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Transmission
Research

ARTIFICIAL DIELECTRIC LENSES FOR MICROWAVES

The recent opening of the New York-Boston microwave radio relay circuit may well presage a new era in long distance telephone and television transmission. The bands of frequencies available among the microwaves cover hundreds of millions of cycles per second and consequently permit many more simultaneous telephone conversations and television programs to be transmitted than any previous type of transmission system. To utilize fully the bandwidths available all elements in the system must possess broad band qualities, since the usable band will be determined by that component having the narrowest band transmission characteristics.

One important element of a relay station is the antenna, the device which directs the energy from one station to the next. Early experiments showed that shielded lenses were in many respects superior to other antennas for focussing microwaves into a beam and thereby concentrating the transmitted energy at the receiving antenna of the next relay station. Four of these antennas atop one of the New York-Boston towers are shown on the cover of this issue. Radio waves are fed through a waveguide behind the lens and spread out along the horn-like shield into the lens which focusses them into a beam. Because of the shield, mutual coupling between antennas on a tower is reduced to a minimum, and the large constructional tolerance permitted in a lens means that clean, sharp beams can readily be attained.

The lenses now in use consist of rows of conducting plates and operate on waveguide principles, whereby waves passing between the plates are speeded up and thereby refracted. Unfortunately, the refracting or focussing power of these lenses depends upon the wavelength of the radio waves, and waves of different wavelengths have different focal points, just as the various colors composing white light have different focal points in an ordinary glass

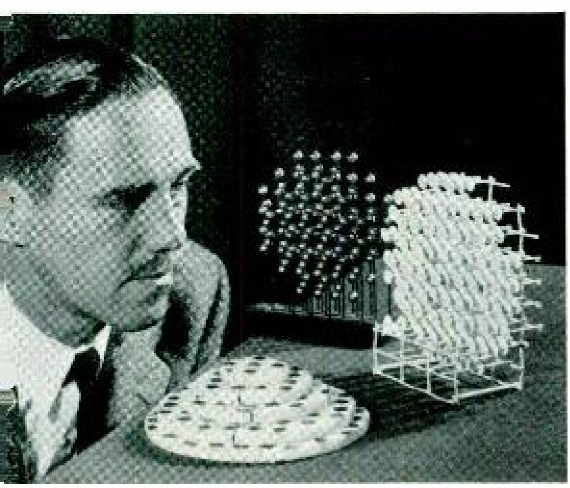

Fig. 1--The author examining lenses of various types: front, a foil disk array supported by dielectric foam; right, conducting disks mounted on rods; and rear, a sphere array

lens. Over a band of wavelengths, then, some frequencies will be more effectively focussed by such a lens than others, and a bandwidth limitation is thus imposed upon the whole system.

Because much of the existing microwave equipment does not as yet fully utilize the broad bands available, the band limitation on the waveguide type lens is not now serious. Nevertheless, developments continually point toward broader and broader bands for relay links and to the desirability of antennas capable of accommodating such bands. It is for this reason that the artificial dielectric lenses were developed.

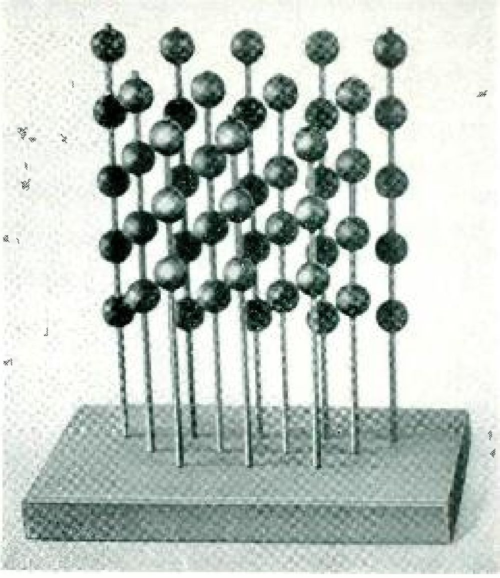

Fig. 3—This conducting sphere array exhibits polarization and therefore refracts electromagnetic waves of sufficiently long wavelength

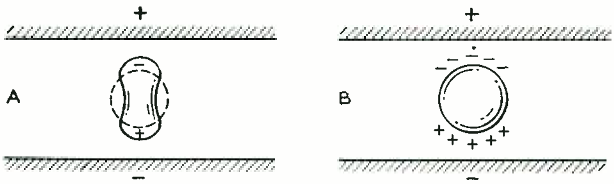

Fig. 2A—Greatly enlarged view of the distortion or polarization of a molecule under the influence of an electric field. The negative charges are drawn toward the positive plate of the condenser so that the centroids of positive and negative charge separate

Fig. 2B—The free electrons of a metallic sphere are drawn to the upper (positive) condenser plate leaving the lower half of the sphere positively charged. The sphere is thereby "polarized"

Radio lenses made of ordinary dielectrics such as polystyrene were known to perform well over very broad bands. But their great weight for ten-foot sizes used in relay links precluded their being considered as alternates for the metal plate lens. An analysis of how these dielectric lenses function, however, led to the conception of a light weight *metallic dielectric* possessing the broad band characteristics of a true dielectric.

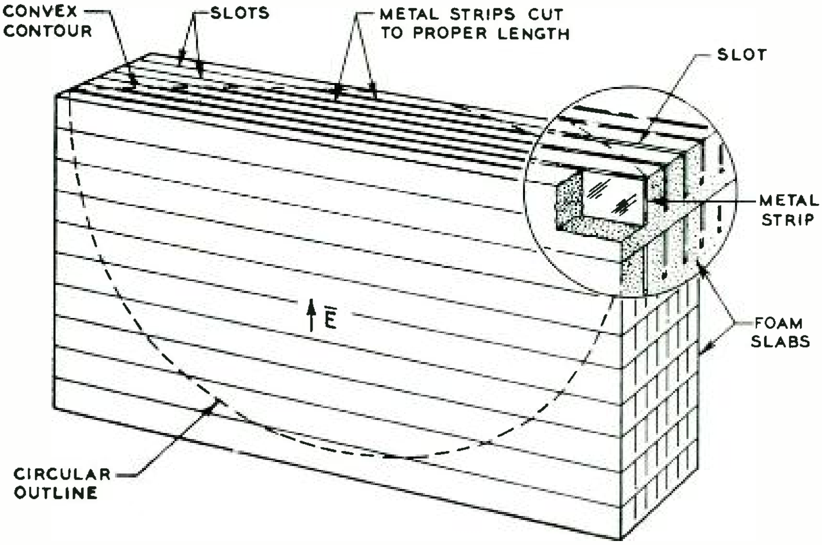

Fig. 4—A strip array supported by polystyrene foam. For vertically polarized waves, the strips are equivalent to the disks of Figure 1

All substances are composed of molecules, which in turn are made up of aggregates of atoms, which themselves consist of a positively charged nucleus surrounded by a certain number of negatively charged electrons. The total number of positive charges in a molecule generally equals the number of negative charges so that the molecule is electrically "neutral". When placed in an electric field such as might exist between two plates of a condenser, the molecule becomes distorted, the plus charges striving towards the negative condenser plate and the minus charges toward the positive plate as shown in Figure 2A. The molecule is then said to be "polarized" and the dielectric constant and refractive index of a substance is dependent upon the "polarizability" of its molecules.

This polarization of a molecule is exactly what happens to a conducting body placed in an electric field. The free electrons in the metal move about under the influence of the applied electric force and the body becomes polarized as shown in Figure 2B. An array of these conducting objects as in Figure 3 thus simulates the lattice array of molecules in a true dielectric and a lens shaped array will effect a focussing of electromagnetic waves impinging upon it. The spacing of the elements of the array must be small compared to the wavelength otherwise diffraction will occur, but since the wavelengths at microwaves are a hundred thousand times longer than light wavelengths, an appreciable "scaling up" of molecular lattice spacings is permitted in these artificial dielectrics. As long as this lattice spacing requirement is met, the refractive power does not vary with wavelength and lenses built in this way exhibit very broad band frequency characteristics. The metallic elements can be made of copper foil to reduce their weight and light weight polystyrene foam can be used as the supporting framework (Figure 1).

Fig. 5—A six-foot strip lens half assembled

For radio repeater applications the lenses are 10 feet square and the construction method for these large sizes is illustrated in Figures 4 and 5. Horizontal metal strips are used because the lens is only required to focus vertically polarized waves.

Because of their broad band characteristics, the new lenses will be used in the recently announced radio relay system between New York and Chicago.

THE AUTHOR: Winston E. Kock received his E.E. and M.S. degrees at the University of Cincinnati in 1932 and 1933, and his Ph.D. degree from the University of Berlin in 1934. After a year as Teaching Fellow at the University of Cincinnati, he continued his graduate study at The Institute for Advanced Study at Princeton, and at the Indian Institute of Science in Bangalore, India. Following several years as Director of Electronic Research at the Baldwin Piano Company, he joined the Holmdel staff of the Radio Research Department in 1942, where he first engaged in microwave radar antenna research, and later conducted research on antennas for radio relay circuits. In January, 1948, he entered the Transmission Research Department as Research Engineer in charge of acoustics.

RUBBER THERMOPLASTIC JACKET FOR BURIED CABLE

C. V. LUNDBERG
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When lead covered cables are buried in the ground, they are ordinarily protected against corrosion by textile and paper wrappings impregnated with asphalt compounds. Metal tapes are also applied when additional mechanical protection is required. In certain areas, however, where chemical corrosion is severe or where stray current conditions are such as to promote electrolytic corrosion, it is desirable to use a protective covering having better resistance to chemical attack and relatively high

Fig. 1—Processability of the rubber thermoplastic material was determined by calendering samples into thin sheets. B. Stiratelli (left) and C. M. Hill (right)

insulation resistance. Where stray current conditions are severe so that the cable is subject to anodic attack, the lead sheath is maintained at a negative electrical potential so as to render it cathodic and thus reduce corrosion of the lead. This protection method is known as forced drainage. By surrounding the lead with a material having high insulation resistance, less power is required for maintaining this potential on the lead. For lightning protection of buried toll cables in areas where electrical storms are frequent and earth resistivity is high, protection consisting of a low resistance copper shield insulated from the sheath by a jacket of material having good dielectric strength is desired. Thus there is need for a material having good resistance to chemical corrosion, high insulation resistance and high dielectric strength. Low cost is obviously very important in view of the great quantities of material required for cable applications.

When the problem was first presented several years ago, a proposed solution was to extrude over the lead sheath a vulcanizable rubber composition. The time required to develop manufacturing techniques and to build or modify manufacturing equipment to provide for this construction and the restrictions on high-grade rubber caused by the war rendered this solution of the problem impractical at the time. A cheaper and less restricted jacketing material was therefore developed by the Laboratories for this use. It consists of a rubber thermoplastic compound in strip form which can be wrapped around the cable sheath and does not require vulcanization.

This material has to be stiff enough to prevent cold flow and damage by handling subsequent to manufacture and during the plowing-in operations. It has to bend without cracking at temperatures down to 0 degrees F, to permit installation operations in cold weather and to withstand earth movements in frozen ground. Excessive softening at 120 degrees F, which is the top working temperature, has to be

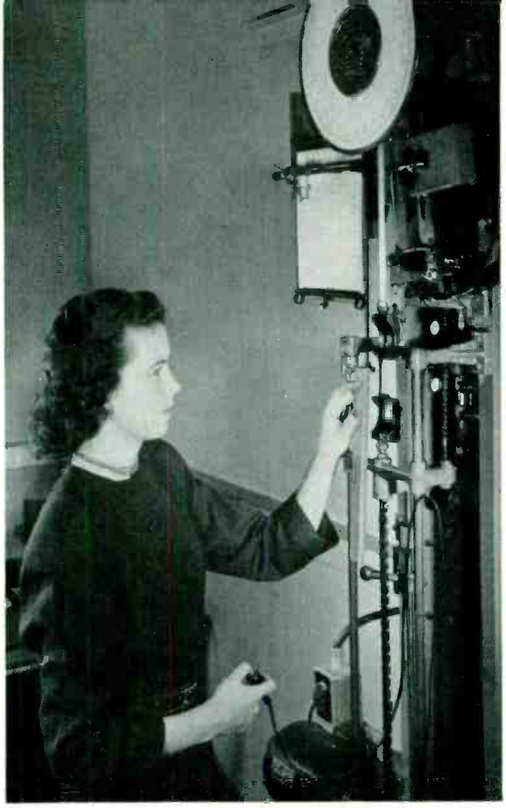


Fig. 2—Tensile strength and elongation were measured by stretching samples on a pendulum-type testing machine. Jean Sanderson is making the test

avoided. A minimum resistivity of about 10^{13} ohm-centimeters is required to insure an insulation resistance of one megohm-mile for a 1/16 inch layer on a cable one inch in diameter.

After various mixtures had been investigated, these requirements were satisfied by a jacket material made of reclaimed rubber to which was added clay, resin, paraffin wax and mineral rubber. Reclaimed rubber is the main constituent and serves as the binder. It was chosen in preference to new rubber because it is more economical and has satisfactory electrical and physical properties for this application. The clay is used as a filler to increase the hardness and stiffness of the compound. The resin, a coal tar derivative; the paraffin wax, a petroleum product; and mineral rubber, a bituminous material produced by air blowing of petroleum residues, are extenders and plasticizers which make the compound suitable for processing into sheets.

The processability of the material was determined by calendering samples in the form of sheeting 1/16 of an inch thick and ten inches wide. Correct balance of the filler, plasticizers and extenders in the jacketing compound produced a material that calendered smoothly and uniformly.

The sheeted material was tested for tensile strength, elongation, hardness and brittle point. Tensile strength and elongation were measured on a pendulum-type testing machine in which dumb-bell shaped specimens are used. The results indicated a tensile strength of 200 lbs./sq. inch at room temperature. Elongation was determined by marking each test sample with two lines spaced one inch apart and measuring the distance between them as the sample broke. At rupture, the compound stretched to 150 per cent of its initial length.

Hardness was measured with a plastometer which consists of a weighted rod with an indentor point of definite dimensions whose penetration into the sample in a given time is a measure of the material's hardness. This test is also used as a control during manufacturing because the hardness of the material is affected by variations in its components and in their proportions in the batch; also by the amount of mixing or degree of dispersion obtained in the mix.

The brittle point of the rubber thermo-

Fig. 3—To insure that the material was hard enough to withstand temperatures of 120 degrees F without deforming excessively, the depth of penetration into a sample of rubber thermoplastic in one minute of a weighted rod was determined. C. V. Lundberg tests a sample in the thermostatically controlled oven

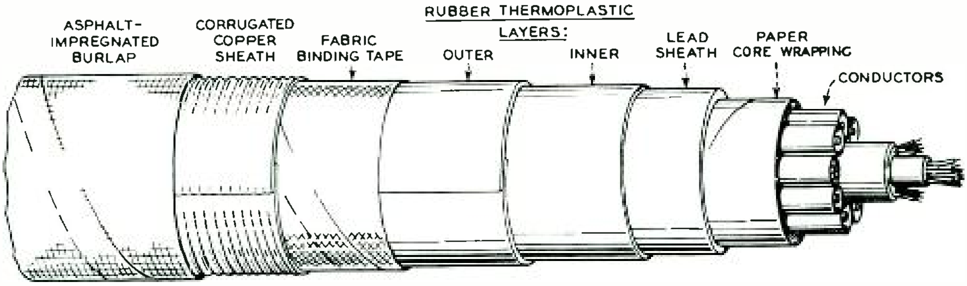


Fig. 4—The rubber thermoplastic jacketing material is applied in two layers with the overlap seams of each layer opposite one another. The lead sheath and the thermoplastic layers are flooded with rubber thermoplastic adhesive.

plastic was determined with apparatus, developed by the Laboratories, in which the sample is anchored to the periphery of a wheel and brought to the temperature desired in a cold bath. The wheel is then spun quickly so that an obstruction in the bath 1/4 inch from the periphery of the wheel bends the sample through an angle of approximately 90 degrees. If the sample is brittle at the test temperature, it breaks on impact with the obstruction; if not brittle, it flexes. The impact brittle-point obtained by this test shows the approximate temperature at which the cable jacket will crack if struck a hammer-like blow. Of more importance is the temperature at which the thermoplastic cracks when bent about a curved surface. To determine this, samples were bent over an arbor 1-1/2 inches in radius in the brittleness tester. They broke at -30 degrees F which is considered a safe low temperature limit as the cable is unlikely to be bent this sharply in use.

In manufacture, 400 pound batches of the material are mixed in Banbury machines and calendered into sheets twenty-nine inches wide and from 40 to 125 mils thick, depending on the size of the cable to be protected. This calendered sheet is wound into rolls, the layers of which are separated by paper or dusted with powder to prevent sticking. For application to the cable the wide rolls are cut into strips.

Jacketing the cable is a continuous operation. The sheath is flooded with a rubber thermoplastic adhesive to stick the dry rubber thermoplastic tape onto the cable. The tape is supplied from a feeder-roll and is brought up to and curved around the cable by guide plates and rubber snuggers to form a wrapping lengthwise on the sheath. The overlapped seam is sealed with rubber thermoplastic adhesive and the jacketed cable is again flooded with this adhesive. A second layer of rubber thermoplastic is applied with the overlap seam of this layer placed on the opposite side of the cable from the overlap on the first layer. After flooding with asphalt, fabric-

Fig. 5—Viscosity of the adhesive was measured by the rate of penetration of a flat bottomed plunger into a sample of the thick fluid. Doris Smith conducts the test

tape is wrapped spirally about the thermoplastic to hold it in place and protect it from cutting by subsequent metallic coverings or from abrasion during burying operations.

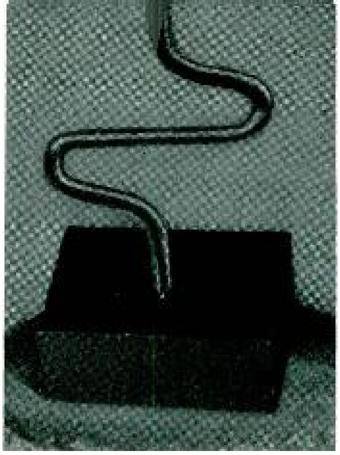
The adhesive used in conjunction with the rubber thermoplastic layers should not be brittle above 0 degrees F nor fluid enough at 120 degrees F to be mobile and exude from the cable. To meet these requirements the rubber thermoplastic jacket material was used as a base for the adhesive, and fluid properties at elevated temperatures and tackiness in the normal temperature range were obtained by adding viscous and tacky hydrocarbon fluids to the base. The resulting mixture was liquid above 250 degrees F. In commercial operations the adhesive is pumped from heated reservoirs and flooded onto the moving cable.

Laboratory tests were made on the adhesive to determine its volatile matter, fluidity and brittle point. The amount of volatile matter had to be kept small because the adhesive is heated for long periods at 250 to 300 degrees F in the applicator tanks. Fluid properties were measured by the rate of penetration into the adhesive mixture of a weighted, flat bottomed plunger 1-3/8 inches in diameter. Brittleness tests for its low temperature serviceability were the same as those for the rubber thermoplastic layer.

The protection offered by this rubber thermoplastic jacket and its auxiliary rubber thermoplastic adhesive will lengthen the life of cable sheath and reduce repairs and replacements in localities where corrosion or lightning damage would otherwise occur.

THE AUTHOR: C. V. Lundberg joined the Laboratories in 1934 as a member of the General Service Organization. In 1936 he transferred to the Rubber Group of the Chemical Department where he has been instrumental in developing and testing natural and synthetic rubber compounds for many of the rubber parts used in the Bell System. This work also involves mold design and the experimental molding and fabrication of rubber details. During the war he consulted with apparatus design engineers on rubber projects for the Armed Forces. Since June 1946 his interests have been focused on rubber covered wire and cable problems. In 1941 he was awarded a B. Ch.E. degree from New York University's College of Engineering, Evening Division. Mr. Lundberg is a member of the Division of Rubber Chemistry, American Chemical Society.

THE SILICON CRYSTAL DETECTOR



Last year when ice floes tore through the submarine cable across North Michigan's Mackinac Straits and an AN/TRC-6 radio link was rushed in to restore telephone service, the event again demonstrated the practicability of centimeter waves (microwaves) as carriers of commercial telephone service. Vibrating at frequencies of the order of 3,000 mc, these very short waves offer some very great advantages: wide transmission bands able to carry scores of telephone conversations simultaneously as well as high quality television pictures; with antennas of reasonable size the waves can be sent and received as sharply focused beams at much lower power level than is possible with longer waves; these beams do not interfere with neighboring systems and are themselves almost immune from interference.

It is now more than fifteen years since the Laboratories set out to utilize microwave transmission. In war, their work bore fruit in the AN/TRC-6*, a light, portable, eight-channel system for the Army and the only American-built system of its kind to be used in actual combat. Since the war, work has been actively continued towards developing more elaborate systems such as the New York-Boston radio relay in which the potentialities of microwaves are more fully utilized.

Behind this successful application of microwaves lies the research which solved the many problems peculiar to the manipulation of energy at very high frequencies. Not least was the problem of converting the incoming signal frequency to lower values at which large-scale amplification is easily attainable. This was solved by means of microwave converters built around a silicon rectifier which began its career at Holmdel more than a decade ago.

In frequency conversion, the received signals are converted to lower frequencies through the principle employed in heterodyne broadcast receivers. The signal is modulated with a locally-generated oscillation at a frequency slightly different from that of the signal. One of the modulation products is a signal which oscillates at the difference between the two frequencies, like the beat note obtained by combining two sound waves of nearly equal frequencies. Thus, a signal frequency of 3000 mc may be modulated with 3060 mc to produce a difference frequency of 60 mc which is then isolated and amplified.

At frequencies well below the microwave region the customary converter is the vacuum tube. But, as this region is approached, tubes become less efficient converters. A serious limiting factor is the transit time for electrons from cathode to anode, which becomes comparable with the half period of the waves. Another factor is the inter-electrode capacitance which lowers the impedance.

Over ten years ago, possible microwave converters were being extensively studied at the Holmdel laboratory as part of basic microwave research. To determine whether point-contact devices no different in principle from the old galena crystal and "cat's whisker" were applicable, tests were made with more than a hundred minerals and metalloids known to have rectifying properties. Iron pyrites and silicon were found satisfactory for microwave converters.

*Record, *December*, 1945, *page* 457.

From then on, crystal converters became thoroughly integrated into the microwave research conducted by the Holmdel group. It was soon evident that much could be gained from research on the rectifying materials themselves. Silicon had proved far better than iron pyrites, but in its commercial form it was subject to uncontrolled variations. Metallurgical studies were undertaken in close coordination with Holmdel's continued studies of the rectifier as a circuit element. These twin lines of investigation not only disclosed how to make crystal rectifiers of predictable performance, but in time added considerably to the knowledge of silicon technology.

So effective did the new rectifiers prove that requests for them came from many other organizations and a number of varieties were developed and made on a limited scale for these various uses in the years up to Pearl Harbor. Then it was that radar brought its spectacular demand for the crystal rectifiers which could provide frequency conversion at the very high signal frequencies needed for accurate target location. At the request of the government, the Laboratories made its knowledge of crystal detection available to authorized research establishments both here and abroad.

The first extensive military application of the silicon crystal rectifier was in ten-centimeter radar. For this purpose the British in the period 1940-41 developed a compact, cartridge-type rectifier structure superficially similar to that shown in Figure 1. It used commercial silicon, could be adjusted permanently in the factory, and fitted interchangeably in the converters of military radar. The U. S. Government, for the purpose of universal interchangeability, adhered to the basic mechanical dimensions of the British design. The Laboratories undertook the task of incorporating existing rectifier materials into this design, as well as that of developing new materials and structures, in cooperation with other research organizations coordinated through the NDRC. Moreover, the Western Electric Company had received a major portion of the quantity orders placed by the military, so that development for manufacture became an additional and important responsibility of the Laboratories.

Because of its dominantly metallurgical aspects, the materials development problem became the responsibility of the Chemical Laboratories. Basic aspects of the problem that had first to be solved may be seen by reference to the equivalent circuit of the point contact rectifiers, Figure 2. The

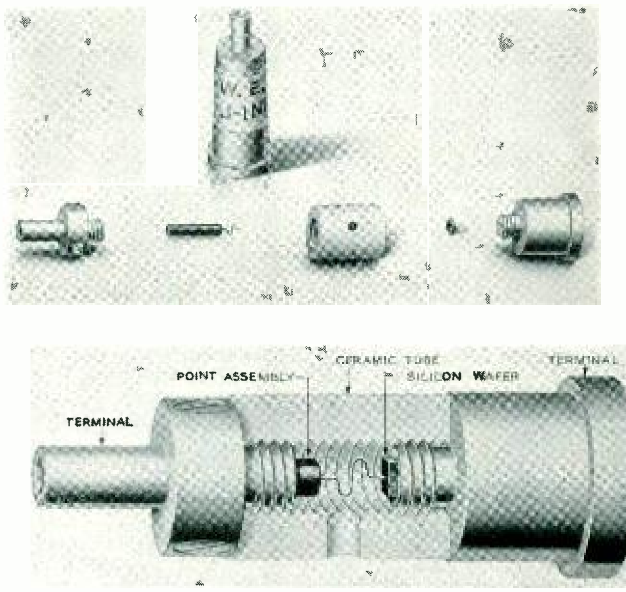


Fig. 1—Ceramic cartridge rectifier developed for wartime radar

three significant elements are the barrier resistance of the surface of the silicon, R_B, which serves as the seat of rectification; the spreading resistance of the body of the silicon, R_S, which is a locale of heat dissipation and power loss; and the capacitance associated with the point contact, C_B, which shunts the rectifying boundary and is a source of loss of rectified output which increases with frequency.

The performance of a rectifier is a function of all three elements, and high efficiency requires optimum relation between them. The problem of development has been first to ascertain and second to obtain the desired values for a particular application; it is complicated by the interdependence of the variables, both as to the effects of processing upon them and their

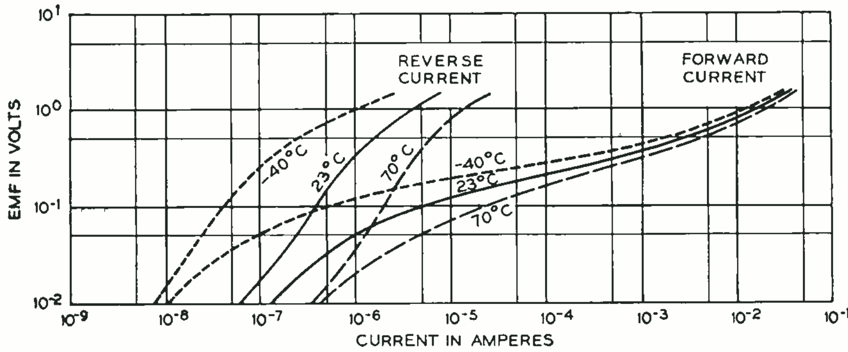


Fig. 3—Direct current characteristics of P-type silicon crystal rectifier at various temperatures

effects upon the various aspects of rectifier performance. Thus, reduction of the area of contact between point and silicon serves to decrease C_B and to increase R_B; while an increase in R_B, for example, improves rectification but may undesirably increase the impedance of the rectifier. Similarly, the decrease in C_B by this means can improve efficiency at higher frequencies but only at a sacrifice in power-handling capacity. This points to the necessity of some degree of independent control of the three basic elements through the processing and design factors affecting them as a first step in developing rectifiers of specified characteristics.

The result of an intensive metallurgical research program was the establishment of the required controls. The body resistance and even the polarity of the rectifying surface were found to be dependent upon composition to such a degree as to be affected by admixtures of as little as 0.001 per cent of aluminum, boron and certain other elements. It was, therefore, possible by the proper alloy additions to bring the resistivity of almost any commercial lot of high-purity silicon within the useful range. Independently of this, the barrier resistance could be adjusted by appropriate thermal oxidation of the polished silicon followed by removal of the oxide layer by etching. Conditions of the heat treatment were dependent on both the properties to be obtained and the composition that had been already established.

Final control was exerted through the contact itself, which was in turn determined by the shape of the spring and its degree of compression, by the diameter of the wire, and particularly by the contour of the point. This last indeed became the subject of an extensive study, due both to the vast number of points to be formed to rigid specifications and to the extreme sensitivity of rectifier performance to the shape of the point. Both the performance and production problems were solved by a contour forming method employing electrolytic etching and polishing.

To exploit their peculiar electrical advantages silicon rectifiers require a mechanical stability at least comparable with that of vacuum tubes. This has been imparted by a special filler, a wax dispersed in a hydrocarbon oil, which seals the unit

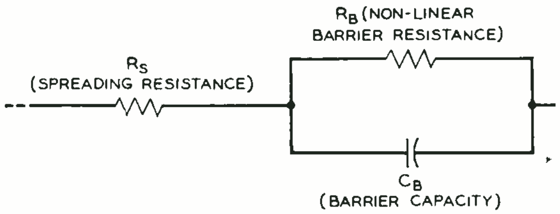


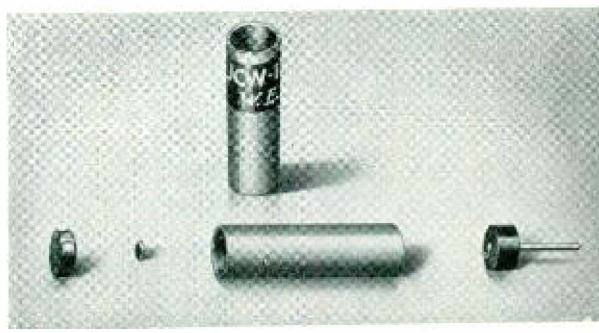
Fig. 2 — Schematic of the simplified equivalent circuit of crystal rectifier

against moisture and corrosive atmospheres, damps the spring against shock vibrations, and has no serious volume changes between −40 degrees C to +70 degrees C. Acceptance for service in fact requires satisfactory electrical performance of representative samples after specified impact tests, water immersion, and temperature-cycling through the above range.

Crucial to the success of the project was the parallel development of basic testing methods and of the complex equipment required for rapid but complete measurement of all the significant rectifier properties at the operating frequency. The fundamental work in this field was done at the Holmdel Radio Laboratory and was later extended at the Radiation Laboratory. Such testing equipment served not only to orient each step in rectifier development, but also to select and grade the manufactured product.

The cartridge type silicon rectifier was produced by Western Electric at a rate finally exceeding 50,000 a month. In wartime, it made possible extensions of frequency, range, and definition of radar far beyond the limits imposed by the best alternative tube circuits then available. It was first used in radar at wavelengths of 10 cm, later at 3 cm, and by the end of the war, a unit for use at wavelengths approaching 1 cm had been developed. This latter unit, Figure 4, is also distinguished by protection of the leads from static discharges in handling and from strong electromagnetic fields.

The valuable properties of the point contact rectifier together with its other more obvious advantages: independence of power supply, simplicity of mounting socket, and small size, have given it a permanent place among electronic circuit devices. It is used in the frequency converters of Bell System microwave radio relay systems in substantially the form in which it was developed for radar and new forms and uses are even now being discovered through research.



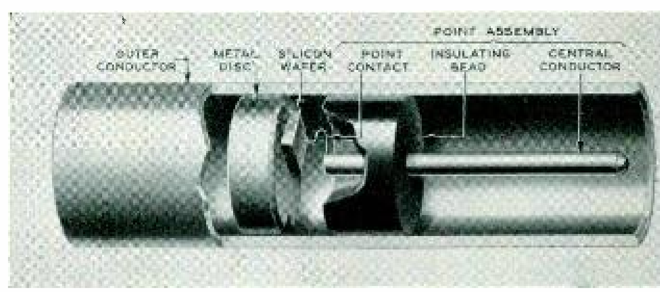


Fig. 4—Later type of crystal rectifier developed for wavelengths of 3 centimeters and less. The shielding that is provided protects structure from static discharge in handling and from electromagnetic fields.

MEASURING TRANSMISSION ON CIRCUITS IN USE

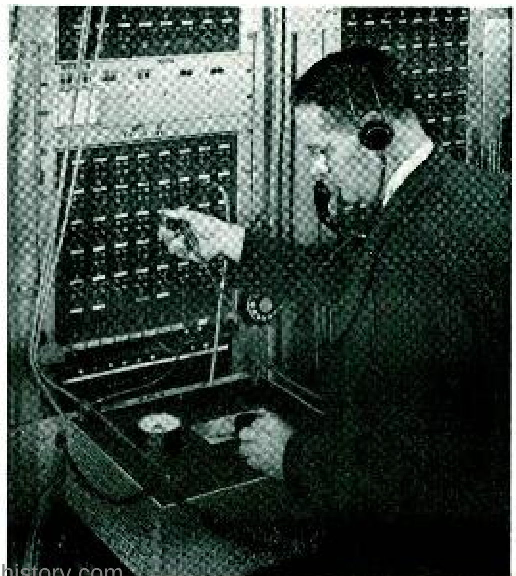
W. H. TIDD
Transmission Development

Measurements of transmission over telephone circuits for maintenance purposes ordinarily require that the circuit to be measured be taken out of service for the period of the measurement. With the K2 carrier system,[1] however, a dynamic system of regulation is employed, and the amplifier gains are determined by pilot and signal frequencies transmitted over the circuit. As a result, if the circuit is interrupted or if an amplifier is removed for test, the control is lost and the amplifier gains change, thus preventing a measurement of the working gain. To take care of this situation, the 31-type transmission measuring set was developed to permit measurements on type K2 circuits without taking them out of service or interfering with transmission. Besides making such measurements possible, the 31-type set has the additional advantage of saving the circuit time formerly required for the tests, which is an important consideration for a twelve-channel system.

Transmission measurements on the K1 system had been made by the 42A transmission measuring system,[2] which measured levels of the pilot frequencies when bridged across the output of an amplifier, but had insufficient sensitivity to make measurements at the inputs of the amplifiers. It consisted of permanently mounted apparatus units, and was not provided at unattended repeater stations. For measuring amplifier gains at both attended and unattended stations, a 17B oscillator[3] and the 30A transmission measuring set[4] were used, and the amplifier had to be taken out of service for the test. In designing the 31-type set, an effort was made to avoid these limitations and disadvantages of the previous methods. The set was to have a high input impedance suitable for bridging measurements, a high enough sensitivity to permit measurements at both input and output of an amplifier, and extreme selectivity to permit measurements of pilot and other test signals on a working system with adjacent channels busy. In addition, it was to be portable so that the same set could be used at auxiliary as well as main repeaters.

The 31-type set comprises two major portions, a detector and a selector. These, with suitable input switching arrangements, may be seen on the block schematic of Figure 1. The detector portion of the set is an amplifier-rectifier arrangement with an input impedance of 8,000 ohms and a substantially uniform sensitivity over the frequency range from 1 kc to 150 kc. Signal amplitudes between –25 dbm (decibels from 1 milliwatt) and +35 dbm

The 31A transmission measuring set in use in the Long Lines Building



[1]Record, *November,* 1941, *page* viii.
[2]*May,* 1941, *page* 277. [3]*May,* 1939, *page* 291.
[4]*August,* 1939, *page* 385.

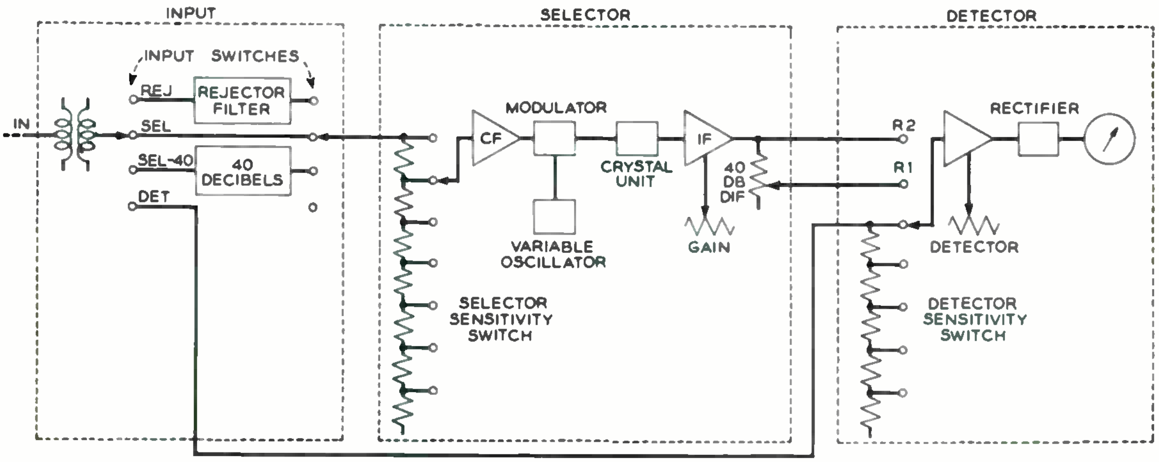


Fig. 1—Block schematic of the 31-type transmission measuring set

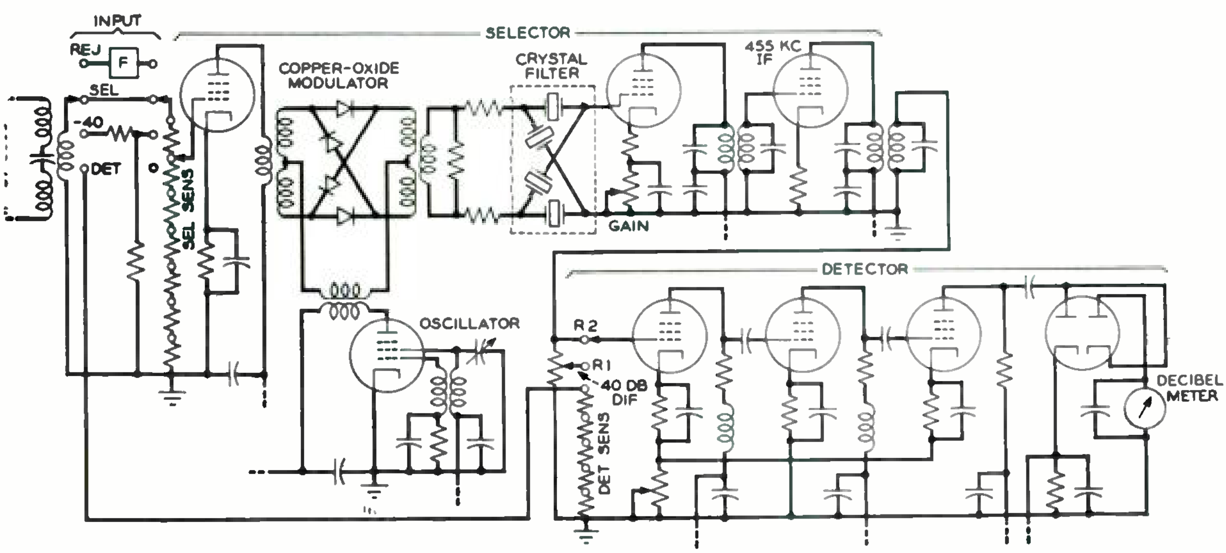


Fig. 2—A simplified circuit diagram of the 31-type transmission measuring set

in a 135-ohm circuit may be measured with it. A meter having a substantially uniform db scale with a 15-db range is connected to the amplifier-rectifier, which in conjunction with a calibrated potentiometer indicates signal amplitude.

The selector portion of the set, also with an input impedance of 8,000 ohms, comprises a highly selective heterodyne circuit, which when used is connected to the detector and meter portion of the set. The selector may be tuned to any frequency between 10 and 150 kc with a response over the band uniform to within plus or minus 0.3 db. It has a band-width of approximately 50 cycles, and a maximum sensitivity of some 7 microvolts. Signal amplitudes on a 135-ohm circuit may be read from –95 dbm to +25 dbm in two ranges, one from –95 to –40, and the other from −55 to +25 dbm. Readings are determined from the db meter and one or the other of the two scales on the selector sensitivity dial. The detector sensitivity dial is turned to position R1 or R2 depending on the range to be used.

A simplified circuit diagram of the 31-type transmission measuring set is shown as Figure 2. A four-point input switch permits the one-to-one ratio input transformer to be connected directly to the detector circuit or to the selector and detector circuits in tandem in any one of three ways: directly; through a 40-db divider; or through a highly selective 49-kc crystal filter. The 40-db divider is provided principally for convenience in calibrating the selector.

A wide-band amplifying stage precedes

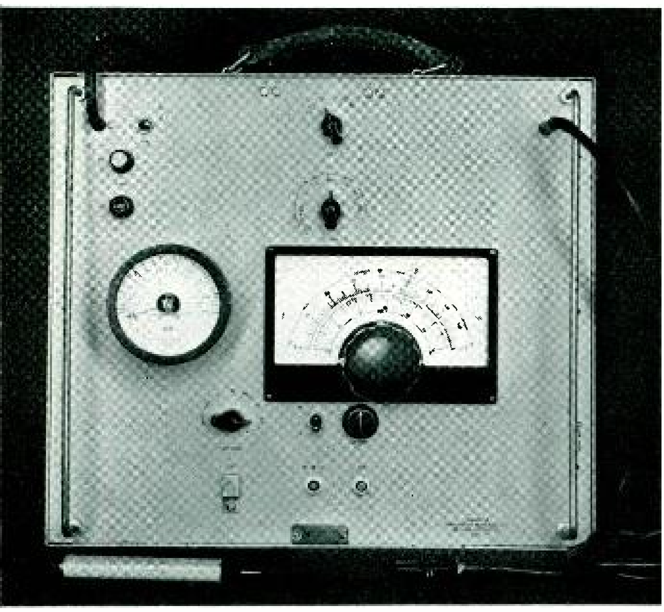


Fig. 3—Face panel on the 31-type transmission measuring set

the modulator or first converter of the set. This latter is a double balanced modulator using a bridge arrangement of copper oxide varistors. The oscillator for the modulator is of the simple coil-feedback type with its frequency-determining circuit in the screen grid circuit. Its frequency range is from 465 to 650 kc, and the output is coupled by the electron stream to the plate circuit and is supplied to the modulator through a transformer.

A 455-kc crystal filter follows the modulator to give the extreme selectivity required for system measurements. Following this filter is a two-stage intermediate-frequency amplifier with double tuned interstages. At 400 cycles either side of the center frequency, the discrimination is at least 32 db, at 1-kc points 42 db, and at 10 kc 70 db.

The heterodyne type of set was selected so that the selectivity could be obtained at any point in the frequency band. The choice of 455 kc for the intermediate frequency was based on a study of possible spurious responses. It was determined that by using a frequency greater than three times the highest frequency of the signal band, spurious responses which involved higher orders of the oscillator frequency with the first order of the signal frequency were eliminated. These responses are the most troublesome. Many of the higher order products up to the sixth order of the oscillator and signal frequencies are also avoided. Performance in this respect is considerably better than that for a system in which the intermediate frequency is either below or just above the band of the set being used.

The detector portion of the set is a three-stage amplifier with negative feedback, and with its output connected to a half-wave diode rectifier. The negative feedback is sufficient to give the amplifier long-time stability, and also to improve the linear response of the output meter and rectifier circuit. A linear half-wave rectifier, or so-called averaging detector, was selected because of its superiority for measuring a signal in the presence of unwanted signals. With it a signal 13 db below the desired signal will cause an error of only 0.1 db. With an rms indicating device, on the other hand, an unwanted signal must be down 16 db to give an error as small as this, while for a peak type rectifier, it must be down 39 db. This discrimination against interference from unwanted signals eases the selectivity requirements for the rest of the set.

The 31-type set is shown in use in the

photograph on page 157 of this article, while a close-up of its face panel is shown in Figure 3. At the left center is the db meter with two scales: one marked A and the other B. The scale to be read is shown by markings on the selector sensitivity switch immediately above the frequency meter in the center, or on the detector sensitivity switch when the detector only is being used. With the switches and dials in the position shown, the R2 scale of the selector sensitivity dial must be used, since the detector sensitivity switch is in the R2 position, and the marking B + 50 opposite the dial pointer indicates that the level is below one milliwatt by 50 db plus the reading of the db meter on the B scale. All A scale readings are plus, and all B scale readings are minus, and thus had the pointer of the db meter been at 9, the readings would be –59 dbm.

The frequency dial also had two scales—from 10 to 70 and from 60 to 150 kc—and one or the other is selected by the switch immediately to the left of the vernier tuning control.

In the top center of the panel is the four-point input switch, while at the upper left is the on-off switch with two fuses below it. At the bottom center, just below the tuning control, are three screw-driver adjustments used in calibrating the set.

For calibrating the selector portion of the set, an external test frequency is employed which is adjusted to exactly one milliwatt. The detector portion of the set may be used to establish this value. This power is then connected through the SEL –40 position of the input switch, thereby applying a signal of –40 dbm to the selector portion of the set. The high-gain range of the set, range 2, is then calibrated by a gain control in the intermediate frequency amplifier stages, which is controlled by the right hand screw-driver adjustment. The low sensitivity range, range 1, is calibrated by adjusting the 40 db DIF control—connected to the R1 position of the detector sensitivity switch and shown in Figure 1.

Measurements of cross-modulation made at various points along a K system are frequently useful in locating a modulation trouble. The test is usually made by taking the top three channels out of service. A signal of 1 kc is applied to channels 11 and 12, and of sufficient magnitude to fully load the system. These channels have carriers of 52 and 56 kc respectively, and the third order modulation product, (2 x 53) –57, appears as 49 kc, in channel 10. The 49-kc pre-selecting filter included in the 31-type set is used in measuring this product. It is connected ahead of the first tube of the set when the input switch is in the REJ position. This pre-selection is necessary to exclude the high-level signals being applied at 53 and 57 kc, the pilots, and other signals on the system. Measurements of the 49-kc signal may be made to –75 dbm, since the filter has a 20-db mid-band loss.

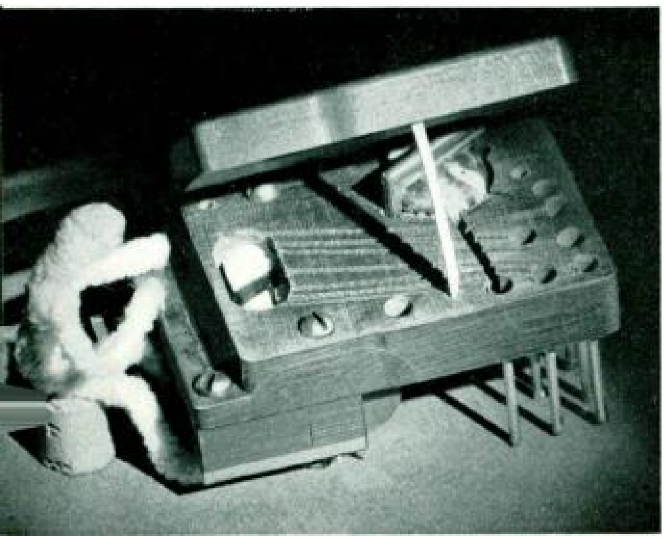
A high impedance test probe, designed as an accessory for the 31-type set for making measurements of voltages within an amplifier of the system, will be described in a future article. The impedance is approximately 800,000 ohms, and the effective shunt capacitance about

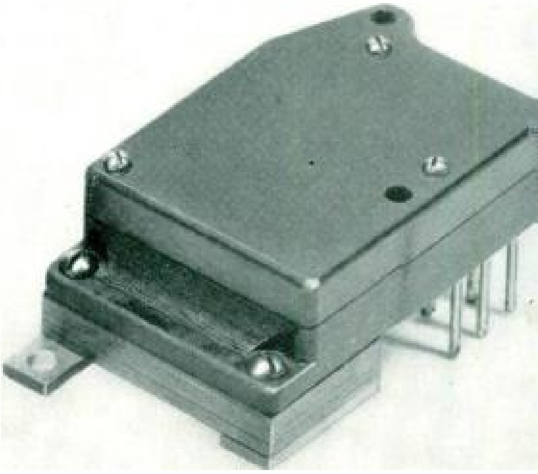
THE AUTHOR: W. H. Tidd was graduated from Cornell University in 1929 with a degree of E.E., and at once joined the Development and Research Department of the A T & T, where he was engaged in the development of carrier telephone systems. With the merger of the D & R with the Laboratories in 1934, this work was continued. It included the design and development of cable carrier, open-wire carrier, and coaxial systems, and field tests in connection with them. During the war he was engaged in the development of radio countermeasures equipment for the Signal Corps. Subsequently, he has been engaged in the development of transmission testing equipment, principally for use in connection with the L1 carrier and television transmission systems.

$9 \mu\mu f$. Essentially a 40-db pad, this high impedance probe may be used in place of the normal input cord.

Several hundred of the 31-type transmission measuring sets have been produced during the war for use with K carrier systems. The 31A and 31B sets are fundamentally alike, but the 31B embodies a few circuit and structural improvements. Mounted in a portable case, each set weighs about fifty-five pounds and draws some 70 watts from 115-volt a-c power supply. This set, more universally useful than any previous equipment used for maintaining K carrier systems, has been of considerable advantage, since it took the place of equipments which were much larger and more expensive to produce, thus saving considerably on the limited producing capacity available to civilian pursuits. Although designed primarily for line-up and maintenance testing of K systems, the frequency band was extended to 150 kc to make it suitable for other testing, and the extension of its use is being considered at the present time.

BABY GRAND





Evidence that apparatus engineers have a sense of humor is this ingenious picture made by W. R. Neiss of a model transformer he was working on. The virtuoso seated on the cork is made of pipe-cleaners; toothpick holds up the lid. The apparatus unadorned is shown at right

H. N. WAGAR
Switching
Apparatus

SLOW ACTING RELAYS

In most of their operations, it is desirable to have relays act quickly; for the U-type relay, the most widely used in telephone switching, the action time is less than 50 milliseconds. In the complicated switching circuits of the telephone plant, however, situations frequently arise where the desired circuit behavior can best be secured by having certain of the relays act slowly so as to permit other functions to take place while they are acting. The delays required usually range from 50 to 500 milliseconds, and methods have been devised for securing any delay within this range. To obtain precision in the acting time, certain features of the mechanical construction of the relay assume much more importance than with ordinary relays, and to obtain these features, a modified U relay, known as the Y relay,* was developed for slow-acting applications. Since the behavior of a relay is more stable when releasing than when operating, the releasing portion of the relay cycle is always used to secure precise delay, and thus relays of this type are usually called slow-release relays.

In its operated condition, the armature of a relay is held against the pole face by a force directly proportional to the square of the magnetic flux in the core, which is maintained by the current flowing in the winding. Since the flux is proportional to the current, the flux, and thus the pull, would immediately disappear when the current in the winding was interrupted, if the operating winding were the only current path associated with the relay. According to one of the fundamental electromagnetic laws, however, a changing magnetic flux induces a voltage in the space surrounding it. If there are conducting elements forming a closed path around the

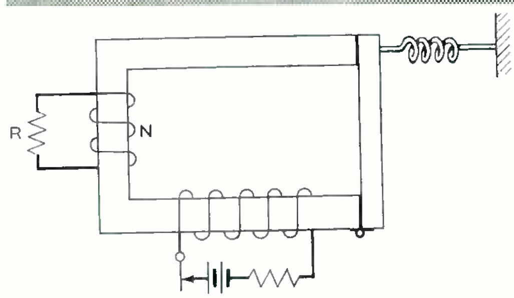


Fig. 1—Diagrammatic representation of a relay with a short-circuited winding

flux, therefore, current will flow in them due to the voltage induced by the decreasing flux, and this current will be in a direction to build up a flux in the same direction as the original, and thus will retard its decay. The lower the resistance of the conducting path, the greater will be the current and thus the greater the retarding effect on the decay of flux.

With a relay having only an operating winding, the only conducting paths in which current can flow when the winding is open-circuited are in the core or structural elements of the relay, and since these are relatively high-resistance and ineffective paths, only a small retarding effect is exerted on the decaying flux, and thus the release times of ordinary relays are short. Delays of appreciable amount can be obtained, however, by adding a high conduct-

*Record, *May,* 1938, *page* 310.

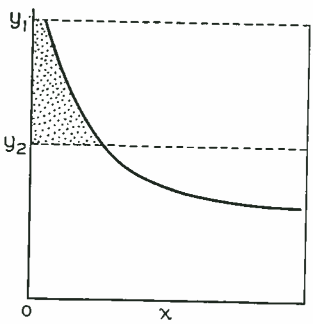


Fig. 2—If y is a function of x, the integral of xdy is the area shown shaded

ing path around the core in the form of either a short-circuited winding or a solid metal sleeve. By varying the resistance of this short-circuited winding or sleeve, a wide range in delay may be secured.

A relay with a short-circuited winding is shown schematically in Figure 1. Under operated conditions, with a steady current flowing in the operate winding, the flux is constant, and the current in the short-circuited winding is zero. When the operating winding is open-circuited, the flux starts to decrease, generating a voltage in the short-circuited winding that causes current to flow in it. The relationship between flux, current, and time may be expressed by writing down the voltages in the short-circuited winding. These consist of the resistance drop and the voltage induced by the decaying flux, and since the voltages around a closed circuit add up to zero, the equation becomes

$$(1) \quad 0 = iR + 10^{-8} N \frac{d\phi}{dt}$$

where $d\phi/dt$ is the rate of change of flux. Integrating this equation and solving for t, gives

$$(2) \quad t = 10^{-8} \frac{N^2}{R} \int_{\phi_2}^{\phi_1} \frac{d\phi}{Ni} \text{ seconds}$$

as the time required for the flux to decrease from ϕ_1, which represents the operated flux, to ϕ_2, which represents the flux when the relay just begins to release, which will be that just offsetting the releasing force of the springs. The expression N^2/R is readily calculated from the number of turns in the short-circuited winding and its total resistance, but the integral expression is not easily evaluated mathematically because ϕ and i are functionally related in a complex manner involving the nature of the iron, the presence of air gaps, and other structural features.

If x is allowed to represent $1/Ni$, and y to represent ϕ, the expression under the integral sign becomes xdy, where x is an unknown function of y. If a curve were available expressing the relationship between x and y as in Figure 2, however, the

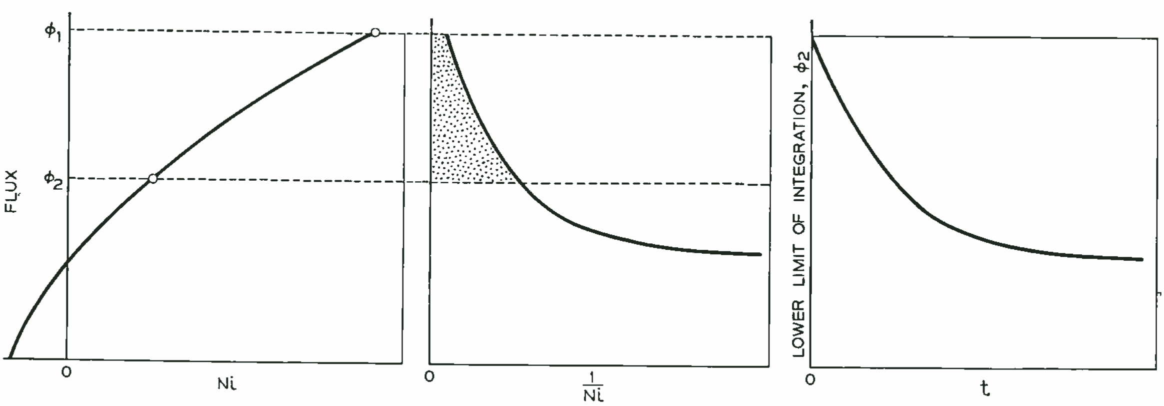


Fig. 3—A plot of ϕ against ampere turns, at the left, is converted to the equivalent plot of ϕ against the reciprocal of the ampere turns in the middle diagram. By multiplying the shaded area by $10^{-8} \times N^2/R$ for various values of ϕ a plot of flux against time is obtained, as shown at the right

integral could easily be found, since it is the area from the curve to the y axis between the two values of y considered, and is thus equal to the shaded area shown.

The flux in a core can readily be measured, and thus a graph can be made expressing the relationship between the flux in the core and the current flowing in a winding around it. If such measurements are made for a particular relay structure from the full value of operating current down to zero current, the curve obtained will be of the form shown at the left of Figure 3. If this curve be redrawn, using $1/Ni$ instead of Ni as the abscissa scale, the curve is as shown in the middle graph. This curve now expresses the functional relationship between ϕ and $1/Ni$, and the integral of $1/Ni$ times $d\phi$ between ϕ_1 and ϕ_2 is the area shown shaded, just as in the example of xdy above. If 10^{-8} times the value of this area for various values of ϕ_2 is multiplied by the value of N^2/R, a curve may be plotted to show the relationship between ϕ_2 and t, as shown at the right of Figure 3.

Curves like that in the middle of Figure 3 may be determined by measuring the flux in the core and the current in the operate winding as the current is decreased from its maximum value to zero. Such a curve expresses the relationship between flux and exciting ampere turns, and, although obtained by measurements on the operating winding, will apply to any winding, because it is the product of N and i and not i alone that is plotted. From such a curve the value of $\int_{\phi_2}^{\phi_1} \frac{d\phi}{Ni}$ of equation (2) can readily be found by measuring the area from the curve to the vertical axis between the value of ϕ when the relay is operated and its value when the relay releases. By multiplying this by the value of $10^{-8}\, N^2/R$ for the short-circuited winding, the release time is obtained.

In a short-circuited winding, the value of N^2/R depends on a number of factors such as the over-all dimensions of the winding, the size and material of the conductor, and the amount of insulation. It is found that for any one value of the ratio of the conductor cross-sectional area to the total area required for one turn, which is called the "copper efficiency" and is designated e, the value of N^2/R varies with the ratio of the outside to the inside radii of the winding, which are designated r_1 and r_2, respectively. Typical curves for various values of e are plotted in Figure 4. The larger the value of e, the greater will be N^2/R for any given ratio of r_2/r_1, and maximum values of N^2/R are thus those when e equals 1. When e is 1, however, the winding is all conductor, and is thus a metal sleeve.

Having determined the value of $10^{-8} \int_{\phi_2}^{\phi_1} \frac{d\phi}{Ni}$ from a curve like that of Figure 3, it is thus possible from Figure 4 to select a winding so that the product of N^2/R and $10^{-8} \int_{\phi_2}^{\phi_1} \frac{d\phi}{Ni}$ will give the desired time.

This method of analyzing release times makes it easy to study the effects of various factors, such as air gaps in the magnetic circuit, the area of the pole faces, or the spring force tending to release the relay. For each condition or combination of conditions of air gap, pole-face area, or spring force, a curve like Figure 3 may be plotted, the value of ϕ at release determined, and the area between the curve and the ϕ axis may be measured. Since for any given short-circuited winding, the release time will be a constant times this area, the areas themselves give a direct indication of the relative release times applying for the vari-

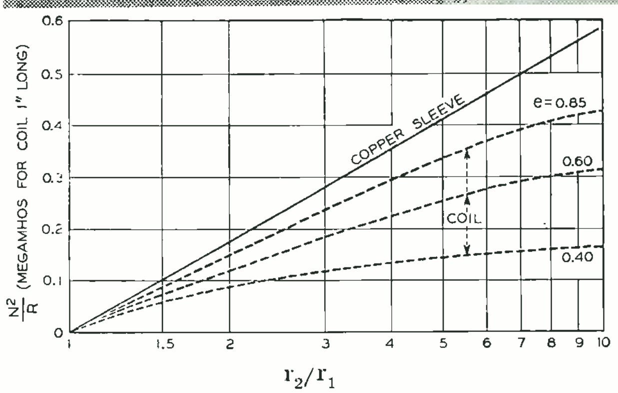


Fig. 4—Conductance of short-circuited windings as a function of the ratio of outside to inside radii for various values of e. Since a solid sleeve is the most effective in securing delay, only the upper curve is used

ous conditions. It is from studies such as these that the basic design of the Y relay was established. Since a solid sleeve is the most effective in securing delay, only the upper curve of Figure 4 is employed. From this curve and the $\phi - NI$ curve, a size of sleeve is selected to give the desired release time for the spring combination employed. This method is so reliable, once these estimates have been made, that relays can be manufactured to give the desired release time merely by adjusting their spring loads until the armature releases on the ampere turns corresponding to the design value of release flux.

For slow releasing relays, it is desirable to have metal-to-metal contact between the armature and pole face when the relay is operated; the low reluctance provides a greater releasing flux and longer delay times. On the other hand, any deviation from perfect flatness at the contact of these surfaces will introduce an air gap over part of the contact area, and because of the very high reluctance of air compared to that of iron, any small variations in this metal-to-metal surface will produce a relatively large effect on the time behavior of the relay. A very satisfactory compromise is made on the Y relay by forming one of the contact surfaces to be spherical. Although this somewhat increases the reluctance of the magnetic circuit, since metal-to-metal contact will exist only over a small circular area, the variations that are due to the possible misalignments of armatures from one relay to another are thereby avoided.

THE AUTHOR: H. N. WAGAR received the S.B. degree in Physics from Harvard University in 1926, and shortly afterward joined the Laboratories. Continuing his studies at Columbia, he received an M.A. in 1931. As a member of the Apparatus Development Department, he has participated in development work on most forms of telephone relays, crossbar switches, and other apparatus involving switching by magnetic means. While working on these problems he developed the first oscillographic system for obtaining simultaneous records of mechanical and electrical vibrations. During the war he worked on anti-aircraft computers, and later on fuses for magnetic mines. He has been an instructor in the frequently given out-of-hour course on relay design, and was the author of a considerable portion of the text used. At present, he is in charge of a group developing relays and magnet coils for large-scale applications.

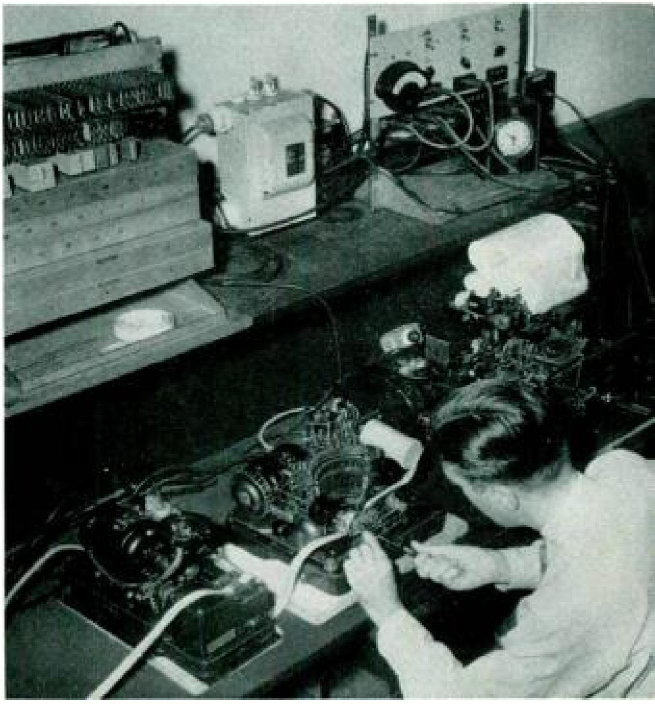
HIGH-SPEED TELETYPEWRITER SERVICE FOR THE WAR

For a number of years before Pearl Harbor, the Army, Navy, and other Government departments had used teletypewriter service, but available facilities were entirely inadequate to meet the enormously increased traffic brought on by the war. Neither materials, labor, nor time were available to supply a sufficient number of new circuits and instruments, and Bell Laboratories was asked to devise methods of utilizing existing facilities more intensely.

Teletypewriters for the most part were built for operation at sixty words per minute, which is about as fast as the ordinary operator can send steadily, but many of the circuits were capable of transmitting at somewhat higher speeds. If the teletypewriter apparatus could be modified to operate at one hundred words per minute, the higher possible speed of transmission could be taken advantage of in several ways. By using these faster machines, tapes could be punched and then transmitted and received at the higher speed, which would nearly double the traffic carried.

To determine what could be done to provide this higher speed of operation, rather extensive studies and investigations were undertaken in the Laboratories—work on transmission requirements and testing being under the general direction of S. I. Cory and that on teletypewriter apparatus being directed by B. S. Swezey. It was concluded that, without fundamental design changes, operation at one hundred words per minute is very near the upper limit, but that with a considerable increase in maintenance cost this speed was practicable when confined to automatic operation. As a result of these studies, the Teletype Corporation undertook to design, test, and manufacture the necessary parts for the teletypewriter apparatus. They were then sent to the Laboratories for test and study, and for trials in the plant.

In the accompanying illustration, S. L. Eppel is shown with one of the over-all test set-ups. A No. 14 transmitter-distributor, a No. 14 typing reperforator, and a No. 15 teletypewriter, all capable of operating at one hundred words a minute, are interconnected to test operation over long periods of time. Mr. Eppel came to the Laboratories from the Illinois Bell Telephone Company for the war period, and until recently carried on most of the testing of this modified teletypewriter apparatus, and assisted the Long Lines Department in early field applications. High-speed apparatus was made available in Government services soon enough to be of considerable value, especially on transcontinental circuits between Washington and West Coast points during the great activity of the final phases of the Japanese conflict.



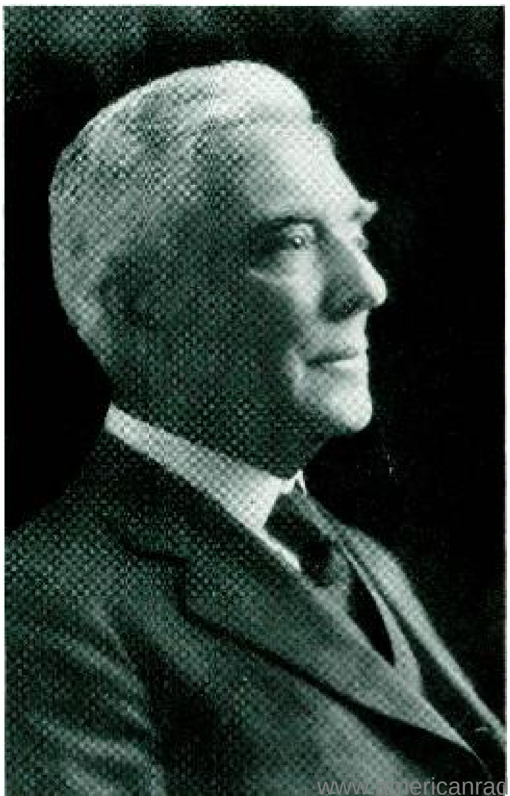
THOMAS A WATSON MAKER OF TELEPHONES

R. B. HILL
General Staff

It has been said that "Rarely has a man been better equipped by inheritance, training, and experience, for solving a particular problem than was Bell when he invented the electric speaking telephone." It might be added, with equal truth, that rarely has an inventor been blessed with such an able assistant and collaborator as Thomas A. Watson; and seldom have the promoters of a new and untried enterprise been so fortunate in the choice of a man to take charge of its technical development. With no scientific background or training, and no formal education beyond the second year in high school, Watson was gifted with the true spirit of adventure combined with the ingenuity, perserverance, and confidence to carry through any task he undertook, and the necessary philosophy to make it interesting and enjoyable.

Born in Salem, Mass., on January 18, 1854, his boyhood days showed no promise of things to come. He was shy and sensitive, and liked to be by himself and to dream. Between school sessions he worked successively in a crockery store, in a paper box factory, and as a carpenter's assistant. The turning point in his life came on July 1, 1872, when, at the age of 18, he got a job as an apprentice in Charles Williams' shop at 109 Court Street, Boston, where telegraphic and other electrical apparatus was made. Finding this work thoroughly to his liking, he soon developed the knack of devising more efficient methods of turning out the work, and at the end of two years had become a skilled mechanic. His spare time was spent in reading all of the books on electricity and magnetism that he could lay his hands on.

T. A. Watson in 1925



In December, 1874, he first met Alexander Graham Bell, who had come into the shop to have alterations made in some instruments that Watson had made without knowing whom or what they were for. These were the harmonic telegraph transmitter and receiver, with which Bell hoped to transmit, over a single wire, six or more simultaneous telegraphic messages.

From then on, Watson rapidly became more closely involved in Bell's work, and before long was his only assistant, devoting his entire time to the experiments and developments that led to the transmission over a wire of the first complete sentence, on March 10, 1876; and to the formation of the first company to commercialize the telephone, during the following year. These achievements have already been adequately described.* In all of this work, covering a period of two and a half years, Watson had a most important part. Under Bell's

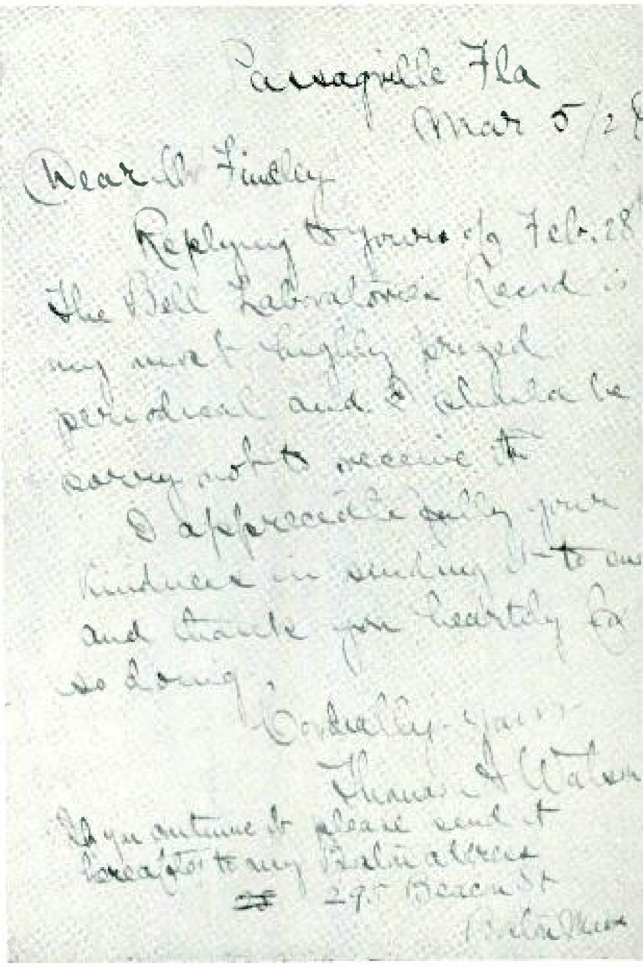
**Exploring Life* and *The Birth and Babyhood of the Telephone*, by Thomas A. Watson; and *Beginnings of Telephony*, by Frederick L. Rhodes.

direction, he built the harmonic telegraph apparatus used in the early experiments, and, on June 3, 1875, the first telephone. He constructed, and to a considerable extent designed, the succeeding instruments which led, by painstaking steps, to the first commercial forms of speaking telephones. He assisted Bell in the outdoor trials of the telephone on telegraph lines, which began in the summer of 1876 and extended over a period of several months, and in the lectures delivered by Bell during the winter and spring of the year 1877 in an effort to popularize the use of the telephone. During these lectures, it was Watson's function to furnish, several miles away at the distant end of the line, the vocal entertainment transmitted to the hall.

When the commercial telephone business was inaugurated by the first parent Bell company, in the summer of 1877, and licenses under the Bell patents were issued to firms and individuals in various parts of the United States, Watson's troubles began in earnest. He had been appointed General Superintendent of the parent company, and was in charge of the manufacture of all telephones, which were made at the Williams shop, and of such subsidiary apparatus as was in existence.

The licensees were, for the most part, people who could command a few thousand dollars and who possessed sufficient courage to embark in an untried enterprise. Few of them had any technical experience. The only telephone instruments, in the summer of 1877, were box telephone transmitters of the magneto type, and wooden hand receivers. There was no battery transmitter. There were no adequate signaling devices, no satisfactory type of line wire, and no switchboards or cables suitable for telephone use. There were all sorts of noises on the grounded iron wire lines, and overhearing from one line to another. These were some of the technical problems that confronted Watson and the small group that was brought in to assist him. There were also financial worries, interferences in the Patent Office, and legal suits against infringers of the Bell patents.

Watson's time during the next four years was devoted to designing and improving



[illegible] Fla
Mar 5/2[illegible]

Dear Mr Findley
Replying to yours of Feb. 28
The Bell Laboratories Record is
my most highly prized
periodical and I should be
sorry not to receive it.
I appreciate fully your
kindness in sending it to me
and thank you heartily for
so doing.
Cordially yours
Thomas A Watson

If you continue it please send it
hereafter to my [illegible] address
295 Beacon St
[illegible]

The above letter was received from Mr. Watson as a result of a letter sent out by the editor of the RECORD *to subscribers outside the Bell System*

the early forms of transmitters, receivers, and substation sets; overseeing their manufacture and testing; issuing circulars to the licensees describing in detail the instruments, signaling devices, switchboards, and line construction to be used in a telephone exchange system; testifying in legal suits; answering by letter the numerous technical questions raised by the licensees; and making flying trips to the field to inspect conditions at first hand. He also found time to design a considerable part of the subsidiary apparatus which was so essential to the operation of the telephone. Between September, 1877, and April, 1881, he filed applications which resulted in about forty United States patents on telephonic devices. The most important of these inventions were the magneto hand generator (U. S. patent 202495), in which the turning of a crank generated an alternating current to ring a bell or operate a switchboard drop at the far end of the line; and the polarized substation bell (U. S. patent 210886), in which a polarized, centrally-pivoted armature of an electromagnet, when an alternating current passed through its winding, operated a striker playing between two gongs, thus ringing the gongs in rapid alternation. Both of these devices have survived to the present day, with their fundamental method of operation unchanged.

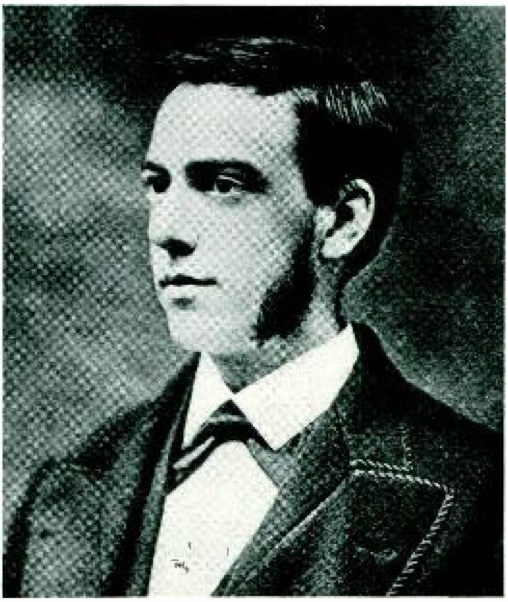
Other inventions of Watson's worthy of mention were an improved form of automatic hook-switch (U. S. patent 270522); an arrangement for connecting a metallic circuit trunk line to a subscriber's grounded circuit through an induction coil so as to avoid inductive disturbances (U. S. patent 232788); and the automatic take-up of switchboard cords by means of a weighted pulley (U. S. patent 280266). This latter invention, originally described in an application filed in April, 1880, is still employed at manual switchboard positions.

Badly in need of a rest, Watson resigned his position with the American Bell Telephone Company (then the parent company) in the spring of 1881. By this time there were more than 50,000 Bell telephone stations in service throughout the United States, as well as a considerable network of short toll lines. Except for his subsequent testimony in legal suits involving the telephone, and addresses delivered before telephone people, Watson's telephonic career was ended, at a time when he was only twenty-seven years of age.

Well off financially, because of his one-tenth interest in the first Bell company, Watson spent two years traveling in Europe and the United States. In June, 1883, he bought a farm in East Braintree, Mass., and went there to live. About 1885, he formed a partnership with a young machinist and started building steam engines for boats, under the name of the Fore River Engine Company. In 1892, he induced the Braintree town officials to construct a municipal electric lighting plant and system, and was the first manager of this electric plant.

In 1897, the Fore River Engine Company, which had been expanding in the meanwhile, decided to construct war vessels for the United States Navy, to give employment in the hard times then prevalent. This led to a further enlargement of the plant, and subsequently to the erection of an entirely new shipyard at Quincy Point. When the decision to build battleships was made, a stock company was formed, with Watson as President. To keep all departments of the shipyard busy, a constant influx of new business was needed,

T. A. Watson in 1874



and the company took on the construction of steel schooners, one of which was the seven-masted *Thomas W. Lawson.* It also built the Steamship *Providence* of the Fall River Line. By 1902, eleven ships were under construction, representing contracts of twenty million dollars.

By this time, the financial load was too heavy for Watson to carry alone and, as he was unable to obtain new capital from brokers upon whom he had counted, he was obliged to relinquish control of the company as a requirement for the underwriting of a bond issue. During the following year, the company was reorganized, Watson resigned the presidency, and soon after retired from the ship building business. Shortly afterward came the foreclosure of the bondholders' mortgage, which wiped out the stock and with it Watson's entire investment.

In 1910, Watson, now 56 years old, went to England and joined Frank R. Benson's company of touring Shakespearean players, while his wife took courses at London University. Starting with absolutely no theatrical experience, he applied himself to the new work so diligently that he soon became a valued member of the company, playing important parts. When he left the company, at the end of eight months, Mr. Benson said to him, "Don't lose your eternal youth, Mr. Watson." Watson says in his book:

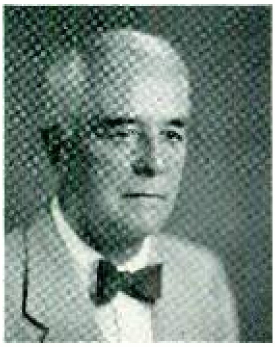
"I was sorry to leave him and his notable group of men and women in his company. The months I had spent with them seemed like a crowded lifetime to look back on. No work I had ever done was more to my taste and if I had been younger I should probably have continued in it as a profession."

Upon his return to the United States, Watson gave public readings from the Bible, Greek drama, Shakespeare, and American authors, and produced and acted in plays for the Boston Browning Society. He also gave lectures on the telephone. In 1913, he delivered his notable paper *The Birth and Babyhood of the Telephone* before the Telephone Pioneers of America.

At the opening of the transcontinental telephone line, on January 25, 1915, Watson, in San Francisco, and Bell, in New York, conversed between those cities more easily than they had talked thirty-nine years before over the line from Boston to Cambridgeport. At the transcontinental opening, Bell also talked to Watson with a replica of his first telephone of 1875.

In 1919, Union College conferred upon Watson the degree of Master of Arts, and in 1921 the degree of Doctor of Engineering was awarded him by Stevens Institute of Technology. In 1926, he published his autobiography, *Exploring Life*, from which many of the incidents in this biographical sketch were taken. On December 13, 1934, in his eighty-first year, he died at his winter home in Florida.

His career in the telephone business was brief but hectic. Not only were his days and hours crowded, but – as O. Henry would have it put – the minutes and seconds were hanging onto straps. His invaluable aid, coming at a time when little was known of the telephone or its future, his eager desire to do everything within his power to advance the interests of his company and its licensees, and his ingenuity in devising the apparatus so badly needed for furnishing commercial service, form one of the bright chapters in the technical development of the telephone.



THE AUTHOR: Roger B. Hill received a B.S. degree from Harvard University in 1911 and entered the Engineering Department of the American Telephone and Telegraph Company in August of that year. For several years thereafter he was engaged principally in appraisal and depreciation studies. When the Department of Development and Research was formed in 1919, he transferred to it, and since then has been largely concerned with studies of the economic phases of development and operation. He has been a member of the staff of Bell Telephone Laboratories since 1934, first in the Outside Plant Development Department and later in the Staff Department. In addition to his work on the economic side of the telephone business, Mr. Hill has exhibited a great interest in the early history of the telephone art, and has assisted with the preparation of several books and articles dealing with that subject.

ADSORBED WATER IN INSULATION

D. A. McLEAN
Chemical
Laboratories

Water is one of the greatest hazards to the satisfactory behavior of electrical insulation because it is universally present in the atmosphere, and many of the most important insulation materials have an appreciable appetite for it. Those of cellulosic base, such as paper and cotton, contain several per cent of moisture when in equilibrium with the air at normal humidities. Water in these materials may lower their electrical resistivity, increase their dielectric constant, and dissolve and ionize residual impurities. Moreover, water often has deleterious secondary effects including degradation of the dielectric by hydrolysis, promotion of thermal decomposition, encouragement of fungus growth and corrosion of wires, electrodes or other metal parts adjacent to the insulation.

One of the most important insulation materials in telephone equipment is paper, of which large quantities are used annually in the form of thin sheets for the dielectric in small capacitors. The effect of water on the capacity, power factor, and insulation resistance of such paper capacitors impregnated with chlorinated napthalene is shown in Figure 1. Of these properties the one most influenced by moisture is the insulation resistance which is decreased by several orders of magnitude by four per cent of water. A still more serious effect is that on the life of capacitors which are subjected to sustained d-c voltages. Four per cent of water decreases the life at 500 volts of a capacitor made of two layers of 0.4 mil paper impregnated with chlorinated napthalene by a factor of 2.5×10^{-5} over that observed when only 0.15 per cent is present. Obviously, to obtain the best insulating properties in capacitors or in other insulation which absorbs water vapor, the insulation must be thoroughly freed of moisture and sealed against its re-entry.

Fortunately, adsorbed water differs from most contaminants in that it attains high vapor pressures in the range of temperatures to which it is permissible to subject organic insulating materials. It can therefore be removed practically completely by elevating their temperature and subjecting them to reduced air pressure. In the processing of paper capacitors, it is common practice to dry the unimpregnated windings in vacuum within the temperature range of 100 to 150 degrees C.

The effect of moisture on cellulosic insulation has received attention at the Laboratories and a large amount of pertinent data have been collected. Among the most important principles established, are those governing the removal of moisture

W. McMahon measures the resistance of a capacitor immersed in an impregnant in the tube at the right

from a porous sorbent solid immersed in a non-volatile liquid. These principles are not only of academic interest but have important applications in the drying and impregnation of sorbent materials and in the determination of moisture in impregnated structures by vacuum extraction. In these applications the impregnant comprises the non-volatile liquid. Its hydrostatic head is negligible compared with the other forces involved. If the solid holds absorbed water it is given up as a vapor and bubbles off through the liquid when the external pressure P1 is lowered sufficiently. This occurs rapidly at first but soon virtually ceases. At this time the pores of the cellulosic material are filled with water vapor at a pressure not of P1 but of P2 which is greater than P1 by $2\phi/2$ where ϕ is the surface tension of the liquid and R is the radius of the pores. $2\phi/2$ represents the force exerted by the liquid in trying to enter the pores by capillarity. If the pressure is held constant, moisture comes off only by diffusion under the pressure differential P1 −P2, a process that is very slow when compared with the earlier one.

Experimental data check this simple theory surprisingly well. Actually R is not a single value but a wide range of values. $2\phi/2$ has been evaluated and found to be about 200 millimeters of mercury for capacitor paper. These findings rationalize the principle, which had been established empirically, that paper must be dried before and not after it has been immersed in an impregnant. The $2\phi/2$ force also acts to prevent removal of air and hence for vacuum impregnation the dried paper should be thoroughly exacuated at the time it is immersed in the impregnant.

In view of the degrading effect of moisture on cellulosic insulation, it is important to have methods for its determination. These are included in specifications to find out whether a product meets maximum allowable requirements for moisture content and in post mortem examination of failed apparatus to determine the extent to which failure can be attributed to the presence of moisture. The method used depends on the nature of the insulation and the pre-

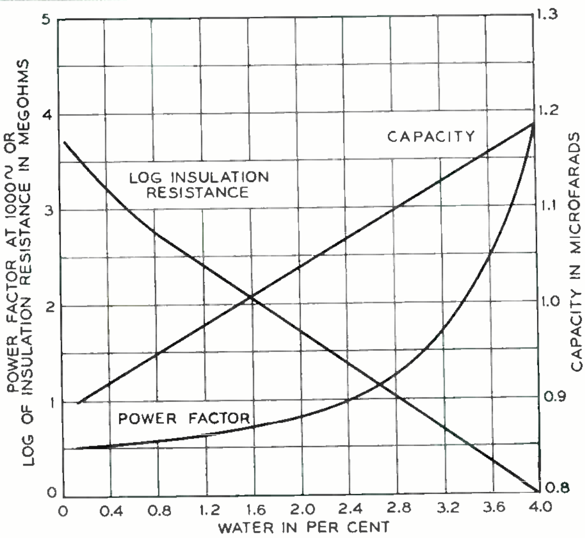


Fig. 1—The resistance of paper insulated capacitors decreases very rapidly with increase of moisture content. The power factor also increases and the capacity becomes greater but at slower rates

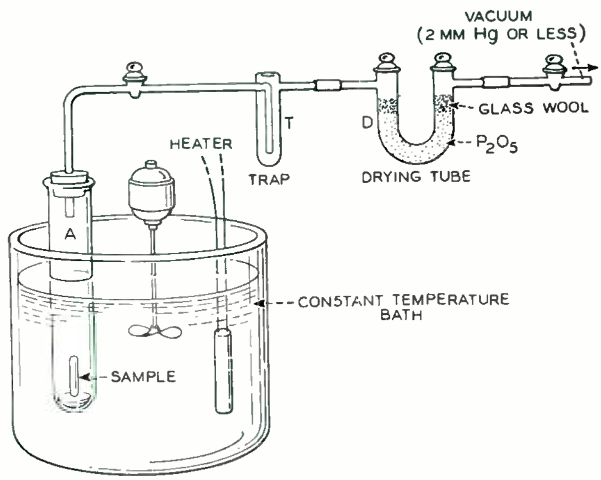


Fig. 2—Distillation method of determining the amount of moisture in impregnated paper capacitors. The sample is heated at reduced pressure in a constant temperature bath. The moisture is collected by a drying agent

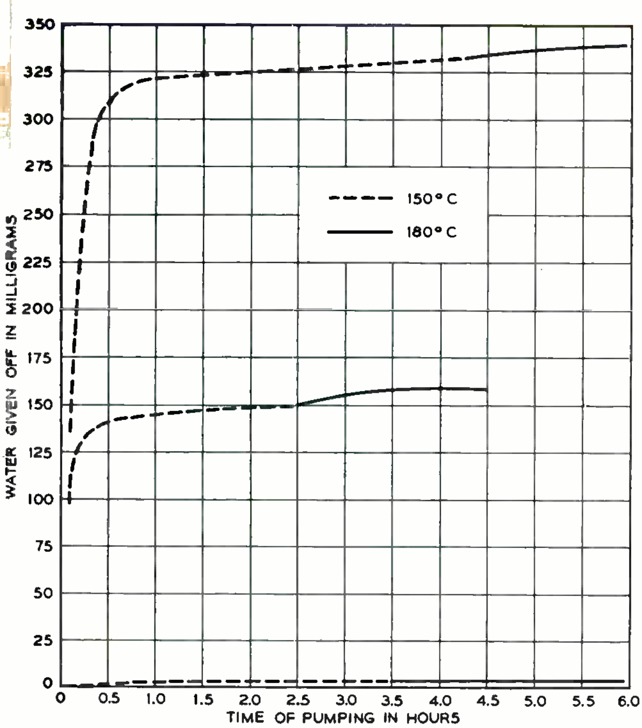
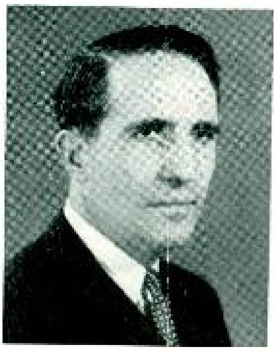


Fig. 3—Moisture in impregnated capacitor papers is nearly all removed in four hours by distillation at 150 *degrees C.*

cision required. A simple distillation method has been developed by the Laboratories for testing impregnated paper capacitors and has been extensively employed for both of the general purposes mentioned above. It is designed to take account of the high forces resisting removal of moisture from impregnated insulation.

The sample is placed in the bottom of a long glass tube, Figure 2, which is submerged to about 70 per cent of its length in a constant temperature bath. A rubber stopper, which fits tightly into the top of the sample tube, contains a centrally located glass tube that connects the sample to the vacuum line through an air-cooled trap and a drying tube. Although the vapor pressures of the capacitor impregnants commonly used are very low, the trap is employed as a precaution to retain small amounts of impregnant which might distill over. It is important that the sample be supported off the bottom of the tube to provide space under the sample to receive impregnant which drains from it or is pulled out by the first efflux of gas and moisture. The moisture is collected in the drying tube which contains phosphorus pentoxide or other suitable drying agent. This tube is weighed at the start and end of the determination and the gain is the moisture content of the sample. For a bath temperature of 150 degrees C about four hours is sufficient to remove the moisture from impregnated paper samples not exceeding ten grams in weight. Figure 3 shows the results for three samples of impregnated paper of widely different initial moisture content.

The Laboratories and the Western Electric Company are constantly on guard against the deleterious effects of moisture in telephone apparatus and are continuing to develop efficient and economical means of drying and sealing it from moisture during service where required.



THE AUTHOR: D. A. McLean joined the Laboratories in 1929, the year he received his Bachelor of Science Degree in Chemical Engineering from the University of Colorado. During the succeeding three years he was occupied with problems in plasticity, viscosity, and the wetting of solids by liquids. Since then Mr. McLean has been concerned with insulating paper, capacitor problems, and measurement of the dielectric properties of materials. He has a number of patents and publications in the field of electrical insulation, particularly on the stabilization of chlorinated impregnants by chemical additives.

R. B. HEARN
Systems
Development

ELECTRONIC REGENERATION OF TELEGRAPH SIGNALS

Regenerative repeaters* have been used for many years on Bell System teletypewriter circuits to reform and retime signals before they become so badly distorted that dependable transmission cannot be assured. The distortion correction provided by these repeaters is secured by allowing the received signal to set in action and guide appartus that generates and sends out a completely new signal identical with the signal sent from the originating end. These previous regenerative repeaters have had motor driven distributors of the type used in the teletypewriter itself.

Where operation at low temperatures and simplicity of maintenance are of paramount importance, and where the a-c supplies are not of constant frequency, a mechanical repeater loses efficiency and requires frequent checking of the speed so that proper synchronization of the distributors at the two ends of the circuit may be maintained. Mechanical maintenance is eliminated in a repeater using electronic tubes, electrical relays, and the usual circuit elements such as capacitors and resistances, which was designed under an Army development contract as the TG-29 repeater. Two development models were turned over to the United States Signal Corps in January 1944.

In the teletypewriter code, a character consists of a combination of "mark" and "space" pulses, totaling five units in length, together with a one-unit start pulse, which is always spacing, and a 1.42 unit stop pulse, which is always marking. At the signal source, changes to and from the marking condition always occur at the end of one of six equally spaced time intervals following the beginning of the start pulse. One particular character would be as shown in the upper line of Figure 1. The receiving device scans the code in the middle of each pulse, and if the distortion has not affected the portion of the pulse scanned, a correct character is received. When signals are transmitted over long lines or multisection lines, the permissible distortion may well be exceeded, and errors in the received copy will result. A regenerative repeater inserted in the circuit before this limit is reached uses the distorted pulses to establish the proper timing of a completely new set of pulses generated within the repeater.

The repeater breaks the line into two lines: an A line extending in one direction and a B line in the other. Each line has a receiving relay and a sending relay, and the receiving relay of one line controls the sending relay of the other. Such an arrangement is shown in Figure 2, which gives the wiring used only for sending from A to B. For sending in the other direction, the B receiving relay controls the A sending relay in a similar manner.

On the first pulse of a character, the operation of the AR relay, by interrupting voltage to lead A shown at the lower left, starts a pulsing circuit, that is shown in simplified form in Figure 3. It is started by the interruption of current in lead A, and once started continues in operation until the beginning of the stop pulse has been retransmitted. The circuit then restores to normal to be ready for the next character.

Before the beginning of a character the plate of gas tube V2, Figure 3, is connected to +115 volts through the mark contact of the AR relay of Figure 2, and current flows through it holding the cathode at about +5 volts. This voltage applied to the left-hand grid of vacuum tube V4 causes

*Record, *August*, 1930, *page* 570.

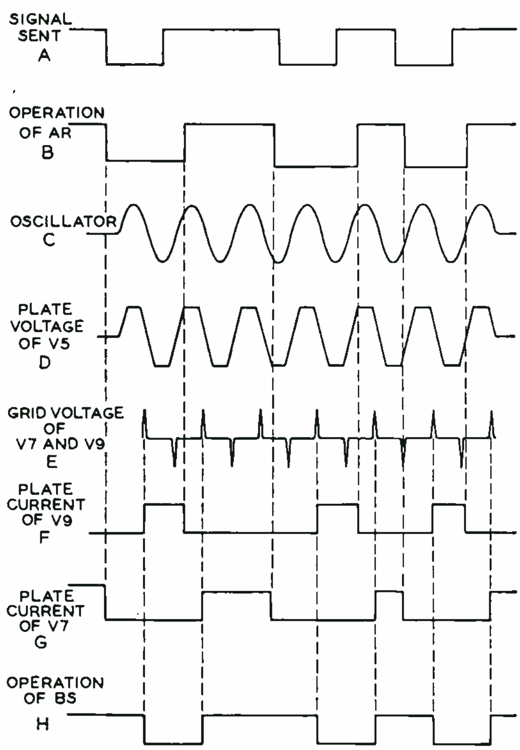


Fig. 1—Operation of various parts of the repeater circuit from the incoming signal at the top to the re-formed outgoing signal at the bottom

this tube to pass current, thus preventing the oscillator from oscillating by maintaining fixed potentials at both sides of the capacitor C2. When the start pulse opens the mark contact of relay AR, the battery is removed from the plate of V2. The charge on capacitor C5, Figure 2, however, maintains current flow for about one-quarter of a unit pulse length, but at the expiration of this interval current ceases, the cathode drops to about –90 volts, and this voltage applied to the left-hand grid of vacuum tube V4 blocks current in the left-hand plate circuit, thus permitting oscillation to start.

Capacitor C2 and inductance L1 together with the right half of vacuum tube V4, all shown in Figure 3, form a circuit that oscillates at the correct frequency when lead X is open circuited because of the stoppage of current through the left half of V4. The voltage across this oscillating circuit shown in line C of Figure 1 is applied to grid V5. The plate voltage of this latter tube is a flat topped wave as shown in line D of Figure 1. The tops of the cycles are flattened because saturation is reached before the grid attains its full voltage and the bottoms are flattened because cutoff is reached. Near the beginning of the rapidly changing current just beyond the flat tap and bottom, capacitors C3 and C4 rapidly charge or discharge, and as a result raise or lower the voltage on the grid of gas tubes V7 and V9. If one gas tube is conducting at this time, the change in grid voltage will have no effect, but if it is not and its plate circuit is closed to positive battery it will start to pass current when its grid voltage becomes positive, and will continue to conduct until the positive voltage is removed from its plate circuit.

The plate circuits of gas tubes V7 and V9 are connected over the E and G leads and the upper and lower windings of the BS relay of Figure 2 to the M and S contacts of the A relay. Positive battery is connected to the armature of the A relay and negative battery is connected through a high resistance to each contact. The middle winding of the BS relay is a relatively weak holding winding connected between the two contacts of the A relay and is used to hold the BS relay on contact during the intervals when neither tube V7 nor V9 is conducting.

Before the beginning of a character, current flows through the upper windings of the BS relay and tube V7 of Figure 3. When the start pulse operates the AR relay to its S contact, a circuit is closed which operates the A relay to its S contact. Thus positive battery is removed from the plate circuit of tube V7, and is applied to the plate circuit of tube V9. This causes V7 to cease conducting and prepares V9 to conduct when a positive impulse is delivered to its grid circuit. Meanwhile current through the middle winding holds the BS relay on its M contact until V9 becomes conducting. At this time the lower winding takes control and operates the BS relay to its S contact. When the received signal re-operates the AR relay to its M contact, the A relay follows, transferring positive battery from the plate of V9 to the plate of V7 through the upper winding of the BS relay. The middle winding now holds the BS relay on its S contact until tube V7 becomes conducting, causing a current to flow in the upper winding of the BS relay and operate it to the M contact. The elements of the outgoing signals are thus retimed to the correct value regardless of the amount of distortion in the incoming signals as long as the incoming signal is correct at the time a positive impulse is delivered by the pulsing circuit.

The process of sending out a regenerated set of pulses is shown graphically in Figure 1. Line A of this diagram represents the true signal as represented by the contact operations of the sending relay at the distant end, and line B shows the time distortion in the signal received, but shifted in time to line up with A. Actually, wave shape distortion of the signals would cause the corners of the pulses to be considerably rounded, but the pulses are shown with vertical sides to assist in following the time sequence down the diagram. The output of the oscillator is shown in line C – the oscillations starting about one-quarter unit after receipt of the start pulse as already explained. Line D shows the plate voltage of V5, and line E shows the grid voltage applied to V7 and V9 as a result of this plate voltage.

When the start pulse was received by the AR relay, V9 was not passing current because its plate circuit was open at the A relay, but V7 was passing current because its plate circuit was connected to battery at the A relay. The operation of the A relay, however, opened the plate circuit of V7, and thus by the time the oscillator started, neither V7 nor V9 were passing current. The subsequent flow of plate current in these two tubes is shown in lines F and G, and the operation of the sending relay BS, resulting from the position of the A relay in conjunction with the starting of flow of current in the two gas tubes, is shown in line H of Figure 1.

At the first pulse of line E, V9 passes current through the spacing (lower) winding of BS and the spacing contact of relay A, and BS operates to space. V7 does not pass current at this time because its plate circuit is open at relay A. None of the negative pulses of line E has any effect on the operation of the gas tubes, since they merely makes the grids of V7 and V9 more negative. Between the first and second positive pulses, however, relay A has operated to mark, and in doing so has opened the plate circuit of V9, thus stopping the flow of current. The second positive pulse thus starts current flowing through V7 and mark winding of BS, and BS operates to mark. Subsequent pulses may be followed in a similar manner. For each, an operation of the A relay connects battery to the proper winding of BS so that when the next timing pulse occurs, BS will send out the proper signal.

The length of time the oscillations continue for each character is controlled by capacitor C1 and potentiometer P3. When the cathode of V2 dropped from +5 to –90 volts after the reception of the start pulse, the potential of the right-hand side of C1 was dropped the same amount, and this high negative voltage applied to the grid of V2 prevents V2 from passing current at the subsequent closures of its plate circuit

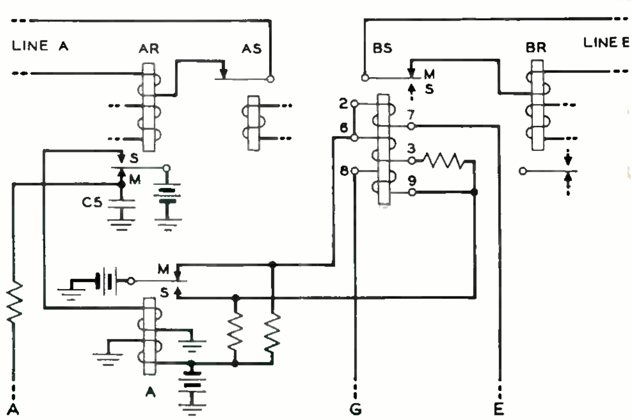


Fig. 2—Relay circuit comprising the regenerative repeater. This gives the wiring used when sending from A to B. For sending in the other direction, the B receiving relay controls the A sending relay

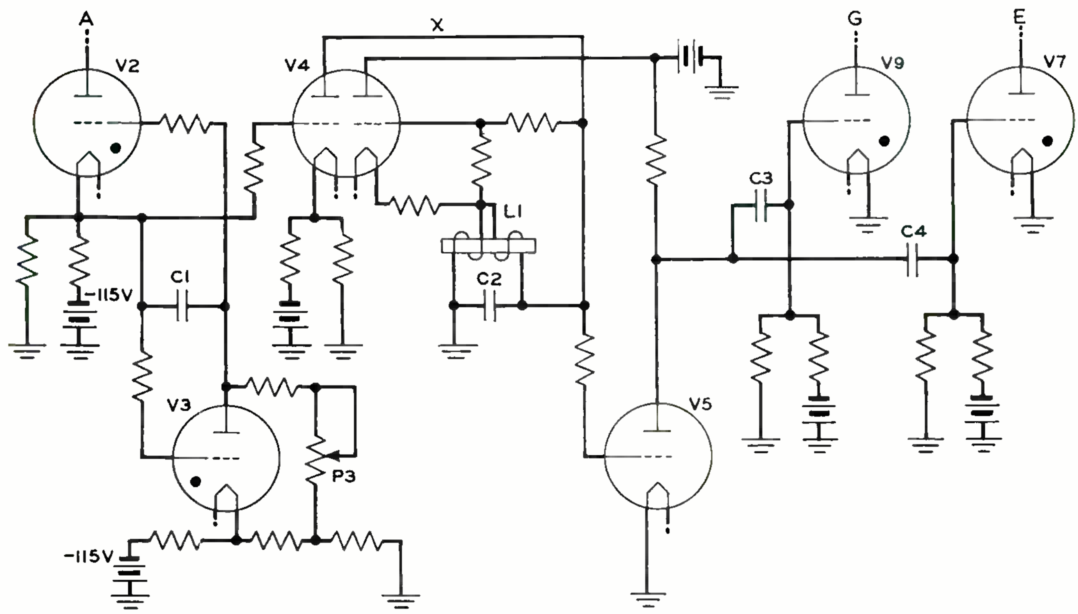


Fig. 3—Vacuum tube control circuit for the repeater

to battery. The high negative voltage on C1 also prevents any current flowing in V3. The charge on C1 gradually leaks to ground through P3, however, and after a time determined by the setting of P3, it has decreased sufficiently to raise the voltage on the grid of V2 to a point where V2 will pass current the next time its plate is connected to positive battery. The discharge period of the capacitor is adjusted to extend from the stoppage of current in V2 to the transmission of the beginning of the stop pulse at the end of the character. When the stop pulse is received, positive potential at the plate of V2 causes the tube to conduct. The resulting current in its cathode potentiometer swings the grid of V3 toward positive. The plate of V3 then passes current, thus placing a charge on C1, which is capable of again blocking the grid of V2 when, in response to the succeeding start pulse, the plate of V2 is opened. The current flowing in V2 stops the oscillator by allowing current to flow through the left half of V4, and thus the circuit is prepared for the next character.

In the actual pulsing circuit there are two other gas tubes, corresponding to V7 and V9, that control the pulses sent out over the A line, and there is a B relay associated with the BR relay, just as the A relay is with the AR relay. Figure 2 shows the circuit as arranged for sending and receiving neutral (open and close) signals,

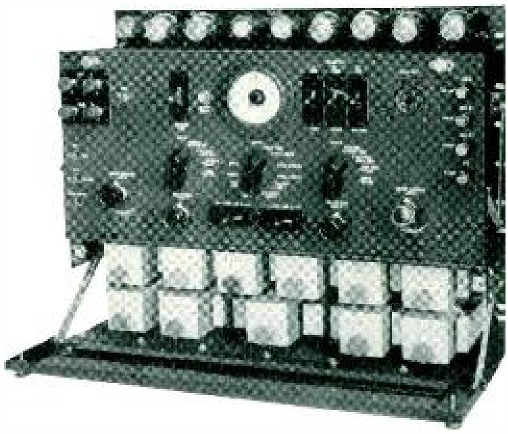


Fig. 4—Front view of electronic regenerative repeater

but the repeaters include switches that permit them to be arranged also for sending and receiving two-path polar signals, or for use as a multiway regenerative repeater. These other two arrangements bring relays into the circuit not shown in Figure 2, but the general scheme of operation is the same. Relays are also included to operate a local teletypewriter. The selection of the type of transmission is made for each line independently of the other. Thus, the A line could be receiving neutral signals and sending polar signals to the B line while the B line was receiving polar signals and sending neutral signals to the A line. Two switches on the front of the repeater permit the desired transmission to be selected for the two lines. A "cut" key associated with each line can be used to prevent one line, which may be in trouble, from interfering with the reception and transmission of signals over the other line.

Figure 4 shows a front view of the electronic regenerative repeater. Included in the repeater are arrangements for testing the polar relays, and for measuring and adjusting the currents and biases in both line relays. Spare relays, tubes, fuses, and maintenance tools are included with the set to expedite maintenance in the field, the repeater requires a source of regulated 115 volt d-c supply and a source of 6.7 volt a-c supply for its operation. These sources may be supplied from a power pack (not shown on Figure 4) to permit operation from 115 or 230 volts, 50 to 60 cycle power.

THE AUTHOR: R. B. Hearn joined the Laboratories in 1929 and engaged in telegraph repeater development and in the design of circuits for telegraph testing and maintenance. Prior to joining the Laboratories, he had begun night courses in engineering at Brooklyn Polytechnic Institute and received the E.E. degree from it in 1931. During the war period, he continued telegraph development work but alomst entirely on projects for the armed services. From September 1944 to January 1945 he was overseas in England, France, Belgium, and Germany on assignments from the Western Electric Company. Since the Fall of 1945 he has been engaged primarily on toll line signaling projects.

PAYMENTS UNDER BENEFIT PLAN TO EMPLOYEES AND THEIR FAMILIES

Pensions were granted to 58 employees during 1947. Of these employees, 27 were retired under the Retirement Age Rule and 12 because of disability. On December 31 282 retired members were receiving pensions.

Sixteen active employees, 16 retired employees and 2 employees on a disability leave of absence died during the year. Payments to their qualified beneficiaries were authorized as provided in the Plan or in the special authorities granted by the Board of Directors.

Accident frequency decreased 36 per cent during 1947 as compared with 1946 and the days lost per 100 man-days of work decreased 7 per cent. Sickness under the Plan decreased 5 per cent while the time lost increased 1 per cent. Payments under the Plan per $1,000 of standard payroll decreased 8 per cent for accidents and increased 8 per cent for sickness.

Payments for sickness absences not under the Plan, charged to departmental accounts, amounted to $466,954. Non-benefit sickness absence averaged 2.31 cases per employee.

Where need of special assistance beyond that provided under the Plan existed, supplementary payments and special pensions, totaling $13,842, were paid to 21 active employees, 15 retired employees and 2 beneficiaries of deceased employees.

There were 293 leaves of absence in effect at the beginning of 1947, 151 granted during the year, and 314 terminated, leaving a total of 130 outstanding as of December 31, 1947. Of these, 51 were granted to employees studying under the G. I. Bill of Rights.

The Plan is administered by the following committee: R. L. Jones, Chairman, R. Bown, A. B. Clark, F. D. Leamer and D. A. Quarles and, and as alternate members, W. H. Martin, W. Fondiller, J. W. Farrell and M. R. McKenney. J. S. Edwards is Secretary and K. M. Weeks is Assistant Secretary.

STATEMENT OF PAYMENTS UNDER THE "PLAN FOR EMPLOYEES' PENSIONS, DISABILITY BENEFITS AND DEATH BENEFITS" FOR THE YEAR 1947

Pension Trust Fund	
Disbursements by Trustee for Service Pensions During 1947	$ 467,783.00
Payments by the Company	
Disability Pensions	17,163.17
Payments After Death of Retired Employees	32,242.99
Accident Benefits and Related Expenses	21,719.76
Sickness Disability Benefits	319,925.94
Sickness and Accident Death Benefits	64,847.00
Total Benefit Payments	$ 923,681.86

STATUS OF PENSION TRUST FUND AS REPORTED BY BANKERS TRUST COMPANY, TRUSTEE

Balance in Fund—December 31, 1946		$20,616,480.98
Additions to Fund During 1947:		
Payments Into Fund by Company	$2,346,839.00	
Interest Revenue, Including Gain or Loss on Investments Disposed of	582,834.12	
Total Additions	$2,929,673.12	
Disbursements for Pensions During 1947	467,783.00	
Net Increase in Fund		2,461,890.12
Balance in Fund—December 31, 1947		$23,078,371.10

FRANK B. JEWETT FELLOWSHIPS

Nine young scientists were named on March 5 by the American Telephone and Telegraph Company to receive the 1948-49 Frank B. Jewett fellowships for research in the physical sciences. The awards grant $3000 to the recipient, and $1500 to the institution at which he chooses to do his research.

Winners of the fellowships are: Dr. Warren John Brehm of Harvard University and New York City; Dr. Ernest Max Grunwald of Portland Cement Association, Chicago, and Los Angeles, Cal.; Dr. Leon Albert Henkin of Princeton University and New York City; James Allister Jenkins of Harvard University and Toronto, Ont.; Robert Karplus of Harvard University and West Newton, Mass.; Alvin Ira Kosak of Ohio State University and Forest Hills, N. Y.; Dr. Joaquin M. Luttinger of Physikalisches Institut, Zurich, Switzerland, and New York City; Dr. Paul Olum of the Instiute for Advance Study, Princeton, N. J., and Cambridge, Mass., and Richard Nelson Thomas of Harvard University and Omaha.

Three of the winners are mathematicians. three chemists, two physicists, and one an astronomer. Dr. Olum, a mathematician, received a similar fellowship for 1947-48.

Grants for the fellowships were established four years ago by A T & T, upon the retirement of Dr. Jewett, vice president in charge of development and research. The purpose is to stimulate and assist research in the fundamental physical sciences and particularly to provide the holders with opportunities for growth and development as creative scientists.

The fellowships are awarded on recommendation of the Frank B. Jewett Fellowship Committee, consisting of seven members of the technical staff of Bell Telephone Laboratories who are actively and creatively engaged in research in physics, mathematics and chemistry. Primary criteria are: demonstrated research ability of the applicant, the fundamental importance of the problem he proposes to attack and the likelihood of his growth as a scientist. The awards are designedly postdoctorate and only scientists who have recently received their doctorates or who are about to receive them are normally considered.

Biographies of winners are given below:

Dr. Warren J. Brehm, 23, of New York City, is at present investigating the possible synthesis of lysergic acid at Harvard. He received his bachelor's degree from New York University in 1944, and his doctorate from Harvard in 1948. In 1945-46 he was engaged in chemical research at Oak Ridge ,Tenn., and was afterward awarded a Du Pont fellowship at Harvard.

Dr. Ernest M. Grunwald, 25, of Los Angeles, will study the activity of non-electrolytes in certain solvents. He is at present in industrial chemical research in Chicago. He received bachelor of science and bachelor of arts degrees from the University of California, Los Angeles in 1944, and a doctorate in physical chemistry from that institution in 1947.

Dr. Leon A. Henkin, 27, of New York City, received the bachelor of arts degree from Columbia in 1941, the master of arts degree from Princeton in 1942, and a doctorate in 1947 from Princeton, where he has since been an instructor in mathematics. His research project is on the application of mathematical logic to the sciences.

James A. Jenkins, 25, of Toronto, is studying for his doctorate at Harvard University. In 1944 he received the bachelor of arts degree in mathematics and physics from the University of Toronto, where the following year he received a master's degree in mathematics. He plans to continue research related to topological mapping.

Robert Karplus, 21, of West Newton, Mass., was graduated from Harvard with the bachelor of science degree in 1945, and a master's degree in chemical physics in 1946. His pre-doctoral studies are being done under a U. S. Rubber Company fellowship. He has worked as a research chemist in private industry. He plans to participate in nuclear research at Princeton.

Alvin I. Kosak, 24, of Forest Hills, N. Y., is at present a research fellow in the chemistry department, Ohio State University. He received his bachelor of science degree from the College of the City of New York in 1943, and expects to receive his doctorate this year. He will continue research in organic chemistry at Harvard.

Dr. Joaquin M. Luttinger, 25, New York City, attended Brooklyn College, Brown University and Massachusett Institute of Technology, taking his bachelor of science degree in 1944 and his doctorate in 1947, both from M.I.T. A physicist, he is now studying in Zurich. His research will be on the theory of the superconductive state.

Dr. Paul Olum, 30, of Winchester, Mass., received a Frank B. Jewett fellowship for 1947-48, in order to engage in research in algebraic topology, and will continue this work.

Richard N. Thomas, 27, of Omaha, was graduated from Harvard with a bachelor of science degree in 1942, and is at present preparing for his doctorate in the department of astronomy, Harvard. He plans to conduct research on superthermic phenomena in stellar atmospheres.

L. F. Porter; J. W. Van de Water, Omaha; R. V. Dean; T. L. Oliver, San Francisco; J. H. Miller; S. C. Bates, Cleveland; R. E. Friedley, New York (covers New England, Southern New England and New Jersey Companies); H. M. Craig, Detroit; D. S. Bender, Washington; L. L. Eagon, Chicago; L. E. Gaige, New York; C. E. Fisher, St. Louis; J. A. St. Clair; G. N. Queen, Atlanta; C. L. Black, Philadelphia; R. E. Johnson

QUALITY ASSURANCE CONFERENCE

Members of the Field Engineering force, Quality Assurance Department, gathered in New York during the week of March 8 to renew personal contacts and be briefed on current activities. On Monday morning G. D. Edwards opened the conference and introduced O. E. Buckley, who welcomed the group, and M. J. Kelly who outlined the Laboratories' functions. R. K. Honaman described the public relations program and how the field engineers might help in it. Informal talks by T. L. Oliver, J. W. Van de Water, H. M. Craig and C. E. Fisher described the Field Engineer as an ambassador from the Laboratories to the operating companies. He channels information from the Laboratories for current operating problems, he gathers information on field conditions, he arranges for field tests which do not justify the trial installation procedure, he welcomes suggestions from operating people and transmits them to the Laboratories, and he passes along the Laboratories' viewpoint. All these functions are in addition to his primary responsibility of investigating complaints about defective apparatus, equipment and circuits.

Monday afternoon was devoted to new developments in switching systems. Following an introduction by T. C. Fry, F. A. Korn and J. G. Ferguson talked on the No. 5 crossbar; M. B. McDavitt on community dial; F. W.

At the bowling party following the Quality Assurance dinner: S. C. Bates, R. H. Gertz, R. F. Elliott and R. V. Dean

Treptow on the 555 PBX; E. F. Watson on TWX; F. F. Shipley and F. J. Singer on toll line dialing; and A. J. Busch, F. J. Singer and J. Meszar on the newest automatic systems.

New developments in switching apparatus were covered on Tuesday morning with a general introduction by H. A. Frederick; new relays and selectors by A. C. Keller; glass tube relays by H. O. Siegmund; and other new developments by J. J. Kuhn. Vacuum tubes were treated in the afternoon by a general introduction by V. L. Ronci and talks on particular details by J. W. West, S. O. Ekstrand, E. G. Shower, R. L. Vance and L. F. Moose. A session on particular problems of the field engineers was addressed by W. A. Boyd, H. M. Craig and L. E. Gaige. Dr. Kelly addressed a dinner of the conferees.

Wednesday morning was occupied by an inspection tour of the Murray Hill laboratories, led by F. L. Hunt and A. R. Brooks. In the early afternoon a session on station apparatus was introduced by W. H. Martin. Talks followed on instruments by W. C. Jones; and substation sets, coin collectors and telephone booths by A. F. Bennett. Later there was a session on outside plant apparatus, an introduction by R. J. Nossaman and talks on alpeth cable by J. W. Kennard and V. H. Baillard; and timber products by R. H. Colley.

The conference convened on Thursday at West Street in a session on transmission apparatus with an introduction by E. I. Green, and talks on crystals by R. A. Sykes; condensers and transformers by F. J. Given; and networks by A. R. D'Heedene. At noontime the group visited 195 Broadway where they had an opportunity to meet people in the O & E; there were talks by H. S. Osborne and P. C. Schwantes. The group was joined by a number of Western Electric people for lunch. Following a short talk by R. M. LaClair, the afternoon was spent at Kearny.

The Friday morning subject was *Transmission Systems.* Following introduction by G. W. Gilman, C. H. G. Gray described the new voice frequency repeater; L. G. Abraham the L1 and L3 carrier; R. S. Caruthers the type-M carrier; and G. N. Thayer the microwave system. M. L. Almquist discussed high-frequency transmission; J. M. Barstow the power-line carrier; and A. C. Dickieson mobile radio. Operating problems of the field engineers were discussed by E. G. D. Paterson, W. A. Boyd, C. E. Fisher, J. A. St. Clair and W. H. Martin. Mr. Edwards delivered the closing address, summing up the conference.

Veterans Hospitals Can Use New and Cancelled Stamps

Members of the Laboratories Stamp Club have been sending assortments of philatelic materials to the patients at Halloran and Lyons Hospitals. Judging by the thank-you notes sent in by Joseph V. McLoone, Assistant Chief of the Recreation Section, the stamps are much appreciated by sick and wounded men who have formed the Halloran Stamp Club. At West Street M. A. Specht, Section 31, Extension 408, and at Murray Hill, A. J. Akehurst, 1D-244, Extension 2116, are accepting stamps to be forwarded to the veterans.

Third Video School

A third Video School for members of Associated Telephone Companies, including the Bell Telephone Company of Canada, was held at the Davis Building from February 9

L. A. Dorff receives the Certificate of Merit from Major General R. M. Webster, commanding general of the First Air Force, "in recognition of his outstanding services in contributing to the design and development of radar reporting and air defense systems."

to March 2, under the general supervision of L. G. Abraham. The course consisted of lectures, demonstrations, laboratory work and a conducted tour of television broadcasting studios in New York. L. W. Morrison and members of his group were responsible for general television background material and video transmission over wire facilities; H. J. Fisher and his group described television test equipment; and K. D. Smith and his group discussed the TE radio relay system.

Murray Hill Telephone System for Project II

In anticipation of the added Murray Hill telephone requirements due to the new buildings, expansion of the original dial system at Murray Hill and added facilities to Whippany and West Street were required. After months of planning and installation work the additions to the telephone system at Murray Mill have been completed. On March 15 telephone users at Murray Hill returned to find a combination 3- and 4-digit telephone numbering system in operation.

As less than 700 main stations were needed for the original Murray Hill buildings, a 3-digit numbering system was adequate, the required number of stations being available in the 200, 300, 400, 500, 600, 700 and 900 series. With the addition of Project II, it was estimated that about 1500 main stations would be required. To provide this it was necessary to use 4 digits in the numbering scheme. However, since the change of the 200 and 300 series of numbers to the 2000 and 3000 series made available 2000 stations, it was not necessary to disturb present numbers in the 400 to 500 group. Changes in the 600, 700 and 900 group had to be made to reserve the 6th, 7th and 9th level for special dialing.

The list of the essential equipments to handle extra lines for Project II includes:

Western installer, J. F. Mulligan, solders new extension multiple jacks for a multiple run to be added to the Murray Hill 701A PBX

The business of tailoring the addition of five new 605A switchboard positions to the Murray Hill 701A PBX proceeds carefully apace with the work being done by Western Electric installers. From left to right J. H. Whitworth, job supervisor, is checking a print; A. V. Gee, Jr. and J. F. Mulligan in the rear are placing additional extension multiple, and D. W. Grabow at new number 7 position is testing lines already placed. In the foreground J. B. Chamberlain concentrates on work layout. Similar scenes took place on the night shift under W. St. Amand

Something new is being added; meanwhile the calls must go through. In the right foreground A. V. Gee, Jr., Western Electric installer, tests newly placed extension multiple at the new number 7 position. Further along the original board, Murray Hill operators Pauline Ryan, Dorothy Carlson and Margaret Kerrigan, concentrate on their duties. At the top center H. N. Spryer of Western is securing cables in place for additional circuits between the PBX and the terminal room. More extension multiple lies on top ready for installation

1470 dial extension lines; 137 line finders; 137 local first selectors; 19 incoming first selectors; 57 second selectors for 4-digit dialing; 93 hunting connectors; 30 rotary out trunk switches for distribution of tie trunks to West Street; 9 switchboard positions; 32 tie trunks to West Street; 13 to Whippany; and 50 to central office trunks.

Calls from Murray Hill to Whippany are now completed on a direct dial basis; calls to West Street are initiated by dialing 8 to obtain the West Street operators who will complete all calls within the New York area. Calls to Kearny are now completed through the West Street operator, but by October of this year they will be a direct dialing basis. Those to Holmdel are now completed through West Street but will eventually be handled by direct manual trunks from Murray Hill.

BTL and the Wisconsin Company Hold Technical Conference

Eight members of the Laboratories, headed by Dr. M. J. Kelly, executive vice president, visited Milwaukee February 23 and 24 for a comprehensive technical conference with executives, supervisors and foremen of the Wisconsin Telephone Company. The conference was arranged through the cooperation of the Operation and Engineering Department of A T & T. W. C. Bolenius, president of the Wisconsin company, welcomed the participants to the conference and surveyed some of the problems of his organization.

Outlining the Laboratories' development programs, Dr. Kelly addressed an assembly of approximately 200 persons at the opening session. His address served as an introduction to more detailed discussions in four group meetings attended by specialists in transmission, central office switching equipment, subscriber station apparatus and outside plant.

Laboratories' participants were: W. H. Martin, Director of Apparatus Development II; G. W. Gilman, Director of Transmission Engineering; A. H. Inglis, Station Instrumentalities Engineer; M. B. McDavitt, Assistant Director of Switching Engineering; R. J. Nossaman, Plant Systems Engineer; L. L. Eagon, Laboratories Field Engineer of Chicago; and J. T. Dixon of Transmission Engineering.

Operating company officials who attended the various sessions included George F. Crowell, vice president; M. P. Naab, general plant manager; F. A. Kindt, general traffic manager; R. C. Siegel, chief engineer, and G. B. Rogers, general commercial manager.

Approximately 30 members of a field study group of the American Association of School Administrators recently visited the Laboratories as part of a tour of various American industries. During their visit to the Laboratories C. H. G. Gray, Transmission Standards Engineer, rear, demonstrated progress in telephone transmission. Members of the group, seated left to right, were H. A. Cocanougher, Superintendent of Boyle County Schools, Perryville, Kentucky; C. W. Clark, Superintendent of Schools, Las Cruces, New Mexico; Lloyd Uecker, Superintendent of Schools, Mitchell, South Dakota, and F. E. Heinemann, Department of Education, St. Paul, Minnesota

Changes in Organization

Effective February 29, W. C. Burger resigned as Treasurer of the Laboratories and transferred to the Western Electric Company. J. W. Farrell resigned as Assistant Treasurer, but retains his post as Secretary and General Attorney.

Effective March 1, William Fondiller was elected Treasurer in addition to his duties as Assistant Vice President; G. A. Brodley was appointed Assistant Secretary in addition to his duties as Assistant Treasurer. As senior Assistant Treasurer, Mr. Brodley, under the direction of Mr. Fondiller, is responsible for the operation of the Financial Department; F. W. Seibel was transferred from General Accounting to the Financial Department and was appointed an Assistant Treasurer.

Men's Bowling League

The Men's Bowling League, headed by C. H. Heller, Chairman, and E. W. O'Hara, Secretary-Treasurer, is nearing the close of another successful bowling season. The active weekly participation by over 400 members this season, which began in September and extends through April, proves that bowling is still a popular Laboratories Club activity.

In addition to the weekly league competition, the New York groups have entered three five-man teams in the New York State Bowling Association tournament and three teams in the Journal American tournament. New Jersey groups have entered four teams in the New Jersey State Bowling Association tournament and one in the Morris County Bowling Association tournament.

After the close of each season, the league holds a get-together where dinner, entertainment and the awarding of the season's prizes are on the program. This year, this annual affair will be held on April 30 at the Jersey City Masonic Club. Everyone is invited to attend. Tickets may be obtained from H. Sagefka, who is program chairman, on Extension 1704, Room 1217 Graybar-Varick.

Chemical Laboratories Dinner

The first annual postwar dinner and entertainment of the Chemical Laboratory was held on February 10 at the Military Park Hotel in Newark. R. Burns, who was toastmaster following the dinner, introduced Dr. R. M. Burns who greeted new members of the department and gave a brief welcoming address before the entertainment. The dinner committee consisted of H. G. Arlt, F. J. Biondi, L. Egerton, J. W. Nalencz, N. R. Pape, R. J. Phair, H. C. Theuerer, A. G. Souden and G. P. Spindler.

North Carolina Commission Recognizes Telephone's Importance

In its order granting the petition of Southern Bell for increases in telephone rates, the North Carolina Utilities Commission said:

". . . . . the net income for the first nine months of 1947, raised to an annual basis, gives the Company a net income of $3,372,422. On the basis of Capital Stock ($210,000,000) this would give a return of 1.6 per cent, and on average investment less depreciation ($381,304,273) a return of only 0.84 per cent.

"This situation is giving this Commission grave concern because it is obvious to this Commission that a Company in this plight is not in a position to get new money needed for its unprecedented expansion program by the sale of stock or bond issues.

"It must be kept in mind that telephone service is different from that rendered by any other utility in that all parts of the country are interconnected. People in this State talk to people in other states; people in other states talk to people in this State, and if the service in any state through which their conversation is transmitted is poor, the whole service is poor just as no chain can be stronger than its weakest link.

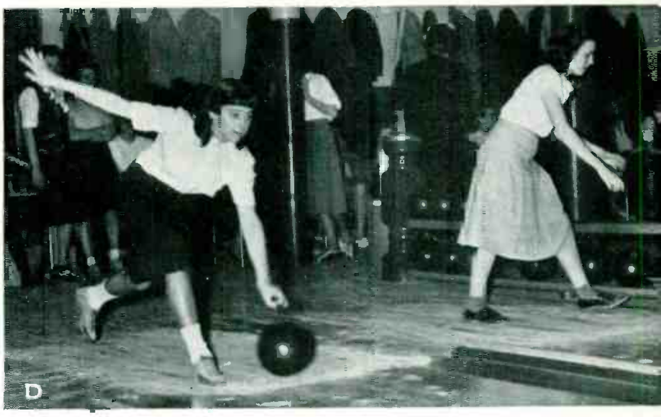
"In North Carolina the expansion program for this year calls for the expenditure of $15,081,000. This fund contemplates the building of additions to outside plants, new buildings and land, central office equipment, pole lines, installation of stations, and additional toll circuits. Thirty-five thousand applications for service were pending on January 1, 1948.

"The people of North Carolina are clamoring for this needed expansion and this Commission is anxious to see it carried out, believing that the increased facilities would add millions of dollars of profits to the business and other interests of North Carolina, while the crippling of the proposed expansion program would no doubt mean the loss of millions of dollars to the people of the state."

". . . . this Commission is anxiously willing to cooperate with every state involved in any effort to provide rates which will assure the Company a fair profit. A contrary course, in the opinion of the Commission, would be like killing the goose that lays the golden egg for it is obvious to even the novice that unless the Company is put in a position to give good service and provide the necessary expansion the result would be disastrous, not only to the Company but to the public as well."

We See by the Papers, That

Taxes charged against the New York Telephone Company, together with government taxes assessed directly against telephone users served by the company, amounted in 1947 to $114,300,000 or about $30.10 per telephone, according to the company's recent report for the year. This was equivalent on the average to 26 cents of each dollar paid to obtain telephone service.—*Telephone News Bulletin, March,* 1948.



Women's Bowling Club of West Street

A—A bite before bowling for Gladys Brocking, Helen Karban and Eleanor Ebeling en route to the Village Recreation Center on West Third Street

B—Rolling true to form, the Club's top bowlers Wilma Cadmus, left, and Ethel Ott, right

C—Keeping score with Winifred Meszaros at the score board are Clare Halpine, Muriel Greenhagen, Mrs. Meszaros, Frances McDonnell and Myra Norris

D—In splendid form, the Club's southpaw, Betsy Bates, performs for the camera. Grace Gillen is shown at the right

E—Muriel Walter chalking up before getting down to the serious business of the evening

F—Helen Karban sending a ball down the alley while Frieda Schulz gets set

News Notes

In Preparation for retirement from active service, Chester I. Barnard, formerly President of New Jersey Bell Telephone Company, has become Chairman of the Board of that company. On retirement, which will be June 30, 1948, Mr. Barnard will become President of the Rockefeller Foundation and President of the General Education Board.

William A. Hughes, formerly President of Indiana Bell Telephone Company, has been elected President of New Jersey Bell Telephone Company and a member of its Board.

Harry S. Hanna has been elected President of the Indiana Bell Telephone Company. He was formerly Vice President and General Manager of that company.

A view of the Patent Files in the Davis Building showing the section where 300,000 classified patents are filed in looseleaf folders according to classifications of the U. S. Patent Office. Using the files when the photograph was taken were, left to right, attorneys D. H. Wilson and E. R. Casey; Patricia Byrne, searching for a patent requested by one of the attorneys; and D. MacKenzie checking a patent reference

O. E. Buckley attended the General Traffic Conference at Seaview where he spoke on the work of the Laboratories.

Dr. Buckley addressed the Minnesota Federation of Engineering Societies in Minneapolis and attended a luncheon conference with executives of the Minnesota Area of the Northwestern Bell Telephone Company.

Dr. Buckley was elected president of the Board of Education of South Orange and Maplewood. He has been a member of the Board since 1938 and at the time of this election held the office of first vice president.

M. J. Kelly, in connection with the annual meeting of the American Institute of Mining Engineers, addressed the Mineral Industry Education Division on *Good Foreign Relations Begin at Home*, on February 15 at the Men's Faculty Club, Columbia University.

R. L. Jones attended a meeting of the Visiting Committee of the Department of Electrical Engineering of Massachusetts Institute of Technology in Cambridge.

D. A. Quarles selected *Behind the Scenes at Bell Telephone Laboratories* as his topic when he addressed a joint meeting of the Cleveland A.I.E.E. Section and the Cleveland Engineering Society.

E. E. Schumacher has been designated the A.I.M.E. Institute of Metals Division lecturer for 1950. This lecture is given each February in New York by an American and a foreign lecturer alternately. Professor E. Orowan of the Cavendish Laboratory, England, will give the 1949 lecture.

Dr. Robert H. Dalton of the Development and Research Department of Corning Glass Works spoke in the Arnold Auditorium on *Photo-Sensitive Glass and Other Recent Developments in Glass Technology.*

C. Kittle and W. A. Yager spoke on *The Ferromagnetic Resonance Absorption at Microwave Frequencies* at the March meeting of the Deal-Holmdel Colloquim held at Holmdel. Mr. Kittle also spoke on *Physical Principles of Magnetic Domains* and H. J. Williams on *Powder Patterns of Magnetic Domains* at a conference on February 18 of the Solid State Research Group in the Arnold Auditorium. Mr. Williams addressed the Rutgers Physics Colloqium on *Ferromagnetic Domains.*

W. Shockley attended a National Research Council meeting of the Committee on Solids in New York.

W. T. Read, R. D. Mindlin and W. P. Mason went to Brown University, Providence, for a meeting on plasticity in metals.

R. M. Burns attended a meeting of the Industrial Research Institute at Rye, New York, where he participated as a discussion leader on *Research to Production.*

Occasion for the happy smiles of Charles E. Ford and Alice Scott in this picture was Charles' winning the C.Y.O. Boxing Trophy in Jersey City. A Golden Glover and member of the Newark Boys Club, he is one of the Murray Hill Restaurant dishwashers under Mrs. Scott's leadership

E. K. Jaycox, at Cleveland, discussed spectrochemical techniques during visits to the National Spectrographic Laboratories, the Cleveland Wire Works of General Electric and the American Steel and Wire Company. Mr. Jaycox presented a paper entitled *The Role of Spectrochemical Analysis in Research* before the Cleveland Spectroscopy Society.

R. D. Heidenreich presided over a meeting in Pittsburgh of the Electron Microscope Society Committee for the Study of Steel Microstructures.

A. C. Walker and J. J. Harley presented the colorful motion picture film *Crystals While You Wait* before the New York group of American Society for Testing Materials.

K. G. Coutlee was at Dayton for meetings of Committee D-9 of the American Society for Testing Materials and at Hawthorne for discussions of problems associated with insulating materials and potting compounds.

U. B. Thomas discussed battery problems at the C. and D. Battery Company, Conshohocken, Pennsylvania. He also presented a paper *Determination of Efficiency of Storage Battery Vent Plugs* at the joint symposium held by the Chicago Section and the Battery Division of the Electrochemical Society in Chicago. M. S. Sparks at the same symposium presented *A Survey of Voltaic Cells.*

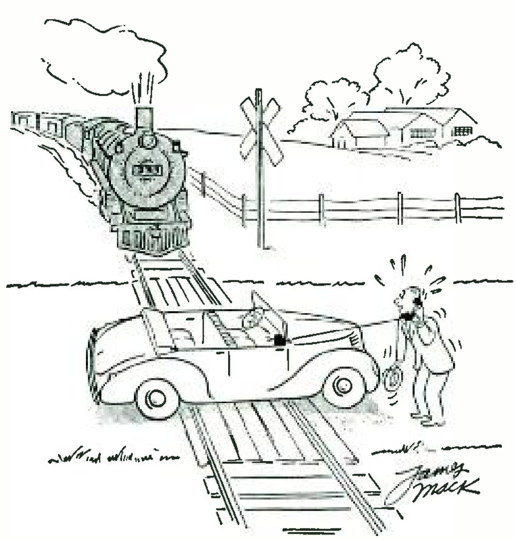
W. O. Baker has been appointed to the Panel on Physical Chemistry, Advisory to the Office of Naval Research. Dr. Baker spoke before the Polymer Group, North New Jersey Section, of the American Chemical Society at Newark. He selected as his topic *Microgel, a New Macromolecule, and Sol-Gel Relations in Rubber and Plastics.*

M. E. Fine and W. C. Ellis presented a paper on *Thermal Expansion Properties of Iron-Cobalt Alloys* at a meeting of the American Institute of Mining and Metallurical Engineers in New York.

L. A. Wooten attended the Analytical Symposium held by the Americal Chemical Society in Pittsburgh and a meeting of Committee B-4 on Cathode Nickel of the American Society for Testing Materials in Philadelphia.

J. R. Townsend visited Tonawanda regarding enameled wire; Hawthorne regarding materials; and Baltimore regarding polyethylene covered cable. He attended Spring Committee meetings of the A.S.T.M. in Washington and district meeting of the A.S.T.M. in New York, where he gave an informal talk on progress with materials.

K. G. Compton went to Tonawanda for discussions of wire enamel.

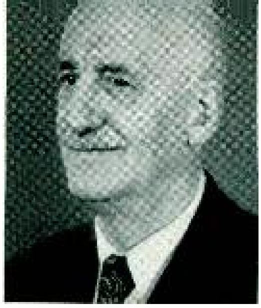


"Hello, Mr. Bunting, I've changed my mind—I'll take that accident policy!"

H. E. Crosby

E. B. Wheeler

W. V. Thompson



F. C. Willis

RETIREMENTS

Members of the Laboratories who retired on March 31 were E. B. Wheeler with 42 years of service; W. V. Thompson, 41 years; F. C. Willis, 35 years; H. E. Crosby, 29 years.

Halsey E. Crosby

Mr. Crosby, or Halsey, as he was known to his friends, first worked for the Western Electric Company in 1907. After a short service he left, returning in 1919. During the next five years he held various positions in the Building Department engineering office, where, among other duties, he was active in studies which resulted in abandoning the isolated steam generating plant at West Street and purchasing central station power. In 1924 Mr. Crosby transferred to the Research Department as Supervisor of the Hudson Street Tube Shop. Reassigned to the Plant Department in 1931, Mr. Crosby has been engaged in Building Department engineering problems. He also was closely associated with safety problems in the Laboratories, being Chairman of the Safety Committee for a number of years. During the war period he maintained contacts with the Plant Security Organization of the Army concerning plant protection matters both in New York and New Jersey. More recently Mr. Crosby has made lighting studies in preparation for the rehabilitation at West Street.

Edmund B. Wheeler

Mr. Wheeler, who has been in charge of repair and maintenance practices in the Transmission Development Department, joined the Western Electric Company in 1905 immediately after his graduation with a B.S. in E.E. degree from the University of Illinois. He started work in the Clinton Street shop in Chicago as a student engineer and in 1907 was assigned to the Physical Laboratory in New York. Two years later he was placed in charge of a group working on telephone apparatus development. During World War I, from April, 1917, to February, 1919, he was in charge of the Physical Laboratory.

During the period from 1920 to 1942 Mr. Wheeler was responsible for the development work on telephone cords, switchboard cable, insulated wire for central office use, switchboard lamps, batteries and air-conditioning apparatus. Under his direction many outstanding developments were completed in this field including purified textile insulation, cellulose acetate treatment of wire, greatly improved cord designs, large scale use of tungsten switchboard lamps and design of resistance lamps to meet specific circuit conditions. In 1942 he became Assistant Repaired Apparatus Engineer and a year later Repaired Apparatus Engineer.

Walter V. Thompson

Mr. Thompson of Transmission Apparatus Development joined the student course of the Western Electric Company in 1906 and then was assigned to central office installation work, later transferring to the inspection of telephone apparatus and its piece parts. When the manufacturing division moved to Hawthorne in 1913, Mr. Thompson joined the Physical Laboratory where he had change of the custody and repair of all testing apparatus. From the Physical Laboratory he went to the Model Shop and worked for about a year on the assembly and inspection of parts for the panel system.

In 1915 Mr. Thompson transferred to the Apparatus Development Department where he has since been engaged in the development of all types of telephone cords. He made many contributions in the development of the

"The Telephone Hour"

NBC, Monday Nights, 9: p.m.

April 12	*Marian Anderson*
April 19	*Jascha Heifetz*
April 26	*Maggie Teyte*
May 3	*John Charles Thomas*
May 10	*Licia Albanese*

tinsel conductor now used in telephone cords and designed many special devices used for the attachment of cords to apparatus or equipment. Mr. Thompson invented the solderless cord tip used on tinsel cord conductors thus eliminating the laborious method of wire whipping and soldering previously required and permitting the development of machine methods of manufacturing cords now used by the Western Electric Company.

Frederick C. Willis

Mr. Willis joined the Engineering Department of the Western Electric Company in 1913 and was assigned to the Physical Laboratories. On a leave of absence from 1914 to 1919, he served with the British Army during World War I. Upon his return to the Apparatus Development Department in 1919, he worked as a design engineer with the radio development group on ship-to-shore communications and later on laboratory and testing apparatus.

In 1928 Mr. Willis transferred to the Electrical Research Products, Inc., as a recording engineer. He later became a supervisor of electrical and acoustic engineering projects in connection with recording sound on film and also on disc. During the latter part of his stay, he was responsible for the development of long-playing-disc recording equipment used throughout World War II as a security measure.

Since his return to the Laboratories in 1941, Mr. Willis has been engaged in various phases of airborne radar development in the Specialty Products Development Department. During the war he acted as project engineer on one of the most widely used radar equipments developed and in 1944 spent several months in Europe advising the British on the operation and maintenance of this equipment.

News Notes

At the Western Electric Company in Chicago I. V. Williams discussed problems concerning metals; N. Botsford, design of networks for a new subset; H. K. Krantz, J. R. Fry and H. M. Knapp, the design and manufacture of relays; R. A. Hecht, molded 309- and 310-type plugs; D. H. Gleason and F. W. Clayden, step-by-step solderless banks; C. C. Barber, crossbar switches; W. J. Adams and C. B. McKennie, the printing and distribution of maintenance information on mobile radio telephone equipment, as well as piece parts lists for designation of fastening devices, drafting, and micro-film practices; L. J. Purgett and J. G. Ferguson, the No. 5 crossbar system; J. T. Motter, equipment development problems on the No. 5 crossbar system; W. L. Tuffnell and W. G. Turnbull, the station handset; and C. T. Wyman, general cable problems.

At Point Breeze, G. N. Vacca discussed rubber-covered wire; W. L. Tuffnell and C. A. Webber, cord problems; W. S. Bishop, improved binders for wire coils; and T. A. Durkin participated in a quality control conference on insulated wire.

R. A. Miller and W. J. Brown were among engineers observing the applications of the first "full train" Western Electric distribution system aboard the round trip on the Chicago, Burlington and Quincy's *Twin Cities Zephyr*. Seven other trains are to be similarly equipped in the near future.

L. A. Meacham gave a talk and demonstration on *Pulse Code Modulation before the* American Institute of Electrical Engineers in Washington and before the Society of Motion Picture Engineers in New York. E. Michaels assisted him both times.

J. H. Waddell, F. M. Tylee and W. A. Munson took high-speed motion pictures at Harvard University of the action of the auditory ossicles and the motion of the ear drum. Mr. Munson attended a meeting of the Naval Research Vision and Audition Advisory Panel at Sands Point, Long Island.

April Service Anniversaries of Members of the Laboratories

35 years
R. E. Coram
O. E. Rasmussen

30 years
R. M. Burns
Herbert Hoyle
Philip Husta
Bernard Leuvelink
Helen Mockler
Louise Muller
A. R. Saunders
Laura Tinelli

25 years
A. E. Bachelet
R. C. Ennis
W. J. Gordon
E. J. Howard
W. C. Jordan
Herman Kords
Pierre Mertz
T. H. Metzger
L. R. Shropshire
H. J. Stewart
J. C. Vogel

20 years
A. B. Crawford
D. T. Sharpe
S. T. Slezak
H. P. Smith
F. S. Wolpert
A. B. Wylie

10 years
W. J. Brackmann
May Johnson
R. H. Kreuder
J. A. Potter
G. G. Smith
Rosemary Lagas

G. D. Edwards, as president, addressed the second annual convention of the American Society for Quality Control and the Fourth Annual Rochester Clinic at Rochester on February 16. Others who attended were H. F. Dodge, R. C. Koernig, W. G. Freeman, J. F. Chaney, G. R. Gause, Mary N. Torrey, H. G. Romig, S. C. Bates, C. E. Fisher and H. M. Craig.

Lloyd Espenschied spoke on *Electrical Experimentation in the Grand Manner of the 18th Century* on March 3 before the dinner meeting of the Institute of Radio Engineers, New York Section.

J. H. Bower attended a Battery Symposium sponsored by the Chicago Section of the Electrochemical Society in conjunction with the new Battery Division of the Society.

J. A. Ashworth and A. A. Chegwidden visited steel manufacturers in Pittsburgh, and Middletown and Warren, Ohio, with reference to magnetic materials.

E. P. Felch and G. N. Packard visited the General Radio Company, Cambridge, in connection with the new frequency standard.

C. N. Hickman was presented with a special trophy in recognition of his achievements in the science and practice of achery at a luncheon on March 4 in the Conference Dining Room. Eighteen members of the Archery Club attended with Mrs. Myrtle K. Miller, a national figure in archery, guest of honor. Seated in the photograph are left to right, J. Jessich, A. Albanese, Dr. Hickman, Mrs. Miller, W. G. Laskey, Alice Jastram, D. R. Thomas, Helen Cruger and Herma Procopiadi; standing, Jean Phillips,, L. J. Stacy, Grace Lakin, K. D. Smith, H. E. Powell, W. J. Rutter, Frances McDonnell, Helen Karban and O. A. Engelhart

R. K. Honaman spoke on *Frontiers of Telephone Development* before the St. Louis Section of the American Institute of Electrical Engineers on February 18 and before a group of faculty and students of the Engineering Department of the University of Missouri at Columbia, Missouri, on February 19.

R. J. Williamson and W. J. Clark visited Haverhill in connection with the introduction of plastic encased retardation coils; and A. B. Haines and B. E. Stevens discussed matters involving the manufacture of power coils.

D. E. Cavenaugh visited the Stavid Engineering Company at Boundbrook, New Jersey, in connection with power transformers and coils in radar equipment.

N. J. Eich will have completed two terms as president of the Civic Association of New Providence Township in April. In addition to his civic activities, he is active in philatelic circles as president of the Bureau Issues Association, a national stamp collecting group, and is a member of the Expert Committee of the Philatelic Foundation of New York.

A. C. Millard participated in a conference at Cleveland for organizing a committee on A.S.A. Standarization of Rivets.

P. L. Burns, C. W. Spader, J. F. Haupt, D. Stewart and W. Ewing of the Bell of Pa. studied, at the Laboratories, the operation and maintenance of the KS-13834 perforator.

V. F. Bohman visited the Kingsbury Machine Tool Corporation in Keene, New Hampshire, in connection with new tools for the step-by-step die cast frame.

E. D. PRESCOTT and R. E. CORAM observed the 10-kw FM transmitter at Radio Station WWDC in Washington.

V. I. CRUSER and L. A. DORFF spent several days in Detroit discussing mobile radio telephone equipment with Ford, Chrysler and General Motor organizations.

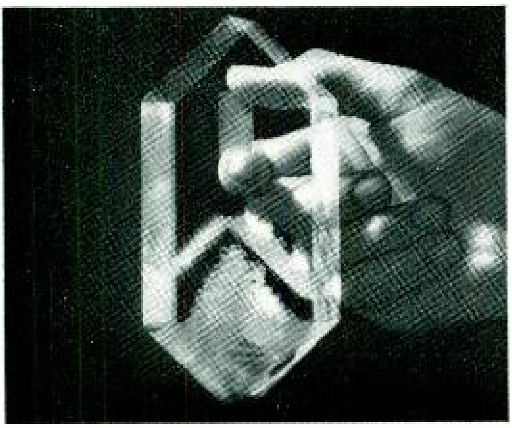
W. C. HUNTER and J. G. NORDAHL's visit to Lancaster, Pennsylvania, had to do with vacuum tube discussions at the R.C.A. Laboratories.

J. W. SMITH was in Washington for consultations with the Navy.

M. L. WILSON was elected to the Board of Trustees of the Morristown Memorial Hospital at the annual meeting.

HELEN McLOUGHLIN spoke on *House Magazine Editing* before the New York Alumnae Club of the Chi Omega Sorority.

J. R. POWER's visit to The Southern New England Telephone Company concerned a special hard-of-hearing problem.



A CRYSTAL THAT GREW FROM A SEED . . . *The large crystal in the foreground is an EDT (Ethylene Diamine Tartrate) crystal. It started from a seed (a piece of mother crystal) and in three months grew in a slowly cooling solution to the size shown. The small plate is cut from a large crystal, then gold-plated for electrical connection and mounted in vacuum. Cultivated EDT crystals can do the same job as quartz in separating the nearly 500 conversations carried by one coaxial circuit at one time.*

Crystals for Conversations

AT WAR'S END, the Bell System began to build many more Long Distance coaxial circuits. Hundreds of telephone calls can be carried by each of these because of electric wave filters, which guide each conversation along its assigned frequency channel. Key to these filters was their frequency-sensitive plates of quartz.

But there was not enough suitable quartz available to build all the filters needed. Bell Telephone Laboratories scientists met the emergency with cultivated crystals. Years of research enabled them to write the prescription at once—a crystal which is grown in a laboratory, and which replaces quartz in these channel filters.

Now Western Electric, manufacturing unit of the Bell System, is growing crystals by the thousands. Many more Long Distance telephone circuits, in urgent demand, can be built, because the scientists of Bell Telephone Laboratories had studied the physics and chemistry of artificial crystals.

BELL TELEPHONE LABORATORIES

EXPLORING AND INVENTING, DEVISING AND PERFECTING, FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE

Louise M. Butler
1909-1948

Miss Butler, who retired on April 23, 1947, after eighteen years of service, died on February 21. She joined the Research Staff Department as a special typist in 1929 and worked there until 1937. At that time she was assigned to the Transcription Department at West Street where she did stenographic and later special typing assignments. In 1940 she transferred to Transcription at Graybar as a special typist until her retirement.

News Notes

R. V. LOHMILLER, C. C. WILLHITE and H. C. BREARLEY of Burlington visited West Street to attend the *Orientation Survey*.

J. T. MULLER attended a symposium on shock and vibration at the Naval Research Laboratory.

J. F. SWEENEY and W. A. FUNDA have returned from MacArthur Field, Long Island, where they completed flight tests for the Army Air Forces.

E. T. MOTTRAM participated in various conferences with representatives of the Air Materiel Command at Wright Field.

ANNE CHEEK and CAROL GARNER are RECORD correspondents for Winston-Salem and Burlington, respectively. ANNE MARKS of Whippany is now responsible for correspondents at that location.

This Laboratories advertisement which appeared last October has been selected as an example for exhibition at the 27th Annual Show of Advertising Art sponsored by the Art Directors' Club of New York. It is one of 320 advertisements selected by a jury of 40 leading art directors from a total of 8000 submitted by advertising agencies. The advertisement was prepared by N. W. Ayer & Son, and the photograph of the crystal was taken by Nick Lazarnick.

Women's Activities Committee of the Pioneers

At the initial meeting of this Committee on February 17 following a luncheon at West Street, Chairman Hazel Mayhew led a group discussion of the possibility of inaugurating after-hours activities for women Pioneers with the idea of helping them to enjoy their leisure time now, thus providing skills which might in some cases add to their incomes after retirement. Of twenty-three committee members, the seventeen present at the luncheon (above) were left to right, seated, Vera Monahan, Philomena Papace, Mary Kane, Hazel Mayhew, May Schupp, Marion Haggerty, Dorothy Carlson and Harriet Filmer; standing, Margaret McNally, Louise Van Bergen, Mildred Molloy, Vivian Kilpatrick, Marie Wright, Hattie Bodenstein, Mary Brainard, Nora Larkin and Molly Radtke.

News Notes

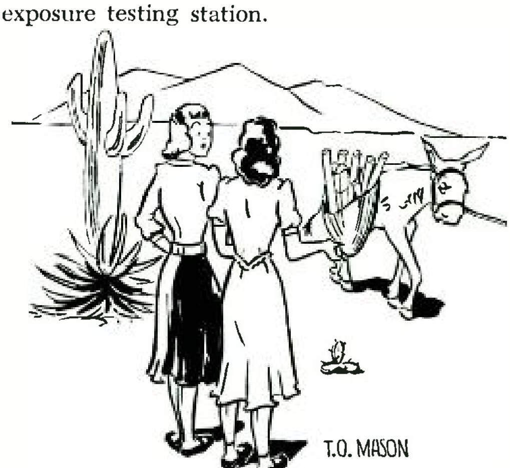
J. H. Bower and R. A. Cushman were at Fort Monmouth on February 26 for a conference with Signal Corps engineers. In the evening Mr. Cushman gave a lecture *Speech Privacy in Military Communications* before the Fort Monmouth Chapter of the Armed Forces Communications Association.

J. J. Harley presented the following 16-mm Kodachrome movies with musical background on February 26 during noon hour in the Arnold Auditorium: *The Flowers of the Old South* by George Meszaros and *The Little Intruder* by Mr. Harley.

Morton Sultzer was presented with a placque designating him as "Mount Vernon's Most Distinguished Citizen of 1947" at a Brotherhood Week Rally on February 23 at Wood Auditorium in Mt. Vernon. Mr. Sultzer received the award specifically for his work in connection with the Inter-Cultural Inter-Racial Committee of which he is chairman; the Bronx Valley Council, the Boy Scouts of America, of which he is a member of the executive board; and Lehigh University of which he is a trustee.

C. T. Boyles, who appeared on the television program *Photographic Horizons* on March 3 over the Dumont station WBAD, spoke about the Metropolitan Camera Club Council of which he is president. On the following evening he was on the *Tops in Photography* television show held by the Council.

K. G. Compton obligingly secured the picture shown in the advertisement on the opposite page and posed in it during a visit to Kure Beach, N. C., where Laboratories' specimens are guests of International Nickel at its exposure testing station.



"Mr. Conner must hear about this"