This microhardness test can be used on thin sections of materials. Thus it was pos-

*This is also known as the 136-degree Diamond Pyramid Test.

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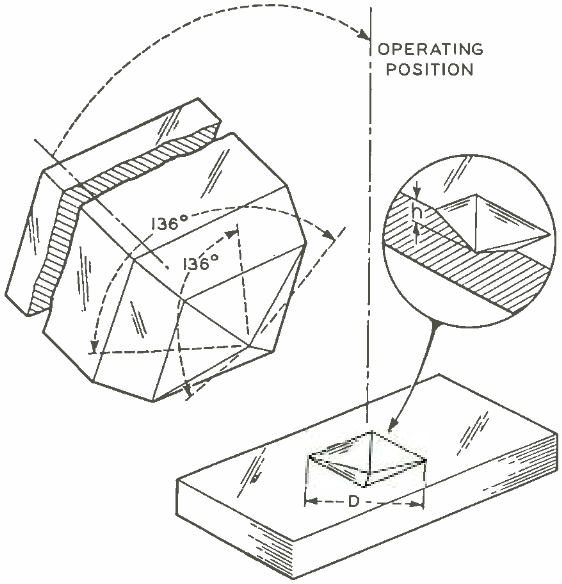

Fig. 2—Vickers indenter and the form of its indentation. D is the length of the diagonal at the surface and h is the depth of the indentation

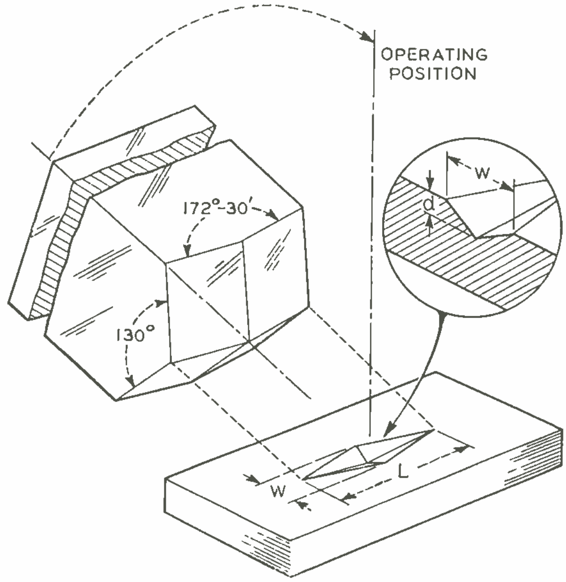

Fig. 3—Knoop indenter and the form of its indentatio L is the length of the long diagonal at the surface, W that of the short diagonal and d is the depth

Fig. 4—Vickers indentations in a diffusion layer of an iron-aluminum alloy (top) and in the low carbon steel base material (bottom). Magnification 500

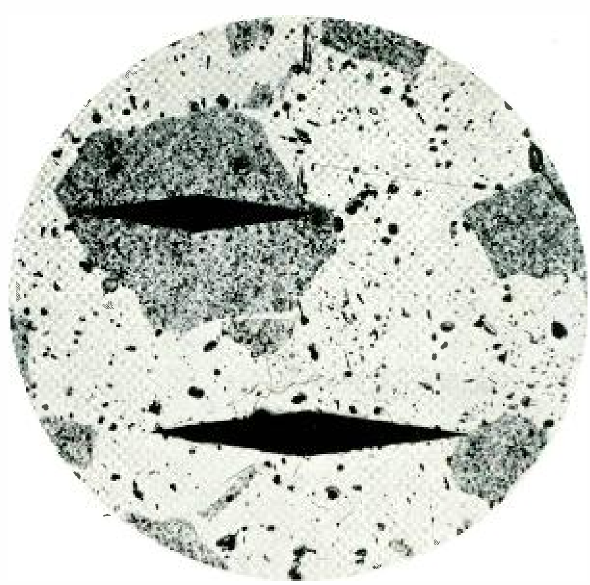

Fig. 5—Knoop indentations for determining hardness of structural areas in a lead-antimony alloy. The magnification in this case was 250

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sible to measure the variations in hardness across the edge of a copper-beryllium alloy specimen which was only 0.032 inch thick. The curves in Figure 6 show that the Vickers hardness of this annealed material is greater at the surfaces of the sheet than at the center, and that a reversed stressing test had not appreciably changed the observed values. The higher hardness at the surface can be explained as due to a light rolling operation used to flatten the sheet after the quench-annealing treatment had been completed.

With the usual, or macrohardness methods, it is generally not possible to test rolled metallic sheet whose thickness is less than approximately 0.010 inch. On the other hand, with the microhardness tester it has been possible to measure specimens as thin as 0.002 inch. Methods for determining the microhardness of such sheets, however, are as yet in the experimental stage and have not been standardized.

Determination of the hardness of metals on a microscopic scale has proved to be a valuable research technique. It is now possible to measure crystals or areas in metallic materials as small as 0.001 inch in diameter. Thus the hardness of either the brittle or soft constituents in certain polyphase alloys may be determined. Data gathered in this manner will help evaluate the properties of metallic materials.

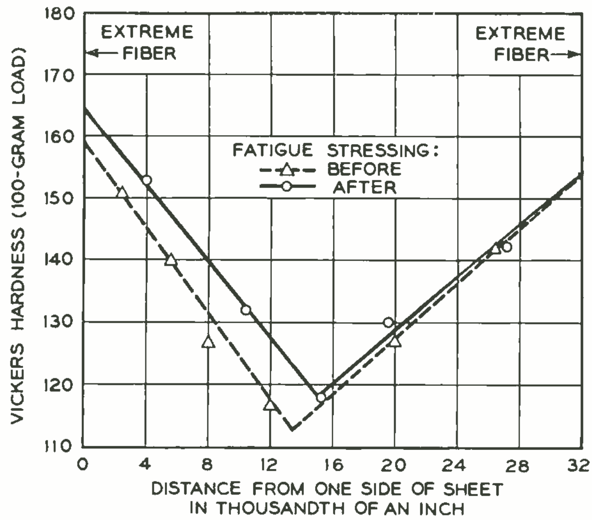

Fig. 6—A thin copper-beryllium alloy sheet is harder at the surfaces than at the middle. Fatigue stressing did not change the hardness appreciably

THE AUTHOR: Earl S. Greiner received a B.S. degree from the Carnegie Institute of Technology in 1928 and an M.S. from Lehigh University in 1930. After coming to the Laboratories in 1930, he studied at Columbia University under the Laboratories' part-time post-graduate plan and received the Ph.D. degree there in 1944. His work at the Laboratories initially was concerned with investigations of magnetic materials for sound recording applications. At present Dr. Greiner is engaged in studies relating to the structure and properties of metallic materials. He is a member of the A.I.M.E., the American Society for Metals, and the American Society for X-Ray and Electron Diffraction.

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DOUBLE-SPEED TELETYPEWRITER TRANSMISSION

G. J. KNANDEL
Telegraph Development

During the war both the Army and Navy found that certain of their major radio-teletypewriter circuits were becoming overloaded with the immense amount of traffic they were required to carry. To establish paralleling circuits seemed undesirable because of the scarcity of available frequency allocations and the additional radio terminals that would be required. The services therefore came to the Laboratories with their problem. Since the circuits were capable of carrying at least 46-cycle teletypewriter signals under normal conditions, while only 23-cycle signals were required for single-channel operation at sixty words per minute, then in use, it was suggested that the signaling speed be doubled by using a two-channel system.

For such a system, only the development of a new two-channel start-stop transmitter-distributor, capable of sending two sixty-speed messages simultaneously over a single radio circuit, would be required, since the two channels could be readily separated at the receiving terminal by suitable adjustment of two standard teletypewriter units. Such a transmitter-distributor was not available, but a preliminary model was designed and built by the Teletype Corporation following suggestions from the Laboratories, and was tested at the Laboratories. The Teletype Corporation then built a production model on which additional tests were made, and then they built the units furnished to the services. The transmitter-distributor is shown in the illustration on page 110. A considerable number of these two-channel transmitter-distributors were supplied to the Army and a smaller number to the Navy by Teletype Corporation during the war.

Two messages previously perforated in tape may be transmitted simultaneously over a single telegraph channel by means of the dual transmitters of the unit, thereby doubling the word-carrying capacity of the channel. Two teletypewriters or typing reperforators operating at sixty-speed are, of course, required to receive the two messages. The transmitter-distributor, by a simple switch operation, may be arranged for operation on a single-channel sixty-speed basis when the extra capacity of the second channel is not required, or when the channel deteriorates temporarily so that it is not capable of carrying the higher frequency satisfactorily. In this case one teletypewriter is stopped.

The two teletypewriter channels into which the telegraph circuit is divided are designated "Channel A" and "Channel B." Signals sent over these channels employ the same start and stop pulses to keep the receiving machines in synchronism, but the five normal selecting pulses are each divided in half. The first half of each normal pulse carries the intelligence of one channel, while the second half of each normal pulse carries the intelligence of the other channel. The receiving mechanisms of the two teletypewriters are connected in series, and start to revolve simultaneously at the beginning of the received start pulse. They are adjusted to select on the proper half-pulses, the "B" teletypewriter selecting at the approximate center of the first half-pulse and the "A" teletypewriter selecting at the approximate center of the second half-pulse. Both receiving mechanisms stop during the stop pulse and await the next start pulse.

The manner in which the signals are sent may be seen by reference to the accompanying diagram, which shows the connections of the unit arranged for two-channel operation. Each of the five select-

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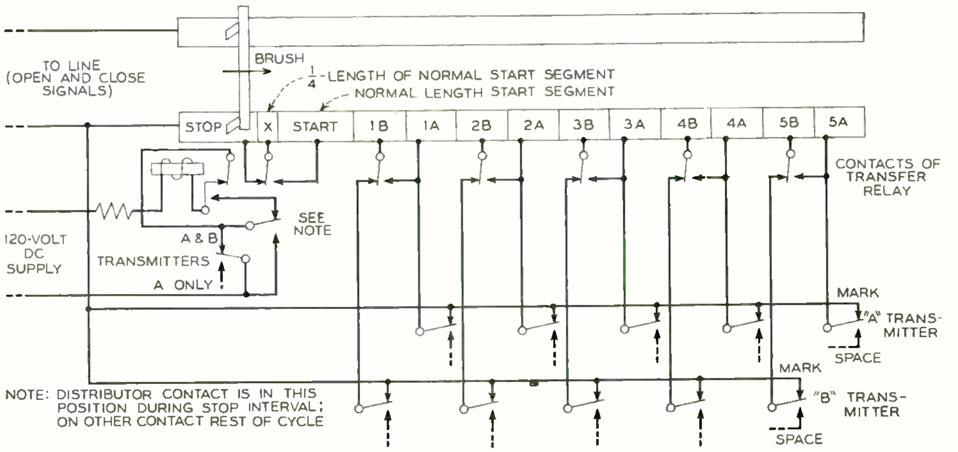
ing segments is cut in half: the first half being designated "B", and the second half "A". The five "B" selecting segments are connected to the contacts of transmitter "B", while the five "A" selecting segments are connected to the contacts of transmitter "A". The "X" segment is part of the normal stop segment, and is connected to it for two-channel transmission. The tape feed mechanisms of the two transmitters are connected together and feed tape simultaneously. A send-stop lever is provided on each transmitter so that the tape feed of that transmitter can be started and stopped while the other transmitter is feeding tape. This permits one transmitter to be stopped to insert and remove tape while tape is being sent from the other transmitter. Under this condition, spacing signals are sent on the channel of which the transmitter is stopped, since the common start and stop pulses are still transmitted. The distributor brushes are normally moving over the segments, but a short circuit

As tapes pass through the transmitters, the tape sensing pins, controlled by the perforations in the tape, operate the transmitter contact tongues to marking or spacing. The distributor brushes, traversing the distributor rings, open and close the line circuit in accordance with the tape perforations and send signals to the line consisting of normal-length start and stop pulses, with ten half-length selecting pulses between in place of the usual five standard-length selecting pulses.

A lever mounted on the right front of transmitter "B" controls a transfer relay that arranges the unit for single-channel or two-channel operation. When the relay is released (single-channel operation) the "B" half-segments are disconnected from the transmitter "B" contact tongues and are connected to the corresponding "A" half-segments, resulting in five normal-length segments, the signals from which are controlled by the "A" transmitter contact tongues. In addition, the "X" segment,



Circuit arrangement for the two-channel teletypewriter system

(not shown) is applied to the line when both transmitters are stopped so that no signals are sent to the line. When a transmitter is started, the short circuit is not removed until the brushes are on the stop segment, so that the first signal that is transmitted to the line is a perfect signal, beginning with a start pulse.

which is part of the normal stop segment and is connected to it when the unit is operating on a two-channel basis, is disconnected from the stop segment and is connected to the start segment. The "X" segment is one-fourth of a normal selecting segment in length and its addition to the start segment results in the start pulse

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Transmitter-distributor for the two-channel system developed by the Teletype Corporation

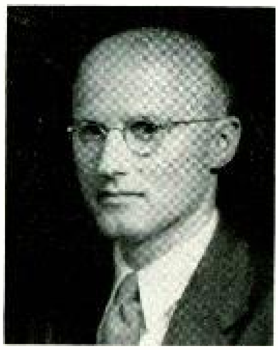
being one-quarter pulse longer than normal when the transmitter-distributor is operating on a single-channel basis.

The purpose of this may be seen by reference to the diagram. When receiving two-channel signals, the "A" teletypewriter is adjusted to select at the approximate center of the "A" pulses, so that an equal amount of shortening or lengthening of pulses can take place before errors occur. If the "A" and "B" pulses are combined into one set, with no other change, it will be seen that the "A" teletypewriter, which selects at fixed times after the beginning of the start pulse, will select at the approximate three-quarter points of the combined pulses, and therefore will not take advantage of the longer-length pulses. By beginning each start pulse one-quarter of a pulse-length sooner, the "A" teletypewriter will select at the approximate centers of the combined "A" and "B" pulses. The "A" teletypewriter, without readjustment, will then take full advantage of the lengthened signaling pulses, and can therefore tolerate approximately twice as much time distortion in the incoming signals before making an error.

When the lever is thrown to single-channel operation, transmitter "B" is mechanically prevented from feeding tape. When thrown to two-channel operation, the transfer relay is operated, but the circuit is so arranged that the relay can be operated or released only while the distributor brushes are on the stop segment, thereby preventing mutilation of a signal combination.

It is, of course, possible to receive the two-channel signals sent from the transmitter-distributor at two different points, recording the signals of channel "A" on a teletypewriter located at one point and those of channel "B" on a teletypewriter located at the second point. When reverting to single-channel operation under these conditions, the teletypewriter at the second point must be readjusted to receive channel "A" signals, and the circuit then shared on a time basis until conditions permit resumption of two-channel operation.

THE AUTHOR: G. J. Knandel received the degree of E.E. from Cornell University in 1924 and immediately joined the Department of Development and Research of the American Telephone and Telegraph Company, where he engaged in the development of teletypewriter private-wire switching arrangements, and later of the TWX system. Shortly after the 1934 consolidation, he transferred to the circuit group, and spent five years in the development of teletypewriter station arrangements. In 1940 he returned to the teletypewriter engineering group, where he was again concerned with the development of central-office teletypewriter exchange equipment. During the war he was engaged in the engineering of teletypewriter terminating arrangements for Army and Navy wire and radio circuits.



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R. W. MARSHALL
Transmission
Development

ECHO BOXES FOR RADAR TESTING

Although radars, among the most complex devices of the recent war, often employ hundreds of electronic tubes, one of the widely used testing devices—the echo box—employs no tubes at all. Moreover, though a test instrument should ordinarily be at least one order of magnitude more precise than the system tested, which tends to add to its complexity, an echo box is extremely simple in conception and manipulation. Its design, however, involves exceedingly complex theory. Extensive studies and experimentation were required to secure simplicity in manipulation and precise and easily interpreted results. Since echo boxes are used for daily over-all checks of radar operation in ships, planes, submarines, and wherever radar is used, the simplicity in operation, combined with small size and weight, has been of immense advantage.

In normal operation, the short intense pulse of power from the radar transmitter is followed by a period during which the receiver is ready to receive the portion of pulse power reflected from an object. Most receivers are sufficiently sensitive so that a reflected signal about one quadrillionth (10^{-15}) of the power of the transmitted pulse will produce a radar indication. The time intervals measured from the beginning of the transmitted pulse to the arrival of the reflected signals are measures of the range to the objects. To maintain coverage, the transmitter power and the receiver sensitivity, both of which are subject to deterioration, must be maintained sufficiently well to disclose small objects such as airplanes and submarine periscopes at the maximum range of the radars. It is the quick and simple measurement of transmitter and receiver performance individually and as a system that the echo box makes possible.

An echo box is merely a cavity in which an electromagnetic field is established by the output pulse of power from the radar transmitter. The cavity acts as a resonant circuit to these waves, and at the termination of the input pulse the stored energy decays, following an exponential curve as does the current of a coil and condenser circuit at lower frequencies. The stored microwave energy is released over a relatively long period of time, furnishing a signal to the receiver. The length of time the energy from the echo box is effective in providing a signal depends principally on the field produced in the box by the transmitter pulse and on the sensitivity of the receiver response to the decaying echo-box signal. Thus the test signal is subject only to the variations due to the radar system performance. The name "echo box" comes from the fact that the test signal is somewhat similar to an actual echo.

The method of test is indicated diagrammatically on the next page. A directional coupler or a small antenna is provided through which a small but known amount of the transmitter pulse is diverted to the echo box. At the termination of the pulse, energy is re-radiated from the echo box, transmitted back through the directional coupler or antenna and picked up by the radar receiver. The resulting radar indica-

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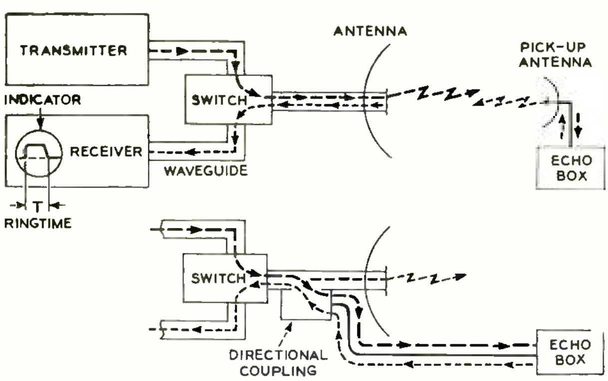
tion of distance, which is equivalent to an elapsed time, is thus a measure of the over-all operating performance. The values of both transmitted power and receiver sensitivity are satisfactory if the duration of the signal from the echo box indicated by the system meets established requirements. Should the time be found short, the transmitter frequency, power output and spectrum may be measured by utilizing the frequency-calibrated dial of the echo box and the meter indications on the test set panel. The latter furnish relative indications of the amount of energy being supplied to the echo box. Likewise, many important aspects of receiver operation can be quickly checked.

As indicated in the diagram, the test set may be connected to the radar system through a directional coupler or pick-up antenna. Corrections for the particular type

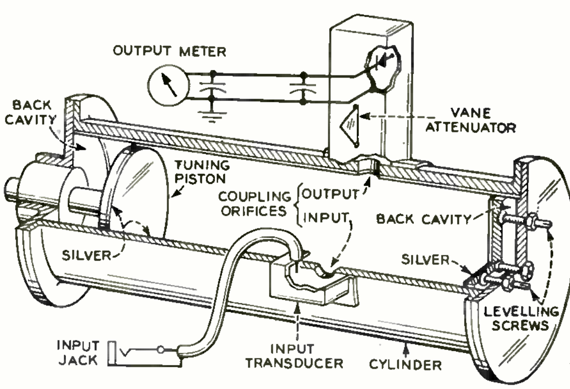


Method of testing a radar with an echo box

of coupling are included in the calibration or "expected ringtime" figures of a satisfactory system. "Ringtime" is the measure of over-all operation, being the interval from the beginning of the transmitted pulse to the time energy from the echo box is no longer detectable. When a bell is struck, its ring is heard until the sound drops below the audible threshold. Since the electromagnetic oscillation in the echo box is analogous to the mechanical vibration of the bell, the term "ringtime" was used to describe a similar interval.

To secure high precision in testing with an echo box, it is desirable to have a long "ringtime." The longer the "ringtime," however, the larger and heavier will be the box, while for testing on board ship, and particularly in planes, small size and weight is imperative. It has been found, however, that entirely satisfactory precision is obtained if the "ringtime" is made a large percentage of the shortest range scale of the radar indicator.

With a given size of echo box, long "ringtime" is secured by a design giving a slow decay of energy in the box, which means that the losses must be low. As with all resonant circuits, the criterion used for losses in an echo box is its Q, which is proportional to the ratio of the energy stored to the energy lost per cycle. At a frequency of 10,000 megacycles and with a receiver capable of indicating 150 db



Cross-section of typical echo box

below the energy of the transmitted pulse, a Q of 55,000 is required to secure a "ringtime" of 20 microseconds, equivalent to an object at 3,270 yards. Echo boxes with Q's much greater than this value were commercially produced.

In seeking the most suitable form for the echo boxes, many types and shapes were studied. Coaxial structures met some of the requirements, but their Q's are not sufficiently high. Hollow metal structures proved more satisfactory, and cubes, spheres, and cylinders were all tried. Of these shapes,

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right cylinders proved the most satisfactory, and were used for the majority of the boxes designed for the Armed Forces. The design is complicated, however, by the possibility of many modes of vibration simultaneously, each having a different Q and thus producing signals of different "ring-times." For high Q cavities, especially those intended for use over broad frequency bands, suppression of these unwanted modes and preservation of flat frequency response involve design problems of the highest order of difficulty. Moreover, the requirements for dimensional precision, extreme fineness of tuning control, and accurate resetting, give rise to difficult problems of mechanical design.

All of the tunable box tests designed by the Laboratories and manufactured by the Western Electric Company consisted essentially of cylinders of precise inside diameters. Tuning is accomplished by a single knob that moves a plunger in and out to change the effective inside lengths. The general arrangement of the box is as indicated in the second diagram. Energy is received and taken out through the input coupling orifice while a small amount of energy is taken from the output orifice to actuate the meter that measures the energy received. The box is fastened to one side of a panel and on the other side are mounted the meter, the tuning control, and the input jack. This panel serves as the cover of a container that encloses the echo box.

Front view of echo box panel, above, and rear view of panel showing echo box, below

Although the echo box was originally intended to provide a day-to-day check of radar performance, its simplicity of operation and the large amount of information that can be obtained with it has greatly increased its use. In many cases it is employed to secure an absolute measure of radar system operation. Other apparatus, such as precision signal generators and power meters, are used for more extensive testing and maintenance, but the echo box is the indispensable "must" in the satisfactory operation of radar.

THE AUTHOR: R. W. MARSHALL received the Bachelor of Electrical Engineering degree from the University of Minnesota in 1934. Attending Columbia University on an A.I.E.E. Scholarship, he obtained the M.S. degree in 1935. He remained on the faculty at Columbia until joining the Laboratories in 1936. Prior to his war work on radar test equipment, principally echo box test sets, he had participated in various phases of carrier systems development. He is now engaged in over-all system studies on the coaxial cable L-1 carrier development. He is a member of the Institute of Radio Engineers.

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CONTINUOUS ELECTRICAL COMPUTATION

C. A. LOVELL
Switching
Research

Electrical computing devices using relays for most of their operating components were developed by the Laboratories before the war, and others of the same general type were developed for war applications.* In solving a simple equation such as $y=v \cos \lambda$, computers of this type refer to a table to find the cosine for a given value of λ, and then multiply the cosine by the corresponding value of v. By repeating this operation for a number of values of v and λ, data are available from which a curve representing y may be plotted. Although the computer itself may work continuously, it determines only discrete results, and for each result obtained requires a time interval that depends on the nature of the problem. For electrical fire-control systems, of which the M-9 director† was one of the first, something different was needed. The position, speed, and direction of the target must be determined continuously and without any lag for relay operation so that its position some seconds in the future will be continuously calculable to permit the guns to be kept trained to the proper position, and the shell-timing mechanism kept continuously set to give the correct time of explosion.

In fire-control problems, the original data and the final answers are in the form of rotations of shafts. The angle of elevation of the target and its azimuth are both given by the positions of the tracking shafts, such as those of tracking telescopes or radar antennas, and the slant range, or distance to the target, is indicated by the position of a phase-shifter shaft on the radar range unit. The final answers are elevation and azimuth of the gun and a time setting for the fuse, expressed as shaft rotations.

The basic conception of the director design was to devise electrical circuits that would carry out all the needed mathematical operations continuously rather than in discrete steps, and convert the results into shaft rotations that would maintain the guns pointed in the proper direction at all times. To the success attained, potentiometers, high-quality condensers, servos, and vacuum-tube amplifiers have rendered essential contributions.

A potentiometer, for example, provides a convenient method for multiplying some factor in the form of a shaft rotation by some other factor in the form of a voltage. The situation is illustrated in Fig. 1, where e_1 is the voltage factor, and θ—the shaft position of the potentiometer—is the rotation factor. The current i that flows through the potentiometer is equal to e_1 divided by the total resistance of the potentiometer, r_m. Assuming that the brush is essentially open-circuited—that is, that no current is taken from it—the voltage e_0 is ir, where r is the resistance from 0 to a. Substituting e_1/r_m for i in this expression gives $e_0=e_1 r/r_m$. If the potentiometer is uniformly wound, this ratio r/r_m is equal to θ_a/θ_m, where θ_a is the angle of the brush at position a, and θ_m is the angle

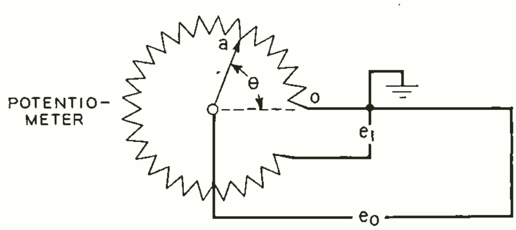

Fig. 1—A circular potentiometer gives as its output voltage e_0 the product of a constant represented by e_1 and an angular displacement θ

*Record, *December*, 1946, *page* 457, *and January*, 1947, *page* 5.
†Record, *January*, 1944, *page* 225.

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the brush covers in traveling to the end of the potentiometer. Thus $e_0 = e_1\, \theta_a/\theta_m$.

In this example, however, e_1 is always multiplied by θ_a/θ_m, which is the relative angular rotation of the shaft, while it might be desired to multiply by the absolute amount of rotation, θ_a, so as to make $e_0 = e_1\theta_a$. This may readily be accomplished by inserting an amplifier, Fig. 2, with the amplification factor μ equal to θ_m in magnitude. The voltage now applied to the potentiometer is μe_1 instead of e_1, and e_0 becomes $\mu e_1\, \theta_a/\theta_m$, and since $\mu = \theta_m$, $e_0 = e_1\theta_a$,

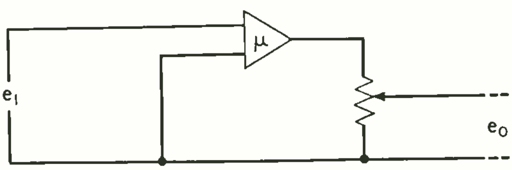

Fig. 2—By inserting an amplifier in the potentiometer circuit, any desired scale factor may be introduced

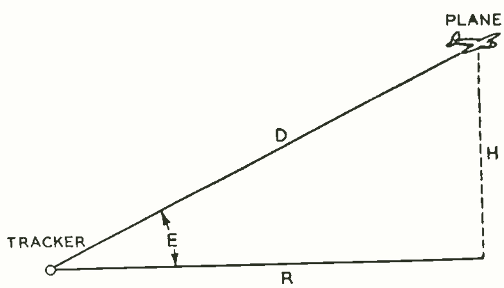

Fig. 3—The height of a plane observed by a tracker is equal to the slant range D times the sine of the elevation angle E

which is the result desired. Such an amplifier provides a means of adjusting scale factors to any desired values.

The great utility of potentiometers for multiplying lies in the fact that they permit e_1 to be multiplied by a function of θ as well as by θ itself. Suppose it is desired by use of a potentiometer associated with the elevation tracker to derive a voltage proportional to the altitude of the target. As indicated in Fig. 3, this altitude H is equal to D sin E, where D is the slant range and E is the angle at the elevation tracker. The problem is to design a potentiometer so that when a voltage proportional to the slant range is applied across it, and the potentiometer brush is driven by the tracker, the output voltage will be D sin E.

Since the general equation, established above, is: $e_0 = r/r_m\, e_1$, and since e^1 is to be equal to D, the problem is to design a potentiometer so that $r/r_m = \sin\theta$, thus making $r = r_m \sin\theta$. The value of r in this equation is the sum of the resistances of all the turns of the potentiometer from the point o up to the point a. This resistance increases by the resistance of one turn each time the brush moves an angular distance equal to the space occupied by one turn. Since very fine wire is employed, the space occupied by one turn is very small, and the resistance of one turn, r_t, may thus be taken as the derivative of r with respect to θ. Further, the angular separation between turns may be made small enough that the computation proceeds smoothly rather than in noticeable steps.

The wire for these potentiometers is wound on very thin cards, and thus the resistance of a turn, neglecting the very small thickness, is proportional to the width of the card at each point, or $r_t = kw$. In the example given above, the card was of constant width, and, thus r_t was constant, but in general the width may be made to vary with θ.

To find the proper width of the card, it is thus necessary only to differentiate the above expression for r and to equate this derivative to kw. This gives $r_m \cos\theta = kw$, or $w = (r_m/k) \cos\theta$. The value of (r_m/k)

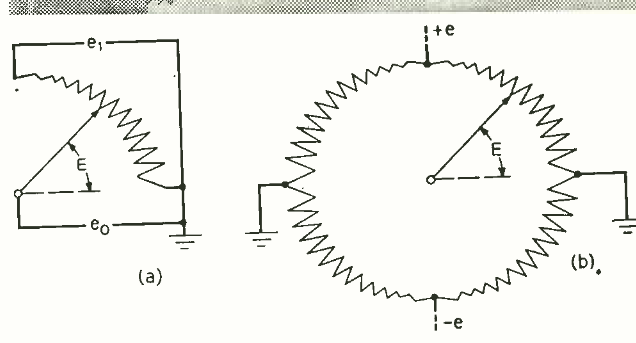

Fig. 4—By making the width of the potentiometer card proportional to $\cos\theta$, the output voltage e_0 becomes equal to $e_1 \sin\theta$

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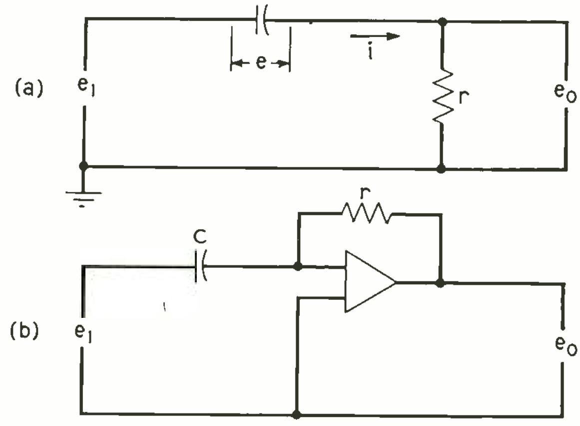

Fig. 5—With a varying input voltage e_1, and the circuit shown at (a), the output voltage e_0 is cr de/dt. By use of an amplifier as at (b), the effect of r may be eliminated and any desired scale factor introduced

may be determined from the width, w_0, of the card at the end where $\theta=0$. Since $\cos 0=1$, $(r_m/k)=w_0$. By substituting w_0 for (r_m/k) in the expression for w, the width at any point is found to be

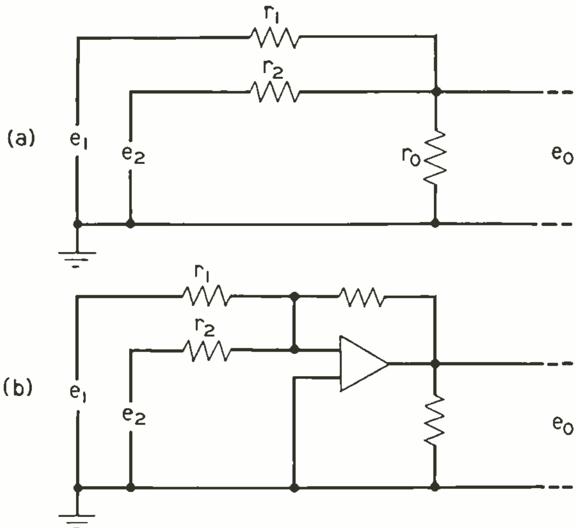

Fig. 6—Electrical adding circuits. At (a) scale factors involving r_1 and r_2 are present, but with a feedback amplifier as at (b) the scale factor may be adjusted as desired

$w=w_0 \cos\theta$. A card designed to this width would be roughly as in Fig. 4a. At the point of $\theta=0$, it would be of width w_0, which could be selected as desired, and from this maximum width it would taper to 0 in proportion to $\cos\theta$. In a practical case, the width of the narrow end of the card cannot be reduced to zero, but it can be made small enough to result in a negligible computational error. Potentiometers of this type, which perform trigonometrical operations, are conventionally known as sinusoidal potentiometers. Where computation over an angle of more than 90 degrees is required, as many as four such cards may be assembled to form a continuous circle.

In deriving rectangular coördinates from polar coördinates, or vice versa, a number of sinusoidal cards are used by the director, but in many of the calculations, multiplication is required by functions other than the trigonometric ones. To secure such multiplication, it is necessary merely to make the width of the card, corrected for thickness, proportional to the derivative of the function of resistance it is desired to obtain.

The ability to multiply by a function of a variable makes it simple to use potentiometers for dividing. Since division by x is identical to multiplication by 1/x, the multiplying circuit can be used to divide for restricted values of x by making the width of the potentiometer card proportional to the derivative of 1/x.

Multiplication and division are by no means the only operations required, but all the elementary operations may be carried out by continuous electrical computing circuits. One of the essential needs of a director is to determine target speeds. From the trackers' data and sinusoidal potentiometer cards, it is possible to continuously derive the rectangular coördinates of the target, and if each of these is differentiated, the rectangular components of the target's velocity are obtained.

The current through a condenser is proportional to the rate of change of the voltage across it. Thus i=c de/dt. If a d-c voltage representing one of the rectangular coördinates of the target's position is applied to a circuit including a condenser and resistance, as indicated in Fig. 5a,

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the current i will be c de/dt, and the voltage e_0 across a fixed resistance will be ir=cr de/dt. The presence of r introduces an error, since, as a result of it, the voltage across the condenser is not equal to the coördinate voltage e_1. By use of a feedback amplifier with sufficient gain in the circuit, as indicated in Fig. 5b, this error may be eliminated, and scale factors may be adjusted to any desired values. Thus, by continuously deriving a d-c voltage equal to the position of the target in a given coördinate, and applying this voltage to a circuit of the type shown in Fig. 5b, a voltage e_0 will be obtained which will be equal to the velocity of the target in that coördinate. Special high-quality condensers with suitable dielectric properties were developed for use in the rate measuring circuits of the director. For differentiating by the circuits shown, d-c voltages must be used, and they are used exclusively for the director circuits.

Besides multiplying, dividing, and differentiating, it is, of course, necessary to add and subtract. All the voltages used in calculating are grounded at one terminal, and thus adding cannot be done simply by connecting the voltages in series. Instead, a circuit of the type shown in Fig. 6a is employed. With such a circuit $e_0=k_1e_1+k_2e_2$, where k_1 and k_2 are functions of the resistances r_1, r_2, and r_0. These k's are always less than one, however, and thus while the proportionality may be correct, the scale factor is always wrong. Again the scale factor may be corrected by using a feedback amplifier as shown in Fig. 6b. With this arrangement, the scale factors k_1 and k_2 may be adjusted as desired, and a correct sum obtained.

With this circuit, and e_1 and e_2 positive d-c voltages, the e_0 will be negative, but this may be corrected by placing an amplifier having unit gain and an odd number of stages in the output, since such an amplifier always multiplies by −1. This method of deriving a negative from a positive voltage, or vice versa, is used throughout the calculating circuits. Among other things, it provides a convenient method of subtracting, since subtraction is effected through changing the sign of the term to be subtracted and adding it.

Another device essential to the work of the director and other fire-control instruments is the servo mechanism.* Besides being used at the gun positions for aiming the guns in comformity with data transmitted to them from the directors, servos are also used in the director.

To simplify its calculations, the director converts the original polar coördinates obtained from the tracker to rectangular coördinates, but after the calculations are made it is necessary to reconvert the rectangular to polar coördinates for transmission to the guns. The azimuth at which

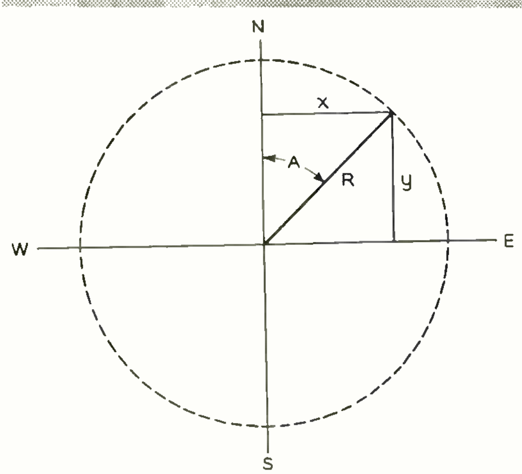

Fig. 7—Horizontal coördinates x and y are functions of the horizontal range R, and the azimuth angle A

the gun must be set, for example, will depend on computed rectangular coördinates x and y, representing distance east or west and north or south from the gun. The azimuth is given as the angle from the north position. One of the values that must also be calculated, for use in other computations, is the horizontal range—that is, the horizontal distance from the gun to a point vertically beneath the position the target will be when the shell bursts. The relationship between these various factors as obtained from Fig. 7 are x=R sin A, and y=R cos A. By simple algebraic manipulation, these may be converted to the two simultaneous equations x cos A−y sin A=0,

*RECORD, *November*, 1945, *page* 409.

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and $x \sin A + y \cos A = R$. Now suppose that four quadrants of sinusoidal potentiometer cards, as shown in Figure 4b, be provided that cover the full 360 degrees of arc so that the brushes may make a complete circuit around them. Voltages representing x and y are assumed to be already available, and these will be applied to the two potentiometers as indicated in Figure 8. Both negative and positive values of the x and y voltages will be required because of the change in sign of the sine and cosine in the course of a 360-degree travel.

Each potentiometer has two brushes spaced ninety degrees apart so that one brush picks off the cosine times the applied voltage, while the other picks off the sine times the applied voltage. The output voltages of the four brushes are marked on the diagram. The brushes of both potentiometers are driven by a servo motor supplied by a voltage which is the sum of $x \cos A$ and $-y \sin A$. The motor is poled to rotate the brushes in the direction that will decrease $x \cos A - y \sin A$, and thus continually maintains the sum equal to o. In other words, it automatically solves the equation $x \cos A - y \sin A = 0$ for A, and because the brushes of both potentiometers are driven by the same motor, both are continually held at the value of A that solves this equation. Since $R = x \sin a + y \cos A$, leads from the brushes giving $x \sin A$ and $y \cos A$ are connected to the lower amplifier. This adds the two quantities together, and gives a voltage equal to R. This R voltage, by a similar servo, is combined with the vertical height of the target's predicted position to secure the vertical angle and range.

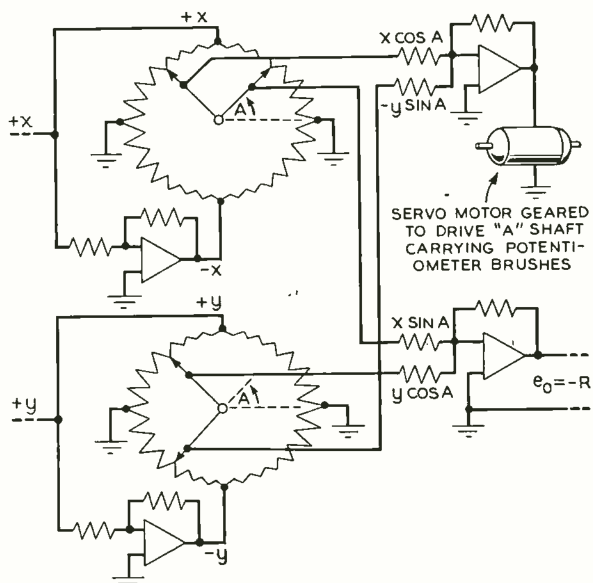

Fig. 8—Method of securing horizontal range R from the x and y coördinates

It is by such devices as these that the M-9 director maintains its battery of guns properly pointed at all times so that every shell fired will explode at or very close to its target. There are no delays due to making a series of calculations in sequence. All the computations keep pace with the motion of the trackers, and thus make the data continuously available.

THE AUTHOR: C. A. Lovell received the B.A. degree from Mississippi College in 1922, and between 1922 and 1929 was occupied in teaching and graduate study. In 1928 he received the M.A. degree from the University of Pennsylvania, and in 1932 the Ph.D. degree from the same institution. In 1929 he joined the Technical Staff of these Laboratories to engage in loud-speaker design. Later he took charge of the design of mechanical means for making experimental studies of telephone traffic. He then was put in charge of fundamental investigation of a number of special problems. Early in the war he took over the development of the first electrical gun director.

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EXCERPTS FROM THE A. T. & T. ANNUAL REPORT

In no year since the telephone was invented has there been such a remarkable increase in the amount of telephone service furnished to the American people as in 1946. Responding to the challenge of demand that soared far above wartime levels, the men and women of the Bell System in all departments and in all parts of the country have done a magnificent job and have set new records of accomplishment.

More than 80 per cent of the two million people who were waiting for Bell telephone service at the start of 1946 had been cared for by the year's end. In addition, the System was able during the year to take care of more than 70 per cent of all new applications received. Yet the total number of new requests for service during 1946 was so great (there were more than five million) that at the beginning of 1947 there were still about two million people waiting for service.

With the current rate of earnings below the average of the last 25 years, many of the Bell Telephone Companies, faced with sharply increased costs and with the need to secure new capital to expand their plant, are finding it necessary to ask regulatory bodies to approve increases in telephone rates. Increased rates amounting to about $12,600,000 annually have become effective in eight states. . . . Applications for rate increases have been made in sixteen additional states and similar applications are planned in a number of other states where earnings are low.

In 1946, Western Electric Company delivered to the Telephone Companies over four million telephones, enough dial central office equipment to serve 2,750,000 telephones, 3,742 manual switchboard positions, 6,170,000 conductor miles of exchange cable, 1,128 carrier telephone systems which increase the call-carrying capacity of long distances lines, and almost 4,000 miles of toll cable.

The telephone was born in the garret laboratory of Alexander Graham Bell, whose Centennial is being observed this year. The original laboratory team of Bell and his assistant, Thomas A. Watson, has grown to a force of 6,000, among whom are many renowned scientists and engineers. But the objective of the Laboratories has remained unchanged. Always it has been to apply research and invention to the extension and perfection of electrical communication, and to create the best facilities for economical telephone service that scientific knowledge can make possible.

Telephone service was extended to about 330,000 additional rural families during 1946. . . . Important advances were made during the year in the development of new methods and techniques. Production of rural power line carrier equipment was begun and the first systems installed commercially are operating satisfactorily. . . . Also new techniques, permitting the joint use of pole lines for both telephone wires and high voltage power lines, were successfully worked out in field trials.

In the eighteen months that have gone by since the end of the war, the Nation has broadened its use of telephone service as never before. . . . The conditions which have been fundamental to the Bell System's progress in public service may be briefly stated. Each is noteworthy:

1. The System has a long-stated policy to render the best possible service at the lowest cost consistent with fair treatment of employees and financial safety . . .

2. The System includes a research organization which leads the world in improving the telephone art, a manufacturing and supply organization which provides the best physical apparatus and tools that can be obtained, and telephone operating organizations throughout the country which are skilled in meeting the highest standards of performance . . .

3. Over the years the System has been permitted, under public regulation, to earn enough to pay good wages and a return to investors sufficient to assure the safety of their investment and to attract the new capital needed to expand and improve the service. . . . It is essential and in the public interest that earnings be adequate in the future to insure to the business the continued flow of capital so necessary to meet the continuing public demands for more and better service.

4. The System carries on its work with full regard for the dignity and worth of the individual and with consideration for the rights and interests of each person associated with the business, whether as customer, employee or owner.

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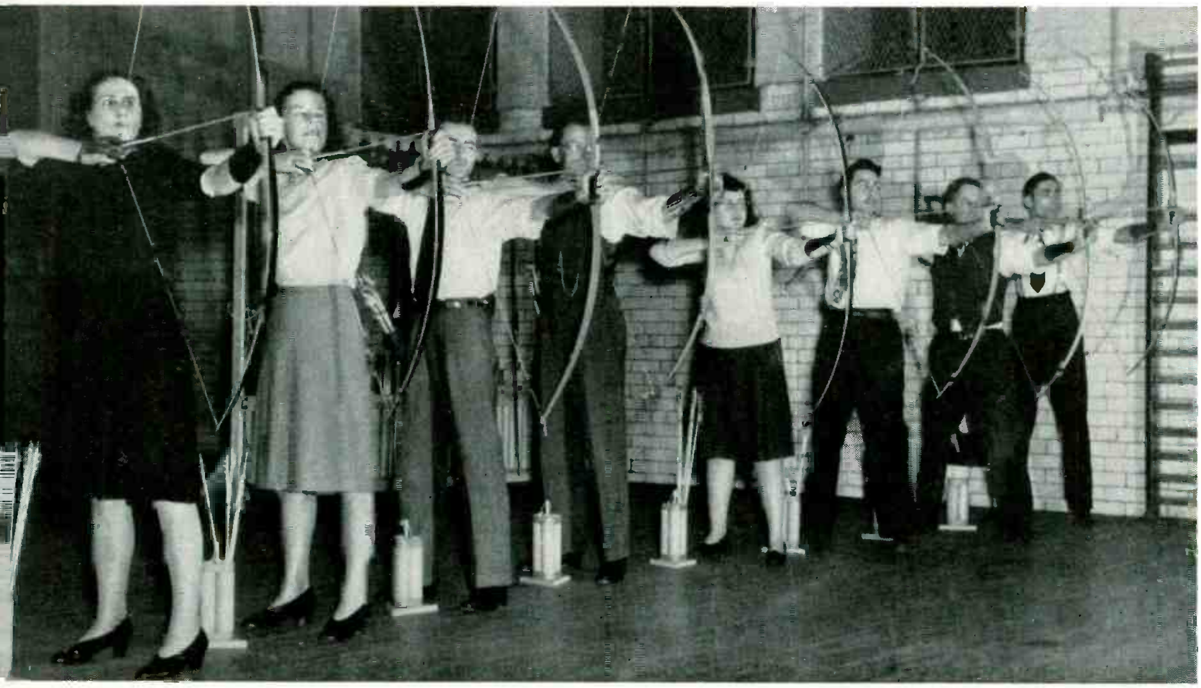

Archery Is Their Hobby

The Tuesday night group of the Laboratories Archery Team (above) line up ready to shoot. Herma Procopiadi is first in line followed by Elizabeth Wilson, G. R. Thomas, Dr. C. N. Hickman, chairman of the Archery Club, Grace Lakin, A. Albanese, J. F. Jessich and S. Rotkowitz. All Laboratories members are welcome to join either the Tuesday or the Wednesday evening group at 6:15 in Washington Irving High School.

Dr. Hickman (directly below) instructs a newcomer, Grace Lakin, in the proper use of bow and arrow.

J. F. Jessich removes well-aimed arrows from a bull's-eye (below, left).

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NEWS AND PICTURES OF THE MONTH

J. B. Fisk Joins Atomic Energy Commission

James B. Fisk, Assistant Director of Physical Research, left the Laboratories on January 31 to become Director of the Division of Research of the Atomic Energy Commission in Washington. He has also accepted an appointment as Gordon McKay Professor of Applied Physics at Harvard University, although he goes immediately on leave of absence from this position.

Dr. Fisk joined the Laboratories in 1939 as Electronics Research Engineer and at once began investigations on the behavior of electronic devices at ultra-high frequencies. When the potentialities of the microwave magnetron for military application were discovered, he was selected to head the development group. Under his leadership, the Laboratories became the outstanding industrial organization in this field during the war.

The photograph at the top of the page shows J. B. Fisk starting a "perpetual motion" machine presented to him by R. W. Hull at his farewell dinner held at the Brook. Left to right, A. T. Nordsieck, H. T. Friis, Ralph Bown, William Shockley, J. R. Wilson, Dr. Fisk and M. J. Kelly. Entertainment at Dr. Fisk's dinner was supplied by "Harvard Students"—J. M. Richardson, W. H. Brattain and K. G. McKay—shown at the right.

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At the luncheon given to L. T. Cox on the occasion of his completion of forty years of service with the Bell System. Seated, left to right, A. B. Clark, Mr. Cox and F. J. Scudder. Standing, left to right, W. H. Lang, R. E. Collis, W. R. Luther, Joseph Irish, J. W. Dehn, A. C. L. Hutner and L. H. Allen

Secrets of German Industry

The Office of Technical Services in the Department of Commerce is making available to American industry a great mass of technical information that is continually being obtained from Germany and other enemy countries, in addition to reports on many wartime Government-sponsored researches and developments in this country from which secrecy restrictions have been lifted. The Office prepares brief abstracts of reports and documents which are published weekly in *Bibliography of Scientific and Industrial Reports*. Each report has a PB number and the price is stated, for which a reproduction, either in microfilm or photostat, may be obtained. The Laboratories receives copies of the Bibliographies for circulation and copies of reports wanted by engineers are handled by the Library, either at West Street or Murray Hill.

The set-up within the Office of Technical Services which handles the investigation program is the Technical Industrial Intelligence Division. This is composed of a dozen or more sections, each concerned with a separate industry, such as Textiles, Chemistry, Machinery, Metals and Minerals, Electronics and Communications. Each section chief recruits investigators in his field, mainly from private industry, and arranges for their work overseas.

Western Electric Shipments

In 1946 Western Electric delivered to the Bell System more apparatus, equipment, and supplies than during any other year in its history. Continuing expansion in the Nation's demand for telephone service sets the goal for 1947 at even higher levels in nearly all categories. The Company's tentative 1947 program for shipments to Bell Telephone Companies compared with 1946 and 1941 follows:

	1947	*1946*	*1941*
Dial C. O. Equipment (lines)	2,222,000	1,396,000	1,020,757
Manual Positions (multiple)	8,410	3,742	2,107
Broadband Carrier Systems	750	355	87.5
Telephone Repeaters	9,000	3,960	5,198
Combined Sets	3,735,000	3,990,000	2,206,000
Lead Covered Exchange Cable (million cond. ft.)	44,000	32,578	32,440
Rubber Covered Wire (million cond. ft.)	3,000	2,765	1,933

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Of principal interest to the Laboratories is the Electronics and Communications section. Acting upon the suggestion of the head of this section, the Laboratories appointed Julian Blanchard of Switching Engineering to go over the technical literature in Washington and search for reports that might be of interest to the Laboratories. He also is acting in the same capacity for the Western Electric Company.

Mr. Blanchard is spending about half his time in Washington, and is available at all times to supplement the search through the weekly Bibliographies by engineers who are looking for reports on particular subjects, or who wish to know if there is anything available on these subjects in the Office of Technical Services, or if procurable elsewhere. He may be reached for such services or consultation at 463 West Street, Room K-45B, Ext. 2372; and while in Washington he may be addressed in care of E. Y. Webb, Jr., Room 6823, Department of Commerce, Washington 25, D. C., or reached by telephone on District 2200, Ext. 2527.

News Notes

O. E. Buckley, at the invitation of the Society of Chemical Industry, American Section, spoke on the personal life and characteristics of R. R. Williams, Perkin Medalist for 1947, at the presentation of the Medal at the Hotel Commodore on January 10.

C. A. Webber and W. J. King conferred with engineers of the Air Matériel Command at Wright Field on cables and connectors.

F. G. Given, A. B. Haines, J. L. Garrison and W. J. Clarke went to Haverhill in connection with applications of casting resin-treatment to coils and transformers.

P. S. Darnell and A. H. Schafer, at the International Resistance Company, Philadelphia, discussed resistor problems.

J. C. Aberer conferred at Haverhill on transformers for type-L amplifiers.

G. F. J. Tyne went to Winston-Salem to assist in setting up the production of filters for type-M carrier.

E. B. Wood, P. S. Darnell, A. C. Ekvall and W. J. Clarke, at Haverhill, discussed problems relating to the use of enamel wire in coils and transformers.

L. B. Hilton observed coil winding machines at the RCA Victor plant in Camden.

F. W. Clayden and R. E. Coleman witnessed trials of a tool designed for the replacement of step-by-step bank insulators at a Schenectady step-by-step office.

M. Fritts conferred on design problems relating to the crossbar switch and its application to No. 1 and No. 5 crossbar equipments at Hawthorne.

C. N. Hickman spoke on *Rocket Research* in Wilmington at a joint session of the Delaware Section of the American Chemical Society and the Delaware-Philadelphia Section of the American Institute of Chemical Engineers.

B. Stallard observed coil winding machines at the General Electric plant in Bridgeport.

J. H. Waddell spoke on *The Fastax and Atom Bombs, Kwajalein-Bikini* before the Monmouth County Section of the American Chemical Society at Fort Monmouth.

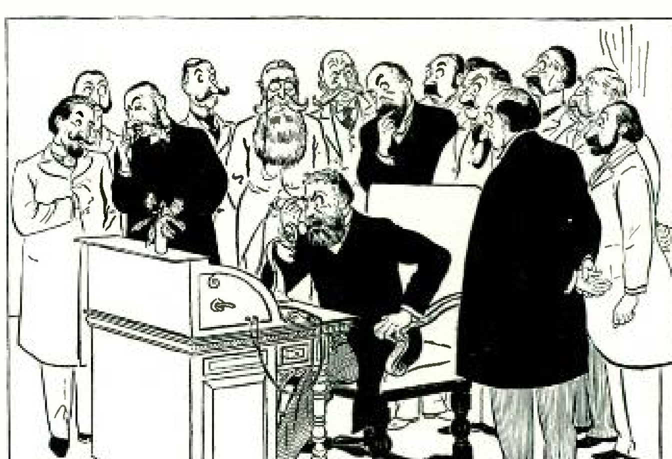
P. Neill visited Hawthorne to discuss plugs, jacks, and similar apparatus.

Footnote to American History

Alexander Graham Bell gets a wrong number during an early demonstration of the telephone

Footnote to a Footnote: The desk pictured here may be viewed any working day between 8:45 and 5:15 in the Historical Museum at West Street. A silver plate records the event—the opening of the New York-Chicago line in 1892. Nearby hangs a photograph of the event, substantially as the cartoonist has drawn it, including the beards.

In the days before telephones were common, sets like this were installed as public telephones and in offices which did considerable long-distance telephoning.



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Retirements

W. F. Mayes

G. R. Lum

G. R. Lum, of the Switching Apparatus Development Department, with twenty-nine years of service, and W. F. Mayes, of the Research Staff Department, with forty years of service, retired on February 28.

George R. Lum

A great deal of Mr. Lum's service has been concerned with the appearance and mechanical design of many products of the Laboratories. His early work can be seen in both the carbon and condenser type microphones and mountings for early broadcasting purposes, loud-speakers, audiphones, artificial larynx, public address systems for schools, the telephone handset, the combined set, and many other products. Over forty patents have been credited to him covering a wide variety of Laboratories' products with which he has been associated.

Before joining the Bell System, Mr. Lum spent six years with Yale and Towne Manufacturing Company on mechanical and ornamental iron and bronze design; a year and a half with Duffner and Kimberly Company on leaded glass windows and lighting fixtures; and then spent six years in business for himself in similar work. His first work at West Street was on the design and development of naval equipment and in this connection he spent some time on U. S. Navy destroyers. During his early years with the Laboratories, besides studying the design of electrical equipment at C.C.N.Y., he spent two years at the Art Students League, another two years of study with Mahonri Young on sculpture and drawing, and several years with Michael Jacobs, drawing and painting. During World War II Mr. Lum was concerned with the mechanical design and general appearance of apparatus developed for the Armed Forces.

William F. Mayes

Mr. Mayes' first telephone work was with the New York Telephone Company, where he assembled and wired desk telephones from 1906 to 1907. He then transferred to similar work on subscribers' sets, and became assistant foreman in 1914. He came to West Street when the New York Telephone Shop was moved here in 1914.

During World War I he was engaged in wiring work on telephone and telegraph apparatus used by the Signal Corps. At the end of the war Mr. Mayes was assigned to what is now the Research Staff Department. He wired and assembled the amplifiers for the short-wave stations at Deal Beach and Rocky Point and performed similar work on numerous other research development projects. From 1940 to the end of 1945 he was concerned with similar work, first in Circuit Research and then in Radio Research.

March Service Anniversaries of Members of the Laboratories

40 *years*

T. C. Rice

35 *years*

W. L. Heard
Hebert Vadersen

30 *years*

E. H. Chatterton
L. P. Collins
J. J. Curley
M. R. McKenney
Michael O'Connell
J. W. Woodard

25 *years*

A. J. Busch
P. P. Harvey
C. J. Hay
J. R. Kieran
H. A. Rosenbohm
V. C. Williams

20 *years*

E. C. Baacke
J. M. Barstow
L. P. Brown
F. J. Desmond
C. C. Engelbart
Helen Grant
G. H. Greb
J. O. Johnson
J. H. King
F. W. Koller
Julius Nachtigall
W. S. Ross
H. R. Schneider
W. O. Sharp
R. O. Soffel
F. X. Sullivan
G. A. Wahl

10 *years*

W. W. Bergmann
Ethel Bjork
J. B. Hays, Jr.
L. T. Miller
W. F. Russell
F. J. Sandor
W. R. Spenninger
R. W. Ulmer
D. J. Van Slooten
T. G. Woods, Jr.

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News Notes

H. J. SMITH discussed the technique of taking high-speed motion pictures with the Clark Controller Company in Cleveland.

H. F. HOPKINS, H. W. HOLMLIN and G. A. SANDER made cost reduction studies on loud-speakers at Burlington.

PAPERS PRESENTED at the A.I.E.E. Convention included: *Rural Telephone Experiment at Cheyenne Wells, Colorado,* by J. H. Moore of A T & T, P. K. Seyler of The Mountain States Telephone and Telegraph Company, and S. B. WRIGHT; *Frequency Shift Telegraphy* by J. R. DAVEY and A. L. MATTE, *Shunt Tube Control of Thyratron Rectifiers* by J. A. POTTER; *Pulse Echo Measurements on Telephone and Television Facilities* by L. G. ABRAHAM, A. W. LEBERT, J. B. MAGGIO and J. T. SCHOTT; *A New Microwave Television System* by J. F. WENTZ and K. D. SMITH; *Television Network Facilities* by H. I. Romnes of A T & T and L. G. ABRAHAM; *Airborne Magnetometers for Search and Survey* by E. P. FELCH, W. J. MEANS, T. SLONCZEWSKI, L. H. Rumbaugh of Naval Ordnance, L. G. Parratt of Cornell and A. J. Tickner of Western Electric; *The Beam Traveling-Wave Tube* by J. R. PIERCE; *A Carrier Telephone System for Rural Service* by J. M. BARSTOW; *Open-Wire Construction for Rural Telephone Lines* by C. G. Sinclair, Jr., of A T & T, D. M. Barnes, Associated Telephone Company, Ltd., and F. V. HASKELL; *The Physics of Electronic Semi-Conductors* by G. L. PEARSON; and *Measurement of High Q Cavities at* 10,000 *MC by* R. W. LANGE. S. B. WILLIAMS (retired) participated in the conference on *Large-Scale Computing Devices.*

T. H. CRABTREE conferred with Raytheon Company engineers at Newton, Mass., on the use of vacuum tubes for hearing aids.

G. A. SANDER visited the Falls Stamping and Welding Company at Cuyahoga Falls, Ohio, in reference to loud-speaker problems.

R. L. LUNSFORD, J. G. FERGUSON, O. J. MORZENTI and A. A. BURGESS discussed the Media trial installation with representatives of the Bell of Pennsylvania at Philadelphia.

W. C. JONES and W. L. TUFFNELL discussed telephone instrument and handset problems at the Archer Avenue plant, Chicago.

F. C. WILLIS and J. R. HAVILAND attended discussions of military equipment problems at Winston-Salem.

H. A. BAXTER witnessed the manufacture of duplexers at the Gorham Manufacturing Company, Providence.

C. R. TAFT and V. I. CRUSER conferred on antennas for military equipment at the Harris-Syebold Company in Cleveland.

J. W. SMITH, S. C. HIGHT, A. L. ROBINSON, J. D. SARROS and R. A. DEVEREAUX discussed Navy projects at Washington. Mr. Smith, C. R. TAFT and R. J. PHILLIPS were also at the Bureau of Ships.

J. R. LOGIE, JR., stopped at Winston-Salem en route from Boca Raton Army Air Field, Florida, where he flight tested equipment.

R. W. BENFER was in Fairbanks, Alaska, and Camp McCoy, Wis., with the Army Task Force's Frost and Frigid project.

J. R. HAVILAND and A. H. KARRER visited the Vanco Corporation in Detroit regarding gears.

GUARDING CLASSIFIED PROJECTS

During the war, the Laboratories carried on many military development projects of a secret or confidential nature, and great care was exercised by all concerned to guard against any "leaks" of classified information.

While restrictions have been relaxed on some of these projects, many of them are still highly classified. Moreover, the Laboratories is undertaking certain new, long-range, military developments that carry high classifications.

During peacetime, it is perhaps even more difficult to maintain secrecy than during war. It is nevertheless very important to do so since time would be heavily on the side of any agent who might be piecing together scattered bits of information. For this reason, our Government is continuing its energetic enforcement of security regulations, imposing stiff penalties for giving any classified information to unauthorized persons.

All employees are urged to keep up the fine record established during the war by avoiding "loose talk" about classified projects and by strict adherence to security regulations as set forth in Laboratories General Executive Instructions.

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During November and December, the United States Patent Office Issued Patents on Applications Previously Filed by the Following Members of the Laboratories:

R. P. Ashbaugh
W. M. Bacon (2)
J. C. Bain
R. Black, Jr. (2)
L. G. Bostwick
E. Bruce
S. I. Cory
F. A. Cox
P. B. Drake
J. O. Edson
W. A. Edson
W. H. Edwards
G. B. Engelhardt
J. B. Fisk
C. B. H. Feldman
A. G. Fox
A. G. Ganz
E. W. Gent
W. D. Goodale, Jr.
A. G. Hall
A. E. Joel, Jr.
W. J. Kindermann
J. H. King
J. P. Laico
C. E. Lane
J. B. Maggio
R. F. Mallina (2)
W. A. Malthaner
W. P. Mason (2)
L. A. Meacham
G. E. Mueller
H. G. Och
J. R. Pierce
J. A. Potter
M. S. Richardson
D. H. Ring
F. F. Romanow
A. L. Samuel (2)
J. C. Schelleng
H. H. Schneckloth
E. H. Sharkey
W. G. Shepherd
T. Slonczewski
K. D. Swartzel, Jr.
R. L. Vance
W. W. Werring
J. R. Wilkerson
W. R. Young, Jr.

A. K. Bohren, E. D. Prescott and A. D. Liguori were in Burlington at various times during January.

E. J. Donohue, G. A. Benson, C. E. Barker, W. Whitney, J. R. Harvey and M. Sorensen, Jr., were at Philadelphia in connection with the No. 4 crossbar system.

A review of *The Engineer in Society* by John Mills was published in the December *Journal of the Franklin Institute*.

G. T. Kohman and A. C. Walker attended conferences at Allentown on the growing of synthetic crystals. Mr. Walker, D. B. Moore and J. Schweitzer inspected crystal growing equipment at the Allentown Electronic Shop.

P. P. Debye visited the duPont Experimental Station at Wilmington, Delaware.

J. R. Townsend attended a Board of Directors meeting of the A.S.T.M. at Philadelphia. Mr. Townsend was at Hawthorne discussing materials for new central office equipment.

F. Hardy went to Washington for meetings of the A.S.T.M. Committee D2 on petroleum products and lubrication.

J. C. Steinberg was in Washington on January 24 and 25 to attend the Board of Directors meeting of the American Association to Promote the Teaching of Speech to the Deaf.

W. Orvis and R. C. Platow conferred on plastic moldings and adhesives at Hawthorne. While in Chicago they attended the Society of Plastics Industries meeting on low-pressure laminates. Mr. Platow has been appointed to an A.S.T.M. Study Committee which will endeavor to evaluate the technical significance of "sandwich" constructions which are essentially thin faces of a relatively high-strength material bonded to a lighter-weight core.

C. J. Frosch, G. Deeg and G. H. Williams, Jr., were at Hawthorne on plastics problems. They also attended the annual meeting in Chicago of the Society of Plastics Engineers.

K. G. Coutlee was a guest at the bon voyage party held in New York in honor of R. O. Podger of Kodarma, India. Mr. Podger is a member of the firm, John Podger and Brother, who are miners, manufacturers and exporters of mica. He has been in this country for several months studying war developments and post-war uses of mica and has shown such keen interest in the electrical methods of testing mica developed by the Laboratories for the War Production Board that he has taken the equipment back to India with him.

J. Leutritz, Jr., has been elected a member of the Preservative Committee of the American Wood Preservers' Association.

G. E. Peterson was present in Chicago from December 29 to January 1 for the meeting of the American Speech Association.

W. A. Tyrrell spoke on *Electromagnetic Propagation in Wave Guides and Horns* before the Columbus, Ohio, Chapter of the I.R.E. on January 10 at Ohio State University.

V. T. Callahan was at General Motors Corporation, Detroit, for discussions on post-war diesel engine alternator sets. He also visited Kohler, Wisconsin, on small gasoline engine-driven alternator sets for mobile radio.

F. F. Siebert and L. D. Fry discussed engine-driven reserve alternators to be used in overseas radio stations at the Consolidated Diesel Electric Corporation, Mt. Vernon.

J. A. Coy went to Washington with F. C. MacMullen of Western Electric to discuss communications in Alaska for the CAA.

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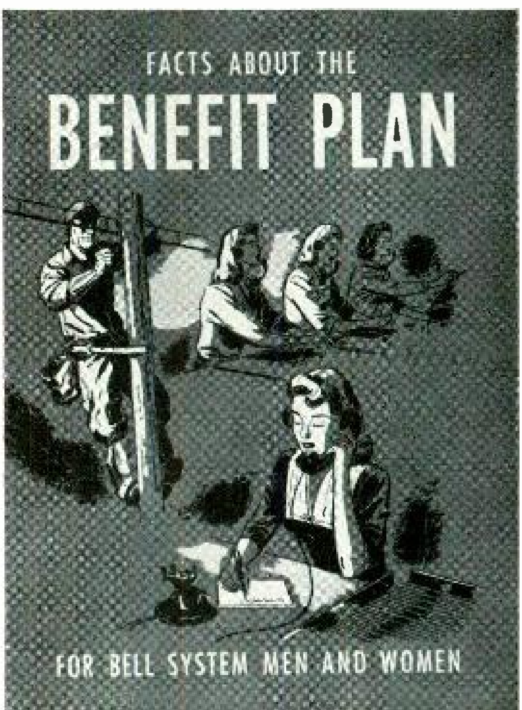
A PAPER, *Microwave Antenna Measurements*, by C. C. CUTLER, A. P. KING and W. E. KOCK was delivered before the International Scientific Radio Union convention in Paris by Sir Edward V. Appleton, president.

R. G. MCCURDY, W. L. CASPER, R. A. SYKES and A. R. D'HEEDENE attended a conference on synthetic crystals with Western Electric engineers at Allentown.

G. M. THURSTON, B. S. WOODMANSEE, F. CAROSELLI, L. F. KOERNER, D. M. RUGGLES, L. J. LA BRIE and J. F. BARRY conferred on the manufacture of crystal units in the Allentown Electronic Shop at various times in January.

W. E. KAHL and J. J. COZINE studied the manufacture of filters at Winston-Salem for the new carrier-telephone system used in power-line circuits.



THIS BOOKLET was distributed to all members of the Laboratories and is given to new members when employed. In case you didn't get one, call Benefit Plan Operation Department, Ext. 435. For further information about specific provisions of the Benefit Plan, reference should be made to the complete text.

R. M. BOZORTH, R. B. GIBNEY, A. N. HOLDEN and A. C. WALKER presented papers on several aspects of the *Growth of Crystals* at a meeting of the Geological Society of America at Cambridge.

T. L. TANNER observed the manufacture of resistance lamps at Allentown.

D. R. BROBST went to Hawthorne to discuss switchboard cables.

H. PETERS and F. S. MALM attended a meeting in Washington of the Hard Rubber Consulting Committee of the Civilian Production Administration.

C. A. WEBBER and G. N. VACCA discussed the production of rubber thread for retractile telephone cords at the Akron plant of the B. F. Goodrich Company. A. R. KEMP and G. N. VACCA conferred in Montreal with the Northern Electric Company on rubber-covered wire and cable problems. They also attended a conference in Washington of the Technical Advisory Committee for the Wire and Cable Industry, the Rubber Reserve and the Office of Temporary Control.

A. C. WALKER has been appointed to the Research Advisory Committee of the Textile Research Institute.

C. H. TOWNES, A. N. HOLDEN and F. R. MERRITT presented a paper on *Rotational Spectra of Some Linear Molecules Near 1-cm Wave Length* at an A.P.S. meeting in New York City.

E. E. SCHUMACHER has been elected director of the American Institute of Mining and Metallurgical Engineers for a three-year term. Mr. Schumacher has been a member and an officer of many of the Institute's committees as well as vice-chairman in 1943 and 1944 and chairman in 1945 of its Metals Division.

G. T. KOHMAN of Murray Hill is one of "Four Kohmans" about whom *Hexagon*, publication of the professional chemical fraternity Alpha Chi Sigma, carried a story and picture recently. In the article, Dr. Kohman's development of a heatless water distiller for lifeboats is mentioned. His brothers and nephew comprise the rest of the foursome.

"The Telephone Hour"

NBC, Monday Nights, 9:00 p.m.

March 10	*Robert Casadesus*
March 17	*Nelson Eddy*
March 24	*Lily Pons*
March 31	*Marian Anderson*
April 7	*Maggie Teyte*

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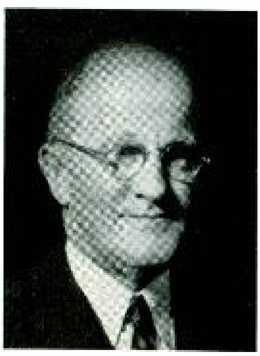
OBITUARIES

R. S. BAIR
1896-1947

ALBERT HUNT
1888-1947

W. A. GRAHAM
1921-1947

F. C. KOCH
1906-1947



J. L. ROHR
1873-1947

E. G. MONTAG
1896-1947

RALPH S. BAIR, January 15

Mr. Bair, of Specialty Products Development, graduated from the Electrical Engineering course of Newark Technical School in 1915 and came to West Street the following year. He continued his education with evening courses at Cooper Union from which he received a B.S. degree in 1924.

In 1917 he joined the Research and Inspection Division of the Signal Corps and spent two years in France. Upon his discharge from the Army he entered the Research Department on radio development work. In 1922 he went to Rio de Janeiro for a year, where he was engaged in two-way radio communication and broadcasting demonstrations in connection with the Centennial Exposition commemorating the independence of Brazil. On his return to West Street, Mr. Bair played an important part in the development of the first Western Electric 5-kw broadcast transmitter and a similar 20-kw radio-telegraph transmitter for the U. S. Army. Two years later he went to Los Angeles to install one of these broadcast transmitters at Station KFI and aided in the installation of others in other sections of the country. In 1925 he was placed in charge of a group which conducted, in cooperation with Boeing Air Transport, an extensive field survey preliminary to the installation of two-way radio-telephone facilities for the dispatching of transport aircraft.

Upon the completion of this survey he was placed in charge of a group to develop aircraft radio transmitters, among which were the 8-type and 13-type for aircraft and the 9-type and 14-type for aeronautical ground stations. He was also associated with the development of ultra-high frequency police radio equipment; radio apparatus for the coastal harbor service; command sets for the Signal Corps; liaison sets for the U. S. Navy; and the portable radio-telephone equipment (221A) that is used for emergency purposes by the Bell System Operating Companies.

During World War II Mr. Bair was concerned with a considerable number of important military radio projects, including airplane

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command sets for both the Army and the Navy; the FM radio-telephone sets employed for communication between tanks; radio transmitting equipment used in the Air Corps teletype point-to-point networks; and the newer types of VHF communication equipment which were employed during the later phases of the war for command purposes.

JOSEPH L. ROHR, February 4

Mr. Rohr, who retired in 1938, joined the Laboratories in 1922 as an instrument maker, but soon became a clerk in Payroll. In 1924 he transferred to what is now Electronic Apparatus Development as a laboratory assistant, first in thermionic cathode development and then as a special inspector of vacuum tubes.

ALBERT HUNT, January 23

Mr. Hunt joined the Development Shops Department at West Street in June, 1944. He worked in the shop as an Instrument and Tool Maker, and also for the major part of his time was engaged in the inspection of a large variety of mechanical work fabricated by both the Development Shops Department and outside subcontractors.

WILLIAM A. GRAHAM, February 3

Mr. Graham attended the U. S. Naval Academy at Annapolis from July 7, 1941, to March 1, 1944, at which time he was honorably discharged because of a physical disability. He joined the Laboratories the following May, and since then had been a Technical Assistant in the trial installation group of the Equipment Development Department. During the war he was concerned with equipment editing on various projects for the Armed Forces, and more recently has been doing similar work on telephone projects, particularly the No. 5 crossbar system.

FRANK C. KOCH, January 24

Mr. Koch joined the Laboratories directly after graduation from De La Salle Institute in 1923 and, after a short interval in the General Service Department at West Street, served continuously in the Analytical Chemistry Laboratory in New York and subsequently at the Summit and Murray Hill locations. He took evening courses at Brooklyn Polytechnic Institute and received a B.S. degree in Chemistry in 1938. He became a member of the Technical Staff in 1936 and in his special field furthered studies on wood preservatives, synthetic rubber research, and various other chemical projects.

EDGAR G. MONTAG, January 21

When Mr. Montag first came to the Laboratories in 1942 as a draftsman in the Apparatus Staff Department, he worked on electrical computers for the Armed Forces, both at Murray Hill and at West Street. Since the war he had been concerned with the design drafting phases involved in the development of hearing aids.

News Notes

C. J. CALBICK and R. D. HEIDENREICH attended the joint meeting in Pittsburgh of the Electron Microscope Society of America and the American Society for X-Ray and Electron Diffraction at which Mr. Heidenreich read a paper *The Application of Electron Diffraction Methods in the Study of Fine Structure*.

K. K. DARROW presided at one of the morning sessions of the American Physical Society New York meeting which was held at Columbia University from January 30 to February 1. At that session one of the invited papers was *Attenuators, Materials, Attenuators and Terminations for Microwaves* by G. K. TEAL, M. D. RIGTERINK and C. J. FROSCH. Other papers presented at other sessions comprised *A New Material of High Permeability* by O. L. BOOTHBY and R. M. BOZORTH; *Alloys of High Temperature Coefficients of Resistance* by W. SHOCKLEY; and *Linearization of Solutions in Supersonic Flow* by J. W. TUKEY.

R. M. BOZORTH has been appointed a member of the executive committee of the Metropolitan Section of the American Physical Society.

W. SHOCKLEY, G. L. PEARSON and J. BARDEEN visited Professor D. H. Andrews at Johns Hopkins University.

E. C. WENTE addressed the Physics Colloquium at Brown University, Providence, on *Some Recent Developments in Acoustical Measurement Techniques*.

H. FLETCHER has been appointed a member of the Committee on Hearing of the Division of Medical Sciences of the National Research Council.

MIRIAM HAROLD, MARGARET PACKER, W. A. SHEWHART and J. W. TUKEY attended meetings of the Institute of Mathematical Statistics and the American Statistical Association on January 24-25 at Atlantic City.

A. E. HARRISON engaged in tests at Winston-Salem on production units of radio transmitters for highway fixed stations.

L. L. BOUTON conducted tests at Dallas on the order wire arrangements for the L-1 system.

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E. ALENIUS spoke on *Photographic Retouching* before the Photographic Society of Rutgers.

GEORGE RISK, L. Y. LACY and Western Electric representatives discussed with the Galvin Manufacturing Company, Chicago, requirements for equipment to be used in Bell System mobile radio-telephone services. Mr. Risk, Mr. Lacy and A. E. RUPPLE visited the RCA Camden plant in connection with other equipment for mobile radio-telephones.

M. B. MCDAVITT, E. L. NELSON, A. C. PETERSON and L. Y. LACY inspected equipment being manufactured at Burlington and Winston-Salem for mobile radio-telephone services.

The Laboratories no longer has Western Electric installers working on its wiring projects. Instead Laboratories men have been trained in Bell System wiring practices and now do the work. H. C. Brown has been transferred to the Laboratories to assist in this training program. Mr. Brown was formerly a foreman in the Installation Department of Western Electric

H. N. MISENHEIMER attended a meeting of the State Department's industry-government committee working on proposals for revision of the Madrid Telecommunications Convention and the Cairo Radio Regulations.

O. C. ELIASON attended a meeting of the American Society of Heating and Ventilating Engineers committee on air filters at Cleveland.

H. W. BODE and J. W. TUKEY have been elected members of the Council of the American Mathematical Society.

S. B. WILLIAMS (retired) presented a paper on *Bell Telephone Laboratories Relay Computing Systems* at Harvard University before the symposium on Large Scale Digital Calculating Machinery. Other Laboratories members who attended included R. W. HAMMING, E. LAKATOS, G. G. MULLER, H. NYQUIST, C. E. SHANNON and E. G. ANDREWS.

O. S. MARKUSON and R. E. ALBERTS of Point Breeze conferred in New York on cable sheathing matters.

H. B. NOYES, F. J. AIMUTIS, F. W. AMBERG, R. M. HAWEKOTTE and ELIZABETH GARROW made comparative transmission tests in Florida on point-transposed and tandem-transposed open-wire pairs. F. W. AMBERG and ESTHER RENTROP conducted similar tests in Ohio.

Helen Hermann of the Keys Team realized every bowler's ambition when she scored 241 at a recent bowling match of the Bell Laboratories Club Women's Bowling League. Helen is a draftsman of Apparatus Development Department in Room 435 at West Street

R. S. TUCKER was in Washington for a Federal Communications Commission hearing.

H. A. AFFEL testified at a hearing by the Federal Communications Commission on January 27 on the Columbia Broadcasting System's petition for the adoption of standards for color television.

S. A. Darby of Holmdel recently won over Chess Master George Koltanowski at the West Street Auditorium in a game in which the resignation followed the loss of two major pieces. Mr. Darby was one of the twenty-eight chess players of Bell Laboratories Club whom Mr. Koltanowski played simultaneously, winning all games except Mr. Darby's

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One of the groups of General Service supervisors who meet for monthly conference luncheons is A. B. Conner's (extreme right). The supervisors at this luncheon are Josephine Barry, responsible for outgoing mail; Margaret McNally, interdepartmental mail; Vera Monahan, telegraph and teletypewriter facilities; Louise Van Bergen, outgoing messenger service; Parnel Bray, mail and messengers at Graybar; Helen Hoar, incoming mail; Dorothy Burkhardt, local messengers; and A. E. Pattinson, office machine service

A. C. DICKIESON selected *Speech Interpolation —An Early View* as his topic when he spoke at the February 7 Deal-Holmdel Colloquium.

R. P. ASHBAUGH spent a week at Hawthorne on various problems connected with lead-covered cable and loading coil cable stubs.

W. E. MOUGEY, R. J. NOSSAMAN and D. C. SMITH witnessed the placing of a number of submarine cables at Philadelphia. The installation was of particular interest because the cables were pulled 3,000 feet across the Delaware River by winch line instead of being laid from a cable barge. Each of three cables contained a video pair.

J. H. SHUHART visited an experimental line near Portsmouth, Ohio, on which crosstalk studies are being made.

W. E. MOUGEY, J. W. KENNARD, J. H. GRAY and D. C. SMITH observed plowing operations along the Baltimore-Washington G cable route.

A. L. RICHEY, L. W. KELSAY, H. PETERS, C. V. LUNDBERG and L. N. ST. JAMES were at Point Breeze regarding gas-tight cable terminals. Mr. Kelsay also participated in discussions at Hawthorne on protected cable terminals.

C. S. GORDON, J. B. DIXON and E. E. SCHUMACHER attended a line-wire production conference at Pittsburgh.

G. Q. LUMSDEN and A. H. HEARN visited Columbus and Orrville, Ohio, in connection with the treatment and use of Douglas fir poles by the eastern telephone companies.

B. D. MOORE and J. L. SCHWEITZER visited Allentown on crystal production matters.

C. D. HOCKER has been appointed a representative on the American Society for Testing Materials Committee D7, Wood Poles.

R. J. GUENTHER appeared before the Board of Appeals at the Patent Office in Washington relative to an application for patent.

A. F. KANE represented the Laboratories in interference proceedings at the Patent Office before the Primary Examiner.

K. W. MILLER was at the Patent Office during January on patent matters.

RICHARD HAARD trained the Laboratories reproduction group at Burlington in tracing and photograph negative reproduction processes.

W. B. VOLLMER conferred with representatives of the Taft Peirce Manufacturing Company in Woonsocket, R. I., on the production of perforators and reader assemblies for the automatic accounting system.

H. P. KNEEN observed the production of frames for the radio relay project at the I-T-E Circuit Breaker Company in Philadelphia.

W. H. BENDERNAGEL conferred at communication centers and radio stations on the Pittsburgh-Chicago route of the United Air Lines regarding the experimental installation of a communications network.

D. S. MYERS and D. R. BROBST visited Hawthorne in connection with wire and cable problems arising from the use of substitute materials.

J. T. MOTTER, O. J. MORZENTI and E. T. BALL studied crossbar developments at Hawthorne.

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FLORENCE GORDON LIEUT. TIRONE F. X. SULLIVAN G. J. VAN DELFT J. F. NICHOLAS A. F. HACKE

RECENTLY RETURNED VETERANS

FLORENCE GORDON, who has returned to the Laboratories in Building T, served in the Air Corps with the Wac. After specialized training she became a surgical and medical technician and was assigned to base hospitals in North Carolina. She also served as receptionist at Mitchel Field.

LIEUT. GEORGE E. TIRONE was in military service for forty-five months prior to his return to Commercial Relations. Before he was commissioned, he studied under the A.S.T.P. at the University of Connecticut and afterwards at the Quartermaster Corps and the Signal Supply Schools. For a year and a half he served at the Philadelphia Signal Depot where he was in charge of processing material returned from overseas.

FRANCIS X. SULLIVAN of the Photographic Department spent his military service in Manila, where he was assigned to Headquarters Detachment, Luzon Prisoner of War Camp No. 1. A staff sergeant, he was in charge of the repatriation of Japanese prisoners.

GEORGE J. VAN DELFT of the Air Corps spent twenty-two months in military service before returning to Local Service at West Street. During that time he was in the Philippines for four months and in Japan for six months.

JOHN F. NICHOLAS' military service was with the Signal Corps at Camp Crowder and Fort Monmouth, where he studied and instructed in telephone carrier systems.

ANDREW F. HACKETT attended Separation Counselling School during his Army career and was assigned to the 2nd Division in various camps throughout the country. He has returned to the Research Drafting staff.

ROBERT A. HAWLEY was assigned as a Signalman aboard the U.S.S. *Merapi* at Eniwetok in August, 1945, and called on all the South Pacific islands, New Zealand, China, Japan, and Korea during his tour of duty. He later became a Master at Arms at Yerba Buena Island signal tower and at Treasure Island.

JACK J. CONFUSIONE was a member of the Air Corps. He studied radio at Scott Field and engine mechanics at Keesler Field before being assigned to permanent duty at Langley Field.

LIEUT. ROBERT I. NOLAN fought with the 409th Infantry, 103rd Division, in two major engagements. After the war ended he transferred to the group assigned to the care, feeding, and repatriation of displaced persons. During that time he met and married a girl who was among the displaced persons. Lieut. Nolan served in the Public Safety Office of the Military Government until he, his wife and baby daughter returned to the United States.

MAJOR JOHN C. ROE'S military career dates back to the Mexican Punitive Expedition in 1916. He also saw action in France during World War I with a combat division at the Voges Mountains, the Argonne and Saint-Mihiel. In World War II he was ordered to duty from the Reserves with the rank of Captain in the R.O.T.C. and assigned as a battalion commander at Fort Dix. His next post was Professor of Military Science and Tactics in the R.O.T.C. at Xavier High School in New York City, where he was Headmaster for three years. Major Roe later served as battalion commander at Fort McClellan.

JOSEPH J. DOYLE in twenty-two months of military duty served with the Infantry on Manila. As company clerk, he maintained personnel records of enlisted men for the 96th and later for the 86th Division.

Leaves of Absence

As of January 31, there had been 1,055 military leaves of absence granted to members of the Laboratories. Of these, 973 have been completed. The 82 active leaves were divided as follows:

Army 46 **Navy 24** **Marines 4**

Women's Services 8

There were also eight members on merchant marine leaves and one on personal leave for war work.

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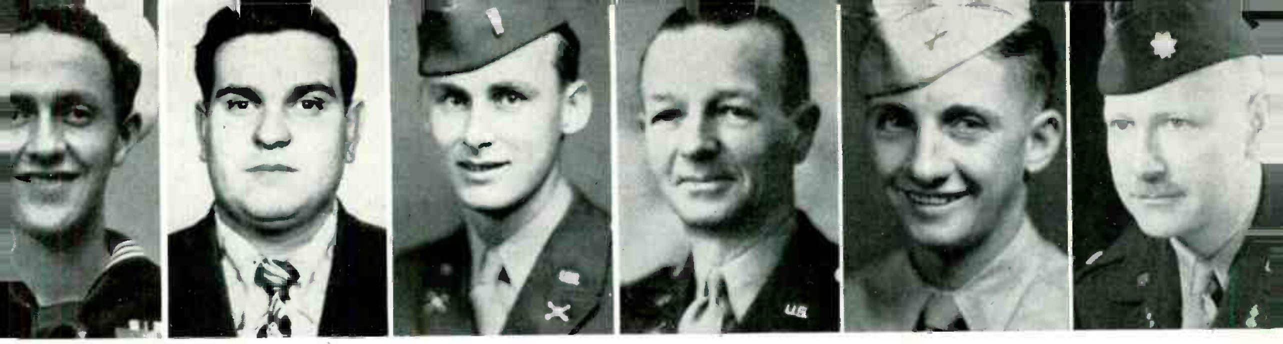

A. HAWLEY J. J. CONFUSIONE LIEUT. NOLAN MAJOR ROE J. J. DOYLE LT. COL. NELSON

LIEUT. COL. C. ERWIN NELSON has reverted to inactive duty with the Ordnance and returned to the Laboratories at 195 Broadway. Upon entering active duty at Frankford Arsenal in 1943, his first assignment had to do with M-9 gun director problems. Subsequently he was placed in charge of the Frankford Ordnance Depot, and then became control officer for the Frankford Field Service Suboffice. Col. Nelson, during his overseas assignment, was in charge of the Optical, Photographic and Precision Instruments Industries in the American Occupational Zone of Germany. He was the United States Representative on quadipartite committees with the Russians, French and British where major problems for those industries were brought for settlement. He was also a member of the committee which framed the control policy recommendations and prepared regulations for German Scientific Research.

The Red Cross Needs 60 Million Dollars

Most Laboratories veterans felt the ministrations of the Red Cross at some time during their military service. It is hoped that they will spearhead the Drive for the 1947 Red Cross Fund Campaign among Laboratories members so that the Red Cross may continue as a strong, virile organization ready to carry on all of its post-war activities and to expand its relief, health and welfare work at home and overseas.

Military Leaves

With the return of peace, the Laboratories' practices as to absences for military service have been brought into line not only with changed public policies, but with our organization's responsibilities, through the Bell System, to the telephone-using public. To those who became members of the Armed Forces, military leave of absence will be granted only

1. If the individual is a regular employee or a temporary employee having one year or more of net credited service; *and*

2. If the individual is inducted, or enlists when subject to induction.

Until further notice, absence of an employee who is a member of a reserve component of the Armed Forces, the National Guard or the Naval Militia for the purpose of active training duty will be treated as enforced absence when such active duty is necessary to satisfy training requirements of his particular branch of service. Payment for a period not to exceed ten working days in any one year will be made upon approval of the immediate supervisor or Department Head. Payment for absence beyond two weeks may be made upon approval of the General Department Head. When the active training duty is not required for reasons specified above, absence of an employee for such training will be treated as personal absence without pay.

Major Fox Awarded Legion of Merit

In the photograph below Major Joseph E. Fox is shown receiving the Legion of Merit from Brig. General C. C. Nutt, Commanding General of the Atlantic Overseas Air Matériel District, during ceremonies on February 3 in Newark. The citation read, in part, "Major Fox supervised the research and development work incident to the design of the 'Gibson Girl' radio transmitter for emergency sea rescue. His skill, patience, and complete devotion to duty were outstanding, and resulted in the production of rescue equipment which was a vital factor in the conduct of long overwater military operations."

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National Geographic Features Labs

In recognition of the centennial of Alexander Graham Bell, the March issue of the *National Geographic Magazine* features as its lead story a 43-page illustrated article on the Laboratories, *Miracle Men of the Telephone.*

The text of the article was written by F. Barrows Colton, staff writer for the magazine, who was also the author of a Bell System article, *Miracle of Talking by Telephone,* which the magazine published in October, 1937.

The current article is illustrated by 20 color photographs, taken by Willard Culver of the *Geographic* staff, as well as numerous black and white pictures. Many of these latter photographs are historical pictures taken at various times during Bell's career.

Plans for the article were begun as far back as last spring, when officials of the magazine envisioned a possible memorial article devoted to the rôle of the Laboratories in carrying on the work begun by Bell.

Mr. Colton spent a total of nearly two months visiting all parts of the Laboratories under the guidance of Wesley Fuller, Information Manager. The story was constantly checked and revised to ensure technical accuracy and yet to keep it interesting and nontechnical for the average reader.

While the article in no way attempts to cover the Laboratories completely, it does give an excellent over-all account of the scope of some of its more important activities.

The Laboratories is planning to distribute a reprint of the article to all members of the Laboratories and many others will be distributed throughout the Bell System.

J. J. Harley, whose name often appears in the Camera column of the *World Telegram,* recently won an honorable mention in the National Amateur Motion Picture Awards. In 1943 he won first prize in the same competition. Mr. Harley is a well-known lecturer on the technical aspects of musical accompaniment for all phases of motion pictures. He also contributes articles regularly to *Movie Makers Magazine.*

Transmission tests on single-sideband program equipment over the Terre Haute-Atlanta K carrier route were made by Z. Rowden of the A T & T and B. A. Fairweather, R. I. Game and D. B. Penick of the Laboratories

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Change in Rates of Blue Cross Plan

In order for present subscribers to keep their Associated Hospital contracts in force on a payroll deduction basis beyond April 30, 1947, it will be necessary for them to sign a new Payroll Deduction Authorization form authorizing the Payroll Department to deduct at the new rates effective May 1, 1947. If a present subscriber does not wish to continue his contract at the new rates, he should fill out and return the Cancellation form. Thus, a new Payroll Deduction form or a Cancellation form will be required from each present subscriber.

Telephone calls at Whippany are handled by the operators shown at the right under the supervision of Louise Norback. They are Margaret Mahon, Mariane Luckey and Sara Warmington

WHAT'S NEW

Construction supervisors from Associated Companies and a number of engineers from the O & E visited the Murray Hill and Chester laboratories on January 8 and 9. The program included a tour to points of interest in the Murray Hill building and demonstrations and lectures of various Outside Plant development activities at both locations. The two photographs show the group watching T. W. Rolph demonstrate the C cable lashing machine.

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George H. Rockwood, Jr., receives from V. L. Ronci some of the "gremlins in gas tubes" which he had battled for many years as head of a group in Electronic Development. Mr. Rockwood has left the Laboratories to become an Associate Professor in the Department of Electrical Engineering at the University of Illinois

We See by the Papers that —

Another honor has come to Amos Dixon, hard-working and best-informed Legislator in the State House—his election as president of the New Jersey Association of Township Committeemen.

Here's a zealous Farm Bureau member who, as a Legislator and Township Committeeman, has done a real job for his home community of Stillwater, his county of Sussex, and the whole state. Farmers can thank him for sponsoring some of the best of recent legislation —revision of T-B control laws, Bang's disease laws, and improvement of secondary highways, to name but a few.

We need more Amos Dixons in the Farm Bureau, in the State Legislature, and in community and civic affairs.—*News Letter of New Jersey Farm Bureau,* Vol. 3, No. 5.

Organization Changes

Effective February 1, W. C. F. Farnell was appointed Consulting Historian, reporting to L. S. O'Roark, Assistant Director of Publication. Coincident with this appointment, J. T. Lowe, Curator, will assume full responsibility for Historical Information and the Museum, also reporting to Mr. O'Roark.

Musical Interludes at Murray Hill

A noon-hour program, sponsored by the Murray Hill Chorus of the Bell Laboratories Club, was given on February 25 in the Arnold Auditorium at Murray Hill. Mrs. Dorothy Kautzman and Larned Meacham, violinists, and Mrs. Louise Bozorth, pianist, presented two instrumental trios.

For March 27, the Chorus has planned a program of choral music with D. P. Ling as guest piano soloist.

"Miracle Men of the Telephone"

The following members of the Laboratories appear in photographs published in the March issue of the *National Geographic's* article on Alexander Graham Bell and the Laboratories.

Page 276, R. J. Riley; 277, Frances and Shirley Zitzmann; Plate II, Carol Vreeland and H. J. Smith; III, Marion Greenberger, Susie Terraccianno and Herminia Dominguez; IV, John Leutritz, Jr.; V, O. J. Barton; VI, R. C. Eggleston and I. M. Miller; VII, Jane Conlon, J. R. Erickson and H. A. Bredehoft; VIII, B. O. Browne (in gray suit); IX, Eileen Kemmler and H. P. Lynch; X, J. A. Oetzman and W. H. Burgess; XI, L. T. Holden and Rae MacEvoy; XII, W. G. Straitiff; XIII, Carol Bockoven; XIV, H. L. Lundberg (standing); XV, C. A. Haas; and XVI, C. Davidson, J. C. Crowley, H. A. Helm, and J. E. Hill.

SIENS UNRAVULS SPEETSH

With Visible Speech, the student of dialect has a machine which not only listens for him but also judges the sounds and writes them down, too. In the record, a spectrogram like that in the facing advertisement may be pictured for the expert eye, even the finer shadings which evade the ear.

It is not the first time that the Laboratories has helped the advancement of science by showing how to lift measurements beyond the frailty of human judgment. The audiometer, to name but one Laboratories "First," pioneered in the study of hearing differences.

Both visible speech and the audiometer spring from a constant ideal of physical science: to put the measurable on a measured basis. It has been the special pride of the Laboratories to do this for sound because carrying sound is the business of the Bell System.

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