BELL LABORATORIES RECORD

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Building Blocks for Long-Distance Army Communication

By J. A. COY
Toll Equipment Engineering

MAGAZINE advertisements show the radio-equipped tanks speeding into action, or GI Joe talking to his command post over the telephone from a foxhole. This is the spectacular side of Army communication–full of action and human interest. The equipment is of the portable type, light of weight but rugged in construction, and designed specifically for use in the forward areas. It is quickly installed, easy to operate and maintain, and provides just enough range to link the various Army units together.

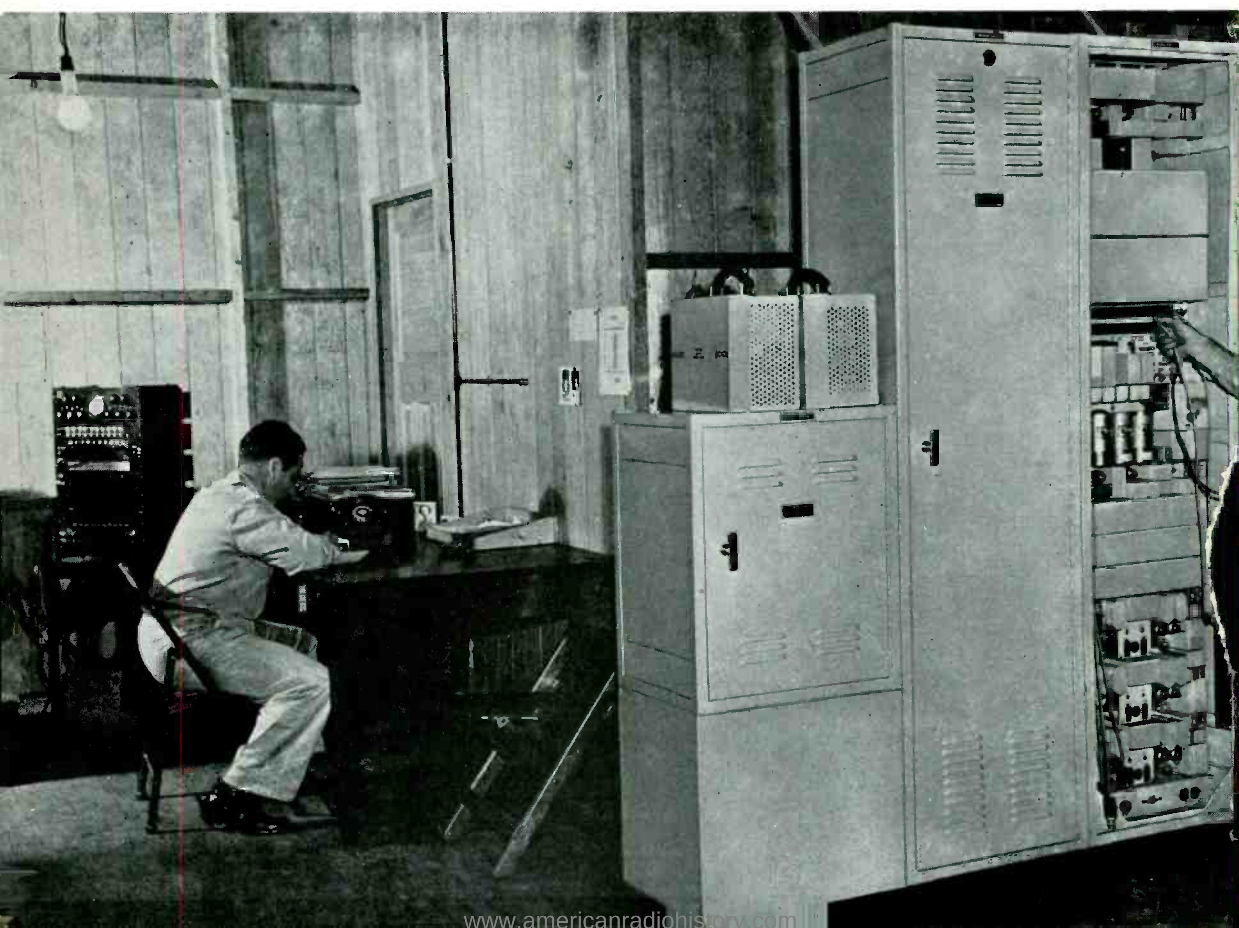
Such equipment is only a part of the story of Army communication, however. As Armies move forward, large territories are liberated or conquered, and into these rear areas come the Army Service groups to set up their shops. Here are the Theater Headquarters, the vast Army supply systems with their depots, train, truck, and airplane transportation systems, pipe lines, rest camps, and hospitals. The tremendous amount of business carried on by these various agencies makes it necessary to provide extensive telephone and telegraph networks, which approach those of a toll system as we know it here at home. The complexity of the network requires the best obtainable in transmission qualities and operating efficiency. Compared to Bell System equipment, more emphasis must be given to suitability for installation or expansion on short notice, and to operation and maintenance without a highly trained technical personnel. The planning must necessarily be done in advance, but in such a fashion that the equipment can be manufactured, stored, and shipped in bulk to the theaters of operation, and there applied as needed, and applied quickly. It must be a "ready to wear" plant in a range of styles and sizes to fit prospective needs rather than a "custom tailored" plant. The so-called "Packaged Equipment" was designed to meet the needs of this comparatively fixed system.

The equipment was designed in "packages," each package containing a major equipment unit such as a type-C carrier telephone terminal. A few options could not be avoided, and are taken care of by including extra parts. Each unit is complete in equipment and thoroughly tested before packing. This means that besides the equipment that in the Bell System would be considered part of such a unit as a C5 carrier terminal, for example, there are included also line filters, composite sets, volume limiters, and other auxiliary equipment needed to round out the installation. The packages must be complete to the smallest item required for both installation and operation. No convenient stores are available to the installation forces to draw on for missing parts.

Some changes in design were necessary. In Bell System practice, for example, the balancing networks used with telephone repeaters are designed for the wire or cable circuits with which the repeaters are to be used. Under Army conditions the type of circuit cannot be foreseen. It may be a commercial cable captured from the enemy or an Army built open-wire line. Because of this situation, a universal network was designed that can be adjusted to balance any type of line likely to be encountered. In addition, each package includes spare replacement parts, the necessary wire for connecting to associated units, and instructions for installation, operation, and maintenance. The essential maintenance tools are made into office packages, while testing equipment is put in convenient packages, each one made complete for a specific class of tests.

Packaging of equipment for convenient manufacture and installation is not, of course, new to the Bell System or to this war. During World War I, equipment for several central offices was packaged and sent to France. It included universal toll

Equipment in use in Australia. The two higher cabinets on the right make up one type-C carrier telephone terminal. The small cabinet contains four voice-frequency ringers and has two transmission test sets on top



Unpacking a cabinet from the shipping case. The cabinet will be set on the parallel timbers at the left and the wiring run in the trough between them

switchboard sections, toll and repeater sections, testboards, and telephone repeaters. There were stocked also for ready delivery, similar equipments for use in military training camps. Since for World War I our expeditionary forces were confined to Europe, no moisture proofing of component apparatus was necessary so long as the initial shipment was made in packages that were waterproofed.

PBX's and community dial offices have been packaged for some time, as also have been two-wire telephone repeaters and type-H carrier equipment for railroad and telephone company use. Complete central offices have been boxed for emergency use as already described.* In this new package project for the Signal Corps, however, the package idea has been carried much further as regards both the range of equipment and the flexibility with which it can be combined to meet field requirements.

The use of this packaged equipment† in connection with the rehabilitation of the French toll cable between Cherbourg and Paris was one of the early proofs of its suitability. On their hurried retreat through France, the Germans managed to demolish beyond repair quite a number of French repeater stations. The Signal Corps, however, moved in with the packaged voice-frequency repeaters and built new repeater stations in unbelievably short time. Sometimes the new equipment would be installed in a still standing corner of the damaged repeater building, where the floor and partially remaining walls would afford some protection. The roof might be only a piece of canvas "borrowed" from a truck or trailer. The cracks in the walls would be neatly covered by tacking up blueprints of schematics and wiring diagrams furnished with the package. Other installations were started from the ground up, so to speak, with the installations mounted on 4x4's laid down in the mud of a vacant lot or a town market place. Afterwards, the Army engineers would move in and

*Record, *March*, 1944, *page* 336.

†Record, *July*, 1945, *page* 255.

erect a suitable building around the working equipment. Some of the French repeater stations were taken over in good condition and made part of the Army network, with the new packaged equipment and the old French equipment working in tandem on the same long-distance circuits.

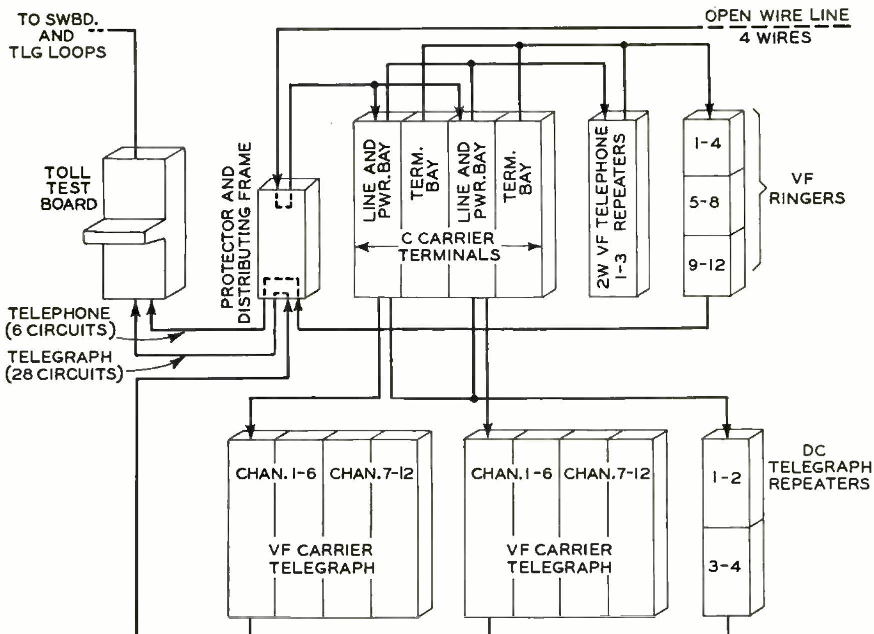
Although the units are the same as their Bell System equivalents in circuit and major operating characteristics, a number of modifications were required to fit Army requirements. Each unit is mounted in a steel cabinet with doors back and front. No unit is more than seven feet high nor weighs more than about 600 pounds net. To permit the equipment to be set in rows of uniform height, and to simplify shipping and storage, three sizes of units are employed, seven feet, three and one-half feet, and two and one-third feet, and thus two of the middle-sized units or three of the smaller ones when stacked on top of one another will occupy the full seven-foot height of the largest unit. Where more than one unit is needed to supply a complete package such as a C5 carrier terminal, the boxed units are marked to indicate the other boxes to be associated with them.

Packaged units arranged and assembled in this manner include type-C* and type-H† carrier-telephone terminals, voice-frequency carrier-telegraph terminals, two-wire and four-wire telephone repeaters, voice-frequency ringers, d-c telegraph repeaters, transmission testing equipment, testboards, and line fault location equipment, distributing frames, and miscellaneous auxiliary units. The various units that might be required at a terminal for an open-wire line of four wires are shown in the block diagram on this page.

Instruction books were prepared in unit form so that the information applying to the equipment in any one package can be packed in that package. An additional instruction book covers the engineering of systems. The cabinets at any one location are set up side by side on two 4x4's—one under the front and one under the back of the cabinets. These provide a trough under the base in which wiring is run.

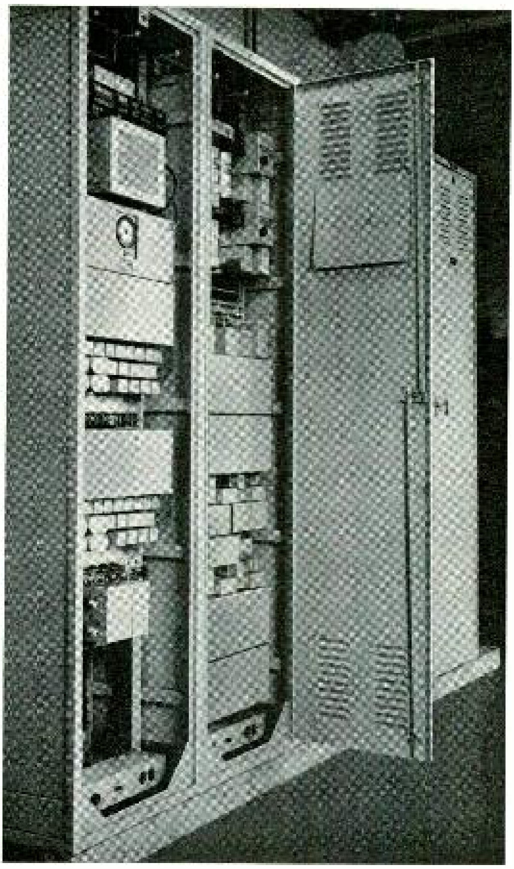
Since the apparatus may be used by the Army anywhere from the Equator to the Arctic Circle, all apparatus must be able to withstand high humidity and a wide range in temperature. Apparatus such as

*Record, *October*, 1940, *page* 53.
†Record, *November*, 1937, *page* 76.



Apparatus provided for a terminal of a packaged type-C carrier system a filter is hermetically sealed in its case. Special compounds are employed for coils and condensers that will not crack at low temperatures, and moisture-resistant wiring and finishes are used throughout. In addition, the equipment must be rugged in design to protect the units from the rough handling it receives during shipment, and its crating, or export packing, must be sturdy and waterproof to protect the units from the elements when it is piled up on the muddy open-air depots of a recently won beachhead.

All of the equipment is designed for operation from 115-volt a-c supply, which may be either the commercial supply, if available, or Army portable gas-engine generators.



Type-C carrier telephone repeaters installed and ready for service. The two open cabinets make up one repeater

It is recognized that packaging of equipment for bulk manufacture and supply is not effected without some penalty in fitness to specific jobs. A universal package cannot be expected to exactly fit each set of field conditions. Under Army conditions, however, the losses in these respects are negligible compared with the advantage of having the equipment available quickly. There may likewise be conditions in the Bell System where this quick availability will be of great value in giving emergency service, and where the ease of installing and removing packaged equipments will be important in giving short term service.

THE AUTHOR: J. A. COY, after receiving his E. E. degree from Syracuse University in 1915, spent one year with the Westinghouse Electric and Manufacturing Company. He then joined the equipment section of the Long Lines Department, where in Buffalo and later in New York he received twelve years of field experience. In 1928 he transferred to the Equipment Development Department of the Laboratories where he has since been associated with development of equipment for toll telephone systems, being in charge of a group working on carrier systems and voice-frequency terminals for radio circuits. Some of the projects to which he has contributed are pilot-wire regulators for four-wire repeaters; voice-frequency terminals for transoceanic radio circuits; terminal equipment for telephoto systems; type-C and type-J carrier systems; and terminal equipment for coaxial systems. During the war he was occupied chiefly with packaged communications equipment, terminal equipment for Spiral-4 cable and terminals for overseas radiotelephone circuits.

Frequency Modulation by Non-Linear Coils

By L. R. WRATHALL
Transmission Research

RADIO communication has been of vital importance during this war, not only because of its inherent advantages for rapidly moving military forces. but because of the many new developments that have greatly increased its scope and flexibility. One of the most widely used and highly satisfactory military radio sets is the frequency-modulated transmitter-receiver used for tanks and command cars, which has already been described in the RECORD.* These sets incorporate many novel features, one of which is a new and simple method of frequency modulation, which was developed in these Laboratories. The great advantage of this new method is that the frequency modulation is accomplished by means of a small coil wound on a permalloy core less than a quarter of an inch in diameter. Besides eliminating the vacuum tubes previously employed for modulation, this method simplifies the stepping up of the frequency that results in a higher percentage modulation.

Frequency modulation by use of this small coil is made possible by the non-linear relationship between the current in the windings and the magnetic flux in the core—which is shown in Figure 1 in a highly idealized form. If the current changes at a fairly uniform rate from a negative value M to a positive value Q, the corresponding changes of flux would be from M′ to Q′. It can be easily seen that a very large portion of the

*RECORD, *January,* 1945, *page* 1.

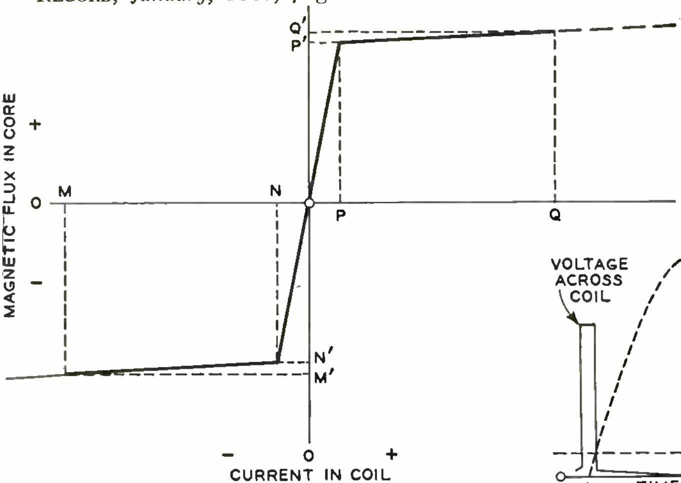


Fig. 1 (above)—Idealized representation of relationship between current and magnetic flux in the non-linear coil

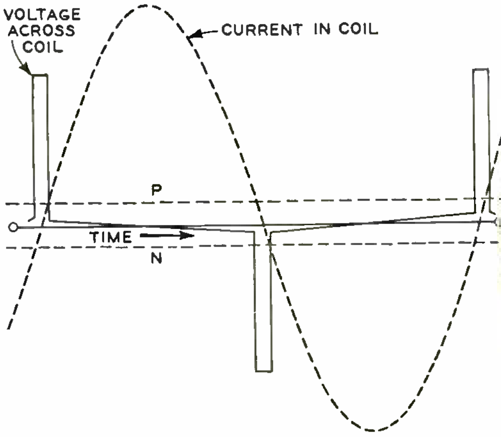


Fig. 2 (right)—Variation in voltage across non-linear coil when a sinusoidal current flows through it change of flux will occur when the current amplitude lies in the region bounded by N and P. This interval is often referred to as the unsaturated magnetic region.

If the resistance of the winding is negligible, the voltage across the terminals of the winding is directly proportional to the rate of change of flux in the core, and hence will be much higher in the unsaturated region than in the saturated one, provided the current changes at a substantially uniform rate. Figure 2 shows the variation of the voltage across the coil with a sinusoidal current in the winding. When the core is unsaturated, corresponding to current values between the horizontal dashed lines, the voltage across the coil will be comparatively large as indicated. When the current reverses, the voltage across the coil is also reversed. If the amplitude of the current is increased, the interval spent in the unsaturated state is decreased because the saturating value of current is reached sooner. The width of the voltage pulse can thus be made as small as desired by sufficiently increasing the amplitude of the current.

How this non-linear coil L is associated in a circuit for frequency modulation is shown in Figure 3. The carrier-supply generator, e, is crystal controlled, and has a power capacity sufficient to send a large carrier current through L. To secure maximum current, L and L_2 are resonated to the carrier frequency with C_2. The signal frequency is much lower than that of the carrier, and is fed into L through the inductance L_1. This latter inductance is large, and prevents much of the carrier from getting into the signal mesh. The signal in turn is blocked from the carrier circuit by condenser C_2.

In the middle diagram of Figure 4, the solid-line sinusoidal curve represents the carrier current passing through the coil L

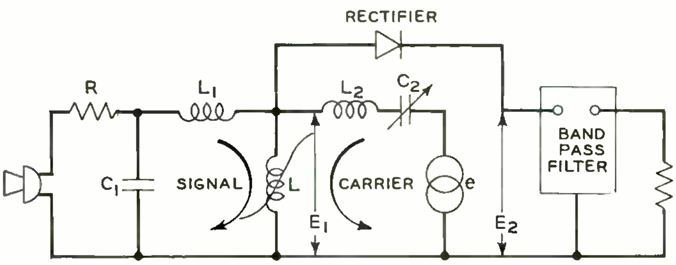


Fig. 3—Simplified schematic of modulating circuit using non-linear coil

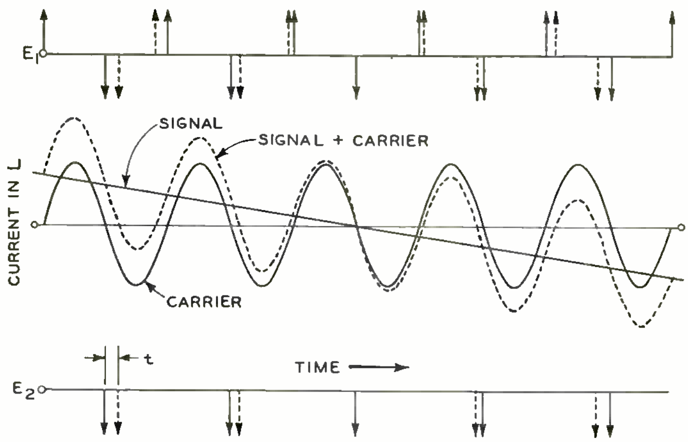


Fig. 4—Combination of signal and carrier indicated by the middle curves results in the pulses indicated in the upper part of the diagram. The rectified output appears as in the lower diagram

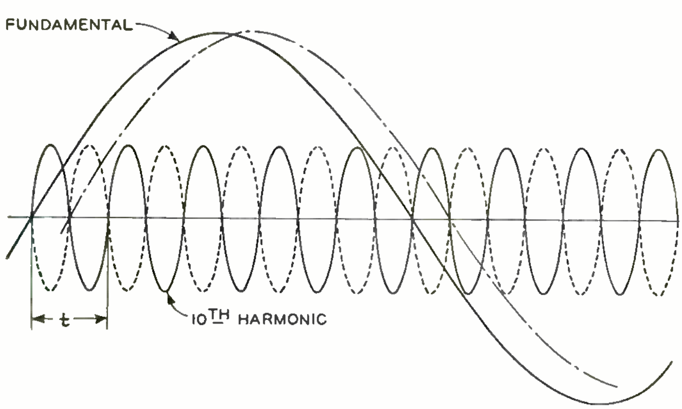


Fig. 5—The fundamental and tenth harmonic for an 18-degree phase shift of the fundamental

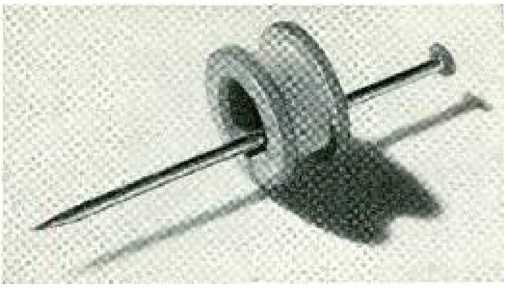


Fig. 6—The extremely small size of the non-linear coil on which the permalloy tape is wound is made apparent by the inserted pin

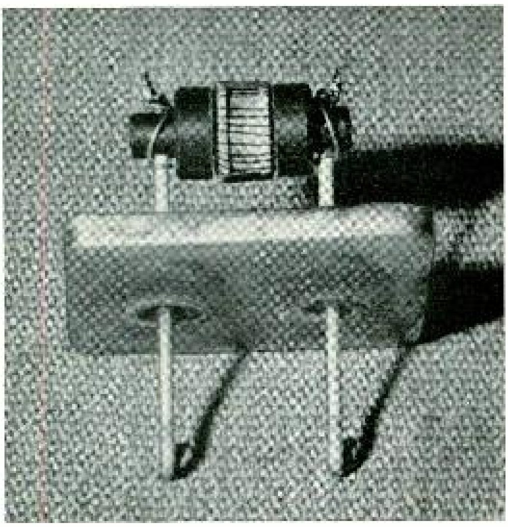


Fig. 7—The non-linear coil is fastened to the cover of its container

of Figure 3. The current is assumed to be large enough to make the voltage pulses very narrow, and thus when plotted they would appear as vertical lines at the points where the carrier crosses the zero axis. These are indicated by the solid lines in the upper diagram. Since the carrier is very much higher in frequency than any possible voice wave, the time covered by Figure 4 permits only a fraction of a voice wave to be indicated. The solid line marked SIGNAL in the middle diagram could thus represent the decreasing section of a voice wave before and after it crosses the zero axis. With the voice wave present, the current producing the voltage pulses is the sum of the voice and carrier currents, which is represented by the dashed curve of the middle diagram. The effect of adding the voice and carrier currents is to shift the positions along the time axis at which the voltage pulses appear. The voltage pulses resulting from the combined current would thus be as indicated by the dashed lines in the upper diagram, and the larger the signal current the greater will be the shift. With positive voice current, the shift is in one direction, and with negative voice current, in the other.

The positive and negative pulses are phase modulated (shifted) by the signal in opposite directions. In order to obtain the desired phase modulated output the pulse of one polarity must be eliminated. This is done by inserting a rectifier in the circuit as shown in Figure 3. The rectified output appears as in the lower diagram of Figure 4, where the solid lines represent the output when no signal is present, and the dashed lines represent the shifted pulses caused by the signal current indicated in the middle diagram. A Fourier analysis of a set of pulses as indicated on the lower diagram shows that they have as components the fundamental carrier frequency and all odd and even harmonics, and that over a wide range of frequencies these harmonics are nearly equal in amplitude. When a series of pulses is shifted, as by the amount t indicated in the lower diagram, the fundamental and all the harmonics are shifted by the same time interval. This is indicated for the fundamental and the 10th

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THE AUTHOR: L. R. WRATHALL obtained a B.S. degree from the University of Utah in 1927 and returned the following year for graduate work. In 1929 he joined the Laboratories' Research Department. Here he was primarily occupied with studies of the characteristics of non-linear coils and condensers. During World War II non-linear coils were used extensively in radar systems, and his work in this field was intensified. Since the end of the war he has been engaged in general circuit research.

harmonic in Figure 5, where the shift t is 5 per cent of the total time between pulses when no signal flows. This 5 per cent represents an 18-degree phase shift for the fundamental, but for the 10th harmonic it is 180 degrees, or ten times the phase shift of the fundamental. A corresponding phase shift is suffered by each harmonic—the shift for any one harmonic being equal to the number of the harmonic times the phase shift in degrees of the fundamental. Thus, for the 20th harmonic it would be 360 degrees for an 18-degree shift of the fundamental frequency.

While such a modulator produces phase displacement proportional to signal amplitude, the effect, for a single frequency signal, is, in most cases, indistinguishable from that produced by a frequency modulator. Insertion of a conventional resistance-capacity network preserves this equivalence for a complex signal such as a speech wave.

With such a resistance-capacity network in the signal circuit, each of the carrier harmonics is thus frequency modulated by the signal, and the higher the harmonic, the greater the degree of modulation. The band pass filter in the output circuit of Figure 3 selects one of these frequency-modulated harmonics and passes it on for amplification. The degree of modulation may be further increased by frequency multiplication.

Because of the high frequency at which they operate, the non-linear coils used for frequency modulation are much smaller than those used for carrier generation.* The entire coil is only about one-quarter inch in diameter. It is made up by winding about a foot of permalloy tape, less than one-eighth inch in width and a little over a ten-thousandth of an inch thick, on the soapstone mandrel shown in Figure 6. Some forty turns of fine copper wire are then wound on this assembly by threading the wire through the mandrel. The ends of the wire are then soldered to terminals projecting through the cover of a small container as shown in Figure 7. A mounted coil and its container is shown about three-quarter size at the head of this article. After the coil has been mounted, the cover is placed so as to bring the coil near the center of the container. The container is then filled with oil through the small hole in the side of the can, and this hole sealed.

This small coil does the work that formerly required four vacuum tubes and two tuned circuits; it is extremely rugged and free from maintenance difficulties.

*RECORD, *July*, 1937, *page* 357.

W. S. Gifford Awarded Medal for Merit

WALTER S. GIFFORD, President of the American Telephone and Telegraph Company, has received the Nation's highest civilian award—the Medal for Merit. Presentation of the medal and accompanying citation was made by Major General Harry C. Ingles, Chief Signal Officer of the Army, on February 15.

Text of the citation, signed by President Truman, follows:

"As President of the American Telephone and Telegraph Company, Mr. Gifford, throughout the entire emergency, from December 7, 1941, to August 14, 1945, made every effort to assure that the facilities of his organization were utilized to the maximum extent possible in the successful prosecution of the war. Under his direction and outstanding leadership radio teletypewriter systems were developed, which replaced laborious and inadequate manual operations with high-speed semi-automatic teletypewriter service for the handling of an unprecedented volume of messages.

"Not only did Mr. Gifford place the technical facilities of his company at the disposal of the Army, but he directed it in playing a major rôle in furnishing highly trained technical specialists to the Army through the affiliated plan. Under this plan technically qualified personnel left their civilian jobs to serve as officers and enlisted men and to form the nucleus of new Signal Corps units. By this means the Army obtained full benefit of the technical training gained by this personnel through long years of experience. The leadership of Mr. Gifford was an inspiring force that helped immeasurably in the guiding of this organization as a part of the Army of Democracy."

Sulfur in Synthetic Rubbers

By F. S. MALM
Chemical Laboratories

SYNTHETIC rubbers, like nature's product, have to be combined chemically with small amounts of sulfur by the application of heat in a process called vulcanization to give them the permanent elastic properties commonly associated with rubber. When Far Eastern sources of natural rubber were lost, quick conversion to synthetic products had to be made and studies of the solubility and diffusion rates of sulfur in synthetics were undertaken by the Laboratories to determine compounding and processing procedures for their use in the manufacture of insulated wire and telephone equipment.

The elastomers studied were GR-S, which has been made in large quantities under Government supervision, Hycar, Perbunan, Butyl, Neoprene and for comparison, natural rubber. Three grades of sulfur, designated A, B, and C, were employed. B and C were commercial grades of ground sulfur used in the rubber industry, and A was a micronized product with an average particle size of three to four microns. Distribution of the particle sizes of the B and C samples are shown in Figure 1. The rate of solution of these three types of sulfurs in the synthetic polymers was studied by adding sulfur to the samples on a mill and removing them every two minutes during the mixing operation for observation under a microscope. When the sulfur was nearly dissolved they were observed every minute to determine precisely when solution in the polymers was complete.

The ratio of the rates of solution for three parts of sulfur in GR-S is approximately 1:3:5 for the A, B, and C grades, respectively. These data show the large influence of fineness on the rate of solution of sulfur in rubber. The rate in natural rubber, GR-S, and Neoprene, GN, is about the same. It is appreciably slower for Hycar and Perbunan even at the higher milling temperatures used with these latter materials. The rate

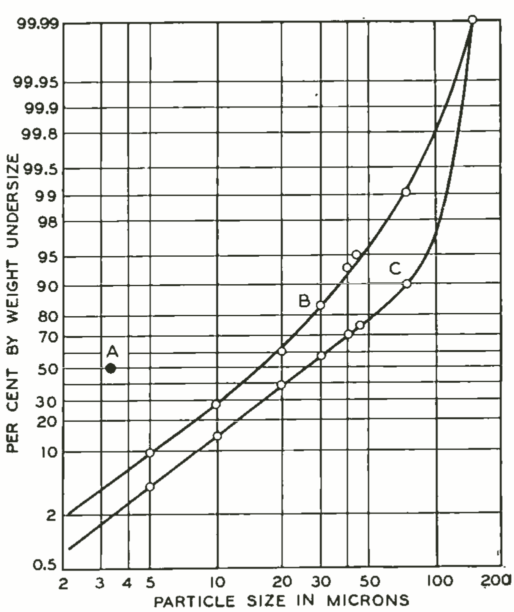
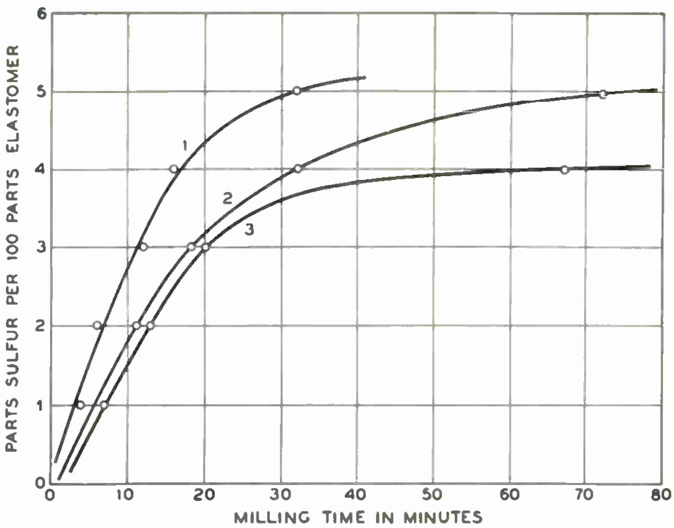


Fig. 1—Distribution of particle sizes in the sulfur used to vulcanize the samples of synthetic rubber studied

Fig. 2—Solubility of sulfur in natural and GR-S rubber at 78 degrees C. during the milling operation: (1) Crêpe rubber with sulfur A, (2) GR-S with sulfur B, and (3) Crêpe rubber with sulfur B



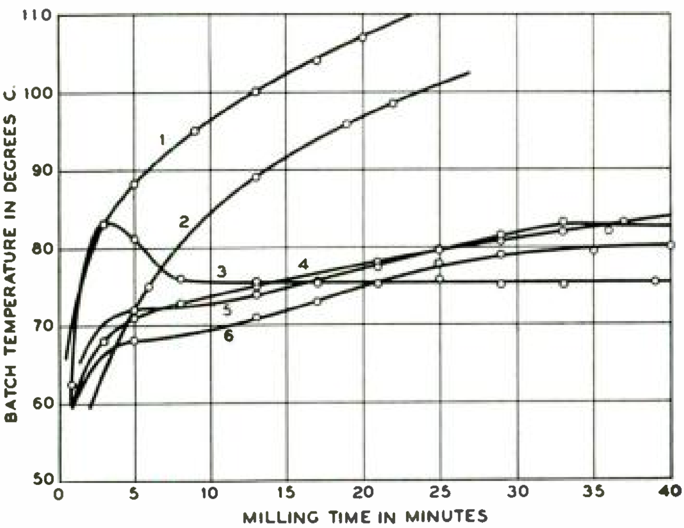
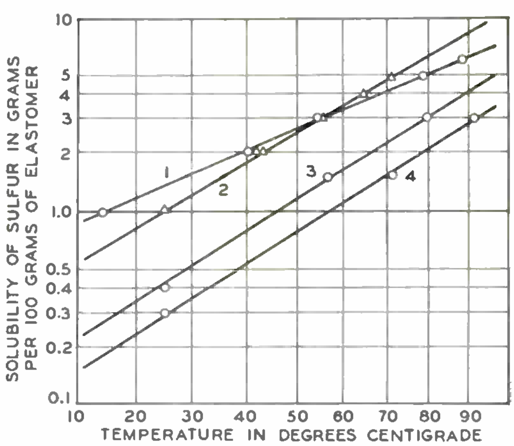


Fig. 3—Heat developed in elastomers during milling: Hycar (1), Perbunan (2), Crêpe rubber (3), GR-S (4), Neoprene (5), Butyl (6)

Fig. 4—Solubility of sulfur in elastomers at different temperatures was determined by observing samples under the microscope for undissolved sulfur

1. *Crêpe rubber*
2. GR-S
3. *Perbunan*
4. *Hycar*



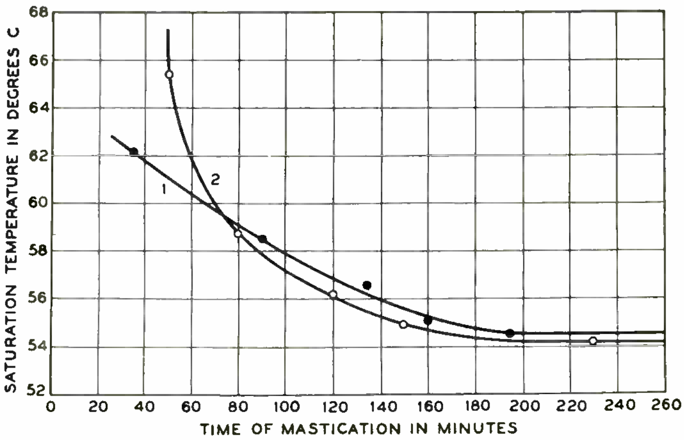
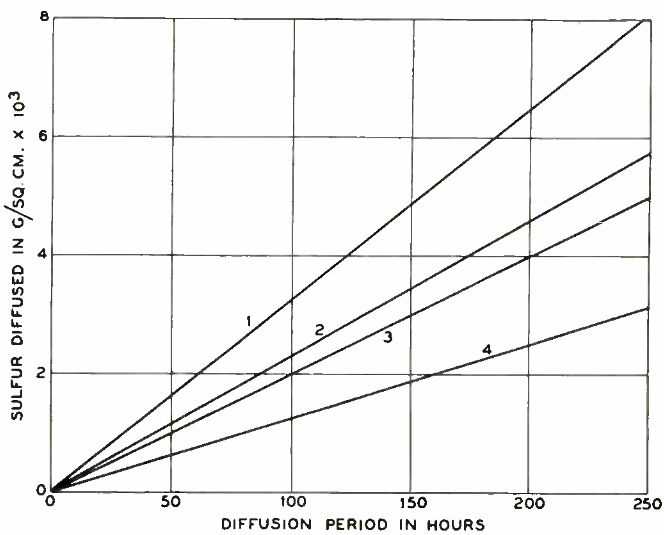


Fig. 5—The temperature at which saturation with sulfur occurs decreases with increased time of mastication in some elastomers. 1, *Crêpe rubber;* 2, GR-S

Fig. 6—Sulfur diffuses faster through natural crêpe rubber (1) *than through* GR-S (2), *Hycar* (3) *and Butyl* (4)



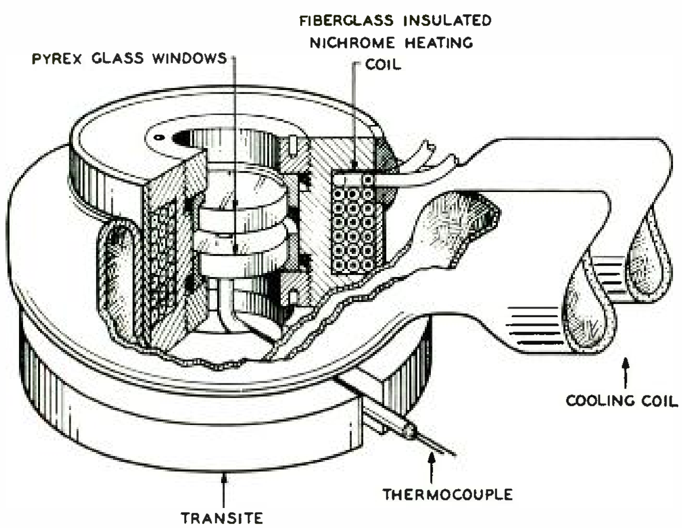


Fig. 7—Comparative rates of re-solution of sulfur crystals of different sizes in natural rubber were observed under a microscope in a micromold at 141.5 *degrees C.*

Fig. 8—If a sulfur-elastomer mixture is allowed to cool before the sulfur is completely dissolved, sulfur recrystallizes on the undissolved crystals and produces the large ones shown in the microphotograph (X45)

Fig. 9—Sulfur crystals change from the branched dendritic form to large rhombic crystals when the mixture is cooled

Fig. 10—If the sulfur-elastomer mixture is milled when below its solubility temperature, very fine uniformly dispersed rhombic crystals are formed

for 1.5 parts of sulfur in Butyl rubber was very slow since the temperature required for this concentration was not reached. Plotted in Figure 2 are values obtained for natural crêpe and GR-S with different grades of sulfur.

Batch temperatures of the various elastomers on the mill varied somewhat. This was due to differences in internal friction in these materials and a study was made of the temperature variation of the batch during milling where all conditions were kept constant, except the type of elastomer used. The data are plotted in Figure 3. Equilibrium batch temperatures of the synthetic elastomers after considerable milling are higher than those obtained for natural crêpe rubber. Solubility temperatures for sulfur in the elastomers were obtained* by observing the clear-to-cloudy transition which takes place on cooling samples, while being masticated on mill rolls. After the sulfur was completely dissolved the batch was cooled but not cut on the moving rolls until cloudiness appears at its edges. The temperatures of the clear and cloudy sections in the bank were taken with a thermocouple. Several checks were made for each elastomer. The slow cooling and constant agitation during this procedure eliminated the supersaturation effects of the sulfur in solution.

Solubilities at lower temperatures were determined by making stocks of crêpe rubber, GR-S, Perbunan and Hycar with small differences in the sulfur content on each side of their approximate saturation values. These stocks were placed in constant temperature rooms at different temperatures for long periods and observed periodically under a microscope for undissolved sulfur. The solubility values plotted semilogarithmically are shown in Figure 4.

Solubility of sulfur in some elastomers increases with the amount of mastication to a limiting value. This characteristic was observed with natural crêpe rubber and GR-S. Figure 5 records the change in sulfur solubility with mastication for these two elastomers when they contain three parts of sulfur.

Rates of sulfur diffusion through masticated GR-S, Hycar, and Butyl rubber were measured at 86 degrees C. The data, which is plotted in Figure 6, shows that the rates decrease in the order—natural crêpe, GR-S, Hycar and Butyl.

*RECORD, *April*, 1942, *page* 190.

Microscopic observations were made on the behavior of sulfur in a mixture of GR-S to which three parts of sulfur had been added. If the sulfur-elastomer mixture is allowed to cool and remain at room temperature before a complete solution takes place, the excess of the sulfur which had dissolved will recrystallize on the undissolved particles and produce large crystals like those shown in Figure 8. If the mixture is slowly cooled after complete solution and is held at room temperature, the sulfur precipitates in the branching dendritic and also in the rhombic state. Transformation from the dendritic form into large rhombic crystals takes place on standing as is shown in Figure 9. If the mixture is milled below its solubility temperature after complete solution, the sulfur precipitates as uniformly dispersed rhombic crystals. This pattern, Figure 10, which causes the cloudiness visible to the naked eye, is retained on standing. As the samples are heated during vulcanization, these very small crystals redissolve quickly and cause the formation of a homogeneous vulcanizate. If the mixture is chilled in ice water after complete solution, the sulfur precipitates in masses of dendrites. Short storage periods at room temperature will not alter this sulfur pattern, but it dissolves quickly on heating and yields a homogeneous vulcanizate.

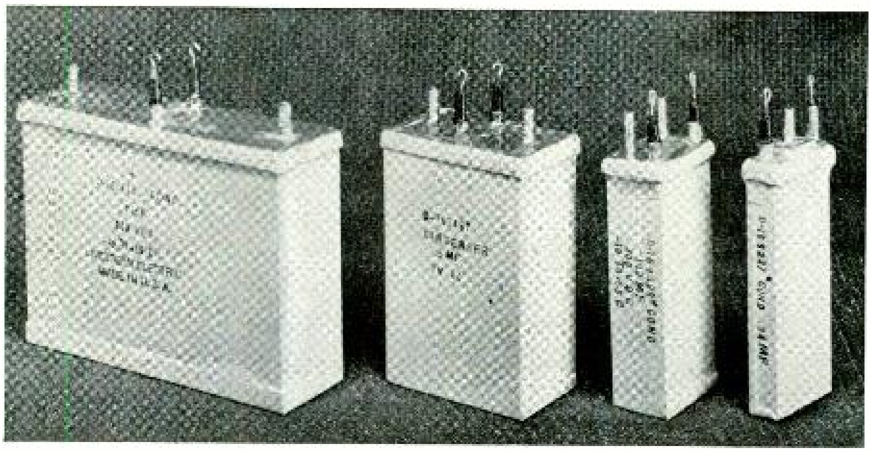
Comparative rates of re-solution of sulfur particles of different sizes in natural rubber were determined in a micromold, Figure 7. The mold was heated to 141.5 degrees C. and loaded with a sample of crêpe rubber which contained fine sulfur crystals. Observations were then made under a microscope at a magnification of forty diameters. These small crystals required only one and one-half minutes to dissolve completely. Larger crystals which separated on standing at room temperature required thirteen minutes to dissolve at 141.5 degrees C. This difference in rate of re-solution is dependent on the solubility and the rate of diffusion of the sulfur in the elastomer and determines whether a heterogeneous or a homogeneous vulcanizate will be formed.

Studies showed that the rate of solution of sulfur in various synthetic elastomers, during milling, depends on their temperature, the solubility and rate of diffusion of sulfur in them, the particle size and type of the sulfur used and the extent of elastomer mastication. This information has been helpful in the change from natural to synthetic rubber which has been required to supply military and Bell System needs.

THE AUTHOR: F. S. MALM transferred to the Laboratories in 1929 from the Western Electric Company where he had been engaged during the previous twenty years in chemical and engineering development work on soft and hard rubber. The year he joined the Laboratories he went to Europe on telephone cable projects. On his return he began the research work on natural and synthetic rubber which has since occupied his time. Mr. Malm is a member of the American Society for Testing Materials, the American Chemical Society and the Institute of the Rubber Industry (England).

Flying Chemical Laboratory

As DIRECTOR of the Army Air Forces tropical science mission, K. G. Compton is flying to Pacific battlefields to study the condition of war equipment stored in the tropics. The mission consists of J. Leutritz, Jr., of Murray Hill, eighteen A.A.F. scientists and five crewmen of the giant C-54, especially equipped as a flying laboratory, which had just left Japan when the RECORD went to press. As the plane bears them from one location to another, the mission studies the geological and climatic causes of deterioration of Army equipment, and records the results of destructive organisms.



Polystyrene Capacitors

By J. R. WEEKS
Transmission Apparatus Development

DURING the development of the M-9 Director,* it became apparent that for certain parts of the circuit, capacitors would be required with characteristics not obtainable with any existing types. Without sacrificing the stability obtainable with the best mica capacitors, a very low dielectric absorption was needed—much lower than possessed by mica or any of the other dielectrics used in capacitors up to this time. When an ordinary capacitor is discharged by a brief short circuit, it is found a little later that a charge has built up again. This is ordinarily described by saying that some of the charge which is absorbed by the dielectric is released slowly. What was desired for the Director was a capacitor that would completely discharge on only a momentary short circuit. Of the insulating materials available in form suitable for capacitors, only polystyrene, one of the newer plastics, had sufficiently low dielectric absorption.

The sheets at first available were too brittle to use in capacitors, but this difficulty was shortly overcome by adding a small amount of plasticizer. Although this removed the objectionable brittleness, the plasticizer detracted somewhat from the desirable electrical characteristics, but not sufficiently to discourage the attempts to apply the new material to capacitors, and work in this direction was initiated. The problem was to develop a capacitor, using a new and untried dielectric, that would be as good as the best mica capacitor in most respects, and far better in the matter of absorption. In view of the fact that mica capacitors had been brought to their present satisfactory form only after many years of development, and that it was hoped to have the new capacitors in production within a few months, this was a challenging undertaking.

Intensive development work was started by members of both the capacitor development group and the Chemical Laboratories. Also, the supplier of the film was encouraged to develop an improved material: one of more uniform thickness, and free from conducting particles and pinholes that reduce the insulating value of the material. He was asked as well to develop methods of making polystyrene sheets of adequate flexibility without the use of a plasticizer. Requirements for polystyrene film were formulated jointly with the Chemical Laboratories, and the supplier who was involved coöperated wholeheartedly in making them effective.

Within six months, preliminary design information was furnished to the Western Electric Company on a capacitor which had

*RECORD, *January*, 1944, *page* 225.

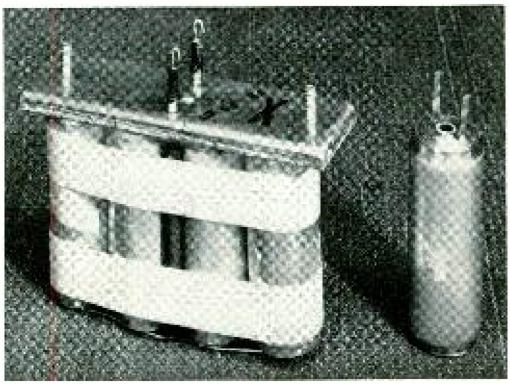


Fig. 1—The polystyrene capacitor for the M-9 Director is made from four units selected to give the desired capacitance

far less absorption than the mica capacitor and was only slightly inferior to it in respect to stability of capacitance with time. When the supplier, with the help of the Laboratories' engineers, found means of making a satisfactory film without the plasticizer, even this inferiority was reduced to the vanishing point. Electrically in only one respect are these capacitors now inferior to mica capacitors, and that is in the temperature coefficient of capacitance. This is inherent in the polystyrene material itself, but fortunately in applications where this factor is important, it can be offset by associating with the capacitors resistances with a temperature coefficient of opposite sign. A change in capacitance in a capacitor is usually detrimental because it changes the value of the time constant of the circuit in which the capacitor is used. The time constant, however, is equal to the product of capacitance and resistance, and thus a change of capacitance in one direction may be offset by a change of resistance in the other. By associating with the capacitors resistances with temperature coefficients of the opposite sign, the time constant of the circuit can be maintained at the same value over a wide range of temperature.

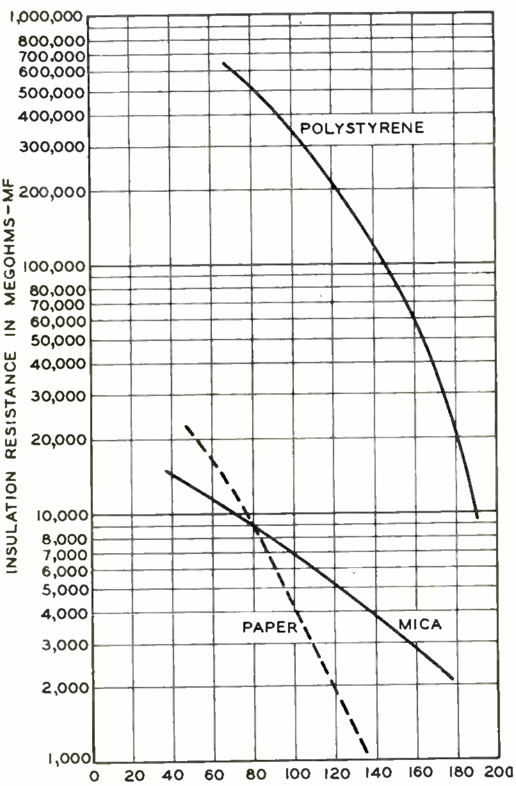


Fig. 2—Insulation resistance is here plotted against temperature of polystyrene, mica, and paper capacitors

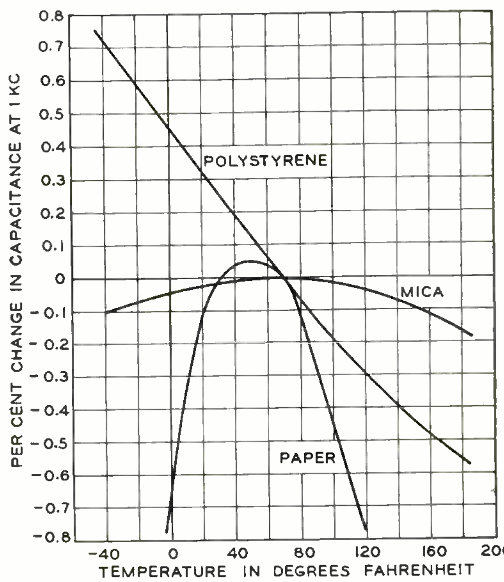


Fig. 3—Change in capacitance with temperature for polystyrene, mica, and paper capacitors

The capacitor designed especially for the M-9 Gun Director is shown at the left in the illustration at the head of this article. It has a capacitance of 1 mf, which is held to limits of ±2 per cent. It consists of four units as shown in Figure 1, each unit

TABLE I—RELATIVE RESIDUAL CHARGE FOR POLYSTYRENE, MICA, AND PAPER CAPACITORS

Type of Capacitor	*Relative Residual Charge* 40° F.	75° F.	150° F.
Polystyrene	1	1	2
Silvered Mica	10	20	23
Mineral Wax-Paper	8	8	40
Mineral Oil-Paper	15	25	30

being wound on a brass tubular arbor in such a way that there are two 1-mil sheets of polystyrene between adjacent 0.25-mil sheets of tinfoil. Contact to the foils is made by thin tinned brass strips laid in at the approximate middle of each sheet. Four such units are selected for capacitance so that the completed capacitor is within the desired limits, and are then assembled as shown. Cylindrical units were chosen since that structure was found to have the highest capacitance stability when using the plasticized polystyrene. Designs used in other projects, also shown in the headpiece, make use of flat units like those of conventional paper capacitors. Although tinfoil of the composition used contains 85 per cent tin, which was one of the very critical materials, it was found that only tinfoil containing more than 50 per cent tin would give the desired capacitance stability. The stiffer foils such as aluminum or lead produced capacitors with excessively large capacitance changes when they were subjected to the wide temperature range encountered in military apparatus.

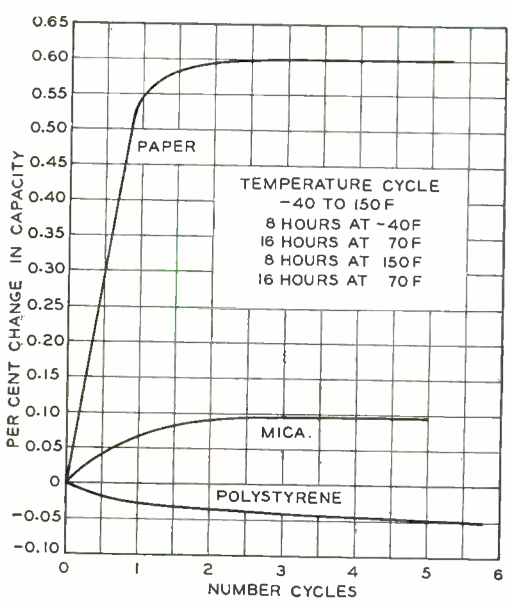


Fig. 4—Aging of polystyrene, mica, and paper capacitors exhibits itself as a change in capacitance following successive temperature cycles from −40 to +150 degrees F

All these capacitors are enclosed in hermetically sealed containers to preserve their high quality in service, since the finished capacitors, in addition to being exposed to a wide range of temperature, must also withstand tropical humidity. The containers are filled with a hard mineral wax, which serves as a blocking medium both to hold the unit in place and to minimize the effects of vibration on the characteristics of the capacitor. After completion, each capacitor is subjected to several temperature cycles from 70 to 150 degrees F., which removes any strains set up in the units by the assembly operations. In final inspection, in addition to the usual capacitor tests for dielectric strength, insulation resistance, and capacitance, these capacitors are also checked for temperature coefficient of capacitance, dielectric absorption, and stability of capacitance. In this way it is made certain that the capacitor will function satisfactorily under the exacting service conditions required.

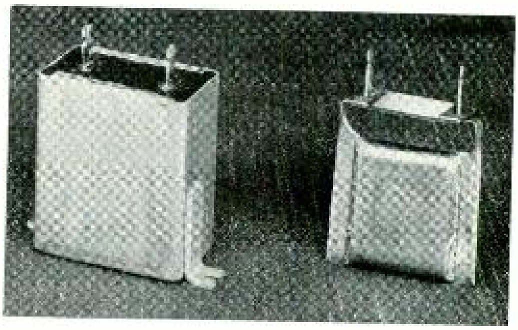


Fig. 5—Extended-foil type of polystyrene capacitor before and after potting. A small silvered mica trimmer capacitor is provided for capacitance adjustment

How these polystyrene capacitors compare with mica and paper capacitors in their characteristics is shown in the accompanying illustrations. Figure 2 shows the insulation resistance of polystyrene capacitors over the important temperature range, and for comparison, that of high-grade paper and mica capacitors is shown

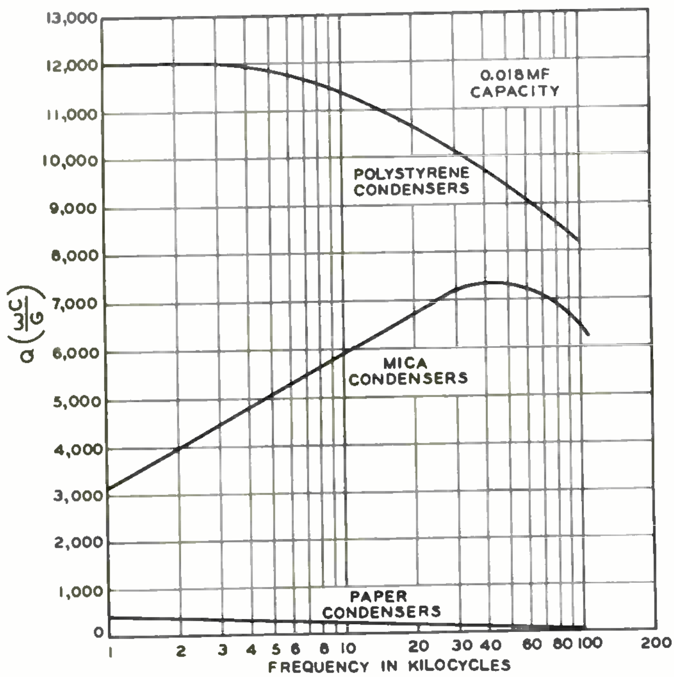


Fig. 6—Ratio of reactance to resistance, Q, of polystyrene, mica, and paper capacitors

as well. The polystyrene capacitor is about fifty times higher in insulation resistance at room temperatures than paper or mica capacitors, which is a very desirable feature for many applications. Figure 3 shows the change in capacitance with temperature, and Figure 4 shows the aging, that is, the change in room temperature capacitance when the capacitor is subjected to a number of temperature cycles. The corresponding characteristics of typical wax-impregnated silvered mica and paper capacitors are shown on both these charts for comparison. Table I gives the comparison of the residual charge of mica, paper, and polystyrene capacitors. The numerical values in this table are in arbitrary units based on a special test circuit developed for measuring the relative residual charge. It will be noticed that only in temperature coefficient are the polystyrene capacitors inferior to mica capacitors.

Many thousands of these capacitors have been used in war projects involving timing circuits or d-c amplifiers. They have materially aided in securing the high accuracy attained in the various computers developed by the Laboratories.

The critical shortage of mica during the war years focused attention on the need for developing a series of polystyrene capacitors to replace mica capacitors in the filters and networks for the telephone systems being manufactured by the Western Electric Company for the Armed Services as well as for the telephone plant. One additional requirement is added to those discussed previously: the capacitor must have very low a-c losses over the operating frequency range. Polystyrene itself fortunately has as low a loss as the finest grades of mica, and it was therefore necessary only to arrive at a design of capacitor that would realize the inherent low loss of the material without sacrificing the desirable stability properties of the designs that had already been developed.

Since these capacitors were to be used in place of the mica capacitors employed heretofore, they had to be mechanically as well as electrically interchangeable with them. Because of the lower dielectric constant of polystyrene as compared to mica, the polystyrene condenser unit is larger for a given capacity. Fortunately there was sufficient space in the containers to permit using the larger polystyrene units in a large portion of

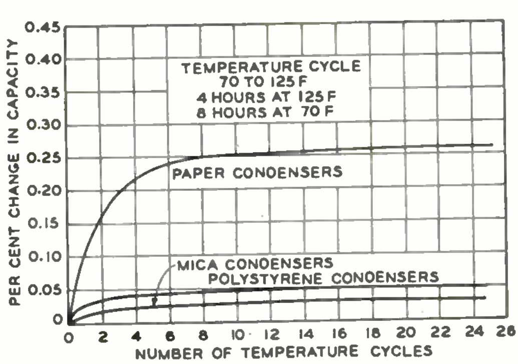


Fig. 7—Stability characteristics of polystyrene, mica, and paper capacitors used for filters and networks

the designs. The unit both before and after it is sealed in its container is shown in Figure 5. A flat construction of the extended-foil type is employed, that is, each foil extends from one end of the winding, and contact is made to the extended foils over the entire area. For their intended application, one of the important characteristics of these capacitors is a high Q, which is the ratio of reactance to resistance. Values of Q for one of these polystyrene capacitors and also for a high-grade mica capacitor designed for use in carrier filters and networks is shown in Figure 6. It will be noticed that the polystyrene capacitor is much superior to the mica capacitor, particularly at the lower frequencies. The stability of this type of capacitor when subjected to temperature cycles is shown in Figure 7, together with that of mica and paper capacitors designed for use in filters and networks. For these curves, the temperature cycle is not as wide as that of Figure 4, since these capacitors are intended for use in buildings.

Although started primarily as a wartime mica conservation measure, these latter types did not get into production before the end of the war. The mica supply situation eased sufficiently—in part through another Laboratories development*—so that these substitute measures were deferred in favor of other more pressing work. Since these polystyrene capacitors give promise of being less expensive than their predecessors, however, it is likely that they will find some future application in filters and networks for carrier systems.

*RECORD, *September*, 1944, *page* 509.

THE AUTHOR: After graduating from Sheffield Scientific School at Yale University in 1914 with the degree of Ph.B., J. R. WEEKS joined the student course of the Western Electric Company at Hawthorne. On completing this course, he transferred to the Research Department in New York where he worked on the manufacture of the vacuum tubes for the Arlington-Paris transatlantic radio-telephone studies. During World War I he served in the Signal Corps and received a commission just after the Armistice. Since 1920 he has been associated with the Apparatus Development Department. He was first occupied with studies of insulations, principally of rubber for submarine cables, and during 1923 assisted in laying and testing the submarine telephone cable between San Pedro and Catalina Island. He then engaged in the design of loading and retardation coils for filters and networks, and later transferred to the development of capacitors. During the war he has developed and supervised testing of capacitors of all types and varieties for the Armed Services.

Radio and Television Research Reorganizes

THE Radio and Television Research Department has been divided into two departments: Radio Projects and Television Research, Department 1500, under the direction of R. Bown, Assistant Director of Research, and Radio Research, Department 1600, under the direction of H. T. Friis, as Director of Radio Research.

In the Radio Projects and Television Research Department, J. W. McRae has been appointed Electro-Visual Research Engineer, reporting to the Assistant Director of Research. A. G. Jensen, Television Research Engineer, and G. N. Thayer, Radio Projects Engineer, continue to report to the Assistant Director of Research.

In the Radio Research Department, H. T. Friis, as Radio Research Engineer, directs the work of those formerly reporting to him. J. C. Schelleng, Radio Research Engineer, and G. C. Southworth, Wave Guide Research Engineer, report to the Director of Radio Research, and continue to direct those formerly reporting to them.

Magnetization and Stress

By R. M. BOZORTH
Physical Research

WHEN a ferromagnetic material is stretched, its permeability may change so much that stress ranks as one of the primary factors which affect magnetic properties. Often the effect of stress is objectionable, and in transformers care is taken to avoid it as much as possible. On the other hand, strain sensitivity can be a useful magnetic property. For example, it often finds application in supersonic equipment and other magnetostriction devices.

In some substances tension causes an increase in permeability whereas in others it effects a decrease. There are instances, notably iron, in which an increase takes place in low fields and a decrease in higher ones. In nearly all materials, however, the maximum, i.e., saturation, value of the magnetization is unaffected by stress.

One of the substances in which there is an especially large increase in permeability with tension is 68 permalloy. When this alloy, which contains 68 per cent nickel and 32 per cent iron, is stretched within its elastic limit, its magnetic induction goes nearly to saturation in very low magnetic fields, as is shown by the magnetization curves of Figure 1. The opposite characteristic is displayed by nickel, Figure 2, where a decrease in induction occurs with increase in stress, although the effect is less marked than in permalloy. These curves were obtained by applying tension when the specimens were demagnetized and keeping it constant while the measurements were made. When the tension is high, the magnitude of the change is large and is limited only by the saturation magnetization of the material and its ability to maintain the stress. As the field-strength is increased from zero to a high value, the change of induction due to a constant stress increases from zero, passes through a maximum and approaches zero again as a limit.

The behavior of annealed iron, Figure 3, is more complicated. Low tensions cause an increase in induction below the knee of the magnetization curve and a decrease above it. High tensions produce an increase in induction for points near the origin of the curve and a decrease for other points.

When increasing tension is applied to a material whose permeability increases under stress, the induction at a given field-strength increases until the elastic limit of the specimen is reached and then de-

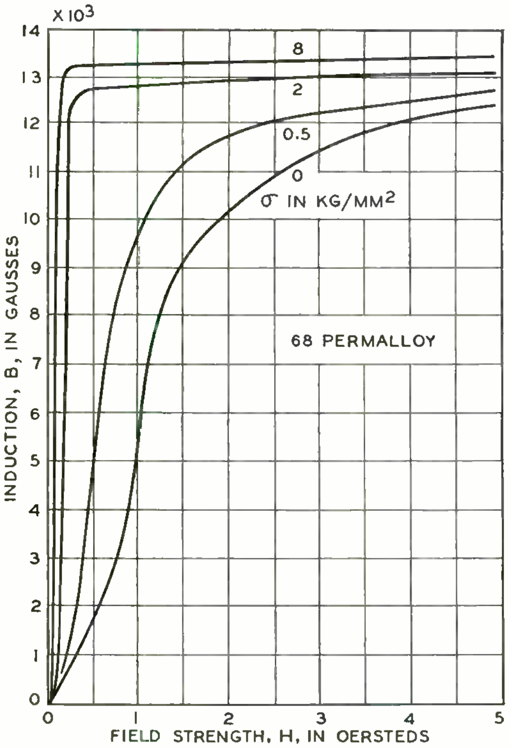


Fig. 1—Tension increases the permeability of 68 permalloy

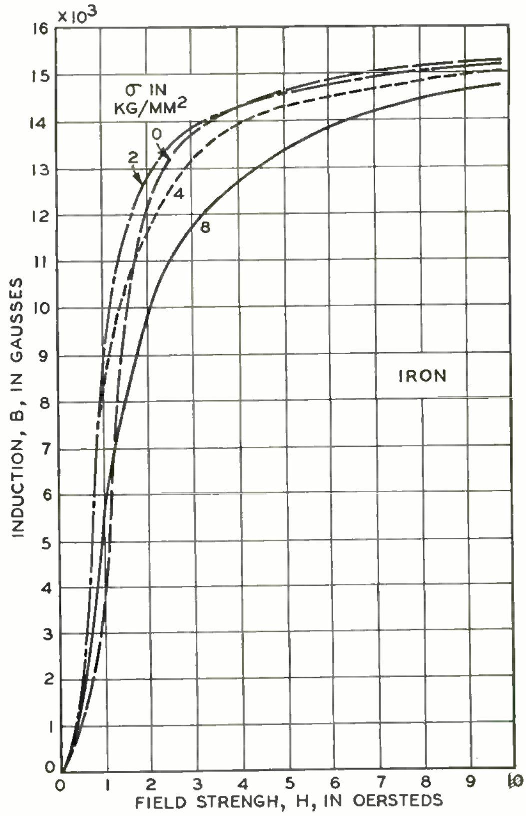


Fig. 3—Tension may cause the permeability of annealed iron to increase or decrease, depending on its amount and the strength of the magnetizing field

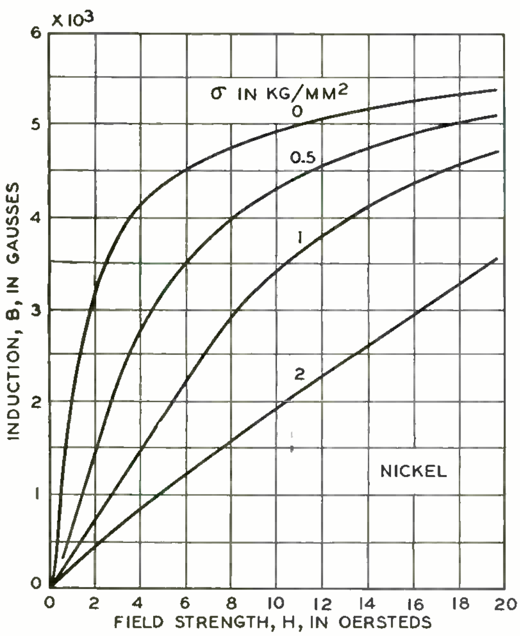
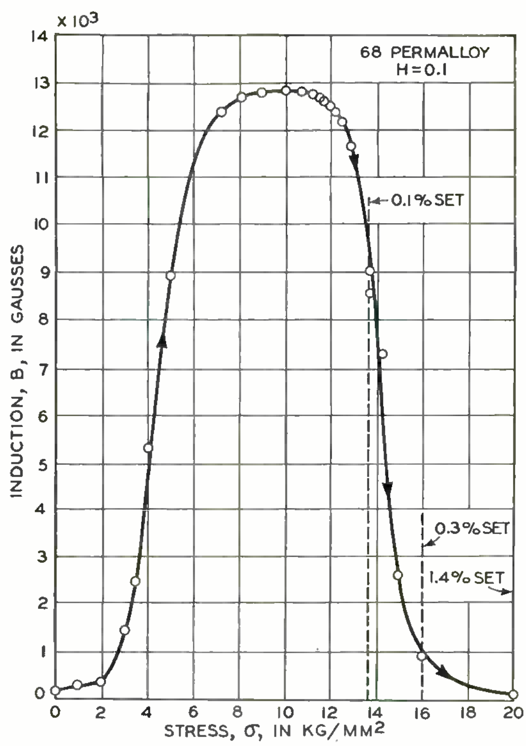


Fig. 2—The permeability of nickel decreases when tension is applied to it

Fig. 4 (at right)—With increasing tension and constant field-strength the induction of 68 permalloy increases until the elastic limit of the material is reached, then decreases



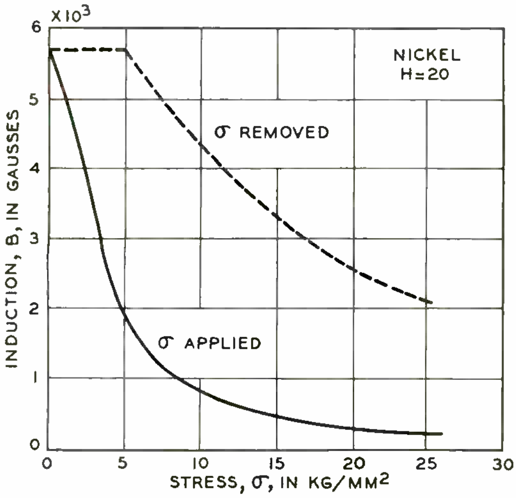


Fig. 5—B versus σ curves for substances whose permeability decreases with tension do not show sharply the point at which plastic flow begins. Determining the induction for a given field-strength after the stress has been removed permits detection of an over-strain of one per cent or less

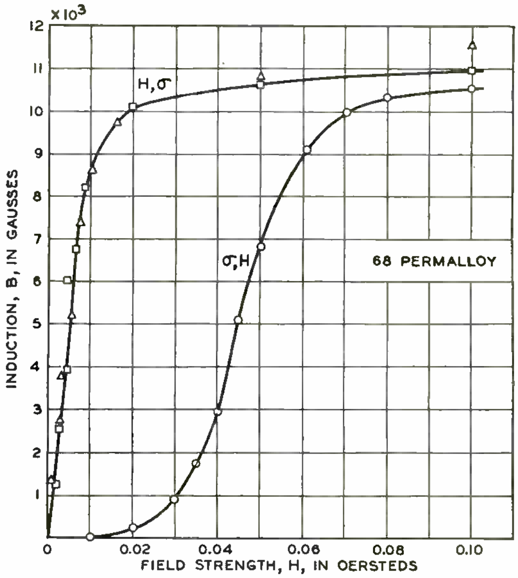


Fig. 6—The shape of the magnetization curve of 68 permalloy depends markedly on whether the tension or magnetizing field is applied first

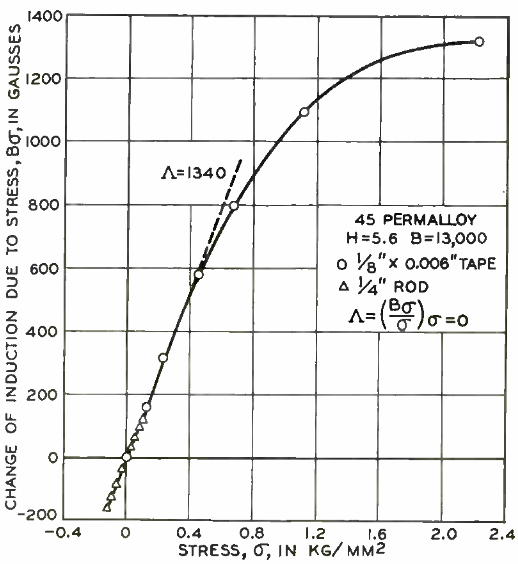


Fig. 7—When a small stress is applied repeatedly to and removed from a magnetic material, in a steady field, the change in induction is proportional to the stress

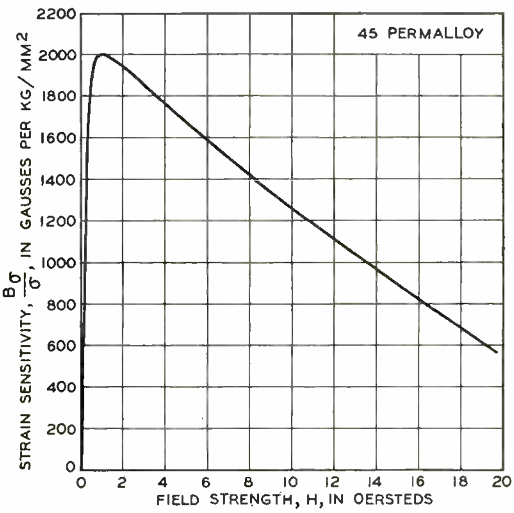


Fig. 8—When magnetic material is used to detect small stresses or strains it is obvious that it should be polarized so that the strain sensitivity is a maximum. As shown in the graph above, this occurs when the polarizing field is about one oersted

creases continuously to a low value as the material is hardened by plastic deformation. The data of Figure 4 refer to 68 permalloy when the tension is increased from zero to about twice the elastic limit. The induction in a field of 0.1 oersted increases until it is almost equal to the saturation density, 13,300, and then decreases when plastic flow begins.

If the permeability of a material decreases under stress, as does that of nickel, the point on the curve at which plastic flow begins is not readily determined. Results illustrating this are given in Figure 5. The elastic limit for such materials is more evident when the induction for a given field-strength is determined after the tension has been applied and removed. An overstrain of one per cent is then easily discernible and under favorable circumstances considerably less than 0.1 per cent can be detected. A curve obtained in this way for nickel is shown in Figure 5 by a dotted line which breaks at the point where flow begins.

In a material, such as 68 permalloy, that is especially sensitive to stress, the shape of its magnetization curve depends markedly on whether the tension or the magnetizing field is applied first. Figure 6 shows curves for low fields when the application of tension, $\sigma = 4 Kg/mm^2$, is preceded (σ, H) or followed (H, σ) by that of the magnetizing field. The maximum slope of the H, σ curve is about $B/H = 10^6$.

When a small stress is applied repeatedly to and removed from a magnetic material subjected to a steady field, the change in induction produced is proportional to the amplitude of the stress. The graph of B_σ versus σ, Figure 7, goes through the origin without change in slope and as σ increases it curves toward the horizontal and approaches a limiting value of B. The data of this figure refer to 45 permalloy to which was applied a constant field, $H_o = 5.6$, corresponding to an induction $B_o = 13{,}000$. When the repeated stress has a small and constant amplitude, the corresponding change in induction, i.e., the strain sensitivity, depends on the constant field to which the material is subjected. A characteristic curve of strain sensitivity versus polarizing field-strength is shown in Figure 8. When magnetic material is used to detect small stresses or strains it is obvious that it should be polarized so that the strain sensitivity is a maximum. In the figure this occurs when the polarizing field is about one oersted.

The effects of stress on permeability can be explained by assuming that a magnetic material is composed of a great many small regions, called domains, each one of which is magnetized to saturation in a direction of easy magnetization. When the material is unmagnetized, the domains are oriented in all directions so that the net magnetization of the body is zero. They are changed by the action of applied magnetic fields and stresses and at saturation all are aligned parallel to the field. Tension changes the alignment of the domains and thus affects the magnetization of the material in a calculable way.

THE AUTHOR: R. M. BOZORTH graduated from Reed College, Oregon, in 1917 with the A.B. degree and spent the next two years in the Army. He then entered the California Institute of Technology where he received a Ph.D. in Physical Chemistry in 1922. After a year as research fellow at that institution Dr. Bozorth came to the Laboratories where he has

since been engaged in research work in magnetics and problems relating to the crystal structure and other physical properties of solids, particularly of metals.

Excerpts From A. T. & T. Annual Report

As the Nation turned from war to peace, demands upon the Bell System for telephone service increased sharply beyond even the previous peak levels reached in wartime. . . . With the end of demands on the System to produce great quantities of electronic and communication equipment for the Armed Forces, the entire organization swung into a program to give telephone service with all possible speed to waiting customers whose orders have been delayed by shortages of facilities caused by the war.

* * * * *

It has long been the policy of the Bell System to pursue a continuous and vigorous program of fundamental research. It is on a foundation of such research that telephone progress both in peace and war has been built. This policy on the part of the Bell System proved to be of great national advantage during the war, for it enabled Bell Telephone Laboratories to contribute to the development of new tools of war with a foundation of vital knowledge. Notable especially was the knowledge that had been accumulated on the methods of measurement and properties of very short radio waves. The application of this knowledge, which was made freely available to all properly concerned, contributed greatly to the development of radar, which proved such an important tool both for offense and defense. The advanced position of Bell Laboratories in ultra-short wave radar was one of the essential factors contributing to the success which marked the turn of naval warfare in the Pacific.

The results of telephone research proved to be valuable in many other military problems, enabling Bell Telephone Laboratories to play a key part in such a diverse array of projects as gun directors, rockets, torpedoes, guided aerial missiles, detection of submarines, magnetic mines, and even airplane crew trainers. In all, over 1,200 military projects were carried to completion.

The further we progress in the sciences underlying telephony, the greater becomes the promise of future benefits. The areas which we have under exploration are steadily expanding and the possibilities as they concern our business of electrical communication seem to excel anything achieved in the past.

* * * * *

As one of the post-war projects of the Bell System, it is planned to introduce methods and equipment which will enable long distance operators to dial calls directly through to the called telephone, even though it be at the other side of the continent. The result is expected to be improvement in speed, accuracy and reliability of long distance service and in overall economies of operation.

* * * * *

"Service to the Nation in Peace and War" is the tradition, the constant purpose and the daily work of the Bell System. From Pearl Harbor to V-J Day, the System met the continuously increasing war communications needs of our country, and its experience in overcoming war difficulties gives further assurance that it will meet the needs and opportunities of peace. Today and tomorrow its welcome task is to make telephone service better than ever before and increasingly useful to more people.

The System has the technical knowledge, the people, and the form of organization needed for the job. It has a full sense of its public responsibility. Its research laboratories are pioneers in extending the art of communications. Its manufacturing branch has the skill and facilities to produce and deliver a great volume and variety of equipment of ever-improving quality. Its physical plant has been kept in excellent condition throughout the war years, although it is now greatly overloaded.

All the talents and physical assets of the Bell System have been developed under our system of private enterprise in the American atmosphere of freedom. This has produced the best telephone service in the world—a service that in extent and speed far surpasses that of any other nation.

Award for Work on the Atomic Bomb

FOR its significant contributions to the research, development and engineering phases of the Atomic Bomb project, Bell Telephone Laboratories has received the 1946 Award for Chemical Engineering Achievement. This Award was set up in 1933 by the magazine *Chemical and Metallurgical Engineering* "to recognize group efforts—particularly the sort of industrial achievement that results from teamwork between science and engineering." Presentation was made at a dinner in the grand ballroom of the Waldorf-Astoria, at which the Laboratories was represented by President O. E. Buckley and several members of the technical staff.

The program directed toward the military utilization of atomic energy was sponsored originally by the Office of Scientific Research and Development. Later the work was taken over by the Manhattan District Army Engineer Corps. Members of the Laboratories participated in this work at various stages of the operations. Contributions to it were made by J. B. Fisk, W. Shockley, F. C. Nix, F. J. Biondi and D. MacNair during the earlier phases of the work. After the Manhattan District was organized, work was carried on in the Laboratories under the supervision of A. H. White, G. T. Kohman and E. E. Schumacher, of the Chemical Laboratories. In all, some thirty-five men in the Laboratories were engaged in this project, which was completed in May, 1945. During this period, significant and practical chemical and metallurgical contributions were made. Although the nature of this work cannot be disclosed, its cost of over a half million dollars indicates its extent. At the time the work was completed, Dr. Buckley received a letter from Captain L. L. Grotjan, of the Manhattan Engineer District, which said, in part:

"The writer thinks it appropriate at this time to mention the substantial assistance to the current War Department program for the development of secret materials for war usage which the whole-hearted coöperation of your laboratories has effected.

"National security precludes, at least until the end of the present conflict, any mention of the specific achievements of this research group which has been forced to perform practically anonymously.

"It is, however, possible to state that discoveries made by these scientists have played a very significant part in determining the ultimate course of a major phase of the above-mentioned program. It is anticipated that these developments of Bell Telephone Laboratories will result in a very substantial contribution to this Nation's war effort and to the early victory of the United Nations."

Bronze Star Medal Presented to Lee L. Glezen

For outstanding service in support of combat troops, the Bronze Star Medal has been awarded to Lee L. Glezen. Mr. Glezen was a technical observer for the Signal Corps in England and on the Continent. During the time he was in the European theater he played a major rôle in setting up vital communications circuits by rehabilitating French and German lines.*

Presentation of the medal was made by Major General George L. Van Deusen of the Signal Corps at an impressive ceremony in the West Street auditorium on January 23 before members of the executive staff, department heads of System Development, representatives from the Western Electric Company, and friends and associates of Mr. Glezen.

The citation, signed by President Truman and read by Brigadier General C. O. Bickelhaupt, to whom Mr. Glezen reported while in Europe, follows:

"Mr. L. L. Glezen served the Army with distinction as a civilian technical observer in direct support of combat operations, from June 1944 to March 1945, in England and France. From the time he arrived in the United Kingdom he gave invaluable as-

*See "Rehabilitating a Telephone System," by Mr. Glezen, in the RECORD for July, 1945, page 255.

Lee L. Glezen receives the Bronze Star Medal from General Van Deusen of the Signal Corps. O. E. Buckley is at the left and General Bickelhaupt, who read the citation, at the right

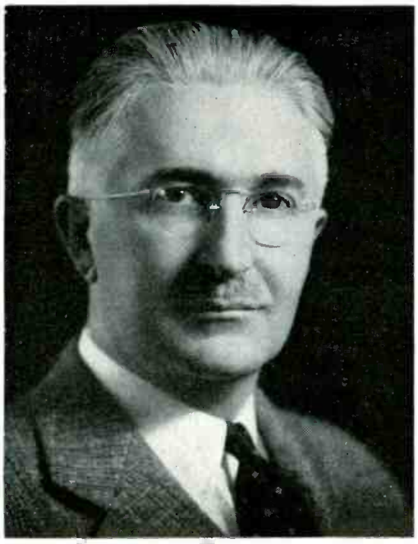
sistance in planning the establishment of communications on the continent. Later, he reported for duty with the Ninth Air Force in Normandy.

"As a civilian technical observer he reconnoitered proposed installations, often going into the combat zones. He ably assisted in organizing and directing an emergency program for extensive rehabilitation of French telephone facilities for military use. He personally labored to restore the vital repeater stations at Rennes, St. Lo, Le Mans, Laval and Nogent. Although not a young man, he often worked for 24 to 36 hours without a break, entirely of his own accord, in order to restore these repeater stations to service. Arriving in Paris shortly after its liberation, he immediately plunged into the tremendous task of establishing telephone trunk circuits from Normandy and the channel ports to Paris and forward to the Armies, a task calling for the utmost in perseverance, technical skill and leadership. His willingness to accept such responsibility and the aggressive manner in which he carried out his mission despite the fact that he held no military command authority, was an inspiration to all of his associates. By his technical ability, resourcefulness and extreme devotion to duty, Mr. Glezen has given invaluable service to his country."

R. V. L. Hartley Awarded I.R.E. Medal of Honor

At the annual dinner of the Institute of Radio Engineers on January 24, the Institute's Medal of Honor was presented to R. V. L. Hartley "For his early work on oscillating circuits employing triode tubes and likewise for his early recognition and clear exposition of the fundamental relationship between the total amount of information which may be transmitted over a transmission system of limited band and the time required."

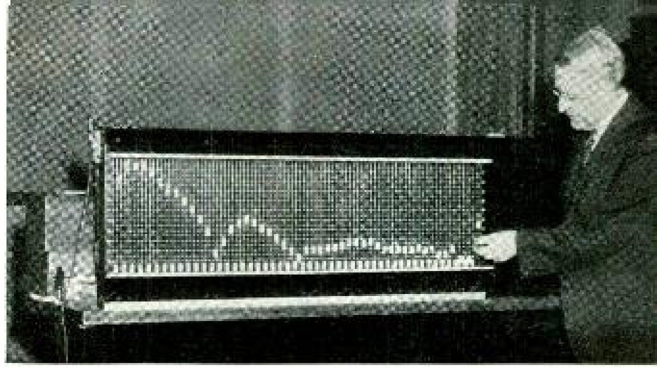
Mr. Hartley, after graduating with an A.B. degree from the University of Utah in 1909, studied at Oxford for three years as a Rhodes Scholar, receiving the B.A. in 1912 and the B.Sc. in 1913. On his return he entered the research laboratory of the Western Electric Company and had charge of the early development of radio receivers for the Bell System's transatlantic radio telephone tests of 1915. The Hartley oscilating circuit was invented during that work. At that time also he invented a neutralizing circuit to offset the internal coupling of triodes that tends to cause singing.



R. V. L. HARTLEY

He was also the first to formulate the relationship between the amount of information transmitted and the width of the frequency band required. He had studied this relationship for a number of years, but it was not until February, 1926, that he published a short account of it in the Record. A fuller report of it was made to the International Congress of Telegraphy and Telephony at Lake Como in 1927.

In 1929, due to a prolonged illness, Mr. Hartley gave up the direction of his group. Since then, as improving health permitted, he has engaged chiefly in theoretical studies. During World War II he acted as a consultant on a variety of projects, working particularly on servomechanisms as applied to radar and fire control.



Dr. Fletcher with the "Tone Synthesizer"

Harvey Fletcher Demonstrates the "Tone Synthesizer"

An electronic device which can produce the sounds of the human voice and of various musical instruments, from the cello to church bells—and in addition can produce tones never heard before—was demonstrated recently before the American Physical Society by Harvey Fletcher.

The device, which exists solely as a laboratory model of experimental apparatus, is known as a "tone synthesizer." It was developed as part of the Laboratories' fundamental research into speech and hearing, with particular reference to improving telephone apparatus. It succeeds in imitating the characteristic tones of various musical instruments and the human voice by sounding their fundamental pitches and the appropriate overtones. By means of electronic circuits, the machine also permits changing the starting and stopping time of the various tones, which determine in part, for example, the difference between a piano and an organ tone of the same pitch.

Experiments with the device have also confirmed for scientists refinements upon the old concept that "pitch depends upon the length of the sound wave, loudness upon its amplitude and quality or timbre upon the form of the complex wave." In the light of recent investigations with the tone synthesizer, these three major characteristics of a musical tone are not independent of each other. By combining the harmonic tones of the synthesizer in different ways, both as to number and loudness, for example, it has been demonstrated that changes in pitch or overtone structure may produce large changes in loudness. Similarly, changes in the intensity of tones may cause small changes in pitch, possibly almost as much as a tone. Certain combinations of overtones may change pitch as much as an octave. Finally, the quality of a tone, which makes it possible for the ear to distinguish different musical instruments—a factor depending primarily on the overtone structure—may vary with large changes in intensity and pitch.

The synthesizer looks somewhat like a telephone switchboard without cords, about two feet high, four feet long and a foot deep. On its face are 100 knobs, each controlling a harmonic tone by movement in its vertical slot. The tones themselves, which cover the audible range of pitches, are

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March Service Anniversaries of Members of the Laboratories

40 years
H. M. Bascom
H. M. Hagland

35 years
J. E. Kelly
L. S. O'Roark
C. F. Seibel

30 years
H. A. Affel
R. S. Bair
O. J. Finch
T. C. Fry
O. C. Hall
A. C. Powell
J. H. Sailliard
J. M. Watson
W. A. Weikert
J. M. Wilson

25 years
L. P. Bartheld
F. S. Entz
G. S. Mueller
A. J. Pascarella
Ada Van Riper

20 years
C. H. Gorman, Jr.
F. J. Grattan
D. E. Haight
J. B. Harley
M. M. Jones
Helen Matej
Daniel O'Neill
E. J. Reilly
S. J. Stockfleth
Ruth Thompson

15 years
Louis Szeglowski

10 years
Elizabeth Chambers
A. G. Fox
M. J. O'Brien
T. T. Robertson
J. P. Schweitzer
L. J. Steinbach
E. G. Weiss

generated by the rotation of a shaft on which the various tones have been magnetically recorded. Knobs are adjusted to produce desired tones which are then sounded through a loudspeaker by closing a switch. Any tone may be repeated at once but the machine must be reset before producing any other tone. The number of possible tones, of course, is tremendously large.

The device is by no means a finished instrument, having been developed to its present stage as a research tool. Future study might reveal additional tones, possibly some of artistic usefulness not now used simply because no available musical instrument can produce them. The Laboratories will continue to use the synthesizer in studies of speech, sound and hearing.

Progress on Rural Telephone Developments

The most aggressive program for extending and improving telephone service in rural areas ever undertaken by the Bell System got under way in 1945. Service was installed for about 75,000 additional rural families in Bell territory during the year. These 1945 activities are being considerably accelerated, and it is the Bell System's objective to provide service to about 250,000 additional families in rural areas this year.

Within the next three to five years the program will provide service to another million rural families and involves installing about 1,200,000 poles and over 1,000,000 miles of wire at a cost of about $100,000,000.

An estimated 80 per cent of all rural families live within the reach of present telephone lines, and such lines will continue to be the most extensively used medium for bringing service to them.

The development of better and more economical methods of providing rural service has advanced rapidly in the Laboratories with the release of engineers from war projects. Equipment to permit the use of rural power lines for transmitting telephone conversations by means of the power line carrier system is undergoing field trials at Jonesboro, Ark., and at Selma, Ala. The study of radio as a means of reducing the excessive costs of serving very remote rural areas has been carried to the point where customer use of the system on a trial basis will soon begin in the ranch country around Cheyenne Wells, Col.

Various phases of the development work on these two projects is being done by a number of Laboratories' Departments. Circuit development is being carried on by Transmission Engineering; equipment by Equipment Development; filters, coils, transformers, capacitors and other components by Transmission Apparatus; switching by Switching Development; and tubes, varistors and similar components by Electronic Apparatus Development.

New methods and materials to permit the joint use of long-span rural power lines for both telephone and power wires, including the development of a new improved structural transposition arrangement, have been devised and used successfully in trials by Outside Plant Development.

Real advances have been made in the design of relatively inexpensive power-driven machinery for digging holes and the equipment is already being used. Work on an improved type of wire which can be plowed into the ground has also been carried forward still further by the Outside Plant Development Department.

E. B. Smith Retires

Edmund B. Smith of the Switching Development Department retired on January 13 after having completed thirty-eight years of service. Before coming to West Street, Mr. Smith had worked for fourteen years on central-office installations for The Southern New England Telephone Company and the Western Electric Company. In 1917 he became a member of the U. S. Navy and served on the U.S.S. *Arkansas* while it was associated with the British Grand Fleet in the North Sea. Mr. Smith came to the Engineering Department of the Western Electric Company in 1920 and worked on test circuits for manual offices. In 1928 he transferred to test circuit design for dial central offices.

R. R. Williams Retires

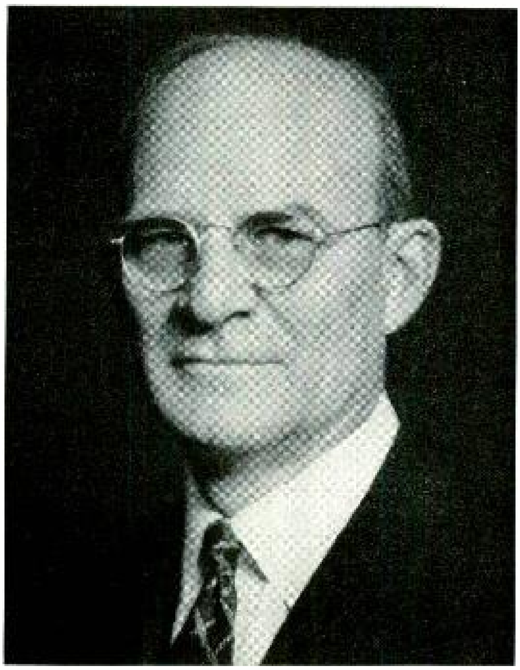
Although R. R. Williams is probably better known to the public for his outstanding research work on Vitamin B_1, he has at the same time made important contributions to industrial chemistry through his leadership of the Chemical Laboratories of which he was Director from 1924 to 1945. Last spring, to enable Dr. Williams to devote more of his time to matters of national interest in the field of nutrition, he was appointed Chemical Consultant reporting to the Director of Research.

Born in India in 1886, the son of a missionary, Dr. Williams was educated in this country. He attended Ottawa University from 1903 to 1905 and then, seeking more specialized training in chemistry, transferred to the University of Chicago. He was graduated in 1907 and received his Master's degree in 1908. He then entered the Philippine Civil Service and two years later began his work on vitamins.

At that time it was known that an extract of rice polishings contained something that would combat beriberi. Dr. Williams took up the study of this factor, searching for means for extracting it and ascertaining its identity. Much effort was expended in developing methods of testing the extracts to measure the concentration of the factor and so to gauge progress toward success. This search lasted for twenty-three years; it was often interrupted, and during much of the time it was carried on as a leisure-time pursuit entirely at Dr. Williams' own expense. Later Carnegie Corporation provided financial assistance.

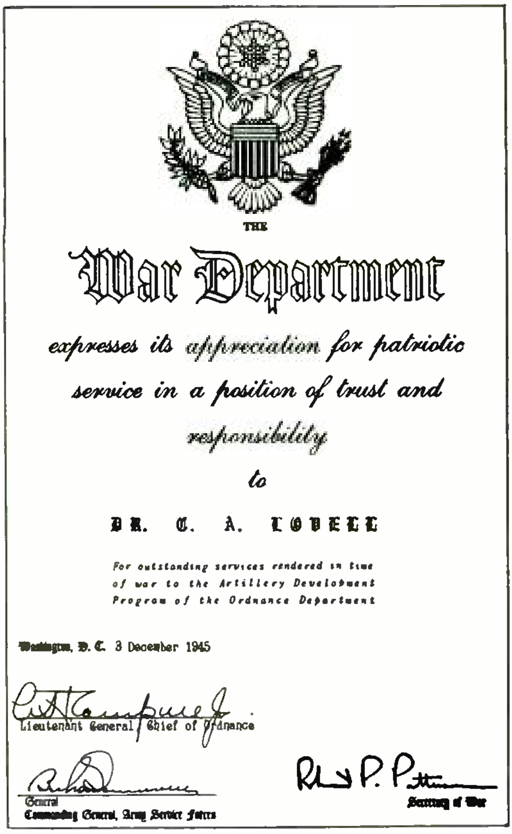
After his entrance into the Bell System as a chemist in 1919, he set up a laboratory in his own garage, but later secured facilities at Columbia University. In 1933 and 1934 he was able to produce a few grams of crystals of the pure vitamin, first called "B_1," and later "thiamin." After further investigation, the chemical structure was determined by Dr. Williams and his associates and a method of synthesis was devised in 1936. Synthetic thiamin is now an important basis of the national program for the enrichment of white bread and flour.

While this work was going on, Dr. Williams, as Chemical Director of Bell Telephone Laboratories, headed a growing and very productive group of chemists. Among their problems have been the metallurgy of magnetic alloys, of lead alloys for cable sheath and solder, and of vacuum-tube materials; an extensive study of the insulating properties of rubber and gutta percha, leading to the new material "paragutta" for submarine cable insulation; studies of fungus toxins to retard decay of telephone poles; purification of textile insulations; evaluation of finishes for wood and metals; the structure of high polymers; the chemistry of dielectric behavior; and the development of rapid analytical techniques, particularly in microchemistry. In 1942-43 he organized a nation-wide research program in synthetic rubber at the request of the Rubber Director.



Robert R. Williams

Among honors which have come to Dr. Williams have been the honorary D.Sc. from Ottawa University (Kansas) 1935, Ohio Wesleyan University 1938, University of Chicago 1941, Columbia University and Yale University 1942. He also received the Willard Gibbs Medal in 1938, the Elliott Cresson Medal in 1940, the Charles Frederick Chandler Medal, the John Scott Medal and the Medal of Honored Merit of the Republic of China in 1942.



THE

War Department

expresses its appreciation for patriotic service in a position of trust and responsibility

to

DR. C. A. LOVELL

For outstanding services rendered in time of war to the Artillery Development Program of the Ordnance Department

Washington, D.C. 3 December 1945

Lieutenant General / Chief of Ordnance

General
Commanding General, Army Service Forces

Secretary of War

Certificate of appreciation that has been presented to C. A. Lovell by Major General G. M. Barnes, Chief of Research and Development Service of the Ordnance Department, for Dr. Lovell's "coöperation and assistance in the Ordnance Munitions Program during the emergency"

Vocal Cord Films

Colonel Norton Canfield, Chief Otolaryngology Section, Surgeon General's Office, in a recent conversation with J. C. Steinberg, related a story concerning the film "High Speed Motion Pictures of the Human Vocal Cords" which were compiled several years ago by the Laboratories and made available for loan to interested groups. Apparently duplicates were made by the Signal Corps of a set of films sent to Major E. P. Fowler, Jr., at an Army hospital in Scotland. One of the sets came into the hands of Colonel Canfield while he was serving as Senior Consultant, Ear, Nose and Throat, European Theater of Operations, and he carried them with him throughout his travels in the European theater. Colonel Canfield said that apparently the films had not been shown previously in Europe, were received with enthusiasm, and created a great deal of interest and discussion. He said they got to be sort of a carte blanche to select medical circles.

He recalled having shown the films before the following groups: Royal Society of Medicine, Section on Otolaryngology, London; French Academy of Medicine, Paris; Society of Oto-Rhino-Laryngology, Hopiteau de Paris; Phonetic Society of Paris; the Otolaryngology Sections of twelve General Army Hospitals in the European Theater of Operations; and at a number of hospitals in special courses in anaesthesia.

Publication Department

Several changes in the organization of the Publication Department have been made. A. R. Thompson, formerly reporting to L. S. O'Roark, has been made Publication Production Manager and reports to R. K. Honaman. His responsibilities include books, booklets, and monographs; illustrations and printing; and displays, demonstrations and motion pictures. Mr. Thompson, since joining the Bureau of Publication, has made an intensive study of typography and printing methods, fields in which his skill has been 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. A graduate of Hamilton College in 1920, Mr. Thompson joined the Laboratories that same year.

L. S. O'Roark, as Assistant Director of Publication, is responsible for historical information and the Bell System historical museum, visitors' clearance, lecture accessory development for the Associated Companies and office services. P. B. Findley, as Editor, continues to direct Bell Laboratories Record and heads up the Laboratories' advertising program and the preparation of special articles. The technical libraries that are located at West Street and Murray Hill and the circulation of Laboratories publications is under Leah E. Smith, Librarian.

Obituaries

Harry A. Reybert of Apparatus Drafting, with continuous service since April 5, 1916, died on February 9. After attending Pratt Institute and then having experience in mechanical design, Mr. Reybert joined the Engineering Department of the Western Electric Company in 1916 as a draftsman. Soon after he was called into active service in the Mexican border campaign and later trained for World War I service. He returned to West Street early in the war and was concerned with drafting phases of the first two-way radio equipment for airplanes and on apparatus for submarine detection. Since then he had worked on designs for numerous pieces of apparatus. In recent years Mr. Reybert has been principally concerned with the drafting phases of new kinds of switching structures. Mr. Reybert was a member of the Western Electric Post of the American Legion and of the Frank B. Jewett Chapter of the Telephone Pioneers of America.

* * * * *

William T. Morgan of the Electronics Apparatus Department, with service since November 18, 1942, died on February 1. As a mechanic and calibrator in the experimental tube construction group, Mr. Morgan was concerned with the heat treating of tube parts and with the pumping of vacuum tubes. Much of his work was on the magnetrons used to generate high-frequency power for radar. Mr. Morgan graduated from Stuyvesant High School in New York City and for sixteen years before coming to the Laboratories had been with the J. V. McKee firm, installing oil burners.

H. A. Reybert
1881-1946

W. T. Morgan
1898-1946

Lieut. John K. Gardner Killed in Action

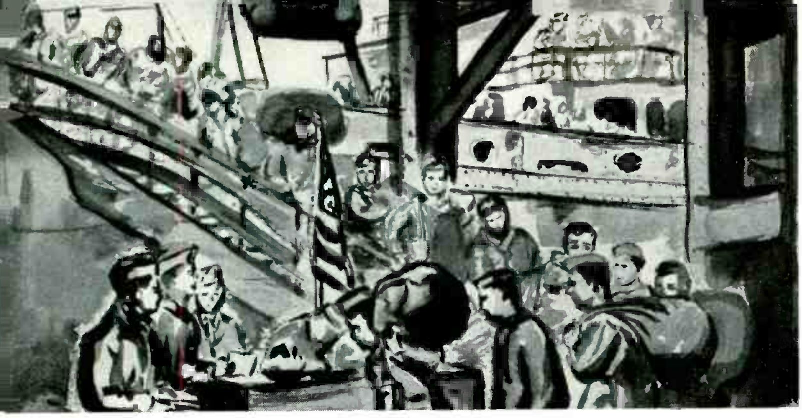
Lieut. John K. Gardner, previously reported missing in action, has been listed as killed in action on February 17, 1945. On that date he navigated a B-17 on a successful bombing mission to Frankfurt, Germany. It was last observed that his plane had lowered its landing gear and dropped out of formation. On a previous mission he had safely navigated his burning ship to an emergency landing in France.

The following excerpt from a letter written by Lieut. Gardner's uncle to L. E. Hunt at Deal represents the latest available information the Laboratories has received:

"Final word has reached us that Jack was killed in the crash of his plane in Hanan, which is about ten miles from Frankfurt. They found eighteen bodies buried in the town's cemetery and although they could positively identify only four bodies, Jack's name was on the cemetery records. Whether they will later identify his body, we do not know. It certainly is sad, as he was on his last mission and was counting on being home last spring. You, of course, know his only other brother was killed on Easter Sunday."

Lieut. Gardner was a member of the 388th Bomber Group, a unit of the Third Air Division, the division cited by the President for its mission to Africa when Messerschmitt plants at Regensburg were bombed.

Joining the Laboratories in September, 1941, he was a technical assistant at the Laboratories at Deal before he entered the Air Forces in January, 1943.



We Welcome Back

Joseph E. Sileo enlisted in the Army Air Corps in 1944 and was assigned to Turner Field after basic training at Keesler Field. He remained there sixteen months, servicing planes and acting as mess sergeant after the cadet program closed.

Charles E. Greene joined the Navy by enlistment and studied radio. He was retained as an instructor at Michigan City, Ind., and later supervised the department of mathematics at the school. After learning the demobilization process at Great Lakes, he was a general interviewer at Lido Beach.

Sgt. Gerard V. Smith attended radio operator mechanic and radar school and did radio maintenance on B-24's prior to going overseas with a bomb group attached to the 15th AAF. In Italy he was communications inspector and also had charge of teletype and switchboard.

August A. Hauth schooled for four months at Aberdeen Proving Ground and continued the study of automotive spare parts at Toledo. For a year he worked on stock control at Frankford Arsenal and was then assigned to a floating spare parts depot.

Major Joseph E. Fox, a reserve officer, was called to active duty in April, 1941. He was signal officer of the Army air base at Augusta for three months. Thereafter he transferred to the Aircraft Radio Laboratory at Wright Field, where he was a project officer in the Communications and Navigation Laboratory. Later, after a course of study at the Command and General Staff School, Ft. Leavenworth, he became Chief of the Communications Branch at Wright Field.

Ambrose J. Vallely took a wire-repeater course at the Signal Corps school at Ft. Monmouth and a course in VHF fighter control equipment at Allenhurst, N. J. He installed, maintained, and operated VHF equipment at an Army fighter field in Iceland for twenty-two months.

Lieut. Comdr. Clifford N. Anderson, from January, 1944, worked with the Bureau of Ships, where he was in charge of a section designing Loran equipment for ship and shore stations. Loran was the only navigation other than celestial used in the bombing of Japan.

Lieut. Col. A. E. Bowen served at two different times in World War II. He had been engaged in the development of radar for aircraft used in anti-submarine work when, in September, 1942, he was commissioned as major on anti-submarine coverage in Trinidad. At the end of one month he returned and went on an inspection tour until November. Nearly a year later he was called for service and, until last fall, served in Washington as Staff of Air Communication Officer-in-Charge of Section No. 7D on airborne radar.

Lieut. Comdr. Vincent M. Meserve studied radar at Cornell, Harvard, and M.I.T. before his permanent assignment to the Philadelphia Navy Yard. Under the Naval Air Matériel Center, he participated in laboratory and flight testing of special airborne radio and radar equipment. For his last six months of duty he was in charge of one of the radio and radar sections.

Eugene E. Flannery enlisted in the AAF in October, 1943. He completed aerial gunnery at Tyndell Field, Fla., and advanced navigation at Selman Field, La., before his release.

Comdr. Ralph H. Miller, a reserve officer, was recalled to active duty on June 1, 1943, for a special assignment in the Division of Naval Communications in Washington. His work had to do with organizing and continuing in operation a teletypewriter system using land wire and radio, for all bureaus of the Navy. He worked with Bell System representatives, including the A T & T "Dull" Committee, and followed Bell System practices as much as possible.

J. E. Sileo

C. E. Greene

G. V. Smith

A. A. Hauth

Maj. J. E. Fox

A. J. Valle

CDR. ANDERSON   LT. COL. BOWEN   LT. CDR. MESERVE   E. E. FLANNERY   COMDR. MILLER   MAJ. SKINNE

Major Frederick J. Skinner took a three-week course in the Aircraft Warning Department under the Signal Corps School at Ft. Monmouth and instructed radar maintenance and operation there for two months. He transferred to the Signal Corps Laboratories at Monmouth and then to the Coles Signal Laboratory, Red Bank, where he was in charge of the Microwave Communications Section until the end of 1943. From 1944 to 1945 he was chief of two main branches: the Applied Communications Branch and the Radio Branch.

Herbert Baker was assigned to bombardment armorer's school at Lowry Field, Denver, upon his enlistment. He then trained in Utah and Iowa with a bomb squadron for five months before assignment to the 8th AAF in England. As an armorer, he loaded bombs and handled ammunition and bomb-bay equipment for B-17's for two years.

Anthony A. Waraske spent twenty-three months in England attached to the 8th AAF as a radio mechanic. He worked on radio receivers and transmitters of DF stations, received six battle stars, and the Presidential Unit Citation.

Louis C. Munch, as an electrician's mate second class, aboard the U.S.S. *Electra,* went to the Marshall Islands, Eniwetok, Kwajalein, Saipan, and Tinian. He took care of electrical maintenance on the ship and on invasion barges which it carried along with Marines and supplies. He later attended electrical school in Washington and was assigned to a destroyer escort.

Richard D. Long was overseas twenty-one months, most of the time in India, but also in the Marianas. He served as message center chief and did cryptography work with the Army Air Forces.

Capt. Robert C. Winans, a reserve officer, was assigned to active duty at the Laboratories from February to July, 1942. He then left Ft. Ord, Cal., with the 58th Sig. Bn. and sailed to Australia as radio officer. Capt. Winans was assigned to General Headquarters as Radar Officer and remained in that capacity for two and one-half years in Australia, New Guinea and the Philippines.

Col. John M. Hayward has returned after five years of service in the Engineering Division of the AAF at Wright Field. During the early part of this assignment he was in charge of liaison on all Air Force projects with the National Advisory Committee for Aeronautics, the Navy and the National Defense Research Committee. Another responsibility was the study of foreign equipment for technical analysis. A veteran pilot of World War I, Colonel Hayward qualified to fly seventy-six different types of aircraft, including German and Japanese. In connection with an investigation of Japanese equipment he made a 25,000-mile trip to the Southwest Pacific area. Later Colonel Hayward was made chief of the Technical Data Laboratory at Wright Field. He also served on the Promotion Board at Wright Field and as President of the General Court Marshal there. His final assignment was Assistant Deputy Commanding General for Intelligence at Wright Field.

Lieut. William F. Bodtmann received his wings at Napier, Ala., in June, 1944. He was a pursuit pilot, and as such was attached to the 3rd Division at Dallas. From that location he ferried planes throughout the United States and Canada.

Lieut. Col. Joseph A. Mahoney accepted a direct commission as major at the request of the Signal Corps in March, 1942, and was assigned to the Office of the Chief Signal Officer, Washington. There he was responsible for preparing studies and recommendations regarding the initiation of development projects and standardization of equipment types. Last April he was made Chief of the Systems Branch, Engineering Division, Signal Corps Engineering Laboratories.

Major Edwin H. Perkins began active duty in February, 1942, and went to Wright Field where he worked with the Air Technical Service Command, at first doing field installation of radio equip-

ERBERT BAKER   A. A. WARASKE   L. C. MUNCH   R. D. LONG   CAPT. WINANS   COL. HAYWAR






LT. BODTMANN LT. COL. MAHONEY MAJ. PERKINS W. B. BACHMANN MARCAE BITOWF ETHEL MCALE

ment. Later he was supervisor of the Special Equipments Unit of the Radar Branch. He was in England from November, 1943, to February, 1944, with the 8th AAF, working on radio countermeasures equipment. From June to August, 1945, he was chief of the Facilities Branch.

Cpl. William P. Knox went to India in September, 1944, after attending radio schools in the States. He was a radio operator on a C-46 stationed at Mohonbarri in the Assam Valley and amassed a total of 715 combat hours.

Walter B. Bachmann was stationed in the Aleutian Islands for thirteen months. He then took the V-12 course at Cornell University and Hobart College. Later he was sent to Saipan and assigned to the U.S.S. *Southampton* as coxswain.

Marcae D. Bitowf took her boot training at Camp Le Jeune and attended aircraft radio school for seven months at Cherry Pt., N. C. She was assigned to a Marine Corps air field in the Mojave Desert, Cal., and for a year and a half was the only girl working with fifteen or twenty men to maintain aircraft radio and radar equipment on Corsairs, Hell Cats and torpedo bombers.

Ethel McAlevey sailed for England after just two months of basic training. She was stationed in and near London prior to her assignment to SHAEF, which took her to the continent in February, 1945. In France and Germany she did stenographical and secretarial work and was stationed in Frankfurt am Main until her discharge.

Lieut. Kenneth E. Waters, after attending OCS, was assigned to Panama with an anti-aircraft unit. Then he transferred to the infantry and later the paratroopers, training at Ft. Benning. He participated in the Battle of the Bulge and made a combat jump in Germany, was hospitalized briefly in Belgium, and rejoined his outfit shortly before V-E Day. He remained in Wesel, Germany, on occupational duty before redeployment.

Eugene A. Hults served aboard the destroyer U.S.S. *Paul Jones* as a radio technician for seven months. After a period of advance training he was assigned to the U.S.S. *Prince William*, a carrier, as a radio operator. He had both Atlantic and Pacific duty,

Col. Robert W. Harper served as officer in charge of a section of the Equipment Coördination Branch of the Office of the Chief Signal Officer after being asked to accept a commission by the War Department in 1942. He was executive officer of the Signal Airways Branch, Plant Engineering Agency, Philadelphia, and was commanding officer, Plant Assembly Center, Brookline, where troops were trained to make overseas installation. He went overseas in December, 1943, and served in the Pacific with the Army Communications Service, Plant Engineering Agency, whose mission was to install and maintain the radio facilities, radio aids to air navigation, and the weather stations for the Army Air Forces. In connection with that work, he was commanding officer of three signal service battalions with headquarters at New Caledonia; Brisbane, Australia; Hollandia, New Guinea; and Hawaii. He was also executive officer for the entire Southwest Sector, Army Communications Service.

Catherine Lennon had basic training at Ft. Des Moine and spent two weeks at the Holabird Signal Depot, Baltimore. She was assigned to the 2nd Signal Service Battalion, Washington, where, for twenty-three months, she was concerned with mathematical studies and did construction work on secret communications equipment.

George W. Galbavy, in 1942, was assigned to a Signal Corps Replacement Training Center for courses in central-office maintenance and wire chief duties. He engaged in wire communications in Townsville, Australia, and worked with the Postmaster General's Department to lease telephone and telegraph lines for the Army. He was wire chief in New Guinea and did PBX work in Manila.

LT. K. E. WATERS COL. R. W. HARPER G. W. GALBAVY P. V. LODATO LT. COL. ALISCH MICHAEL COF











.EN DI STEFANO RUTH RYDBERG H. W. DOHLMAR H. H. GEORGENS J. U. MEATS LT. COL. ST. CL.

Peter V. Lodato was a B-29 radio operator and gunner and flew three missions at Saipan. On his second, his plane was rammed, and on the third, it was ditched in the sea after being damaged by flak. After two and a half days, he was rescued and briefly hospitalized. He was then assigned to a ground radio station as an operator.

Lieut. Col. Emil Alisch began active duty with the National Guard on September 16, 1940. He was intelligence officer and plans and training officer with the 71st Infantry at Ft. Dix until the regiment moved to Camp Claiborne, La. He attended the Command and General Staff School, Ft. Leavenworth, and rejoined his regiment at Ft. Lewis, Wash., where they guarded the coasts of Washington and Oregon. On a similar assignment at Phoenix, Ariz., he remained with the 364th Infantry until 1943, in the meanwhile taking a battalion commander's course at Ft. Benning. When the regiment moved to Mississippi for further training, he accompanied it, but also took a course at the 3rd Army Mine Laying School, Camp Swift, Tex. Again rejoining his regiment, he went to Adak, Alaska, for a twenty-three-month assignment to the Post Headquarters, and was promoted to Lieutenant Colonel.

Michael Coffey, EM 2/c, completed radio school at Bainbridge, Md., and was assigned to the U.S.S. *Thenakite* for maintenance of electrical equipment. He saw service at Key West and Guam, where he stayed ten months.

Helen A. Di Stefano began active duty with the WAC on June 7, 1944. After basic training at Ft. Oglethorpe, she spent two months in Wilmington as an automobile mechanic's helper. She drove a truck on a year's assignment in Memphis, Tenn., while attached to the A.T.S., and later did similar work at LaGuardia Field.

Harold H. Georgens was a radio operator on a B-17 until December, 1944, when he crashed in France on Christmas Day. His twelve combat flights were followed by supply missions in France. He received the Bronze Star for the design and construction of a VHF test set, used for testing communication equipment on all planes.

Ruth E. Rydberg, U.S.M.C.W.R., went through boot training at Camp Le Jeune, N. C. She was assigned to Quantico, Va., for the rest of her period of military service. There she did clerical work at the officer's candidate school.

Harry W. Dohlmar was assigned to the Seabees and trained at Camp Peary, Va., and Camp Parks, Calif. He spent twenty months overseas in Hawaii, Midway, and the Philippine Islands doing telephone construction, repair and maintenance work.

Joseph U. Meats went from Camp Peary, Va., to the Marshall Islands with the Seabees. He was transferred to Tinian in the Marianas, where he spent thirteen months building air strips, roads, camp sites and radio towers.

Lieut. Col. Ward K. St. Clair was placed in charge of the wire section of the Signal Office at Governor's Island in October, 1940. He planned, constructed, and supervised military wire installations with the 2nd Service Command for a year before his assignment to the Caribbean Division Engineering Office to assist in constructing defenses for Central and South America. He returned from this assignment to the Office of the Chief Signal Officer in Washington, where he was in charge of a branch in the military personnel division. From there he transferred to the Plant Engineering Agency in Philadelphia to work with the Airways Branch. In September, 1943, Col. St. Clair flew to India and became wire officer for the CBI theater having charge of construction, operation, maintenance, and supervision of all wire communications in China, Burma and India.

Vincent J. Wycheck served at Ora Bay, Buna and Gamma-Dodo, all in New Guinea, where for twenty-four months he maintained and operated generators and refrigeration units.

J. WYCHECK HENRY HENKEL J. I. PICARD L. P. NEWBY E. J. SCHNABEL ENS. W. F. LYN






S. N. FOSTER


L. J. ANTONUCCI


E. F. KRAUTTER


C. J. EFINGER


R. C. LAMONT


J. L. SMITH

Henry Henkel started on the aviation cadet program in March, 1944, and had basic training at Greensboro, N. C. After further schooling at Marshall College, W. V., he spent a year at Foster Field, Tex., servicing planes and then transferred to Officer Candidate School.

Jack I. Picard cooked aboard a Coast Guard cutter on patrol duty to Newfoundland for 19 months, had charge of a kitchen at a radio station in Marshfield, Mass., and served as cook aboard a buoy tender operating out of Boston and Portland.

Leon P. Newby trained with the Seabees at Camp Peary, Va. When he went overseas he was attached to the 1st Marine Division in Guadalcanal and participated in the Palau Island push. He later transferred to the 3rd Marine Division and was stationed in Guam.

Edwin J. Schnabel acted as an official interpreter for the Allied Military Government during his stay in Germany and Holland. Originally he studied anti-aircraft artillery and his unit served with the following armies: 9th Army, Canadian 1st Army, British 2nd Army, American 7th Army, and French 1st Army.

Ens. William F. Lynch flew PBY's after receiving his wings at Pensacola and his operational training in PBM's at Corpus Christi. After returning to the Laboratories he left to attend college.

Spencer N. Foster, after a storekeeper's course at Sampson, was assigned to a PC which did convoy duty between Kodiak and Attu in the Aleutians, and later in the South Pacific.

Louis J. Antonucci instructed at the machinist's mate service school, Norfolk, for seven months. Then he transferred to the maintenance department of the Naval Operating Base as machine shop foreman. After several months he was assigned to the U.S.S. *Argonne*, a repair ship, which he boarded at the Marshall Islands. He worked in the machine shop there and went with the 3rd Fleet to Tokyo.

Eugene F. Krautter took a radio course at Ft. Monmouth, a single-channel radio teletypewriter course at Long Lines and was then assigned to the southeast sector of the Plant Engineering Agency at Miami. He visited South and Central America to install radio equipment for the AAF.

Charles J. Efinger, shortly after completing his boot training at Williamsburg, Va., was assigned to the U. S. Naval Mine Warfare Test Station at Solomons, Maryland, as a machinist's mate.

Robert C. Lamont, after attending several Navy service schools, was assigned to an Aircraft Service Unit, where he was engaged in the repair and maintenance of aviation radio and radar equipment. These duties took him to the Southwest Pacific for six months.

James L. Smith served in the Mine Warfare Branch during most of his three years' service and was an instructor in Sweep Gear Maintenance and Direct Current Electricity for about one year. His last assignment was aboard the aircraft carrier *Franklin D. Roosevelt*, where he assisted in maintaining communication equipment.

Karl J. Ogaard was called to military service in February, 1941, took basic training, and was then placed on reserve status for being over age. After "Pearl Harbor" he was recalled and served eleven months with the Military Police. He transferred to the AAF at Wright Field and installed radios on fighter planes. After a sojourn in Hawaii, he returned to Wright Field, and from there made an extensive trip to various air fields to install airborne equipment. He then attended radar school, and last July made airborne radar installations in planes at Guam and Tinian.

Boyd E. Brown attended Ft. Monmouth radio school for radar repairmen and studied FM radio at Holabird Signal Depot, Baltimore. He landed in Normandy on D plus 17 and operated VHF radio stations in France, Belgium, Holland, Luxembourg, Germany and Austria. The Bronze Star Medal was awarded to him for taking command

K. J. OGAARD


B. E. BROWN


S. F. LUBNIEWSKI


E. MCILRAVEY


P. E. O'DONNELL


E. J. DIXON


J. Emmons

W. R. Carolan

Capt. Giertsen

Lt. F. J. Schwetje

H. H. Sharpe

E. R. Clark

Leaves of Absence

As of January 31, there had been 1,025 military leaves of absence granted to members of the Laboratories. Of these, 372 have been completed. The 653 active leaves were divided as follows:

Army 340 **Navy 231** **Marines 23**

Women's Services 59

There were also 17 members on merchant marine leaves and 3 on personal leaves for war work.

Recent Leaves

United States Army
Edward T. Clifford

United States Marines
Allan S. Westervelt

United States Navy
Charles C. Murino

of a radio station overrun by enemy forces and for repairing equipment under fire.

Stephen F. Lubniewski had radio specialist training at Ft. Sill, Okla., and then went to Italy. He was a forward observer with the 45th Division in the invasion of southern France and stayed in that area attached to a parachute battalion lending gunfire support along the coast. He rejoined his outfit in Strassbourg and crossed the Rhine into Germany. He was a battalion electrician, had charge of camp maintenance and served with the Military Police at Lindenfelo, Germany. He was awarded the Bronze Star for service in Germany.

Elizabeth Mc Ilravey joined the Air Wacs in June, 1944, and had basic training at Ft. Oglethorpe. She was assigned to Redistribution Station at Atlantic City, where she did statistical control work until she was assigned to Santa Ana, Cal.

Peter E. O'Donnell studied finance at Ft. Benjamin Harrison, Ind., before permanent assignment to Panama, where he worked in the officers' pay section of the U. S. Army Finance Office.

Edward J. Dixon spent seven months in the Pacific theater at Saipan, Iwo Jima and other spots as an aerial gunner on a B-29 bomber. He flew thirty missions over enemy installations in some of the toughest of the Pacific fighting.

Joseph J. Emmons participated in the Normandy invasion on D-Day and has five battle stars for the Normandy, Northern France, Ardennes, Rhineland and Central Europe campaigns. The 487th Port Battalion, with which he was associated, broke the record for loading and unloading ships three times—at the Normandy Beachhead, at the port of Antwerp and at Bremerhaven.

William R. Carolan trained with the 13th Armored Division after A.S.T.P. at the University of Utah. He went directly to Le Havre and served with the 7th, 1st and 3rd Armies as an operations sergeant directing field artillery fire and was awarded the Bronze Star Medal for his work.

Capt. Owen N. Giertsen, as a P-38 fighter pilot, completed ninety-eight combat missions. While serving with the 5th AAF, he fought over New Guinea, the Dutch East Indies, and Philippines. He was shot down near Rabaul and spent three months on an island before rescue. After returning to the States, he was with the Dugway Proving Ground Command in Utah.

Lieut. Fred J. Schwetje completed his Marine Corps pilot training in Corpus Christi, Texas, and was given further operational training in Florida and California before going to the Gilbert Islands, where he made thirty missions.

Henry H. Sharpe stayed with the 562nd Ordnance Company for his entire three years of military service. He studied artillery and automotive repair and fought with the 4th Armored Division of the Third Army in France and Belgium.

Edward R. Clark trained in AAF aeronautical mechanics for one year at the Aviation Institute, Long Island City, and the American Airlines School at LaGuardia Field. Operating from Casablanca, he acted as aircraft maintenance inspector.

The Laboratories has employed 675 veterans of World War II

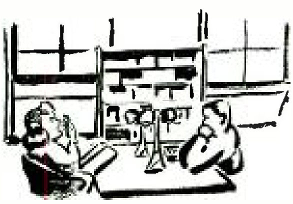
News Notes

M. J. Kelly attended the Vice-Presidents' Conference in New York.

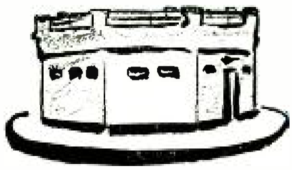
Mr. Kelly, A. B. Clark and D. A. Quarles attended the Chief Engineers' Conference held at Absecon, N. J. H. H. Lowry, G. W. Gilman and G. D. Edwards also attended part of the time.

R. L. Jones attended a meeting on January 21 of the Visiting Committee of the Department of Electrical Engineering of Massachusetts Institute of Technology at Cambridge.

The American Physical Society held its 1945 annual meeting at Columbia University from January 24 to 26. The retiring presidential address of Harvey Fletcher, a lecture demonstration on *The Pitch, Loudness and Quality of Musical Tones,* is summarized on page 123 of this issue of the Record. Papers by J. M. Richardson and William Shockley, *A Solution of the Equation for the Propagation of Waves of Finite Amplitude in One Dimension* and by F. H. Willis, *Measured Values of Ultrasonic Absorption and Velocity in Liquid Measures* were presented at a meeting presided over by Dr. Fletcher. He also presided over the *Nuclear Energy Symposium* and the business meeting of the Society. J. A. Becker presided over the January 26 afternoon session. L. A. Wooten presented *Some Chemical Studies of Oxide-Coated Cathodes* as one of five papers in a symposium on this subject.



During the Institute of Radio Engineers' 1946 Winter Technical Meeting held in New York from January 23 to 26, F. B. Jewett was the speaker at the annual banquet. F. B. Llewellyn, president of the I.R.E., was honored by a luncheon and was chairman of the Microwave Vacuum Tube session. Papers were presented by W. E. Crock, *Metal-Lens Antennas;* W. W. Mumford, *Directional Couplers Microwave Converters;* C. F. Edwards, *Microwave Converters;* R. E. Graham, *Linear Servo Theory;* W. W. Sharpless, *Measurement of the Angle of Arrival of Microwaves;* S. D. Roberts and A. P. King, *Microwave Propagation, Part I, The Effect of Rain Upon the Propagation of Waves in the One and Three Centimeter Region;* G. E. Mueller, *Part II—Propagation of Six Millimeter Waves;* and R. A. Sykes, *High-Frequency Plated Quartz Crystal Units Made for Military Equipment.*



E. B. Ferrell lectured on *Frequency Spectrum Theory Applied to Servomechanisms.* This was the fourth lecture in the Servomechanism Symposium conducted by the Basic Science Group, New York Section, A.I.E.E.

K. K. Darrow discussed *Atomic Energy* on January 31 at a joint meeting in Charleston, W. Va., of the A.I.E.E., A.C.E., A.I.C.E. and A.S.M.E.

P. B. Oncley spoke on *Music and Science* before the Rotary Club of Bernardsville.

A. E. Bowen spoke on *Radar in the Army Air Forces* at the Deal-Holmdel Colloquium.

W. H. Doherty, at a luncheon in his honor at the University Club in New York City on January 26, spoke on *Radar.*

Engagements

*Frank Dormer—*Mary Cusack
*R. Shiels Graham—*Isolde Holoch
John W. Green—*Ann Boerke
L. Thomas Leonard—*Ruth Kampfe
*Roy V. Lohmiller—*Betty Waldeck
Karl D. Melroy, Jr.—*Elsie Kopetz
Frederick J. Thomsen—*Mildred Avoglia
*Donald L. Viemeister—Agnes Perry

Weddings

*L. Charles Brown—Agnes Griffin
Arthur Bruvik—*Marguerite Jensen
Clifford R. Dorsey, U.S.N.—*Ann Ribachuk
*Lieut. (jg) Martin P. Hughes—Margaret Hodapp
Arthur LeSauvage, Jr.—*Aubrey Fabry
Paul W. Meyerhoff—*Ruth Rydberg
Edward C. Newton, U.S.N.—*Hilda Muller
*Lieut. Robert I. Nolan, U.S.A.—Juta Krunwald
*Lieut. Donald R. Schoen—Barbara Taylor

*Members of the Laboratories. Notices of engagements and weddings should be given to Mrs. Helen McLoughlin, Room 803C, 14th St., Extension 296.

ROBERT POPE attended the directors' meeting of the National Association of Corrosion Engineers in Chicago. While there he visited the offices of the Long Lines and the Illinois Bell Telephone Company to discuss their corrosion problems.

AT THE Philadelphia Signal Depot, PIERRE MERTZ, with R. H. McCarthy of Western Electric Company, examined German carrier system equipment.

R. M. BURNS was at Hawthorne to discuss chemical and metallurgical matters.

MEMBERS of the Laboratories who have been elected to serve on the Board of Education in their townships include J. R. TOWNSEND, Essex Fells; M. B. LONG, Glen Ridge; R. J. NOSSAMAN, Madison; and R. G. WATLING and F. E. WATKINS, Mendham.

A GROUP of Laboratories engineers paid a visit to Coles Signal Laboratories on January 16 to view captured German and Japanese communications equipment. Of particular interest to the group were a number of items of German Army tactical equipment: ten-channel radio link equipment; voice-frequency telephone and telegraph equipments; light-weight field teletypewriters and various types of radio, intercept and direction-finding equipment. Those who inspected the equipment were M. L. ALMQUIST, F. A. BROOKS, R. L. CASE, L. L. GLEZEN, T. J. GRIESER, A. A. OSWALD, L. PEDERSEN, F. A. POLKINGHORN, E. R. TAYLOR and J. A. WORD.

R. S. PLOTZ has been appointed Assistant to Vice-President, reporting to A. B. CLARK, Vice-President and Director of Systems Development. Mr. Plotz handles special technical and administrative assignments.

C. SHAFER, JR., was in Pittsburgh and Harrisburg to discuss aerial cable lashing.

F. V. HASKELL, on a trip to Charlottesville, Va., was concerned with a field trial of intra-span tandem transportation brackets.

F. S. MALM has accepted a request to serve with the Reconstruction Finance Corporation as a consultant on sales of surplus materials which were used in the manufacture of insulated wires and cables for the Government.

"The Telephone Hour"

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

March 4	*Lily Pons*
March 11	*Ezio Pinza*
March 18	*Marian Anderson*
March 25	*Jascha Heifetz*
April 1	*James Melton*

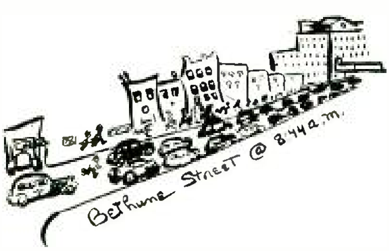
PLASTIC PROBLEMS in telephone station apparatus were discussed at Hawthorne by C. J. FROSCH, W. L. TUFFNELL, G. A. WAHL and J. F. DALTON.

W. O. BAKER and C. S. FULLER attended the 1945 annual American Physical Society meeting at Columbia University.

D. H. GLEASON discussed step-by-step and crossbar switch problems during a visit to Hawthorne.

AT THE A.I.E.E. winter convention held in New York from January 21 to 25, papers were presented by E. S. WILLIS, *A New Crystal Channel Filter for Broad Band Carrier Systems;* A. G. GANZ, *Applications of Thin Permalloy Tape in Wide Band Telephone and Pulse Transformers;* D. E. WOOLDRIDGE, *Signal and Noise Levels in Magnetic Tape Recording;* D. A. QUARLES, *Radar System Consideration;* E. I. GREEN, H. J. FISHER and J. G. FERGUSON, *Techniques and Facilities for Radar Testing;* E. B. FERRELL, *Statistical Methods in the Development of Apparatus Life Control;* and K. K. DARROW, *Physics of Nuclear Energy.* J. D. TEBO presided at the Symposium on *Nuclear Energy.*

CURRENT PRODUCTION and engineering problems in connection with the reconversion program on the crossbar switch were discussed by C. C. BARBER at Hawthorne.



OTHER LABORATORIES men who conferred at Hawthorne recently were H. B. SMITH, on multi-contact relays; F. W. CLAYDEN, on mechanized solderless step-by-step banks; and V. F. BOHMAN, on step-by-step apparatus problems.

Please put your RECORD in the "Correspondence-Out" Box when you are through with it so that it can be sent to a Serviceman's family.

L. N. Hampton and F. D. Fessler made several visits to the Sanborn Company, Cambridge, Mass., to discuss computing mechanisms.

W. Lemann reviewed problems on a servo unit at the Lombard Governor Company, Ashland, Mass., and the Doelcam Company, West Newton, Mass.

R. V. Terry witnessed tests at Fort Bliss, Texas, on a new target tracking device.

C. A. Webber visited the Southern Bell Telephone Company at Atlanta, Ga., as well as at New Orleans, La., in connection with cord studies.

R. T. Staples and H. H. Staebner discussed cord development problems at the Point Breeze Plant.

J. H. Bower conferred with members of the National Bureau of Standards and members of the Applied Physics Laboratory of Johns Hopkins University on the subject of special battery supplies.

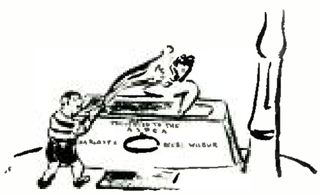
J. P. Radcliff visited the Washington and New York coaxial terminal offices in connection with tests of a carrier program channel for television transmission. W. D. Mischler and R. L. Tambling were also engaged in these tests at New York.

W. S. Gorton discussed *Demountable Soundproof Rooms* in an article which appeared in the January issue of *The Journal of the Acoustical Society of America.*

D. B. Penick, H. H. Felder and G. W. Cowley have returned from Denver, where they have been testing the first installations of the single-sideband program channels as applied to type-K carrier telephone systems between Omaha and Denver.

A. J. Christopher and D. A. McLean studied condenser problems in Chicago recently.

At a recent meeting of R.M.A. Sub-Committee on transformers for radio transmitters, E. A. Potter was designated as leader of a group to draft specifications.



W. L. Filer, J. Irish and R. G. Koontz visited Hawthorne to discuss problems relating to customer held orders.

J. W. Woodard and E. J. Quinn visited the Engineering Departments of Operating Companies at Washington, Richmond and Atlanta to analyze current orders.

J. H. Pettrus investigated problems concerning switchboard multiple cables at Parkersburg, W. Va.

During the month of December the United States Patent Office issued patents on applications previously filed by the following members of the Laboratories:

E. L. Alford	C. W. Lucek
D. G. Blattner	M. L. Martin
C. W. Carter, Jr.	D. A. McLean
L. I. Egerton (2)	G. L. Pearson
K. E. Fitch	O. E. Rasmussen
H. E. Ives	I. C. Shafer, Jr.
K. G. Jansky	V. G. Sprague
W. V. K. Large	G. K. Teal

W. B. Graupner studied extruded aluminum mounting plate problems at the Bohn Aluminum and Brass Company, Detroit, and at the Pittsburgh Aluminum Company, Pittsburgh.

E. T. Ball and J. G. Ferguson were concerned with problems concerning sheet metal racks when they visited Dahlstrom Metal Company in Jamestown, N. J.

F. W. Treptow studied the 81B1 private line automatic switching telegraph system at the Republic Steel Company in Cleveland, Ohio.

U. S. Ford was in Selma, Ala., during the installation and cutover of a rural power line carrier unit.

C. M. Hanley and A. M. Zillian were in Washington during the trial installation of automatic message accounting equipment.

V. T. Callahan and T. S. Taylor made engine tests at the Duplex Truck Company in Lansing, Mich.

Problems involving improved rectifiers were D. E. Trucksess' concern on a recent visit to the Power Equipment Company in Detroit.

C. M. Harris is the author of *The Effect of Position on the Acoustical Absorption by a Patch of Material in a Room*, in the January *Journal of the Acoustical Society.*