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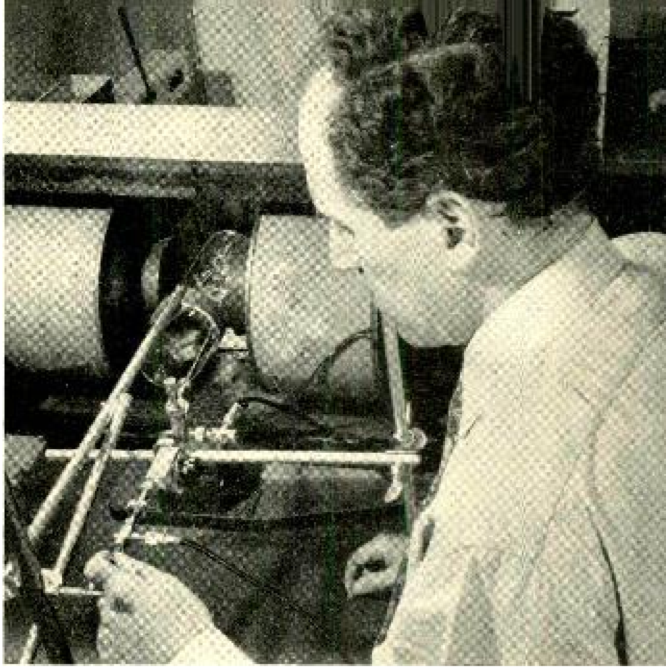


Testing the output of a backward-wave oscillator tube.

Backward-Wave Oscillator

R. KOMPFNER
Electronic Research

As communications systems are extended further into the microwave region, complex new apparatus and equipment are required. High-frequency oscillators that could be tuned rapidly over a wide range, for example, would be very useful in existing microwave systems and in future systems that may operate at millimeter wavelengths. The interaction of an electron beam and an electromagnetic wave has been used to provide an experimental oscillator of this type.

Recent investigations have shown that traveling wave tube amplifiers can be modified to provide electronically tuned oscillators capable of operating over a wide range of frequencies. Such oscillators would be extremely valuable in microwave test equipment, for example, since they make it possible to sweep the entire 500-mc band of a TD-2 system rapidly and accurately. In addition, these electronically controlled oscillators may aid in bringing communications by waveguide systems much nearer realization since broadband oscillators are required to transmit many channels of millimeter waves through the guides. Broadband oscillators which can be tuned relatively slowly have been available in the centimeter-wave range, but any available millimeter-wave oscillators have had limited ranges and could be tuned only very slowly.

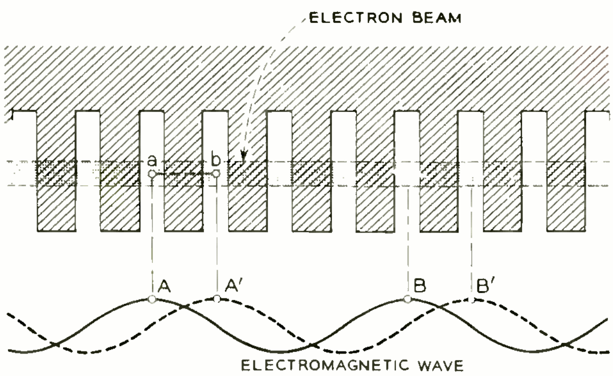


Fig. 1 — Interaction between electromagnetic wave and electron beam in a traveling-wave tube.

The new electronically-tuned oscillators can be tuned rapidly and easily over broad bands in both the centimeter and millimeter ranges.

These new oscillators, having a potential range of frequency response of thousands to tens of thousands of megacycles, are called "backward-wave oscillators." They operate by means of the interaction of a traveling wave and an electron beam similar to those used for high frequency amplification in traveling wave tubes.* In the oscillator application, however, the direction of motion of the traveling wave is reversed.

To provide amplification in a traveling-wave tube, electrons moving at about one-tenth the velocity of light interact with an electromagnetic wave. The velocity of the wave is made approximately equal to that of the electron beam by making the wave follow along a wire helix. Since the effective velocity of the wave down the axis of the helix is approximately equal to the velocity of the electron beam, the electrons interact with approximately the same phase of the wave through many cycles. This leads to a strong action on the electrons by the field of the wave and conversely to a strong action by the electrons on the field. The over-all result is that the electromagnetic field increases exponentially with distance — amplification.

As higher and higher frequencies were investigated for millimeter wave transmission systems, however, the wire helix required in the traveling-wave tubes designed to amplify at these frequencies became progressively more minute, fragile, and difficult to manufacture. To overcome this difficulty of vanishingly small components at increasingly high frequencies, a new tube, based on the interaction of an electron beam and the so-called "spatial harmonic" components of a traveling wave, was developed by S. Millman at Bell Telephone Laboratories.*

In this new tube, no effort was made to reduce the effective velocity of the electromagnetic wave to that of the electron beam, but rather, the tube is so arranged that the wave, traveling a great deal faster than the electron beam, is screened by a copper block from the beam over most of the transit path. A number of regularly spaced gaps were provided, however, in which the beam and the wave could interact. If the electron beam and the electromagnetic wave move from left to right in Figure 1, and the potential across the tube is so adjusted that individual electrons traverse the distance between successive gaps, a to b, in the same time that a particular point on the wave, point A for example,

* RECORD, *January*, 1951, *page* 14.

* RECORD, *November*, 1952, *page* 413.

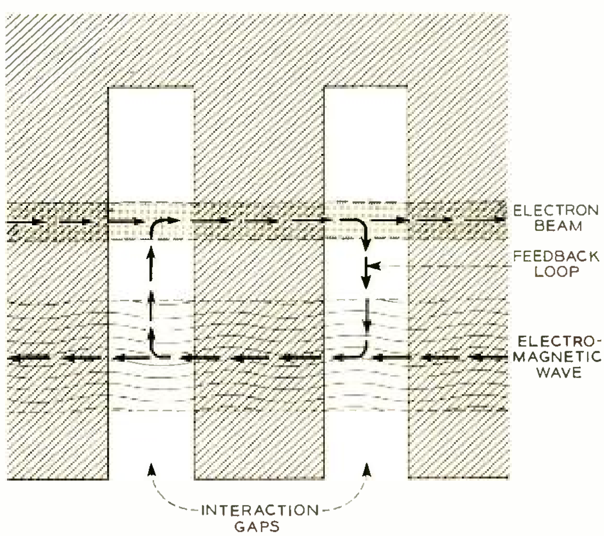


Fig. 2 — Diagrammatic representation of feedback loop, a combination of the beam and the electromagnetic wave.

travels through one wavelength plus the distance between the two gaps, A to B plus A to A′, the electrons will encounter the same phase of the wave at each gap or interaction point. The interaction is essentially the same as if the electrons moved with the high velocity of the electromagnetic wave. Since they do not actually attain this velocity, however, a relatively low accelerating voltage can be used.

As shown in Figure 1, the electrons and the wave interact only intermittently, and hence interaction will occur if the beam and the wave move in the same or in opposite directions. If the electrons move from left to right and the electromagnetic wave from right to left in Figure 1, the interaction is of the backward-wave type. In this application, electrons travel from one gap to the next, a to b, in the time taken for the wave to travel one wavelength less the distance between successive gaps, B to A minus A′ to A in Figure 1. The interaction is of the traveling wave type but there is an important difference from the application in which both wave and beam travel in the same direction. With opposing directions, he electron beam serves not only as a source of energy to sustain amplification but also as a feedback path; the combination of the beam and the electromagnetic wave provides a feedback loop as shown in Figure 2. Actually the tube contains many such loops; one formed by the first and second gaps, one by the second and third, the third and fourth, and so on. Similarly, loops exist on the first and third, first and fourth, second and fourth, and all possible pairs of interaction gaps.

The interaction of the beam and the wave in this tube is such that the feedback provided is positive; that is, the feedback energy supports the initial wave. If the loop contains a whole number of wavelengths, the feedback wave, after traversing the loop and returning to the initial point will have the same phase as when it started. The returning "fed back" wave thus reinforces the original wave. Moreover, a long loop can be thought of as being made up of two or more shorter loops, and, if each of these contains a whole number of wavelengths, all longer loops do too, and the feedback around all the loops is positive.

If the beam voltage is changed, changing the velocity of the electrons, the time the electrons take to travel from one gap to the next changes. If a feedback loop is to continue to have a whole number of wavelengths around it, the time – measured in the corresponding number of cycles – that the wave takes to traverse the circuit part of the loop must change. This time can change

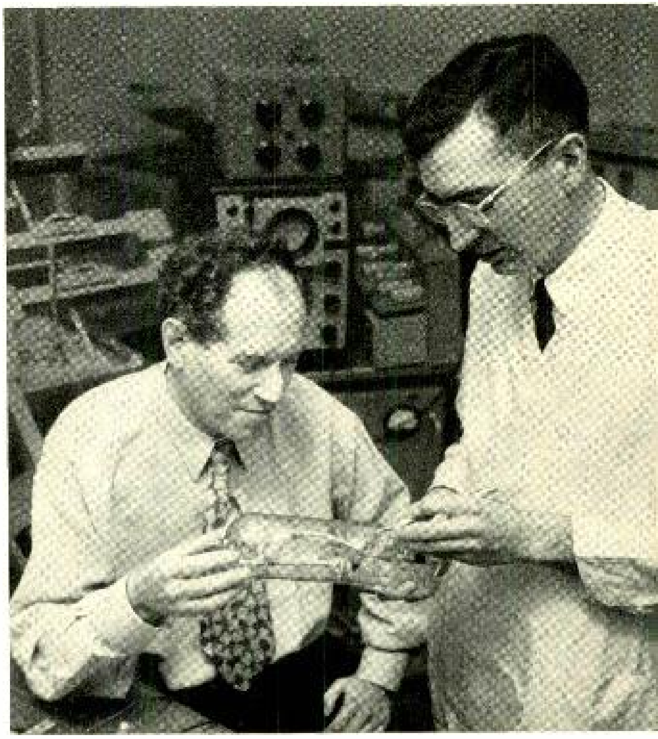


Fig. 3 – The author (left) and G. E. Helmke discussing a hairpin backward-wave oscillator tube.

only if the frequency of oscillation changes. The change occurs in such a way that the feedback loops are still a whole number of wavelengths long at a new frequency and wavelength, and the feedback remains positive.

When the beam current in a traveling-wave tube arranged with the beam and wave oppositely directed, is less than some critical value – usually less than one milliampere – the tube amplifies the electromagnetic signal at a frequency determined by the beam voltage. If the beam current is increased beyond this critical value, the net gain in each feedback loop will exceed the loss, and the tube will oscillate at the frequency at which it previously amplified. In common with all positive feedback circuits, oscillations begin in this tube when the gain around the feedback loop exceeds the loss. The frequency of these oscillations can be varied over a wide range by merely varying the beam voltage, and an electronically-tuned oscillator is obtained. A traveling-wave tube of the type developed by Millman, for example, can be made to oscillate over a frequency range extending from 40,000 to 50,000 mc by varying the beam voltage from 1,600 to 4,000 volts.

The frequency of oscillation in such a tube depends on the gap spacing, the phase velocity of the electromagnetic wave, and the velocity of the electron beam. Since the gap spacing is constant, the frequency of operation is governed primarily by the beam voltage. The exact way in which the frequency varies with voltage, however, depends on how the phase velocity changes with frequency.

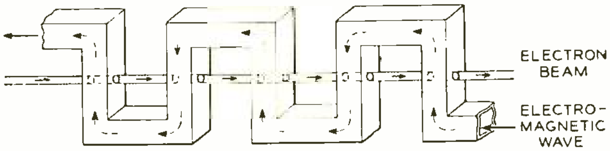


Fig. 4 – Backward-wave interaction in a folded waveguide.

The spatial harmonic traveling-wave tube was specifically designed as a high-frequency amplifier with a bandwith of about 2,000 mc. Its recently discovered application as a backward-wave oscillator involved a higher beam voltage and dissipation than was considered practical. Various other structures that might favor the backward-wave type interaction over a wide frequency range and at reasonably low beam voltage were therefore investigated. The possibility of obtaining oscillation at even higher frequencies with moderate beam voltage by modifying the geometry of the tube was also considered. These considerations led to the decision to design and construct an entirely new type tube for use as a backward-wave oscillator.

A waveguide can be folded in zig-zag fashion, as shown in Figure 4, so that the wave travels down a long sinuous path. Holes can then be drilled through the walls of the guide in such a way that an electron beam can traverse the length of the assembly without encountering any obstacles. The wave then crosses the beam repeatedly, from top to bottom and from bottom to top alternately. If an electromagnetic wave is transmitted down the guide and an electron beam transmitted in the opposite direction along a path through the holes, a backward-wave type interaction will result. If an electron spends the same time in coming from one section of the guide to the next as is required for one-half cycle of the wave to

THE AUTHOR: Rudolf Kompfner was an architect in London until 1941, pursuing physics and radio engineering as a hobby until he accepted a position from the British Admiralty to serve in the Royal Naval Scientific Service, at Birmingham University. His work on the traveling-wave tube, done during his association with Birmingham University, was of considerable significance to the field of microwave repeater development. In 1951, after three years at Birmingham, and seven years as a member of a research team at the Clarendon Laboratory, Oxford University, Mr. Kompfner joined the Laboratories where for the past eighteen months he has concentrated his interests in vacuum tube research, devoting much of his time to work on the backward-wave oscillator. He is currently investigating various developments related to millimeter wave tubes and their potentialities at higher and lower frequencies. Vienna-born, Mr. Kompfner received his engineering degree at Technische Hochschule, Vienna, in 1933, and his Ph.D. at Oxford in 1951. He is a fellow of the I.R.E.

pass a point, it will encounter the same phase of the wave at each fold, and the conditions required for backward-wave oscillations as described are fulfilled.

The devising of practical ways of perforating the waveguide wall to allow as much electron beam current as possible to traverse the length of the guide system, and of keeping the holes perfectly aligned to prevent unnecessary interception of the beam current presented difficult design problems. Moreover, when various possible configurations were evaluated in terms of the field strength of the wave accessible to the beam, the indicated design did not resemble a folded waveguide, but rather a guide with interleaved fingers projected from opposite walls. These structures are called "interdigital" waveguides.

In actually making such a structure to operate at millimeter wavelengths, the required gap spacing of a few thousands of an inch and the near-perfect regularity in hundreds of these gaps led to the use of tube grid winding techniques in forming the projections within the guide. The internal appearance of an experimental tube of this type, described in the following article, led to the use of the name "hairpin" tube.

This experimental backward-wave oscillator operates over a frequency range extending from 43,000 to 63,000 mc by varying the beam voltage from 500 to 2,500 volts. The frequency versus beam-voltage characteristic is shown in Figure 5. The electron beam current required to start the oscillations is about 0.2 milliamperes and a uniform field of 2,000 gauss is required to direct the electron beam. The output power is in the milliwatt range.

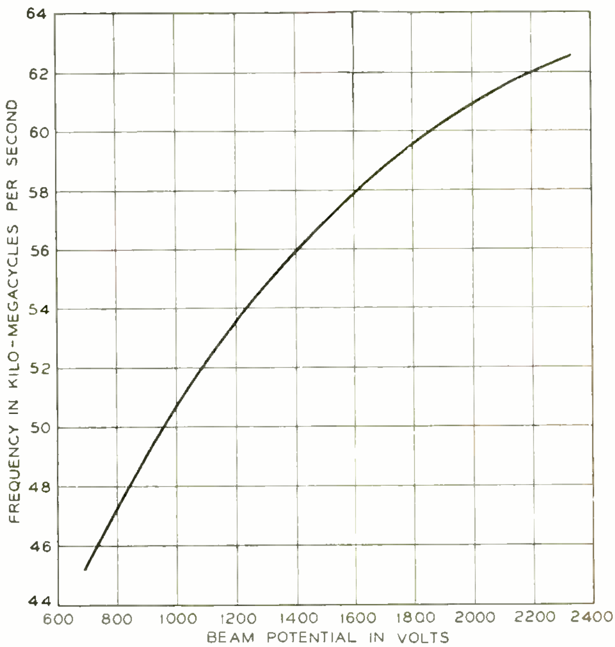


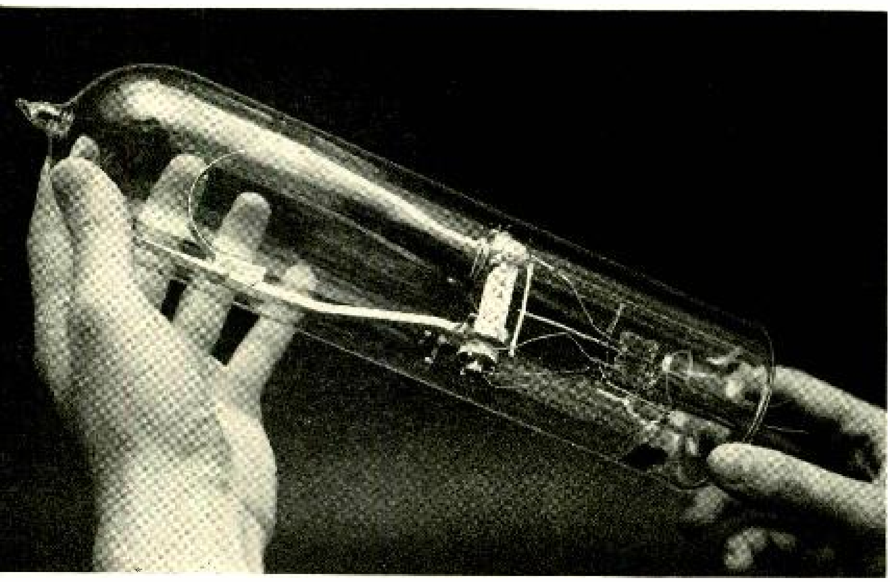
Fig. 5 – Frequency of oscillations versus beam voltage in hairpin tube.

M. J. Kelly Honored

In recent weeks, several notable honors have been conferred on M. J. Kelly, President of the Laboratories.

In June, Dr. Kelly, was elected a Life Member of the M.I.T. Corporation, a significant honor in the world of science. Chancellor Heald of New York University appointed him a member of its Advisory Board to the Institute of Mathematical Sciences. He was elected Chairman of the Advisory Council to the Department of Electrical Engineering at Princeton University.

Also, Dr. Kelly was the principal speaker at a banquet of the Dayton, Ohio, Section of the Institute of Radio Engineers recently, culminating the National Conference on Airborne Electronics. He spoke on *The Electronics Industry – Its Past and Future.* His talk referred to the important effect of the transistor in cutting the cost, space, and equipment required for airborne electronics.



An experimental hairpin tube backward-wave oscillator.

A Hairpin Tube Backward-Wave Oscillator

G. E. HELMKE
Electronic Research

Tiny wire loops resembling rows of hairpins mounted in a special section of waveguide form the essential parts of an oscillator which operates in the millimeter range, and can be tuned over a wide range of frequencies. An experimental "backward-wave oscillator" tube of this type oscillates at frequencies up to 63,000 mc per second and can be tuned electronically over a range of as much as 20,000 mc per second.

Need for an oscillator that can be tuned electronically and used in the millimeter-wave range has steadily increased as communication systems have been extended to operate at higher and higher frequencies. The "backward-wave" oscillator described in the preceding article seemed particularly suited to fill this need. Experiments with a "spatial harmonic" traveling-wave tube* have indicated that the backward-wave interaction principle can readily provide the desired electronically tunable oscillations in the frequency range in which the spatial harmonic amplifier was designed to operate. To investigate the possibility of making an oscillator based on this interaction, that would be easier to build and that would have an even larger tuning range, a tube design including a section of waveguide with interleaved fingers extending from opposite walls was adopted. An experimental tube of this type was built that provided electronically tunable oscillations over a frequency range extending from 43,000 to 63,000 mc.

* RECORD, *November,* 1952, *page* 413.

The photograph at the beginning of this article shows this experimental oscillator tube, called a "hairpin" tube from the appearance of the interleaved projections in the special waveguide section. The assembly near the center of this tube consists of the interdigital waveguide section in which the oscillations are generated, an electron gun and collector, and output waveguides to convey the electromagnetic wave through the over-all glass envelope. This assembly is centered in the tube by a mica-tipped support spider that is evident in the illustration.

An exploded view of the various parts as they are used in the tube assembly is shown in Figure 1, and the relative sizes are indicated in Figure 2. In Figure 1, the electron gun at the right supplies an electron beam that traverses the interdigital section to the collector at the left. Conventional waveguide sections are connected to the interdigital section by means of 90-degree waveguide bends having known broadband characteristics. Oscillations are generated in the interdigital section and emerge as an electromagnetic wave through the guide near the electron gun at the right of the diagram. In principle, no signal should appear at the collector end of the interdigital section. In practice, however, some mismatch is unavoidable, and an output guide has therefore been provided near the collector at the left of the diagram so that observations of the reflected power can be made. The heater, cathode, and electron accelerator grid in this assembly are identical to those used in the spatial harmonic traveling-wave amplifier.

To obtain efficient operation of the tube at relatively low beam voltages, 500 to 2,500 volts, the projections in the interdigital section of the apparatus had to be carefully placed with a separation of 0.005 of an inch between their centers. Since the gold plated molybdenum wire from which these loops or hairpins are made is itself 0.002 of an inch in diameter, the gap between adjacent loops is slightly less than the thickness of this page in the RECORD. This spacing is provided by arranging hairpin loops as shown in Figure 3 on each of two plates. These loops are spaced within 0.010 of an inch—slightly more than the

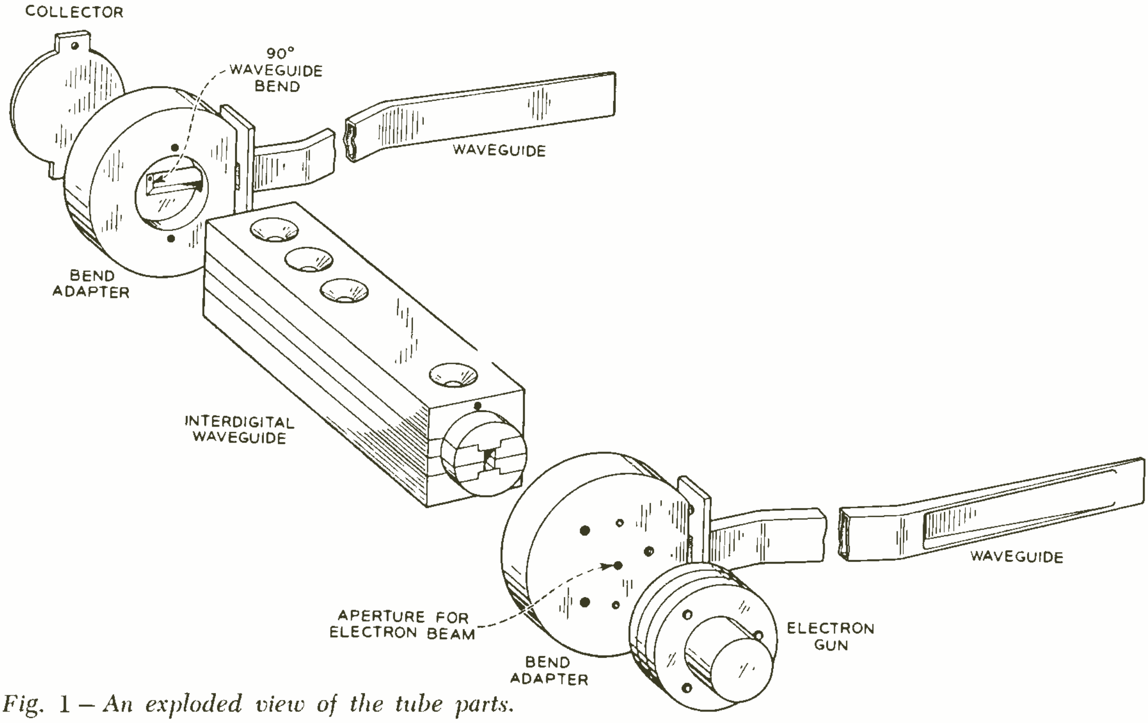


Fig. 1 — An exploded view of the tube parts.

Fig. 2 — Parts used to form the interdigital waveguide section showing the relative sizes of the various units.

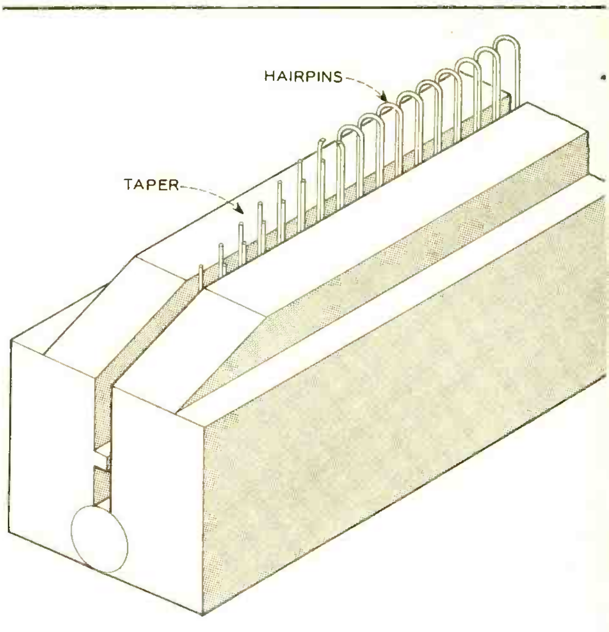


Fig. 3 — Diagram illustrating the position of hairpin projections in special waveguide section of tube.

thickness of the cover of this issue of the RECORD — between their centers. The two plates are then fitted together in such a way that the hairpins interleave, and the final distance between their centers is 0.005 of an inch. The upper part of Figure 4, which was taken through a low power microscope, shows the final position and appearance of the hairpins, magnified 17.8 diameters.

In the experimental tube illustrated in this article, the digital members — hairpins — consist of the turns of a wire helix which have been brazed to the copper surface of the guide. This helix is approximately 1.6 inches long. As shown diagrammatically in Figure 3 and photographically in the lower part of Figure 4, the loops at both ends have been clipped progressively shorter to provide a taper in the interdigital section. This taper is necessary to make an effective transition path for the electromagnetic wave between the interdigital and conventional waveguide sections. Normally, increasing the length of the taper increases the efficiency of the transfer. Since this experimental tube was designed to operate in the millimeter wave range, the over-all length of each taper, about 0.3 of an inch, represents more than one wavelength in the guide and hence a good transition is provided.

After two identical helix assemblies were prepared, they were arranged with the loops on one plate alternated with those on the other, and their relative positions were carefully checked under a microscope. Side plates equipped with observation ports used in checking the alignment and in viewing the effect of bombarding the hairpins with the electron beam were then attached to complete the interdigital waveguide section.

Preliminary studies indicated that more than 90 per cent of the electromagnetic field in the vicinity of the interleaved hairpins is concentrated in a cylinder with a radius of 0.015 of an inch extending from the central axis of the interdigital waveguide section. To take full advantage of this field strength, it was decided to use an electron beam 0.030 of an inch in diameter directed along this axis. Holes of this size were therefore arranged as shown in Figure 1 to provide for passage of the beam through the apparatus to the collector. This

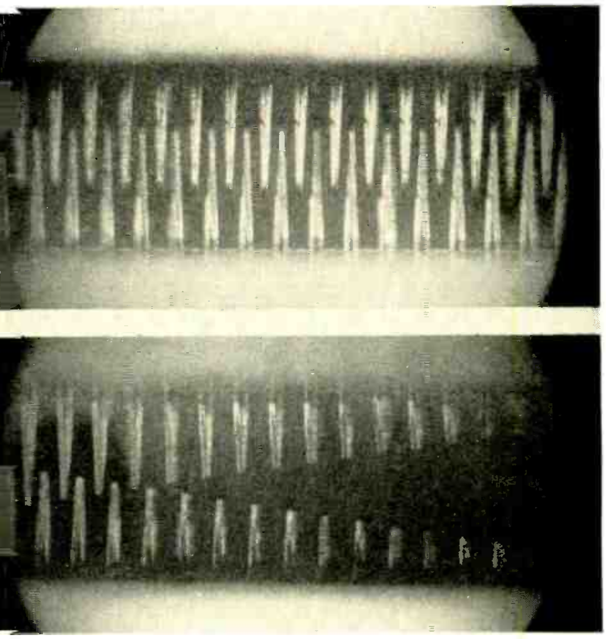


Fig. 4 – Loops of hairpin helix magnified 17.8 diameters: (top) center section (bottom) tapered end-section.

collecting electrode is a tantalum plate which helps maintain a good vacuum in the tube by acting as a "getter" when it is subjected to high beam currents.

One of the principal advantages of the hairpin tube is that the frequency of oscillations can be tuned over a very wide range merely by changing the beam voltage. It would be impossible to maintain this advantage, if the internal waveguide circuit were coupled to the external circuit through semi-resonant waveguide windows, as in magnetrons having a waveguide output and in the spatial harmonic traveling-wave tube. Preliminary experiments indicated, however, that a sheet of glass placed across a conventional waveguide at an acute angle of about four degrees, and perpendicular to the narrow face of the guide, would provide good broadband characteristics without introducing excessive loss. To provide this transition, the long sections of the conventional waveguide shown in the head piece and in Figure 1 were arranged so that the open ends formed an angle of about four degrees with the glass envelope of the tube. Additional waveguide

Fig. 5 – The author winding a helix for the hairpin tube.

Fig. 6 – The author preparing the surfaces of an interdigital waveguide section.

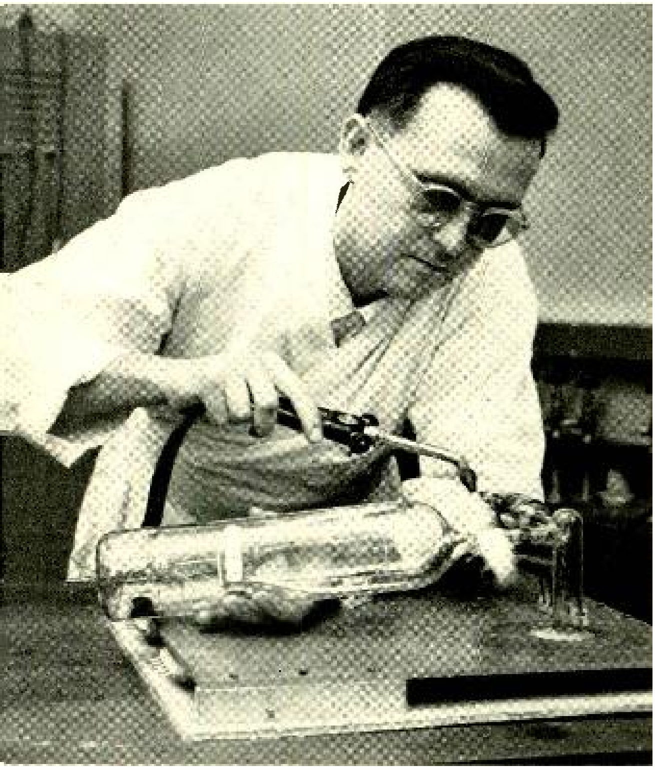


Fig. 7 — G. W. Knott, Jr. sealing off the glass envelope of an oscillator tube.

sections cut at the same angle are placed against the outside of the envelope approximately opposite the internal guides. These external guides form the input ends of the external circuits. The use of an over-all glass envelope is also advantageous in that it simplifies construction by minimizing mechanical problems not directly associated with the working parts and also exposes the inside of the experimental tube during its operation.

When this design for an electrically tuned high-frequency oscillator based on a backward-wave interaction was first devised, it was feared that the construction of an experimental model might prove to be impracticable, since there was some question as to whether or not the required helixes could actually be made. It was decided that if the construction was possible, it would have to be based on the techniques used in winding the grids of ordinary vacuum tubes. In forming the helix for this tube, however, the wire must be wound on a mandrel consisting of an iron strip with rounded edges, 0.008 of an inch thick and 0.105 of an inch high. A helix for use in the hairpin tube could not be formed in the conventional way since the flexible nature of this mandrel would prohibit the application of sufficient tension to assure the required accuracy. The required helix was built using a special grid-winding apparatus developed at Bell Telephone Laboratories, and illustrated in Figure 5.

In this apparatus, the mandrel is rotated and advanced laterally while stationary guides position the wire. During the winding process, a constant torque motor maintains a tension at 90 per cent of the force necessary to break the wire. To obtain this tension, a spool holding a supply of the wire used in forming the helix is mounted on the shaft of the constant torque

THE AUTHOR: George Helmke joined the Electronics Research Department in 1947, transferring from the development shop where he had been engaged in construction of electron tube processing equipment and tube components. In association with the electronics research group, he has been concerned with studies on magnetrons, and storage and delay tubes, and is currently engaged in design and construction work on traveling-wave tubes and "hairpin" tubes. His Laboratories career began in 1937 and has twice been interrupted by calls to active duty in the U. S. Naval Reserve.

motor. This motor operates in such a way that its rotation tends to pull the wire away from the mandrel on which it is being wound. As the mandrel rotates, however, it draws the wire from the spool slowly against this torque, and hence rotates the motor in the reverse direction. By adjusting the voltage on this constant torque motor, correct tension is obtained. After the completed helix was brazed to the copper waveguide surface, the gold plating was removed from the molybdenum wire, and the iron mandrel completely dissolved in dilute hydrochloric acid.

Since the tube described is an experimental model, the methods used in its construction differ from those that would be used for the manufacture of large numbers of tubes. In mass production, a variety of tools, fixtures, and methods are used which make reproduction possible while requiring a minimum attention to individual details. In the construction of a "single tube," however, parts can be fitted together individually, and methods can be used that would be too time consuming in the construction of more than a few units. This experimental hairpin oscillator described in this article is a "single tube," and it was designed and built accordingly.

Patents Issued to Members of Bell Telephone Laboratories During May

Augustadt, H. W. – *Alternating Wave Generator* – 2,639,385.

Babcock, W. C. and Nylund, H. W. – *Waveguide Isolation Coupling System* – 2,639,371.

Bennett, W. R. – *Wave Transmission System and Method for Synthesizing a Given Electrical Characteristic* – 2,640,105.

Edson, R. C. – *Sealed Waveguide Window* – 2,637,776.

Espenschied, L. and Skellett, A. M. – *Electronic Transmission System* – 2,640,162.

Gannett, D. K. – *Monitor System Insensitive to Impedance Variations* – 2,640,094.

Gardner, L. A. and Rea, W. T. – *Telegraph Trunk and Control Circuits* – 2,639,320.

Hampton, L. N. and Salzer, M. – *Flexible Card Feed* – 2,639,149.

Ketchledge, R. W. – *Temperature Control System* – 2,640,137.

Kock, W. E. – *Achromatic Lens Antenna* – 2,640,154.

Lewis, W. D. – *Hybrid Ring* – 2,639,325.

Mallery, P. – *Indicator Selecting and Lock-In Circuit* – 2,639,415.

Nylund, H. W., see W. C. Babcock.

Parkinson, D. B. – *Rotating-Field Pulse Transmitter* – 2,639,332.

Pierce, J. R. – *Solenoid Delay Line* – 2,638,502.

Pollard, C. E., Jr. – *Formation of a Surface Easily Wettable by Mercury* – 2,640,020.

Rea, W. T., see L. A. Gardner.

Retallack, J. B. – *Automatic Message Accounting System* – 2,639,092.

Ring, D. H. – *Electromagnetic Wave Microwave Frequency Structure Using Hybrid Junctions* – 2,639,326.

Salzer, M., see L. N. Hampton.

Skellett, A. M., see L. Espenschied.

Warner, A. W., Jr. – *Masking Device for Crystals* – 2,639,392.

A Speech Volume Survey on Telephone Message Circuits

V. SUBRIZI
Transmission Engineering

In determining margins to be designed into telephone circuits and apparatus, it is useful to know not only the electrical characteristics of the equipment but also the speech characteristics of telephone customers. A measure of this combination is provided by an electrical quantity called speech volume. From time to time surveys are made by Bell Telephone Laboratories to re-determine these speech volumes when changes in the telephone plant indicate that existing values may no longer be accurate.

Miss Esther Rentrop measuring speech volumes at a telephone switchboard.

Speech volume is an electrical quantity which depends on the acoustic power of the talker, the manner in which the telephone transmitter is held, the efficiency of the transmitter, and the circuit elements between it and the volume indicating apparatus. It is thus a characteristic of both the customer and the telephone circuit. These speech volumes are measured by volume indicators of the type previously described in the RECORD*. A knowledge of the results of speech volume measurements is useful in designing better apparatus, circuits, and systems which will provide the margins required for crosstalk limitation, signal-to-noise ratios, and to prevent overloading circuits and apparatus in the telephone plant.

From time to time, Bell Telephone Laboratories has conducted field surveys to determine the values of speech volume levels on telephone message lines under the existing conditions. One such survey was undertaken in 1938-39 at the New York City toll board on calls from New York to Dallas and Philadelphia at the time when most of the station instruments in use were deskstands and E-type handsets. The E-type was the first widely used handset. This survey indicated speech volumes equivalent to −10 vu for long distance connections and −11 or −12 vu on local calls. Other available information, dating as far back as 1924, indicates speech volumes of about −17 vu going into local interoffice trunks and −15 vu going into tandem trunks.

* RECORD, *June*, 1940, *page* 310.

Within the past few years, however, the results of field investigations made in connection with crosstalk studies, trials of the new 500-type telephone sets, and some laboratory investigations have shown that the average speech volume levels obtained in past surveys are not correct for the present telephone system. As a result, a new survey was conducted during 1950 and 1951. In this later survey, measurements were made on local, long-haul tandem, and long distance connections in New York City, Atlanta, and Cleveland. Most of the measurements were made in the New York area, however, to take advantage of the large numbers and diverse types of facilities available. The Atlanta and Cleveland areas were chosen as being representative of the Southern and Midwestern sections of the country but the data that had been gathered in these three areas agreed so well that additional work in other areas was considered unwarranted.

The local circuits on which measurements were made included connections within the same office, between adjacent offices, and between offices connected by short tandem trunks. The long tandem connections were about 25 or 30 miles long and the long-distance connections ranged from circuits extending over a distance of about 80 air miles, such as those between New York and Philadelphia, to those extending over 2,500 air miles, as between New York and Los Angeles. The connections involved crossbar, manual, step-by-step, and panel office types of equipment. Most of the telephone instruments in use at the time of the survey were the 302 anti-sidetone type commonly employed today. Measurements were made on near-end talkers using volume indicators which included standard vu meters.

The results of this survey indicate that present-day speech volumes are lower than those in the past. This was expected since the many improvements in the modern telephone system make it possible for the listener to hear clearly and distinctly when the talker uses a lower speaking volume than was possible in the past. On the average, this reduction amounts to about 3 decibels for each of the various types of connections. Some of this reduction is due to the finer gauge wire used in subscriber loops with the introduction of the 302 telephone set. The remainder is believed to be due to the subscriber who seems to have taken advantage of the improved transmission characteristics of the 302 set to reduce his talking effort.

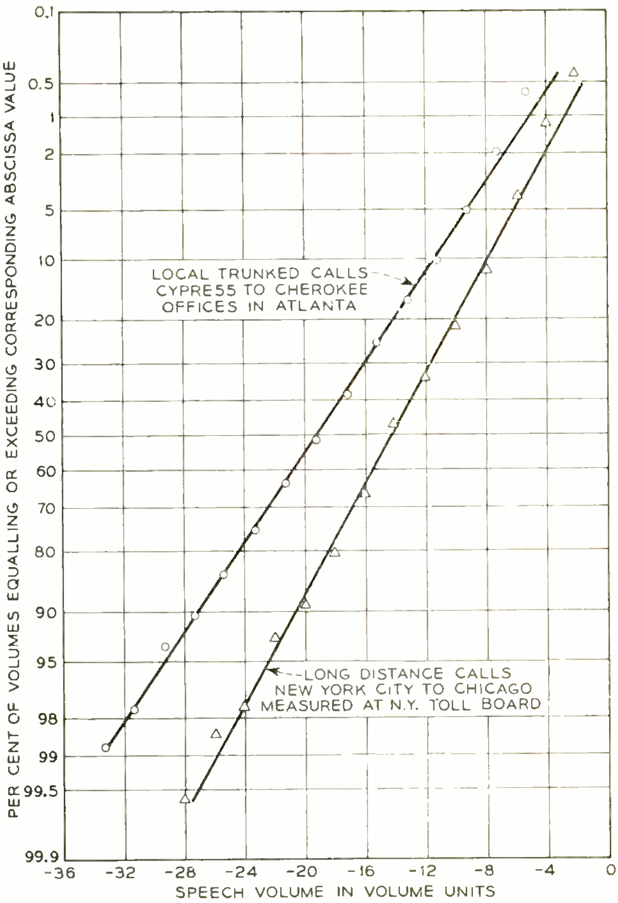


Fig. 1 — Typical cumulative distributions curves of speech volume data.

Considerable information was obtained from the data gathered in the survey by plotting a series of graphs of the type shown in Figure 1. These are called cumulative distribution curves, and they all turned out to be straight lines when plotted on arithmetic probability paper, indicating that the original data occurred in the familiar "normal" distribution. In this type of graph, the abscissa represents the range of speech vol-

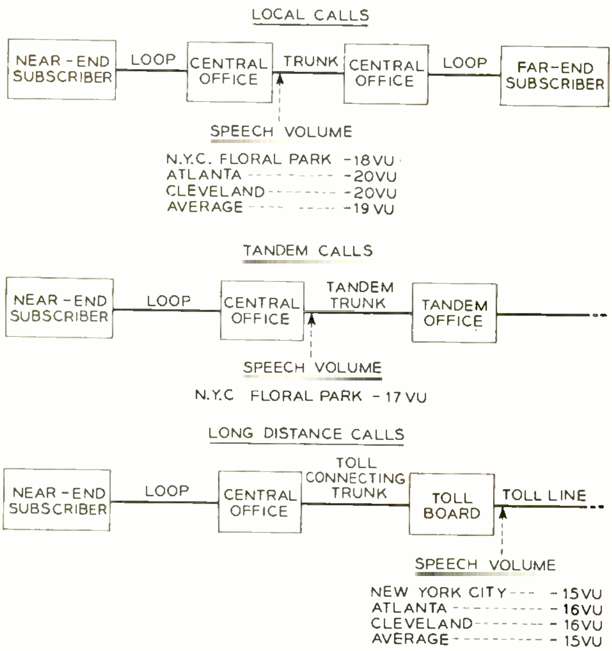


Fig. 2. — A summary of the speech volumes for each area surveyed with an over-all average for each type of connection.

umes measured and the ordinate represents the percentage of the volumes measured that equal or exceed that of the corresponding abscissa value. Average speech volumes can be determined directly from these curves by noting the abscissa value that corresponds to the 50 per cent point on the ordinate scale. Figure 1, for example, indicates an average value of −19 vu in this way. The slopes of these curves are related to the standard deviations in the data which are a measure of the range of speech volumes included in a given percentage of the measured values.

In all, 31 groups of measurements were made and analyzed: 19 on various types of local connections, 5 on long-haul tandem, and 17 on long-distance connections. Each of these groups included an average of about 160 calls and every call represented 4 to 10 individual readings each on portions of speech 3 to 10 seconds long. Median volumes and standard deviations were determined for each of the 31 resulting distributions. The results of these tests are summarized in Figure 2 which indicates the average volumes for each area surveyed and an over-all average for each type of connection. As indicated, the over-all average is −19 vu for local connections, −17 vu for long tandem connections, and, −15 vu for long-distance circuits. Since the long distance measurements were made at the toll boards of the various localities, they include the effects of losses in the toll-connecting trunks as well as the subscriber loop.

In addition to the information derived from graphs, such as those shown in Figure 1, the original data yielded a number of other interesting results. For example, with a particular type of telephone con-

THE AUTHOR: Victor Subrizi started his Bell System career in 1918 at Western Electric, transferring to the Laboratories at the time of its incorporation in 1925. He was associated with early telephone carrier, picture transmission, and television systems before joining the sound picture laboratory in 1929. Since that time he has been concerned with the development of sound picture recording and reproducing apparatus and magnetic recording and reproducing equipment including the first B.T.L. machine weather-announcing system, and the Mirrophone. During World War II Mr. Subrizi did development work on speech privacy devices and more recently he has been concerned with telephone subscriber speech volume studies. He is currently engaged in transmission engineering for special projects such as the CAA and New York State Thruway private line communication networks and central office machine announcement systems. While associated with Western Electric he received his B.S. in 1924 from Cooper Union Night School.

nection, the average subscriber talks in such a way that the acoustic volume reaching the diaphragm of his transmitter is the same whether he is a native of New York, Atlanta, or Cleveland. An increase in line noise, however, would cause him to raise this volume level several db to override the additional noise. Increasing the length of the connection would again cause him to increase his acoustic volume. In this case, the increase over the local call average will amount to about 2 db on longer tandem connections and 5 db on average long-distance connections. Moreover, some reaction prompts the average subscriber to raise his talking volume about 1½ db for every 1,000 air mile increase in the length of his call. He may do this through habit or in an attempt to reduce repetitions.

This survey has also shown that the average speech volume used by the typical male subscriber is 1 to 2 db higher than that employed by the average female.

The results of this survey have already been used in the Laboratories. For example, they have provided a baseline for some recent judgment tests carried out by the Transmission Engineering Department to appraise the grades of transmission of telephone circuits. Also, the effect of the new data on the load-rating of carrier and repeater circuits is being carefully considered.

Transistor Licensees

A total of forty firms are now licensed by Western Electric to manufacture and sell transistors commercially. At the same time, more than 500 firms have been licensed to produce and sell equipment containing circuits developed by Bell Laboratories. That this many firms can now use the transistor in their products is evidence of the impact that the revolutionary little device promises to have on our everyday lives.

Outside Plant Meeting

The Midwest Intercompany Conference on Outside Plant Items, held on May 13 and 14 in Detroit, Mich., was attended by several Laboratories and A T & T men including R. J. Nossaman, Director of Apparatus Development; F. F. Farnsworth, Director of Outside Plant Development; R. C. Koernig, Outside Plant Quality Engineer; S. L. Eppel, Field Engineer in the Detroit area; and A T & T representatives P. J. Buch, Methods & Materials Engineer, and R. M. Cunningham, Outside Plant Design Engineer. The two-day meeting began with an address by Mr. Nossaman on "The Laboratories' View of Outside Plant." Representatives were present from the Illinois, Indiana, Michigan, Ohio, and Wisconsin telephone companies.

Before the convention opened, the Laboratories and A T & T engineers accompanied representatives of the Michigan Bell Telephone Company on an inspection of "low level" rural installations under trial in the area.

Telemetering Service

Telemetering service for the National Cooperative Refinery Association was begun recently. The service employs a teletypewriter circuit connecting pumping stations at Abilene and Blue Rapids, Kan. and Tecumseh, Neb. with a control station at McPherson, Kan. Remote control arrangements, designed by the Western Area Engineering Department, permit a control attendant to do the following: start and stop pump motors at the pumping stations, get readings of suction pressure, discharge pressure, and motor loads, and obtain indications when safeguard arrangements have automatically functioned to prevent damage to the pumping equipment.

Guy Anchors

J. W. HOYT
Outside Plant Development

From the simple basket of stones used by the ancient Greeks to hold their ships in place, anchors have developed to the scientifically designed and tested types used to hold Bell System telephone pole guy wires in place. These anchors are constantly being improved to fit every conceivable set of conditions and for use in every type of soil.

The author (left) and Charles H. Swayze of the Indiana Bell installing an expanding guy anchor in a hole bored by the digger shown at the extreme left. Mr. Swayze is holding an expanding bar used to strike the top of the anchor and force the blades into the sides of the hole.

Many times during our lives most of us have witnessed or been a party to the installation of a guy anchor, whether it be the experience of watching the circus roustabout crews driving tent pegs or ourselves burying some solid object in the ground to guy the end poles of a clothesline. In any case, the attempt has been to provide a means for restraining movement of an upright structure due to unbalanced loads which tend to pull it to the ground. The loads involved are generally not too great and the guying is usually of a temporary nature.

In the construction of communication and power lines, certain poles require permanent bracing or guying to enable them to withstand the loads they are required to support. Even with proper guying, poles sometimes break and lines collapse under severe storm load conditions. Usually, guying is not necessary in straight runs but where the lines change direction and at dead ends the poles must be reinforced. The general method of providing the necessary reinforcement is to secure a wire or strand near the point of concentrated load on the pole and connect it to the eye of a guy rod which extends from the ground in line with the guy wire. The anchor itself is attached to the end of the rod well beneath the surface of the ground. The anchor remains in the ground for the life of the pole line and must provide the necessary resistance to pull-out under expected loading.

The aerial loads we are interested in here are those unbalanced horizontal loads which tend to pull the poles to the ground and thus put the line out of service. The anchor must develop the necessary holding power through the guy rod and guy wire to create the desired state of pole equilibrium. Obviously the horizontal loads change from time to time due to temperature effects upon wire tension, storm loading, and sudden jump loads, resulting from trees falling across the line. Figure 1 is a sketch illustrating a typical cable dead-end pole with the guying attachments used to balance the aerial load. At corner poles where the pole line changes direction, it is only necessary to balance the resultant of the horizontal loads. If it were possible to install an anchor at the same level and in line with the aerial load (FA in Figure 1), the restraining load developed in the anchor would equal the horizontal aerial load. However, the terrain rarely offers a chance for guying in this manner and the anchor must be placed in the ground well below the level of the cable. This means the anchor must develop considerably more holding power for a given horizontal cable load and this anchor load increases rapidly as the angle formed by the line of guying and the pole becomes less than 45 degrees. The relationship between this angle and the anchor load is shown in Figure 2. In practice, an angle of about 45 degrees is

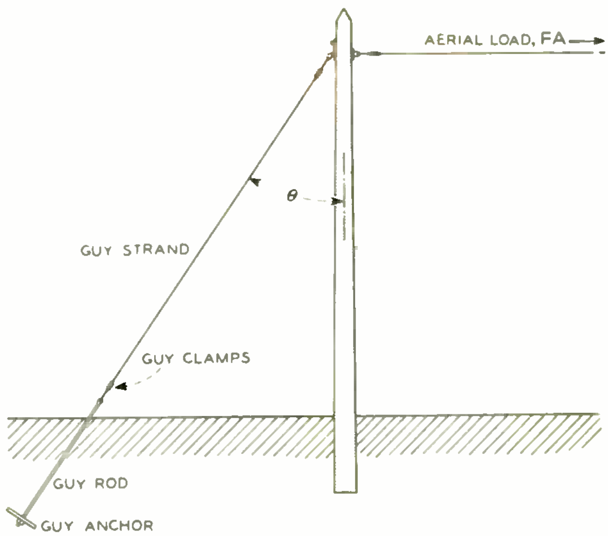


Fig. 1 — Typical dead-end pole with guying attachments used to balance the aerial load.

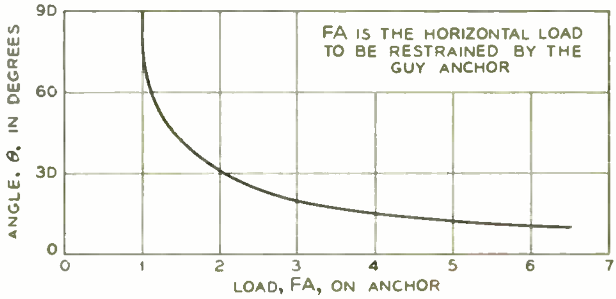


Fig. 2 — Angle between guy-strand and pole versus anchor load.

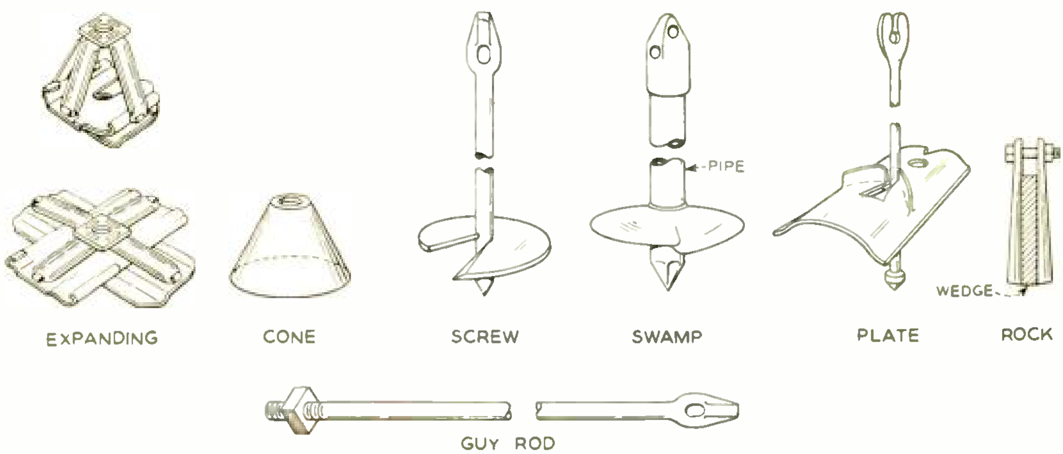


Fig. 3 — Six types of anchors approved for use in the Bell System.

generally used as it is desirable to remain close to the pole with the down guy to save material and space, and for safety reasons. At the same time, the load on the anchor is kept to as small a value as is practicable.

For many years the Outside Plant Development Department has been testing and investigating various types, sizes, and makes of guy anchors and anchoring techniques so that the associated companies can be provided with the most efficient and economical anchors available. Tests have established that the ability of any earth anchor to remain in a fixed position in the ground depends primarily upon the following factors:

1. Mechanical strength of anchor.
2. Anchor area normal to direction of pull.
3. Depth of installation.
4. Type of soil.

Factors 1 and 2 are controlled by anchor design and in application are somewhat dependent upon each other. The greater the area normal to the direction of pull, the greater the holding power developed by the anchor and any loss of this area due to deformation of the anchor will result in a loss of holding power. Anchors are generally installed from 5 to 7 feet deep, depending on the size of the anchor and type of soil. For a given type soil a deeper installation will give more holding power. Soil and its moisture condition are the most variable factors associated with guy anchor engineering and determine to a great extent how well the anchor will remain in a fixed position. Obviously, an anchor placed in a swampy location will hold only a fraction of the load it would hold in a dry clay soil. Thus soil conditions have had an important bearing upon the design of guy anchors. Figure 3 shows the six different type anchors now approved for the Bell System.

The use of new materials and improved design features in guy anchors has made it

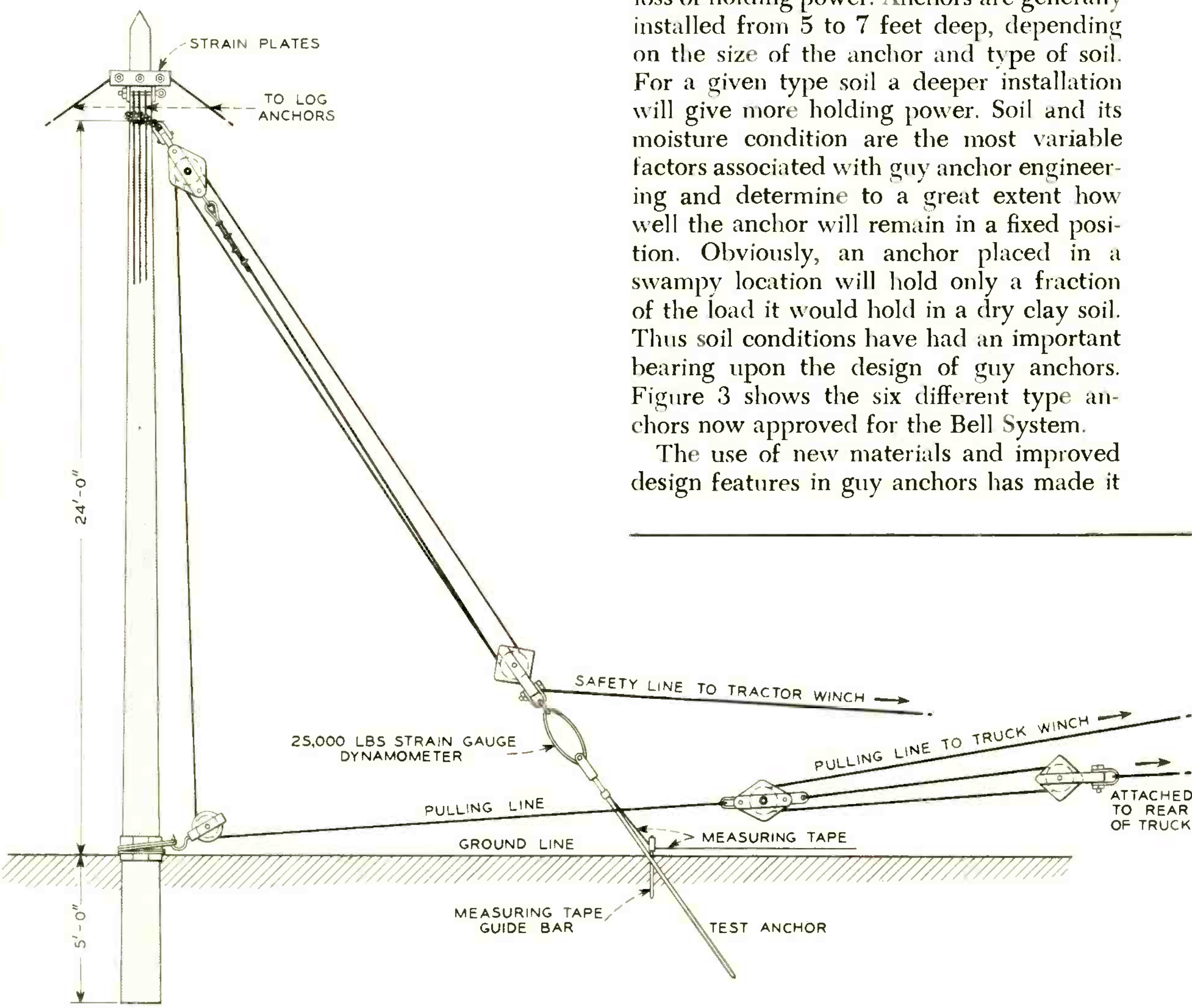


Fig. 4 — Typical setup used at Chester Laboratory for testing anchors.

necessary to conduct frequent test programs to aid in evaluating the various makes, types, and sizes available for Bell System use. Soil conditions and facilities at the Chester Field Laboratory have proved invaluable for obtaining the desired data under controlled conditions, and it is here that anchor testing has been carried on for some years. Truck and tractor mounted power winches are coupled through pulleys to obtain the loads necessary for testing anchors to destruction. The schematic diagram in Figure 4 shows a typical test setup at Chester and the comparable photograph in Figure 5 illustrates the arrangement of the test anchors and associated guy rods. Notice the heavily guyed gin pole, associated tackle, and measuring devices required. The tackle blocks employed in the guy line weigh 300 pounds each, and the gin pole will withstand pulling loads in excess of 50,000 pounds.

Test anchors under consideration are installed in either hand augered or machine augered holes, concentrically located around the gin pole. Only enough clearance is provided in the holes to permit placing of the anchors at the bottoms by means of the attached rods. Such information as soil type and condition, lead to height ratio (angle θ in Figure 1), and ease of installation, are noted. The displaced earth is then very carefully back-tamped

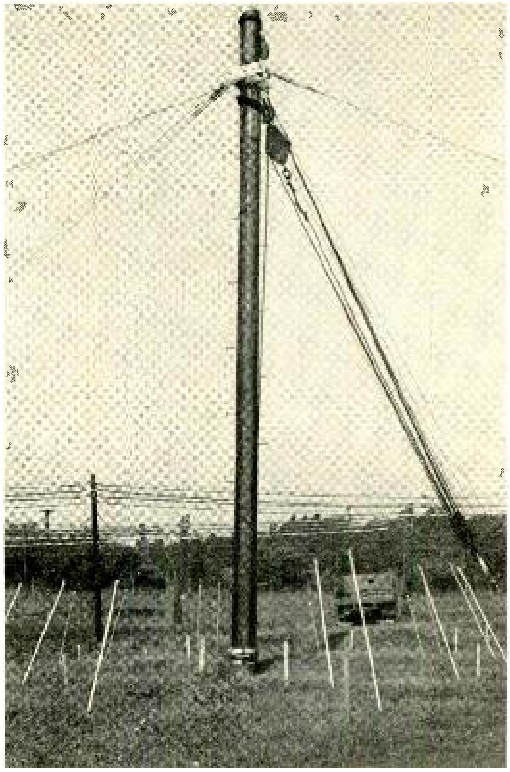


Fig. 5 – Test equipment with anchors and associated guy rods in place.

or packed in the holes around the anchors to insure a firm soil resistance. In addition the anchors are left in the ground for a sufficient time for the soil to settle before load-

THE AUTHOR: Jack W. Hoyt returned to the Indiana Bell Telephone Company in May, after completing two years as a member of the Laboratories' Outside Plant Development Department at Murray Hill. While here he was engaged in development, design, testing, and current engineering work related to outside plant hand tools and pole line hardware. Among the tools and hardware equipment with which he was particularly concerned were guy anchors, screwdrivers, measuring rules and tape, floodlights and heat-lamp reflectors. His first experience in the telephone field was in 1942 and 1943 on pole line construction along the Alcan Highway. Following this, in World War II he was engaged in pole line construction with the Army Signal Corps in the European-African theatre. He received his B.S. from Purdue University in 1948, and then spent three years at the Indiana Bell Telephone Company.

ing so that the full soil resistance will be developed.

For an ideal installation, the anchor should develop its maximum holding power with no movement (creep). However, some anchor movement will result as load is applied, due primarily to compacting and displacement of the frontal soil. This creep versus load characteristic is a very important consideration in the determination of anchor merit. Typical curves illustrating this relationship for two 10-inch expanding anchors rated for use with one-inch guy rods and 16,000-pound guy strands are shown in Figure 6. In these tests, properly designed anchors should develop their maximum holding power within three inches of creep. Any falling off of the applied load accompanied by accelerating creep indicates failure either in the anchor or in the soil resistance.

Results of the testing program and field experience assist in the determination of the suitability of guy anchors under consideration for Bell System use. Adequate safety factors are employed for anchor ratings to insure sufficient holding power for a given guying condition. So the next time you drive along the highway and see a guyed pole, consider the importance of guy anchors which, although hidden from view, are serving the very important function of reinforcing the aerial plant structure in order to provide dependable telephone service.

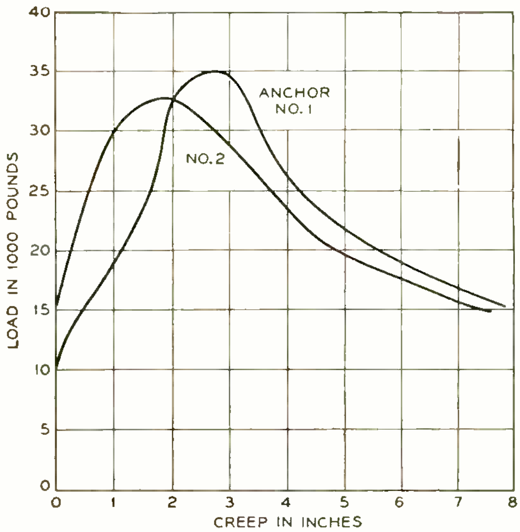


Fig. 6 – Creep versus load characteristics for two 10-inch expanding anchors.

New Teletypewriter System for Federal Reserve

A new automatic teletypewriter communications system, handling hundreds of millions of dollars in bank credit throughout the country daily, was put into operation by the Federal Reserve System on July 6. Headquarters of the network that will link together 46 stations in 37 cities across the nation will be a switching center in the Federal Reserve Bank of Richmond.

Known as the Federal Reserve leased wire system, the new network spans some 11,000 miles, bringing the twelve Federal Reserve banks and their twenty-four branches, the Federal Reserve Board of Governors, and the Treasury's offices in Washington and Chicago within seconds of each other. It will also on occasion handle messages of the Reconstruction Finance Corporation and Commodity Credit Corporation.

Speeding up the wire transfer of funds for commercial banks, the system will also handle the messages by which the Reserve banks adjust their accounts daily through the Inter-District Settlement fund.

Developed by the Bell Telephone Laboratories and provided under contract by the Long Lines department of the American Telephone and Telegraph Company, it is technically the most efficient automatic Teletype hookup yet devised. The new switching system has a mechanical "brain" able to spot human errors. Entirely automatic – except for the typing of the original message by the operator – it incorporates several new techniques in written communications to speed messages and insure against loss of traffic, such as an intercept machine which picks up misdirected messages.

Adjustable Inductors

G. F. J. TYNE
Transmission Apparatus Development

Inductance measurements on a CAA Inductor are being made on a high-frequency Maxwell bridge by Ruth Clark.

Equalization of loss and delay on television transmission circuits requires a high degree of precision in the construction and adjustment of the networks used. Adjustable inductors for these networks are important features in obtaining this desired precision. In these inductors, compressed carbonyl iron screws threaded into the coils provide the means for close adjustment.

For telephone service, the requirements on equalization of loss and delay on coaxial lines are fairly modest, but when these lines are used for television transmission, the requirements are much more severe because of the effects of loss and delay on signal-to-noise ratio and modulation, and on distortion of the picture in the form of fringes or "ghosts." Consequently, a high degree of precision is necessary in the construction and adjustment of the equalization networks. Basically, the same types of circuits are used for both television and other high-frequency transmission, but with special emphasis on precision for those used for television circuits. To attain this precision, therefore, inductors having facilities for adjusting the inductance to very close limits have been designed.

A delay equalizer, such as is shown in Figure 1, consists chiefly of a large number of network sections having the basic configuration shown in Figure 3. Each of these sections is assembled within its own shield, and all of these small units are assembled in a larger shield, interconnected to form the complete equalizer. One such equalizer, shown in Figure 1, is composed of 52 elemental networks.

As shown in Figure 3, each unit section comprises two inductors, two resistors, and three capacitors. The series arm combination of C1, C2, C3 and L1 must be adjusted to resonate at the critical frequency of the section, and its loss controlled by the appropriate value of R1. The shunt combination C2, C3 and L2 must also be adjusted to resonance at the critical frequency of the section and its loss is controlled by changing R2. Each section must be adjusted to resonate at its own critical frequency and must have a particular value of loss at that frequency. The tolerance on frequency adjustment is of the order of ± 0.02 per cent.

In the early equalizers of this type, each inductor was designed for the specific nominal inductance required for its position in

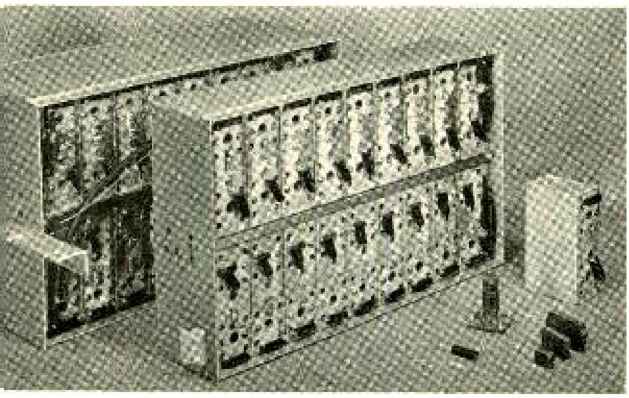


Fig. 1 — A complete equalizer, composed of fifty-two elemental networks. Each section is assembled with its own shield and all small units are assembled in a larger shield, interconnected to form the complete equalizer.

the section, and a small inductance range of about ±5 per cent was provided to permit tuning the section. This inductance adjustment consisted of a phenolic screw, carrying a small slug of permalloy powder, which could be screwed in and out along the axis of the inductor. Because each equalizer was designed to fit a particular set of conditions, a large number of inductors of a wide range of inductance was required, and the number became greater as the demand for equalizers of different

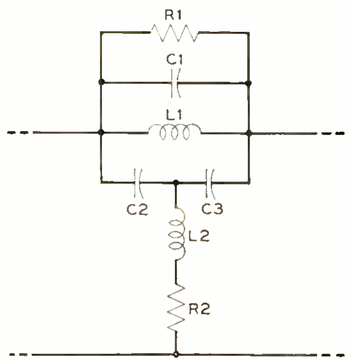


Fig. 3 — A large number of network sections having the basic configuration shown comprises a delay equalizer.

Fig. 2 — Adjustment of the inductor is accomplished by a compressed carbonyl iron screw that is threaded into the coil to a position that provides the desired value of inductance.

characteristics increased. This absorbed a large amount of engineering effort, and resulted in an uneconomical manufacturing situation.

An obvious step toward improving this situation would be to increase the adjustment range of the inductors, and if possible, to provide a series of standard inductors having overlapping inductance ranges; thus the number of different inductors could be held to a minimum. Development efforts have resulted in the design of the series of CAA-type retardation coils, a typical example of which is shown in Figure 4. An elemental network assembly in which this type of coil is used may be seen in Figure 5. Such inductors are used in approximately 250 codes of elemental networks that make up some 15 complete equalizers used in the L1 carrier system.

Standard CAA-type Retardation Coils are two-terminal inductors wound on a low-loss molded phenol plastic form. The ends of the winding terminate on solid terminals molded into the body of the core tube. The four terminals on the inductor head are not used for inductor connections, but are provided for the convenient assembly of the other components of the network. These terminals are hollow, so that external connections may be made using stiff wires that form a part of the whole network terminal; these wires are

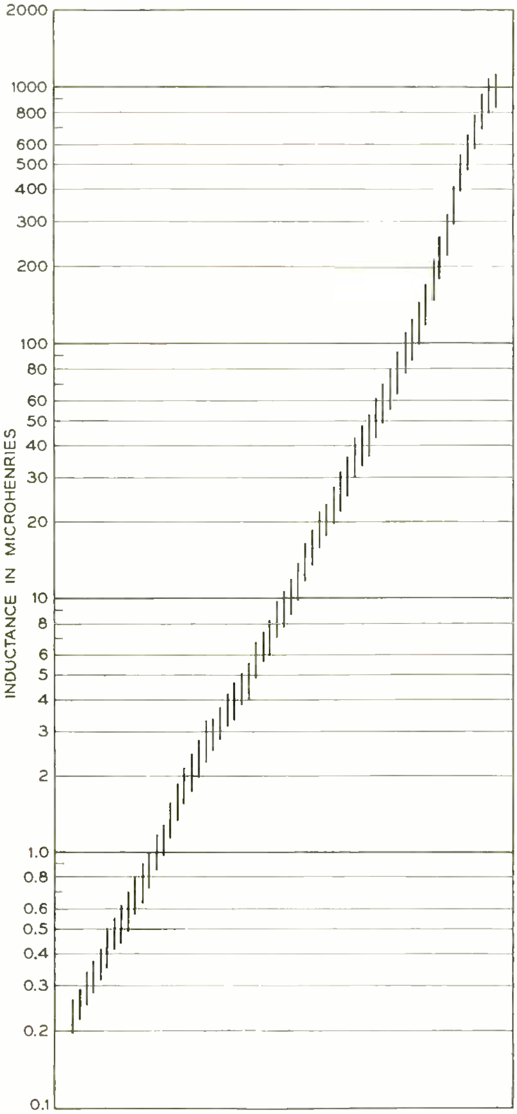


Fig. 5 — Ranges of the series of inductors provided for 0.2 microhenry to 1,000 microhenries.

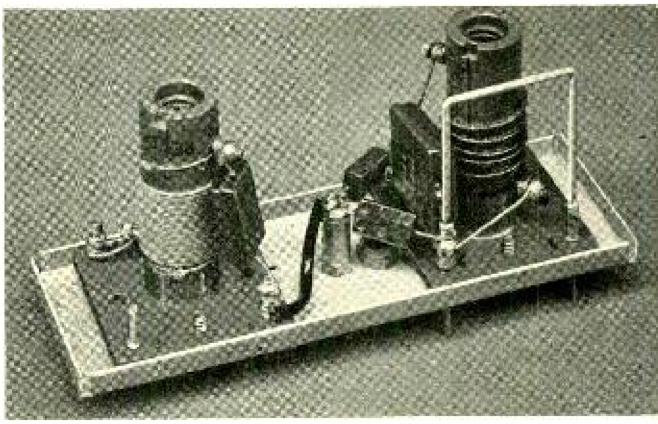


Fig. 4 — An elemental network assembly using adjustable inductors.

soldered into the hollow terminals on the inductor head. Threaded mounting holes in the head are arranged so that two inductors may be mounted back-to-back on opposite sides of a shield. A shield may also be mounted on the opposite end of the coil form, or a molded part, similar to the head, may be assembled to that end, if desired.

Adjustment of the inductance, as shown in Figure 2, is accomplished by means of a molded screw of compressed carbonyl iron powder, which can be moved along the internally threaded phenol plastic form with a screwdriver. Both ends of the adjusting screw have molded slots to permit adjustment of inductance from either end of the inductor. To assure that the adjustment does not change, the threads of the form and those of the adjusting screw are coated, before assembly, with a special adhesive material that prevents the adjusting screw from moving under vibration or shock but which offers little opposition to adjustment by screwdriver.

Sixty coils comprise a series of inductors that cover the range from approximately 0.2 microhenry to 1,000 microhenries. The ranges of the individual coils are shown in Figure 5. Inductance ranges are of the order of ±15 per cent, with median values of the coils about 20 per cent apart. With the overlap thus provided, it is possible to obtain any nominal value of inductance within the limits of the series, and to have an adjustment range of at least ±5 per

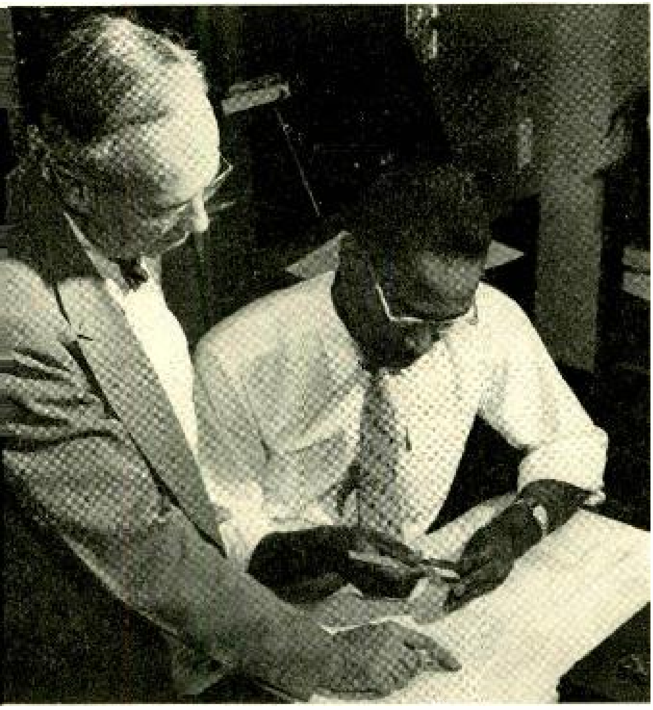


Fig. 6 — E. B. York (right) checks the dimensions of an inductor. The author is at the left.

cent about that nominal value. This ±5 per cent adjustment range permits compensation for the variations in capacitors from their nominal or design center values, enabling the network engineer to specify lower precision of capacitor adjustment and hence lower cost in the capacitor elements.

Loss level of an equalizer is determined by the characteristics of the elements of the elemental network operating at the highest frequency. For these networks, the highest frequencies are in the 5- to 10-mc range; hence, the inductors are designed to have low losses at these frequencies. At lower frequencies, the desired loss characteristics can be obtained by "loading" the inductors with resistance, that is, by using a parallel resistor such as R1, which loads L1, or by means of a series resistor R2, which loads L2 (Figure 3). The loading method employed is determined by the convenience of adjustment in the factory.

Loss characteristics for typical CAA coils are shown in Figure 7, expressed in terms of "Q", the ratio of reactance of the coil to

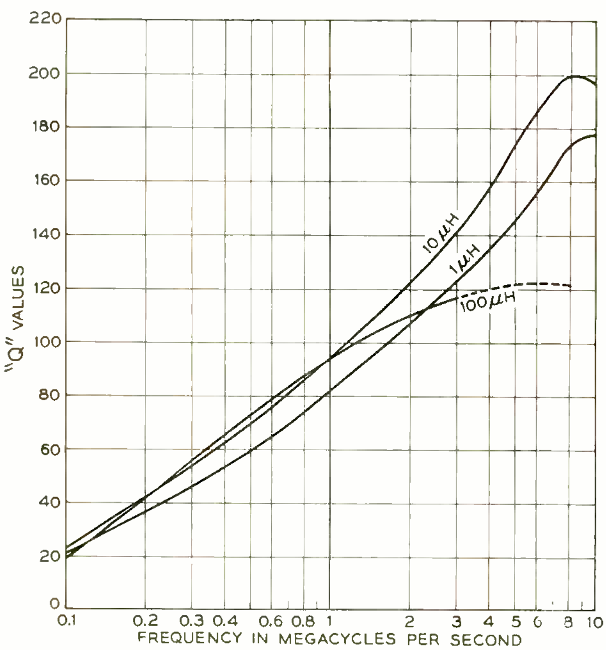


Fig. 7 — Loss characteristics for typical CAA adjustable inductors expressed in terms of "Q".

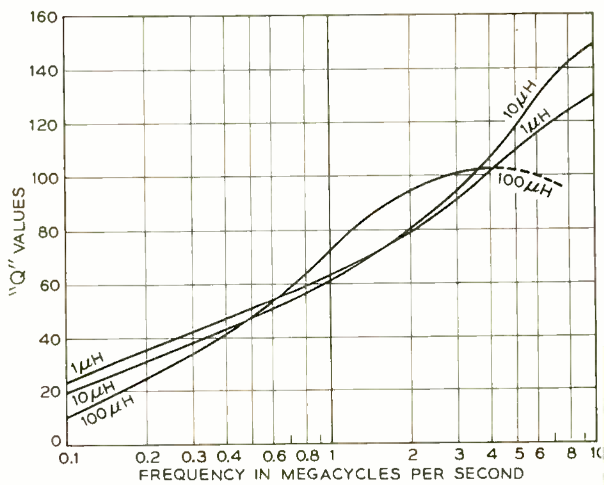


Fig. 8 — Typical loss versus frequency characteristics of type CAB adjustable inductors, expressed in terms of "Q".

its effective resistance. The higher the "Q", the lower the losses.

In loss equalizers, where lower Q's than those of the CAA-type inductors can be tolerated but where space limitations are more severe, a companion series of inductors known as the CAB type is available. The inductor on the left in Figure 4 is the CAB-10, and typical Q versus frequency characteristics of CAB-type retardation coils are shown in Figure 8. These inductors may be obtained for the same range of inductance as the CAA series. They are arranged to mount differently, since the mechanical assembly of the loss equalizers differs from that of the delay equalizer. A typical assembly of a loss equalizer is illustrated by Figure 9.

Occasionally an elemental network is required in which an inductor that is not resonated is required. Such an inductor must be pre-adjusted to a specified value of inductance. To meet this need, the CAF and CAG-type retardation coils are available. These are simply suitable CAA or CAB-type inductors, adjusted to the required inductance at the factory and with the adjusting screw sealed to insure permanence of adjustment. These are stamped with the value of inductance to which they have been adjusted.

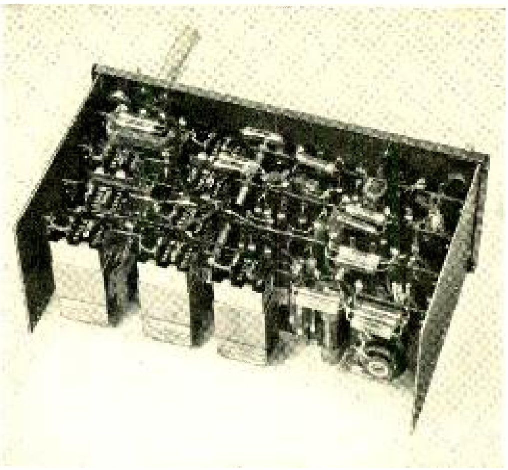
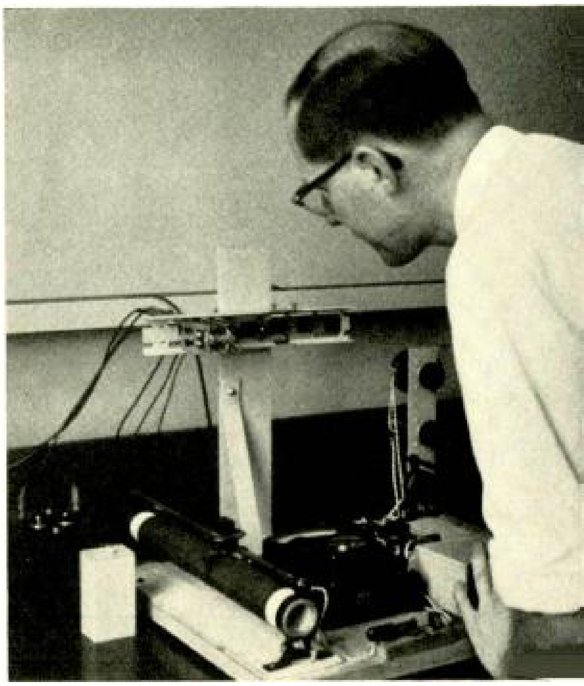


Fig. 9 — Assembly of a loss equalizer using CAB inductors.

THE AUTHOR: GERALD F. J. TYNE joined the Laboratories in 1929 after spending eight years on the faculty of Rensselaer Polytechnic Institute and a short time in the New York Department of Public Works. He has been concerned primarily with the design of repeating coils, condensers, and since 1938 with retardation coils and inductors. He is currently in charge of a group engaged in the design of high-frequency inductors. Mr. Tyne has also been interested in the history of the development of vacuum tubes and has written extensively on the subject. He is a member of Sigma Xi and holds an E.E. degree (1921) from R. P. I.

A polarized relay is fundamentally different in its operation from an ordinary neutral relay in that it is selective to the polarity of the operating current, and it may also be more sensitive in its operation. When directional characteristics only are needed, however, two neutral relays may be combined with a permanent magnet to produce a polarized relay.



J. Jacobsen measures the operating current of a 266A relay.

A Polarized Relay of Simple Construction

J. S. GARVIN (retired) *Switching Apparatus Development*

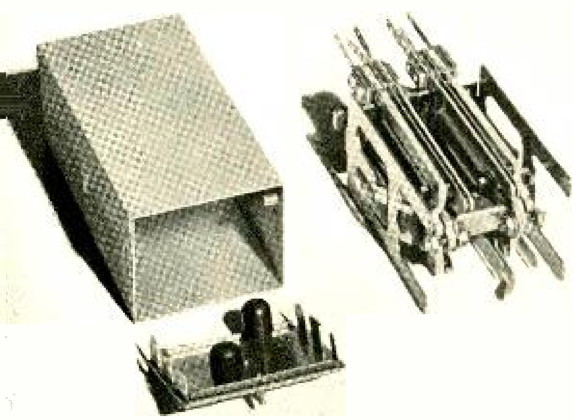
Polarized relays are relatively sensitive, fast operating, directional relays, and are usually equipped with only single making or breaking contacts. Their particular characteristics, so different from the ordinary neutral relays, have made them expensive to manufacture and maintain. For some purposes, however, where only the directional characteristic is needed, a modification of existing neutral relays has resulted in a very satisfactory polarized relay, known as the 266 type. This relay is a twin armature, three-position device; that is, when unoperated, the armatures are in a neutral position and operate to the left or right in accordance with the direction of the current in the windings. As many as fourteen contact springs can be operated in either direction.

Actually, this relay is made of two neutral (R-type) relays, mounted side by side, with the cores connected near the front and rear ends, as shown in Figures 1 and 2. A Remalloy permanent magnet connects the cores at the front end, and a rod of magnetic iron connects them at the rear. Remalloy is a molybdenum-cobalt-iron alloy developed by the Western Electric Company and Bell Telephone Laboratories especially for high coercive force permanent magnets. Armatures and cores of the two relay structures are made of 45 per cent Permalloy. Figure 3 shows a sketch of the magnetic circuit of the combination.

Because of the permanent magnet, there is a closed magnetic circuit through the permanent magnet, relay armature and cores, and the yoke at the rear. When current flows through the windings, which are connected in series, an additional magnetic flux is produced in the cores and armatures of both relays; this flux is in the same direction in both cores and armatures. If, as indicated in Figure 3, the right hand coil flux is in the same direction through the air gap as that of the permanent magnet flux, the right hand armature will be attracted. At the same time, the coil flux in the left hand air gap is in the opposite direction to that of the permanent magnet flux, and the resultant flux in that air gap is not sufficient to overcome the spring load on that armature. If the current through the windings is reversed, the left hand armature will be attracted, and the right one will not.

Measurements of the pull of these relays show that the ampere turns that must be applied to the windings to attract the armature in opposition to the polarity of the permanent magnet are far above the ampere turns required for the corresponding neutral relay. In other words, when the direction of current is such as to operate the right hand armature, for example, there is no danger of falsely operating the left hand armature, unless the current through the windings is raised excessively.

Fig. 1 — The 266A relay with cover and cover cap removed. The cover cap is provided with studs that, with the cap in place, mechanically operate an auxiliary contact to connect battery to the fixed contacts of the relay, but open these contacts when the cap is off.



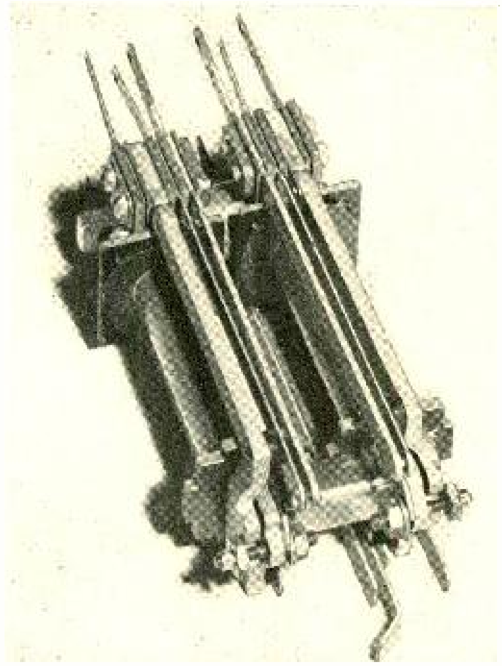
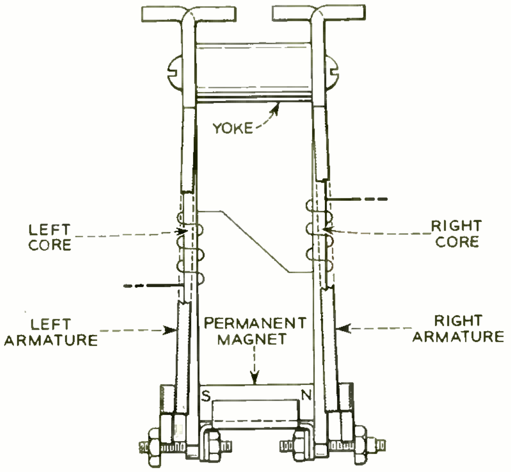


Fig. 2 — The 266A relay without cover and cover guides.

One of the principal advantages of this type of polarized relay is that practically all of the spring combinations used on E and R type relays can be used on this relay. It is also possible to use each of the two units individually, directing the current in the windings, of course, so that each armature will be attracted when current passes in the favorable direction through the winding for that side. In this case, the presence of the permanent magnet improves the pulling capability of the individual armatures of the relay.

As originally developed, the 266-type (266A) relay was intended for use in the panel machine switching system for two-party line circuits arranged for remote control, zone registration, and non-zone overtime charging. Figure 4 illustrates a simplified schematic of one of the circuits in which it is used. When the polarity of the voltage across the relay windings is in one direction, only one message register, say MR1, will operate. When the polarity of the voltage is reversed, the other message register, MR2, will operate. In order to avoid the possibility of operating a register when



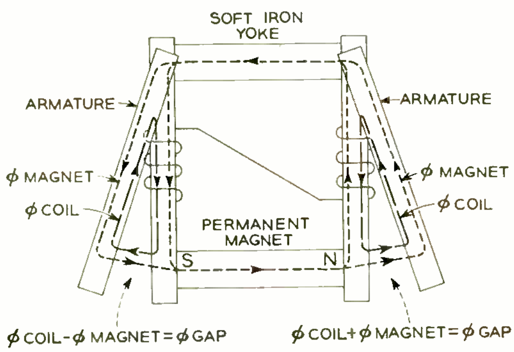


Fig. 3 — Magnetic circuit of the 266-type relay.

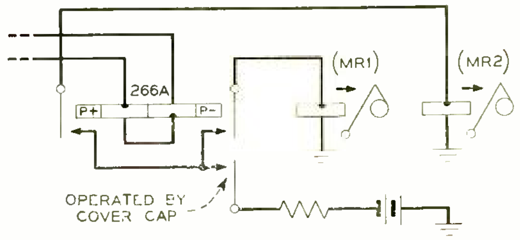


Fig. 4 — Simplified schematic of the panel system two-party line message register circuit. The message registers are operated by different polarities applied to the 266A relay winding.

the relay is being adjusted, it is equipped with a contact that opens the circuit to both message registers if the cover or cover cap is removed—which, of course, would occur when the relay is being adjusted.

Since this relay was developed, other applications have been found for it, and there are now four codes. The 266B relay is used in a step-by-step automatic ticketing circuit, 266C in a step-by-step trunk circuit, and the 266D in a No. 5 crossbar trunk coin control circuit. In the latter application, one 266D relay serves the purpose that would require two conventional polarized relays and two U-type relays.

THE AUTHOR: J. S. Garvin was graduated from the University of Kentucky in 1910 with a B.M.E. degree. Shortly afterward he joined Western Electric Company in Chicago. A few months later he transferred to Western's Engineering Department in New York. For six years he participated in the development of telephone apparatus. In 1917 he joined the relay development group of the Apparatus Design Department, where he remained until his retirement in April of last year. As designer and supervisor, Mr. Garvin left his mark on nearly every type of telephone relay in use today.

N1 Carrier:

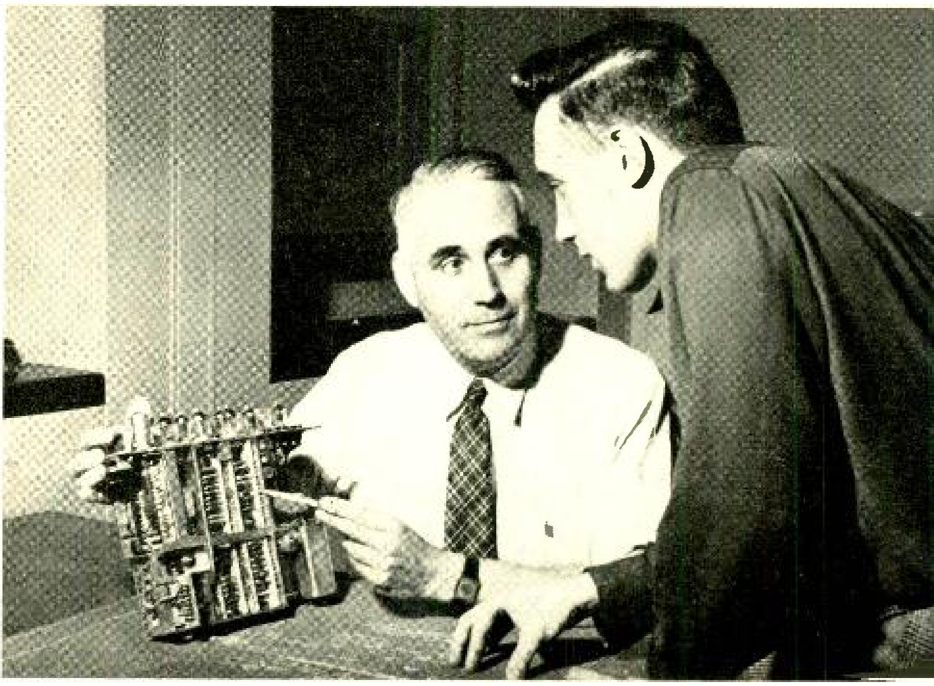
Packaging of Equipment

W. R. STEENECK
Transmission Systems Development

Trends in equipment design toward small, lightweight components have been exemplified to a large degree in the N1 carrier system. Aluminum die castings, new thermoplastic materials, and the use of plug-in units to form sub-assemblies and complete assemblies, have made possible a "packaged" system that is economically feasible for use on short routes.

A basically new approach in telephone equipment design has been introduced in the development of N1 carrier. Instead of following the conventional practice of using a number of relatively large panels arranged for permanent relay rack mounting, the major transmission components are "packaged" as small, lightweight, compact units which plug into a common framework to form a complete system terminal or repeater assembly.

This fundamental concept has made possible a design that has a number of distinctive features and advantages. These include the extensive use of die castings, a new method of mounting pigtail type apparatus, application of plug-in design to essentially all transmission elements, maximum use of



The author (left) discusses with A. Kerken the method of mounting pigtail components in the channel unit.

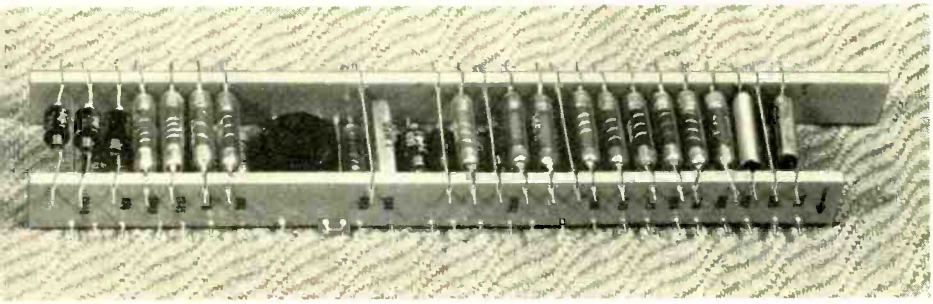


Fig. 1 — Mounting of pigtail components. The leads of the components are imbedded in two parallel thermoplastic strips.

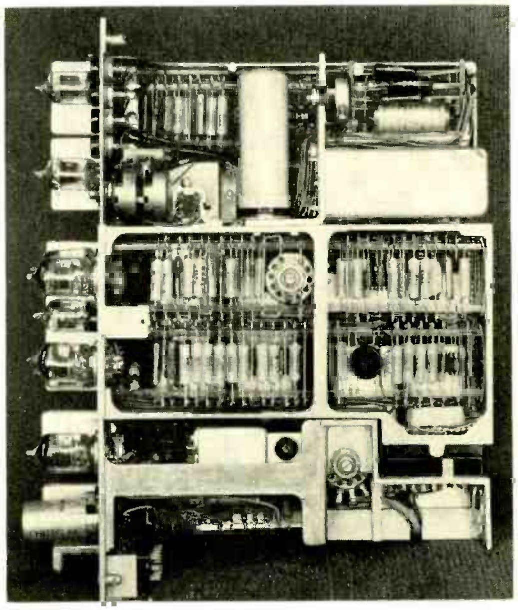


Fig. 2 — Channel unit with cover removed; right side view.

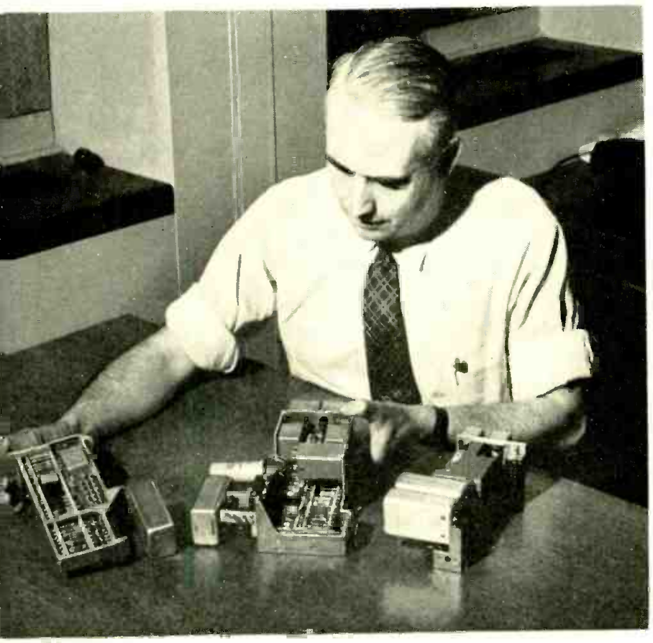


Fig. 3 — The author shows a partially disassembled channel unit. Compressor at the left, expandor and signaling at center, and carrier subassembly at the right.

available space, and the assembly of complete terminals or repeaters in single packages convenient for engineering, installation, and testing. These features have made possible a twelve-channel cable carrier system sufficiently low priced to permit widespread use on short routes formerly outside the economic range of carrier facilities.

Use of aluminum die castings instead of fabricated designs, for the relatively complex chassis required, and the new method of assembling pigtail components, are large factors in the reduction of assembly and wiring costs. The advantages of aluminum die castings, in addition to the cost reduction factor, include dimensional uniformity, which provides interchangeability of parts, light weight, which is so essential in a plug-in design, chassis of complex construction that would not otherwise be obtainable, and the incorporation of equipment identifications in the dies, thereby eliminating subsequent stamping or adding this information as a separate operation. The application of die cast techniques to "N" carrier will be discussed more fully in a subsequent article.

Mounting of pigtail components, such as resistors and capacitors, is accomplished by imbedding the leads of these components in two parallel thermoplastic strips, as shown in Figure 1. Simple assembly jigs position the strips and components so that the terminal leads rest on the edges of the strips. The jigs are then placed in a machine, which, by applying a slight pressure to a heated shoe, imbeds all the terminal leads into the plastic material, and at the same time, shears off the excess length of the leads. The entire operation is completed in a matter of seconds. As indicated in Figure 1, components can be assembled on both edges of the strips by turning over the assembly and repeating the process. Such assemblies in Type N contain as many as 40 or 50 parts, but the process may be expanded for larger assemblies if necessary.

Use of small, lightweight apparatus components has made possible a small, compact plug-in unit that can be removed from service when not operating properly, and replaced by a satisfactory unit, thereby restoring service with a minimum of lost circuit time. The defective unit can then be removed to a centrally located maintenance center for repairs. At these maintenance centers, complete tools, testing equipment, and experienced personnel permit efficient servicing at lower cost than if repairs were made at the equipment location.

Miniaturization, although providing the advantages mentioned, introduces a more severe problem in obtaining adequate accessibility of all parts for shop assembly and field maintenance than had existed previously on permanently mounted equipment where the apparatus is located on flat panels. The solution of this problem was to make the various plug-in units in the form of two or three subassemblies, each of which consists of a logical circuit subdivision. Each subassembly is completely shop assembled, wired, and tested, and it is terminated in plugs and jacks to provide ready assembly into a complete unit.

It was realized right from the beginning of the development that the use of compact, miniaturized construction would introduce heat dissipation problems. Many Type N repeaters are pole mounted, where there is no power available for cooling fans

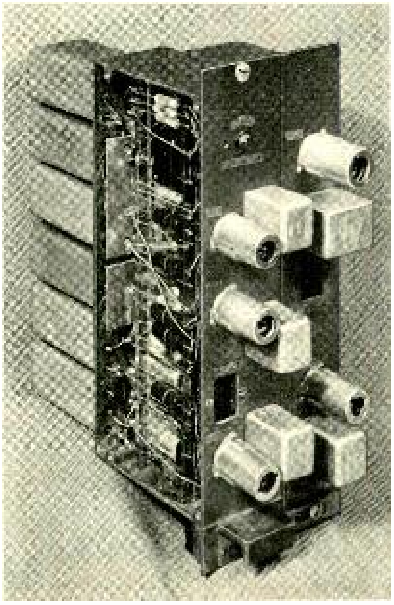


Fig. 4 (left) – An LGR (low group receiver) unit.

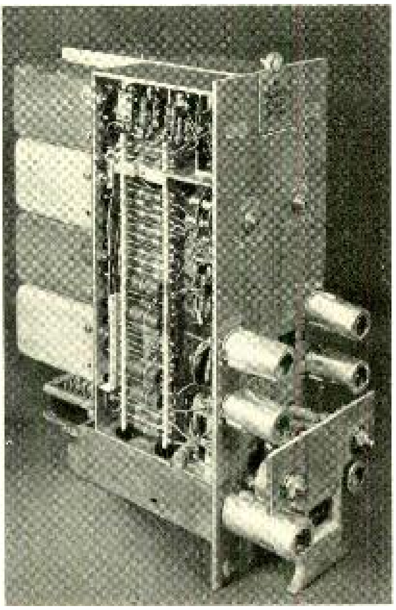


Fig. 5 (right) – Assembled H-L (high to low) repeater.

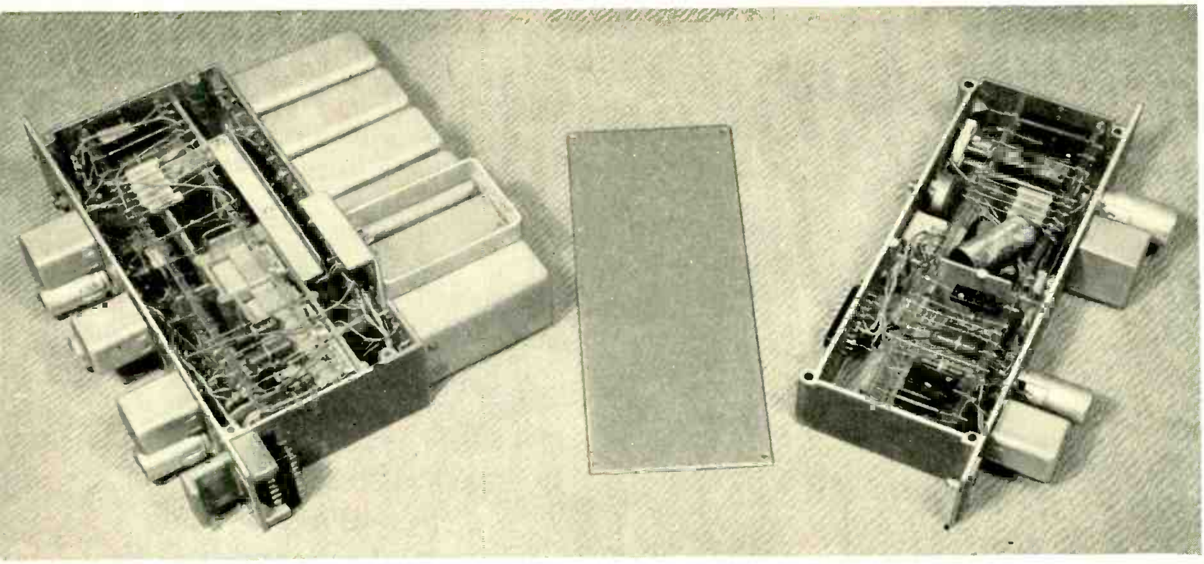


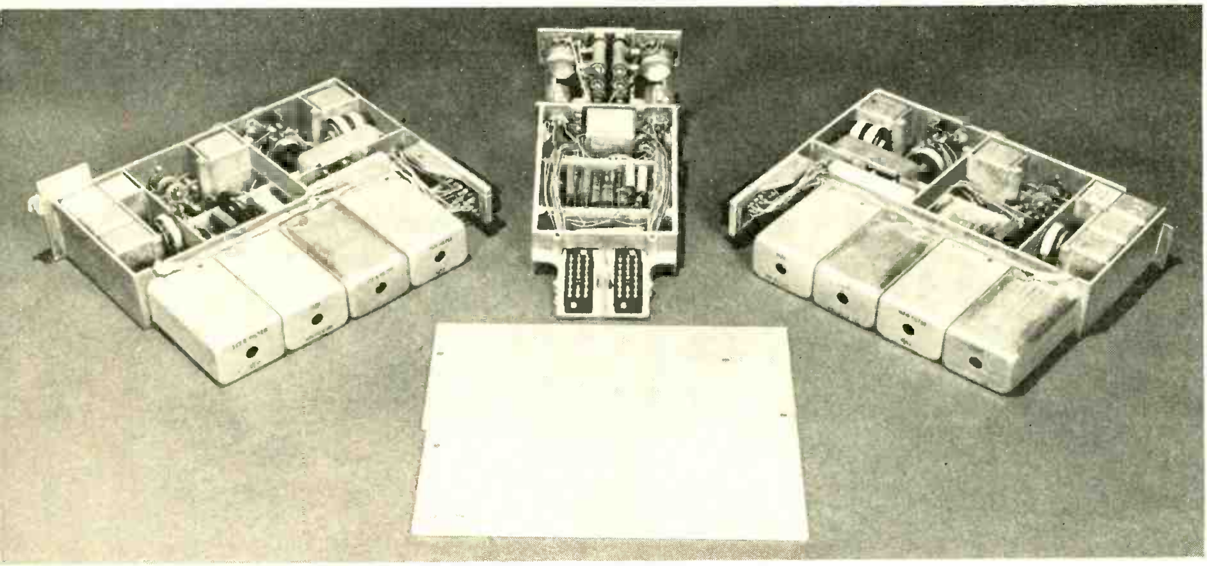
Fig. 6 – Partially disassembled view of the group unit of Figure 4.

that otherwise could be used*. Large terminal installations pose a particularly serious problem in this respect. In these installations, blowers are provided at the bottom of the racks, with ducts to carry the air up each side of the rack. These ducts are slotted so as to direct the cooling air toward the heat producing areas.

* Pole mounted repeaters will be described in a subsequent article.

To minimize heating effects, all plug-in units are so designed that heat-producing apparatus, such as electron tubes, power adjusting resistors, and potentiometers, are mounted on the faces of the chassis, and non-heat producing and heat sensitive apparatus at the rear. Heat producing apparatus has also been arranged to permit the natural flow of heat from floor to ceiling to be as unimpeded as possible to expedite heat removal.

Fig. 7 – Partially disassembled view of repeater unit of Figure 6.

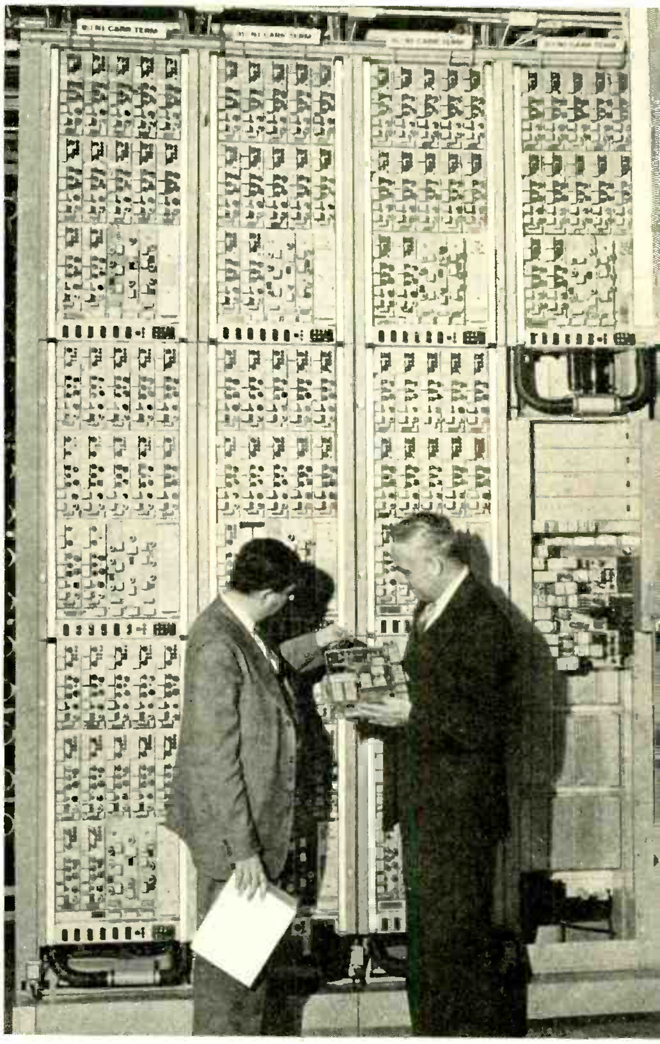


Plug-in units consist of the channel, group, and repeater units. Twelve channel units are required for each N terminal; these are all identical except for the receiving filters and the crystal unit that determines the channel carrier frequency. There are four types of group units. For a terminal that transmits high group frequencies and receives low group frequencies, there is a high group transmitting unit (HGT) and a low group receiving unit (LGR). For a terminal that transmits low group frequencies and receives high group, there is a low group transmitting unit (LGT) and a high group receiving unit (HGR). There are two types of repeater units, the high-low repeater (H-L) which receives high group frequencies from the line and modulates them with 304 kc to low group frequencies, and the low-high repeater (L-H), which translates low group frequencies to high group.

The channel unit shown in Figure 2 contains all the apparatus, including that required for signaling, for one channel. This unit is made of three die cast subassemblies: (1) the compressor, or voice frequency transmitting subassembly; (2) the expandor, or voice frequency receiving subassembly, and the signaling equipment; and (3) the carrier frequency subassembly. The first two subassemblies are identical for all channels and are now wired and equipped so that they may also be used for channel units in the Type-O carrier system. These subassemblies are terminated in plugs and jacks so that they may all be connected together to form one complete unit. A partially disassembled view of the channel unit is shown in Figure 3.

Transmitting and receiving group units combined contain the transmitting and receiving amplifiers, the group modulator, which may be used either in the transmitting or receiving branch, the signaling oscillator, and the carrier alarm circuit. A single group unit consists of a combination of three of the following die cast subassemblies: (1) high group transmitting, (2) low group transmitting, (3) high group receiving, (4) low group receiving, and (5) oscillator. The oscillator subassembly contains the 304-kc carrier oscillator and the 3,700-cycle signaling oscillator. It may be plugged into a low group transmitting subassembly or a low group receiving subassembly, the combination being provided with a common cover to form an LGT or LGR unit. High group transmitting and high group receiving subassemblies are not associated with an oscillator, since the required frequency band is received directly from the channel units. With their individual covers, therefore, they are complete HGT and HGR units. Figure 4 is a view

Fig. 8 – R. M. Morris (left) of the New Jersey Bell Engineering Department, discusses adjustment of a channel unit with the author; in the background are type N Terminal Bays at the New Brunswick, New Jersey, Central Office.



of an LGR group unit. Figure 6 is a partially disassembled view of this unit.

The H-L and L-H repeaters each consist of three subassemblies. In the H-L repeater a West-to-East high-to-low amplifier and modulator subassembly, and a similar East-to-West subassembly, are plugged into a common 304-kc oscillator and voltage regulator subassembly, all mounted under a common cover. The L-H repeater is similar to the H-L repeater except that the amplifier and modulator subassemblies are designed for low-to-high conversion instead of high-to-low. An assembled repeater is shown in Figure 5 and a partially disassembled view in Figure 7.

A complete N terminal, as shown in Figure 8, consists of twelve channel units, a group transmitting unit, a group receiving unit, and miscellaneous equipment, such as power fuses, voltage adjusting facilities, alarm lamps and relays, and test power jacks. The terminal assembly consists of a fabricated aluminum framework that contains the jacks required for the associated plug-in units. These jacks are wired to terminal strips for external connections, and also to the power supply fuses and alarm circuits.

Installation, therefore, only requires making the outside connections and plugging the proper units into their associated jacks. Channel units for channels 1 to 5 are plugged into the top row of jacks, channels 6 to 10 into the middle row, channels 11 and 12 at the left side of the bottom row, with the transmitting and receiving group units to the right of channels 11 and 12. Additional jacks are associated with the group unit jacks, so wired that these units may be tested and replaced without interruption in service. Mounting can be accomplished on any relay rack that will mount 19-inch panels, and three complete terminals can be mounted on a standard 11½-ft. bay.

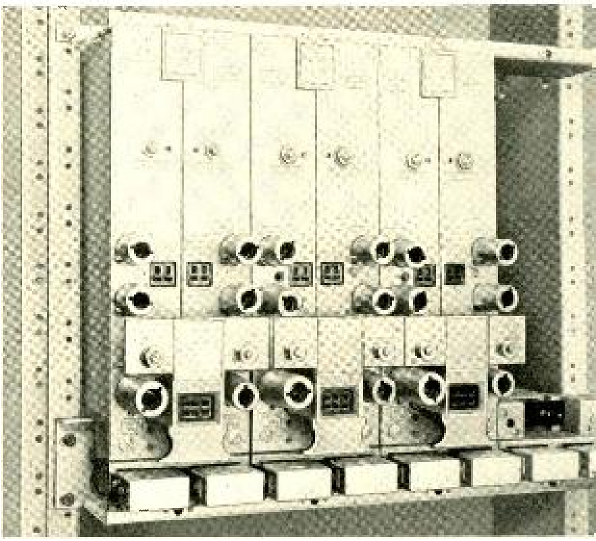


Fig. 9 — Repeater mounting shelf equipped with three repeaters and space for one additional repeater.

Repeaters are designed to mount four across a 19-inch relay rack bay. The jacks which the repeaters engage, instead of being located on the mounting framework, are assembled on a die cast bracket, which is fastened to the rack by screws. Figure 9

THE AUTHOR: Immediately after receiving his B.S. in E.E. from New York University in 1926, W. R. STEENECK joined the Laboratories as a member of the Equipment Development Department. Several of the projects with which he has been concerned in this capacity include development of equipment for radio-telephone systems, the No. 1 crossbar system, Type-J carrier telephone, and, for the Armed Services, radio and carrier equipment. He has also worked on the development of radiotelephone equipment for non-associate use and more recently with N and O carrier telephone equipment. In association with the Whippany military organization he is currently engaged in work on wired transmission systems, including a militarized version of the Type O carrier. Mr. Steeneck is a member of Tau Beta Pi and Iota Alpha.

shows three repeaters in position and space for one additional repeater. In addition to the regular repeater jacks, the bracket contains two additional jacks for testing and replacement of the repeater without interrupting service, an arrangement similar to that provided for group units. The bracket also mounts span pads, or artificial lines for building out the line loss to the required value, all completely wired to a terminal strip. Use of plug-in repeaters and the assembly of all associated elements on a removable bracket provides accessibility and permits complete maintenance of an individual system without the hazard involved in working on or near other equipment in service.

Throughout the development of the N1 carrier system, accent has been placed on small, compact, inexpensive plug-in units requiring a minimum of installation effort and capable of immediate replacement, when necessary, with a minimum of lost circuit time. The result of these efforts has been a high quality carrier system that has proved economically feasible on short routes – almost 50 per cent of the installations made to date are less than 40 miles long – a field previously below the range of carrier equipment.

Papers Published by Members of the Laboratories

Following is a list of the authors, titles, and place of publication of recent papers published by members of the Laboratories:

Bies, F. R., Attenuation Equalizers, Audio Eng. Soc. J., 1, pp. 125-136, Jan., 1953.

Bozorth, R. M., Behavior of Magnetic Materials, Am. J. Phys., 21, pp. 260-266, Apr., 1953.

Burns, R. M., Science and Scientists in Telecommunications, Electrochem. Soc. J., **100**, pp. 90C-94C, Apr., 1953.

Colley, R. H., see G. Q. Lumsden.

Coy, J. A., and E. K. Van Tassell, Type-O Carrier Telephone, Elec. Eng., 72, pp. 418-423 May, 1953.

Fine, M. E., Elasticity and Thermal Expansion of Germanium between –195 and 275°C., J. Appl. Phys., **24**. pp. 338-340, Mar., 1953.

Groth, W. B., Principles of Tape-to-Card Conversion in the AMA System, A.I.E.E., Trans. Commun. and Electronics Sect., **5**, pp. 42-52, Mar., 1953.

Haynes, J. R., and J. A. Hornbeck, Temporary Traps in Silicon and Germanium, Phys. Rev., **90**, pp. 152-153, Apr. 1, 1953.

Hornbeck, J. A., see J. R. Haynes.

Hughes, W. T., and J. J. Lander, Vacuum Tube Electrometer Amplifier, Rev. Sci. Instr., **24**, pp. 331-332, Apr., 1953.

Kersta, L. G., Interesting Property of Certain Conductive Rubbers, J. Polymer Sci., **10**, pp. 447-448, Apr., 1953.

Kock, W. E., Acoustic Gyrator, J. Acoust. Soc. Am., **25**, p. 575, May, 1953.

Kohman, G. T., see M. C. Wooley.

Lander, J. J., see W. T. Hughes.

Luke, C. L., Photometric Determination of Antimony in Lead Using the Rhodamine B Method, Anal., Chem., **25**, p. 674, Apr., 1953.

Lumsden, G. Q., and R. H. Colley, Review of American Standard Fiber Stresses of Wood Poles, Standardization, **24**, pp. 114-117, Apr., 1953.

McMahon, W., see M. C. Wooley.

Pearson, G. L., and M. Tanenbaum, Magnetoresistance Effect in InSb., Phys. Rev., **90**, p. 153, Apr. 1, 1953.

Shive, J. N., Properties of Germanium Phototransistors, J. Opt. Soc. Am., **43**, pp. 239-244, Apr., 1953.

Slepian, D., On the Number of Symmetry Types of Boolean Functions on n Variables, Can. J. Math., **5**, pp. 185-193, 1953.

Tanenbaum, M., see G. L. Pearson.

Van Tassell, E. K., see J. A. Coy.

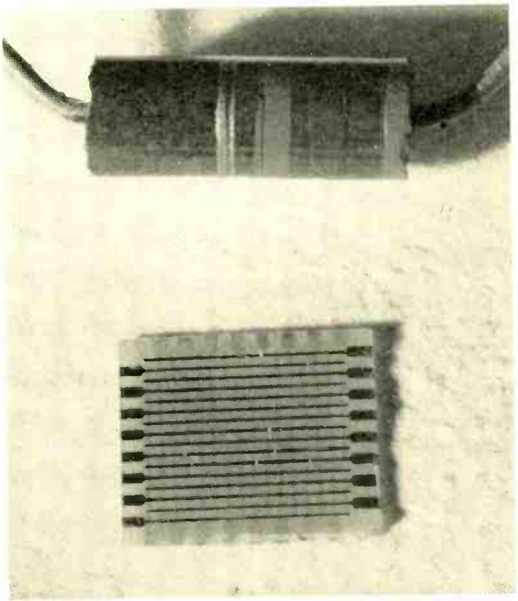
Wood, E. A., Simple Attachment for Low Temperature Use of an X-Ray Diffraction Camera, Rev. Sci. Instr., **24**, pp. 325-326, Apr., 1953.

Wooley, M. C., G. T. Kohman, and W. McMahon, Polyethylene Terephthalate – Its Use as a Capacitor Dielectric, A.I.E.E., Trans., Commun. and Electronics Sect., **5**, pp. 33-37, Mar., 1953.

Crystals That Remember

Ferroelectric crystals a few thousandths of an inch thick with the ability to remember vast amounts of information have been developed at the Laboratories. One such crystal only half an inch square can store approximately 250 bits of memory for an indefinite period.

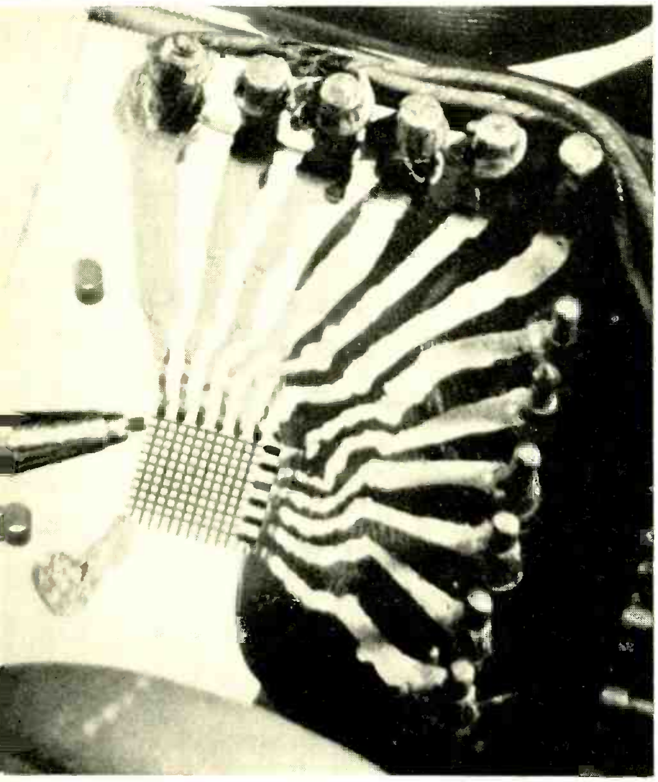
Artificially grown from the chemical barium titanate, these amber-colored crystals were developed to meet communications needs. Memory is vital to the operation of the telephone system. A dialed number is remembered on a set of relays in the central office until the connection is made with the other party. Memory also figures prominently in computing machines, which employ electronic tubes, magnetic drums and other devices for this purpose. These generally occupy large volumes of space. On the other hand, a few square inches of the crystals have a potential for information storage equal to many cubic feet of currently used apparatus. Hence the crystals may have significance in decreasing the space occupied by telephone switching systems.



This half-inch square barium titanate crystal can store 256 "bits," or items, of information, using a "yes or no" code. Note its size compared with the small carbon resistor.

Several members of the Laboratories' technical staff have cooperated in this development. The technique of using the crystals for memory devices has been developed by J. R. Anderson employing crystals grown by a special process, worked out by J. P. Remeika. W. J. Merz has been carrying on studies on the relevant physical properties of these crystals.

The telephone dial system and most computers use special codes. Telegraphy and wireless telegraphy were made possible by the universal dot-and-dash Morse code. The memory crystals store their information in



A magnified view of a barium titanate crystal only five-sixteenths of an inch square. The six active terminals on each side permit the storage of thirty-six "bits" of information by the crystal. Six other electrodes between the active ones may be connected to terminals, raising the number of bits of information that can be stored to 144.

Present and past Laboratories officials recently conferred at the Sandia Corporation, Sandia, New Mexico. Left to right: Donald A. Quarles, President of Sandia; Mervin J. Kelly, President of the Laboratories; James E. Dingman, Vice-President and General Manager of the Laboratories; and Timothy E. Shea, Vice-President and General Manager of Sandia. Both Mr. Quarles and Mr. Shea were previously Vice-Presidents of the Laboratories.

the "binary" code. This code consists of only two symbols designated by either a "yes" or a "no." Words, sentences or a series of numbers can be coded by using a large number of these symbols.

Coded information is "fed" into the crystals by the simple application of a positive or negative voltage, depending on whether a "yes" or "no" is desired. The information can be retained indefinitely in the crystal. When the crystal is read out it simulates the human process of "bringing to mind." Other circuits then interpret the stored charges in a millionth of a second, using microscopic amounts of electricity.

Microwave Routes

A new radio relay system to provide additional telephone circuits and a new route for TV programs between Chicago and Milwaukee has been placed in service. This system is the first section of a microwave route to connect Chicago, Milwaukee and Minneapolis. Construction along the Minneapolis leg is nearing completion with service scheduled for July, thus making telephone circuits available over the entire route in time for the height of the summer season. Initially, the new Chicago-Milwaukee route will provide one channel for TV transmission in addition to telephone circuits totaling 300 by late summer.

Plans for construction of a radio-relay route between New Orleans and Baton Rouge, La., were recently filed by Long Lines with the Federal Communications Commission. The 76-mile system would supplement existing routes now furnishing communications to southern Louisiana, and would interconnect with the nationwide long distance telephone facilities via the New Orleans-Jackson coaxial cable. Construction of the proposed route is scheduled to be completed early next year. Five channels on the new system are to be constructed – one westbound for television and two in each direction for telephone message service and protection. According to present plans, the westbound video channel will be ready to carry network programs to Station WAFB-TV, Baton Rouge, next February. Telephone channels will be completed later in 1954.

Talks by Members of the Laboratories

During the month of May, a number of Laboratories people gave talks before professional and educational groups. Following is a list of the speakers, titles, and place of presentation.

American Physical Society, Rochester Meeting

Becker, J. A., Field Emission from Oxygen on Tungsten.

Ditzenberger, J. A., and C. S. Fuller, Diffusion of Lithium into Germanium and Silicon.

Fuller, C. S., see J. A. Ditzenberger.

Geballe, T. H., The Seebeck Effect in Germanium.

Hagstrum, H. D., Theory and Experiment Concerning Resonance and Auger Transitions Which Occur as an Ion Approaches a Metal Surface.

Herring, C., Theory of Thermoelectric Power of Semiconductors.

Johnson, J. B., Secondary Electron Emission from a Diamond.

Kisliuk, P., Electrical Breakdown of Extremely Short Gaps.

Lander, J. J., Auger Peaks in the Energy Spectra of Secondary Electrons from Various Metals.

McAfee, K. B., and K. G. McKay, Measurement of Charge Multiplication in Germanium and Silicon p-n Junctions.

McKay, K. G., see K. B. McAfee.

Pearson, G. L., see H. Suhl.

Suhl, H., and G. L. Pearson, Faraday Rotation in Germanium.

I.R.E. Electron Tube Conference, Stanford University

Clogston, A. M., and H. Heffner, Periodic Focusing of Electron Beams.

Cutler, C. C., Excess Transverse Velocity in Electron Guns.

Heffner, H., Theory of the Backward Wave Oscillator.

Heffner, H., see A. M. Clogston.

Hines, M. E., Space Charge Wave Amplification in the Multi-Cavity Klystron.

Karp, A., Some Easily Built Spatial Harmonic Tubes and Circuit Structures.

Kompfner, R., Coupled Helices.

MacNair, D., Cavity Cathode Studies.

McDowell, H. L., Measurements of Change of Output Phase with Variations in Input Levels in Traveling Wave Tubes.

Mendel, J. P., see W. H. Yocum.

Saloom, J. A., Excess Transverse Velocity in Electron Guns.

Tien, P. K., Helix Modes of Propagation, Presented by J. R. Pierce.

Yocum, W. H., and J. T. Mendel, Periodic Magnetic Focusing of Electron Beams.

A.I.E.E. Summer Meeting, Atlantic City

Aikens, A. J., Control of Noise and Crosstalk on N1 Carrier Systems.

Bennett, W., Telephone System Applications of Recorded Machine Announcements.

Dickinson, F. R., see L. H. Morris.

Early, J. M., and R. M. Ryder, Measurements Made on Finished Transistors for Industry Standardization.

Ehrbar, R. D., see C. H. Elmendorf.

Elmendorf, C. H., R. D. Ehrbar, R. H. Klie, and A. J. Grossman, L3 Coaxial System Design.

Felch, E. P., Preliminary Development of a Magnettor Current Standard.

Finch, T. R., see R. W. Ketchledge.

Goertz, Matilda, see H. J. Williams.

Graham, R. S., see J. W. Rieke.

Gramels, J., Problems to Consider in Applying Selenium Rectifiers.

Grossman, A. J., see C. H. Elmendorf.

Jones, T. A. and W. A. Phelps, A Level Compensator for Telephotograph Systems.

Karnaugh, M., Map Method for Synthesis of Combinational Logic Circuits.

Ketchledge, R. W., and T. R. Finch, L3 Coaxial System Equalization and Regulation.

Klie, R. H., see C. H. Elmendorf.

Lange, R. W., 40 to 4,000 Microwatt Power Meter.

Lovell, G. H., see L. H. Morris.

Mallery, P., Transistors and Their Circuits in the 4A Toll Crossbar Switching System.

Morris, L. H., G. H. Lovell, and F. R. Dickinson, L3 Coaxial System Amplifier.

Phelps, W. A., see T. A. Jones.

Rieke, J. W., and R. S. Graham, L3 Coaxial System Television Terminals.

Ryder, R. M., see J. M. Early.

Schnettler, F. J., see H. J. Williams.

Sherwood, R. C., see H. J. Williams.

Slonczewski, T., Precise Measurement of Repeater Transmission.

Washburn, S. H., An Application of Boolean Algebra to the Design of Electronic Switching Circuits.

Williams, H. J., R. C. Sherwood, Matilda Goertz, and F. J. Schnettler, Stressed Ferrites Having Rectangular Hysteresis Loops.

Other Talks

Albano, V. J., Films on Metals, A.S.T.M. Subcommittee, Atlantic City, New Jersey.

Anderson, O. L., and D. A. Stuart (Cornell University), Kinetic Theories of the Glassy State, Third International Glass Congress, Venice, Italy.

Bozorth, R. M., Two Problems in Ferromagnetism, Watson Laboratories, Columbia University, New York City.

Burns, R. M., Chemical Problems in the Telephone Plant, Ohio Bell Plant Operation Conference, Cleveland, Ohio.

Calbick, C. J., Inorganic Replication: Interpretation of Electron Micrographs, A.S.T.M. Convention, Atlantic City.

Campbell, M. E., see C. L. Luke.

Campbell, W. E., Boundary Lubrication, Northwestern University, Evanston, Illinois.

Campbell, W. E., Solid Lubricants, M.I.T., Cambridge, Mass., and Northwestern University, Evanston, Illinois.

Darrow, K. K., Solid State Electronics, University of London, England.

Goucher, F. S., Quantum Yield in Photoconductivity, Naval Ordnance Laboratory Seminar, Silver Springs, Md.

Harris, J. R., Transistors (Series of Lectures on Transistor Electronics), University of Toronto, Canada.

Haynes, J. R., Some Fundamental Experiments in Transistor Physics, American Association of Physics Teachers, Mellon Institute, Pittsburgh, and Colloquium of College Physicists, State University of Iowa, Iowa City, Iowa.

Honaman, R. K., Looking Ahead in Telephony, Public Utilities Commission of Ohio, Columbus, Ohio.

Luke, C. L., M. E. Campbell, and Miss E. C. Wennerblad, Determination of Impurities in Semi-Conducting Materials, Rensselaer Polytechnic Institute, Troy, N. Y.

Mason, W. P., Domain Wall Relaxation in Nickel and Low Temperature Relaxations in Fused Quartz, Physics Seminar, Goettingen, Germany.

Mason, W. P., Use of Temperature and Time Stabilized Barium Titanate Ceramics in Transducers, Mechanical Wave Transmission Systems and Force Measurements, First International Congress on Electro-Acoustics, Holland.

Peters, H., see R. J. Tillman.

Peterson, G. E., Recent Progress in Experimental Phonetics (Series of Lectures), Pennsylvania State College.

Pfann, W. G., Zone Refining, American Chemical Society, Monmouth County Section, Squier Signal Laboratory, Fort Monmouth, N. J.

Read, W. T., Dislocation Theory, American Crystallographic Association, Ann Arbor, Mich.

Ryder, R. M., Junction Transistors, Transistor Short Course, Pennsylvania State College.

Schlaack, N. F., Development of the Long Distance Radio System, Symposium, I.R.E. Professional Group on Communication, American Telephone and Telegraph Long Lines Building, New York City.

Shockley, W., Semi-Conductor Theory, Transistor Short Course, Pennsylvania State College.

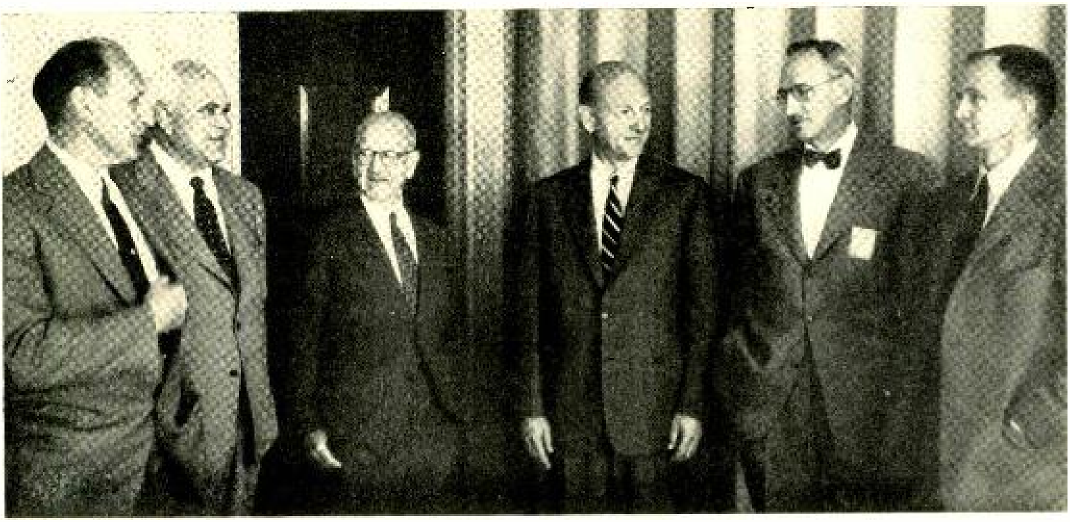
Shockley, W., Transistor Physics, Stanford University, Stanford, and University of California, Berkeley, Cal., and A.I.E.E.-I.R.E., San Francisco.

Struthers, J. D., and C. D. Thurmond, Equilibrium Thermo-Chemistry of Solid and Liquid Alloys of Germanium, A.C.S.-A.P.S. Meeting, Schenectady.

Tillman, R. J., and H. Peters, Submarine Cable Laying Operations in Bahama Islands for U.S.A.F., Kiwanis Club of Peapack-Gladstone, Peapack, N. J.

Thurmond, C. D., see J. D. Struthers.

Wennerblad, Miss E. C., see C. L. Luke.



David E. Lilienthal, former Chairman of the Atomic Energy Commission, was one of several visitors to the Laboratories in recent weeks. Shown here at Murray Hill are (left to right) Vice President J. E. Dingman, H. T. Friis, Director of Research – High Frequency and Electronics, Vice President W. H. Martin, Mr. Lilienthal, Vice President Ralph Bown, and J. B. Fisk, Director of Research – Physical Sciences.

Telephone for Plane Passengers

Air-to-ground communications, in which Bell Laboratories was one of the pioneers, have now been made available to airplane passengers as well as the crew. Bonanza Airlines, operating in Arizona, Nevada and Southern California, has announced regular telephone service for its passengers. The coastal harbor station at San Pedro, Calif., supplies the necessary relay linkage with ground lines.

Vocational Guidance Manual

S. P. Shackleton of the Laboratories is the author of a new book, *Opportunities in Electrical Engineering*, published by Vocational Guidance Manuals, Inc., New York City. In it he discusses the field of electrical engineering as a career in terms designed to be helpful to a high school or early college student.

The scope of electrical engineering and its place in the engineering profession are discussed in introductory chapters, after which the author considers qualifications and educational requirements. Licensing, the problems of getting started, opportunities for employment and advancement are discussed in separate chapters. Also listed and discussed are the various technical societies and professional organizations of interest to electrical engineers. There is also a list of accredited undergraduate engineering schools and their engineering curricula, together with a sizable bibliography.

Air Force Gets 100-Speed Teletypewriter Network

Private line service orders have been received from the United States Air Force for upgrading its teletypewriter weather network to 100 words per minute operation. DC telegraph sections on these circuits will, in most cases, be replaced with carrier. The type of facility to be used will be a newly developed telegraph system which, when used for end sections, can be terminated in the subscriber's office.

Network TV Addition

A new microwave link making network television service available to station WTPA, Harrisburg, Pa., was placed in service recently. Network programs to Harrisburg's second TV station are beamed from a microwave tower on the transcontinental radio-relay route to a telephone company building in Harrisburg. Local facilities, provided by the Bell Telephone Company of Pennsylvania, carry programs from there to the WTPA studio. With the addition of the new TV station, network programs are now available to 142 stations in 94 cities in the United States.