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The Channel Unit of the N1 Carrier

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Transmission Systems Development

One of the three general types of units that make up the N1 carrier equipment is the "channel unit"; the other two, that will be described in subsequent articles, are the terminal group units and the repeaters. As mentioned previously*, all units are of the "plug-in" type, which permits great concentration of equipment without appreciable loss of accessibility, and makes it easy for maintenance men to test each component and replace individual parts. Miniaturized equipment has been used throughout.

Figure 1 shows a channel unit. Each such unit is composed of three sub-assemblies shown in Figure 2. One includes the circuits for the compressor and resistance terminating circuits. Another contains the expandor and signaling equipment, while the third supplies the carrier oscillator, modulator, demodulator, and regulator equipment. Several of these component sub-assemblies will be described in detail in forthcoming issues of the RECORD. This article describes the interconnection and functioning of the sub-assemblies that make up the channel unit itself.

A block schematic of the channel unit is shown in Figure 3. The resistance terminating circuit at the left is mounted in the compressor sub-assembly and is arranged to permit the connection of the four-wire channel unit to a two-wire line. It may or may not be used depending upon the type of connecting switchboard or terminal circuits. Its use is limited to non-gain switching points, that is, for terminal use only.

Details of the terminating circuit are shown in Figure 4. The line to the switchboard forms one side of a resistance bridge. The input to the compressor is designed to operate at a level of 16 db below that of the switchboard, so the inherent loss of the resistance terminating circuit between the switchboard and the compressor is 16 db. The output of the expandor is connected to the resistance bridge through an adjustable attenuator. Minimum loss between the expandor and the switchboard is about 2 db.

Referring to Figure 3, voice signals pass from the terminting bridge circuit to the compressor, where they are compressed to half the input volume range. From the compressor, the path leads to the modulator through an input resistance pad (Figure

* RECORD. *July*, 1952, *page* 277.

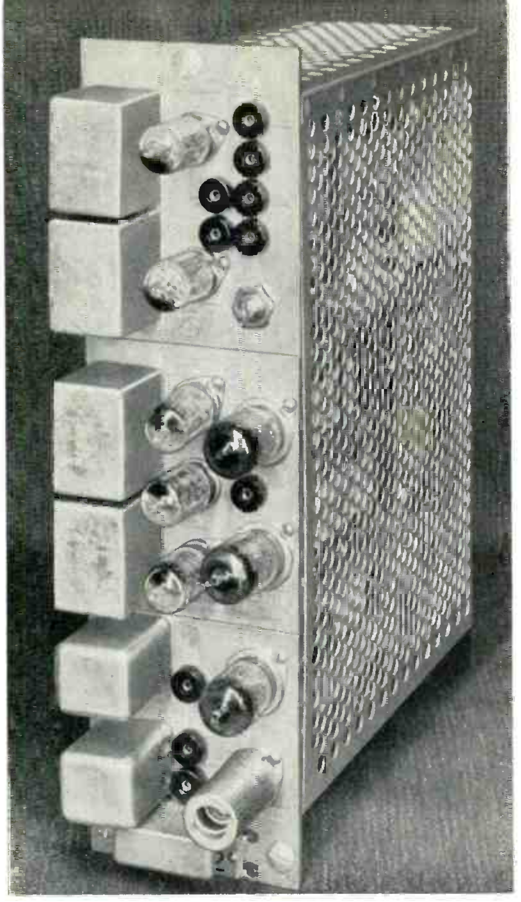


Fig. 1—Front view of a channel unit.

5). The modulator is a bridge arrangement of germanium varistors connected in series between the compressor and the combining multiple, which is essentially a resistance pad that connects each of the twelve channel units to the transmitting group unit that follows.

The crystal controlled oscillator supplies carrier power to the modulator. When the carrier and voice frequencies are combined in the modulator, two sidebands are generated that lie directly above and directly below the carrier in frequency. Since the N carrier is a twelve-channel system there are twelve different oscillator and modulator circuits that produce side bands which fall in a carrier frequency range from 168 kc to 256 kc. Higher order modulation products produced in the modulator are low enough so that no filtering is necessary except at second and higher harmonic frequencies of the carrier and these are removed by a low pass filter in the common circuits that follow the channel unit. Reduction of these harmonics is necessary to facilitate transmission measurements, reduce unnecessary loading of the amplifier, and minimize interference with other systems.

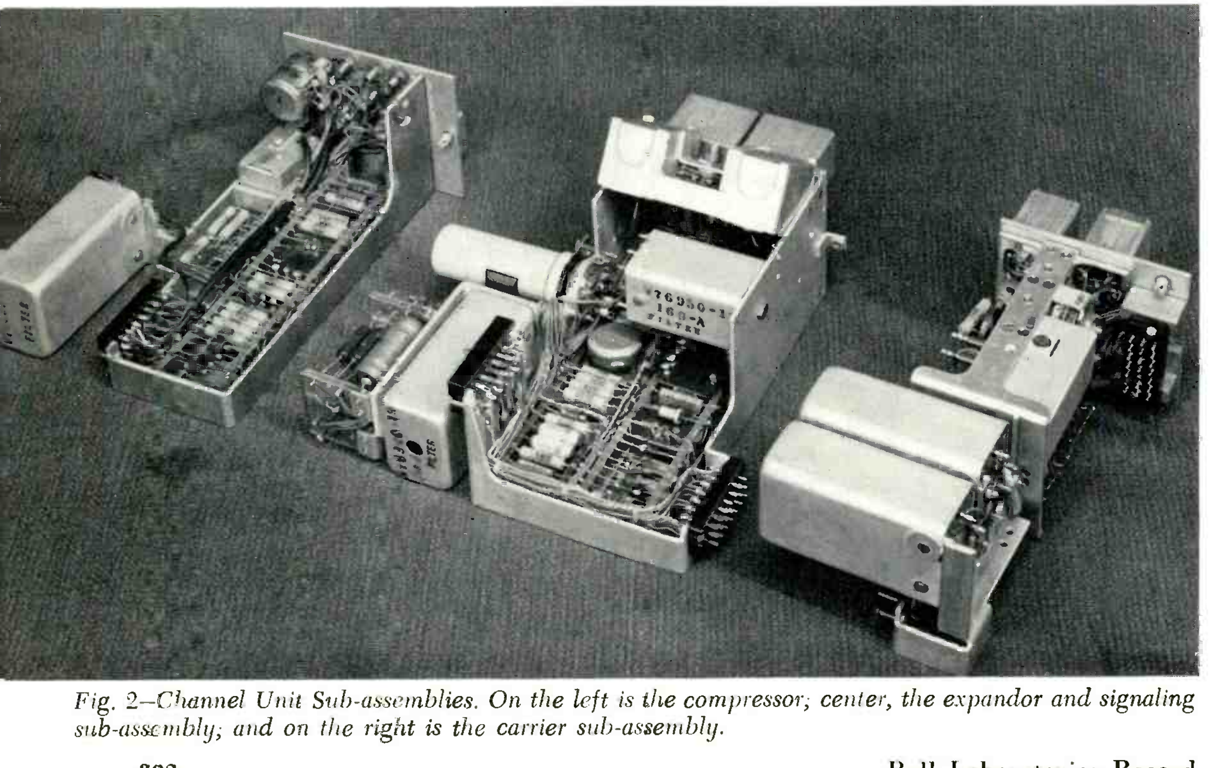


Fig. 2—Channel Unit Sub-assemblies. On the left is the compressor; center, the expandor and signaling sub-assembly; and on the right is the carrier sub-assembly.

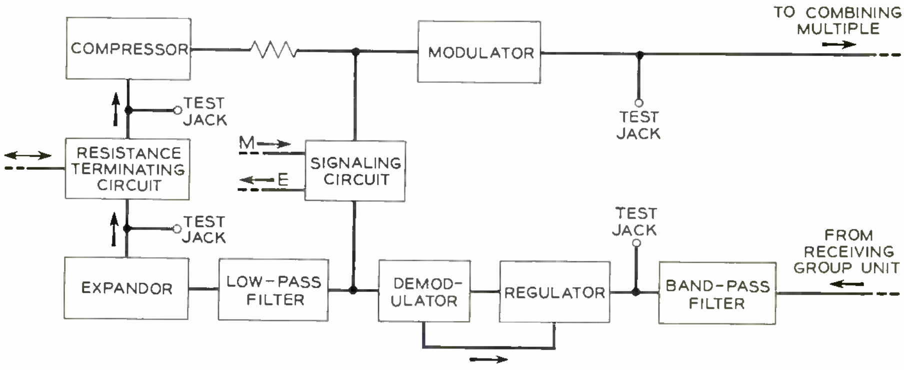


Fig. 3—Block schematic of the channel unit.

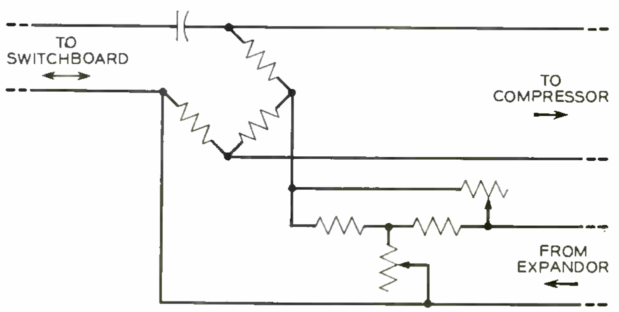


Fig. 4—Details of the terminating circuit.

Carrier frequency is transmitted over the line for demodulating the associated carrier frequency band back to voice frequencies and for regulation. To avoid overmodulation between the carrier frequencies in the terminal amplifier and repeater units, as well as to obtain stability of channel net loss, the carrier amplitude is held relatively constant by inserting a dc input to the balanced modulator. It is interesting to think of the modulator as a high frequency switch, in which the resistance to the flow of current is zero during one polarity of the carrier, and infinite for the opposite polarity. As long as the carrier voltage is high enough to make the modulator an efficient switch, changes in the carrier amplitude result in little or no change in the carrier that is transmitted.

In the receiving portion of the channel unit (Figure 3), the band pass filters at the input select the particular carrier and its associated sidebands from a group of twelve. The filter design is such that one or more channel units can be removed from service without affecting the performance of the others.

At the output of the bandpass filters, a potentiometer is used to adjust for transmission inequalities. This is followed by an automatic volume control type of regulator that adjusts for any subsequent changes in level of the received channel signals.

The demodulator, which uses the carrier transmitted over the line to detect the signal, is simply a rectifier, and the dc component of the output is used to control the gain of the receiving circuits. A simplified sketch of the regulator circuit is shown in Figure 6. Regulation results from a change in the grid bias on the first tube – low bias giving high gain and high bias giving low gain. If there is no received signal, the dc output of the demodulator is zero and the grid bias is +13 volts. A normal signal produces a dc voltage of –16 volts at the output of the demodulator, so there is a net bias of –3 volts. This method of operation gives what is generally known as "stiffness"; that is, over the normal control range, a change of 1 db in the input to the regulator results in approximately 0.1 db change in output, or a "stiffness" of ten.

From the demodulator, the voice frequencies and signaling frequencies are separated by a band pass filter and a low pass filter, and the voice frequencies then enter the expandor. Here the volume levels are restored, and the voice frequencies pass on to the resistance terminating circuit shown in Figure 3.

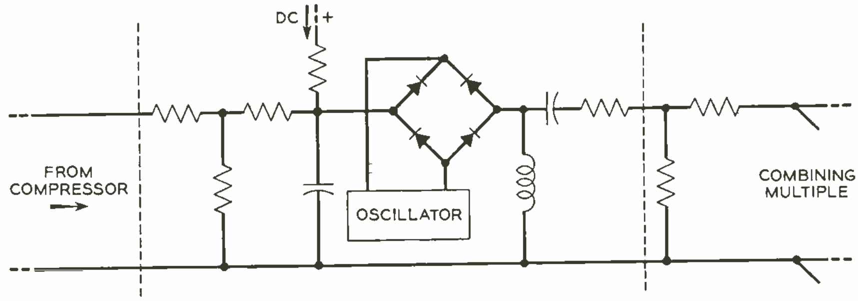


Fig. 5—Modulator circuit.

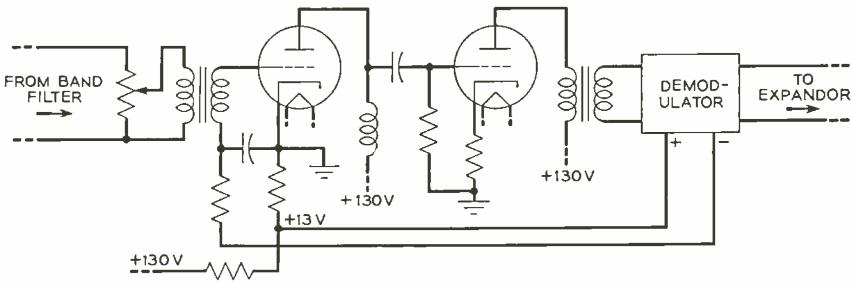


Fig. 6—Regulator circuit.

Transmission of supervisory and dial signals over the system is accomplished principally through the use of a 3,700-cycle tone, which is outside of the message transmission band. The usual battery and ground signals from the switchboard are connected to the M lead (Figure 3); they modulate the 3,700 cycle tone so as to operate a relay at the distant terminal, thereby transmitting ground signals over the E lead to the switchboard. The signaling arrangement will be fully described in a subsequent article.

No patching jacks are provided in the channel unit, nor are any required; lineup tests are made with a vacuum tube voltmeter connected at designated points throughout the unit. The most frequently used points, necessary to the maintenance of the system, are brought out to small test jacks located on the front of the channel unit assembly, and indicated in Figure 3. If local conditions indicate that patching jacks are needed, these can be supplied by the Telephone Company in that area.

THE AUTHOR: Immediately following his graduation from the University of Michigan in 1925, V. J. HAWKS came to the Bell Laboratories. His first work was in connection with long wave transatlantic radio; after two years, he became concerned with privacy systems and control terminals for use with radio telephone for radio transmission. This work included installation of a control terminal and privacy system in Hawaii in 1938.

Continuing in this field until World War II, he then turned to "Spiral-4" carrier systems for the Armed Forces, subsequently working on a Spiral-4 converter used to convert the terminal input and output frequencies to frequencies that would be satisfactory for transmission over open wire lines. This was followed by activities in the development and construction of sound operated devices for the U. S. Navy and a pulse code modulation system for the Signal Corps.

In 1946, he returned to control terminals for radio, until the N1 carrier development began. More recently, he has been involved in the development of Type-O carrier for open wire lines, and on rural carrier.

Magnetic Domains

H. J. WILLIAMS
Physical Research

When a piece of ferromagnetic material – a relay core, for example – is demagnetized, a compass will be unaffected when brought near it, and iron filings sprinkled on it do not indicate the presence of magnetic fields. But when examined microscopically, the entire object is found to consist of small regions, each of which is magnetized to saturation in a certain direction. These regions, called "magnetic domains", are oriented in various directions so that the net magnetization in any direction is zero.

Between two adjacent domains is a transition region or boundary that has been given the name of "Bloch wall", after Felix Bloch who first worked out the theory of this intricate layer. When a magnetic field is applied, a pressure is exerted on the domain boundaries, causing them to move so that some domains grow, while others shrink, thus producing a resultant magnetization in the direction of the applied field.

A piece of ordinary iron is usually composed of a number of relatively small crystals oriented in a random manner, and each crystal itself contains a large number of domains. The resulting domain structure is so complex that it is practically impossible to determine the complete structure. The study of domain structure, however, is greatly simplified by using large size single crystals. Specimens from single crystals have been cut in the form of closed magnetic circuits, which may be considered a special kind of transformer core. These cores have a relatively simple domain structure; this structure and the manner in which it changes under the influence of a magnetic field can readily be studied. By this means, the theoretical principles of domain geometry and dynamic behavior have been checked experimentally.

Experiments on such crystals of iron show that they are much more easily magnetized in some directions than in others. Figure 1 illustrates this in relation to the positions of the atoms in the crystals. The circles represent the positions which centers of the atoms occupy on an imaginary framework or lattice. Only a fraction of the atoms in a crystal of ordinary size is shown in the figure, because of the smallness of atomic dimensions, but the same pattern, that of a cube, is repeated throughout the whole of the single crystal. The arrows indicate the directions of "easiest" magnetization, which are along the edges of the cube. The magnetization in a domain tends to lie parallel to one of these directions.

Single crystals of iron containing 3.8 per cent of silicon by weight have been produced by melting pure materials in pure hydrogen and solidifying very slowly.* The addition of silicon facilitates the growth of the single crystal, without materially changing the domain structure. Figure 2 shows a single crystal specimen cut in the form of a hollow rectangle having each side parallel to a direction of easy magnetization. After cutting, the specimen was deeply etched and annealed in pure hydrogen; it was then carefully polished, with the surfaces to be examined being electrolytically polished, until microscopic examination showed that all scratches had been removed.

To observe the domain structure, a colloidal mixture of extremely fine iron oxide (magnetite) in a soap solution was pre-

* J. G. Walker, H. J. Williams, and R. M. Bozorth "Growing and Processing of Single Crystals of Magnetic Materials," *Review of Scientific Instruments,* Vol. 20, No. 12, *pages* 947-950, *December*, 1949.

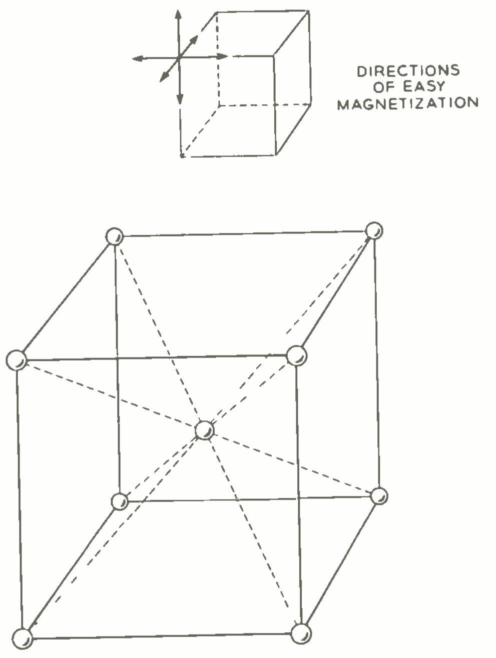


Fig. 1—Positions of the atoms in an iron crystal and the directions of easy magnetization.

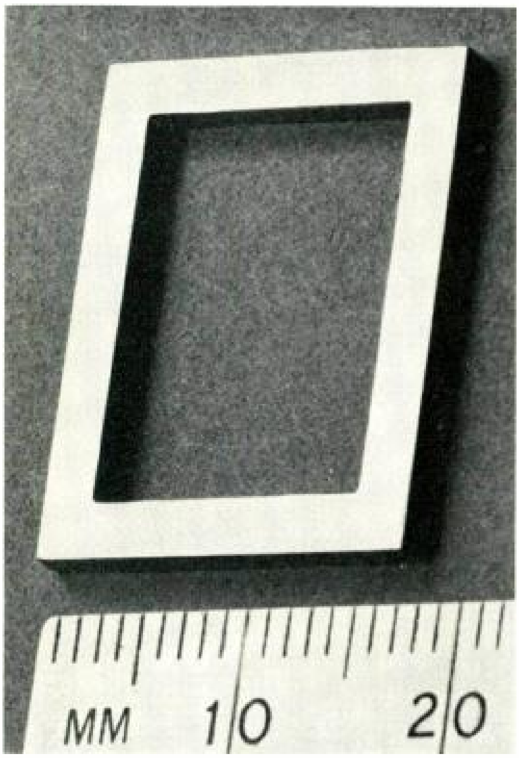


Fig. 2—A specimen cut in the form of a hollow rectangle with sides parallel to directions of easy magnetization.

pared.* A drop of this colloidal suspension was placed on the crystal surface, which was then covered with a microscope cover glass, so that a thin layer of the suspension was left between the crystal and the cover glass. The assembly was then placed under a microscope having a magnification of about 150 diameters. The stray magnetic fields at the domain boundaries attract the tiny particles of magnetite and cause them to collect along the domain boundaries; the patterns formed in this manner show the complete outline of the domains.

A pattern so formed on the corner of the crystal is shown in Figure 3, where the enlargement of (b) is shown at the right. Similar patterns were observed on the other corners. Following the pattern around the crystal, the domain structure is that presented by Figure 4 – a domain boundary at each corner and one that extends completely around the rectangle, forming eight domains in all. The four inner domains form a flux circuit carrying flux in a clockwise direction around the crystal, and the four outer domains carry flux in a counterclockwise direction.

Now, if a magnetic field is applied to the crystal by passing current through a winding on one leg of the rectangle, the magnetic field exerts a pressure on the long boundary that forces it to move. Displacement of the boundary causes the relative values of the two flux circuits to change so that the net flux around the crystal varies. As the boundary moves from one side to the other, the net flux changes from saturation in one direction to saturation in the other direction.

To understand the nature of this domain boundary, it is desirable that we review the nature of magnetism itself. The electrons that are responsible for the magnetic properties of iron, cobalt, nickel and their alloys lie in a definite "shell" in the atom. As shown in Figure 5 there are four shells or regions, more or less well defined, into which all the electrons circulating about the nucleus of

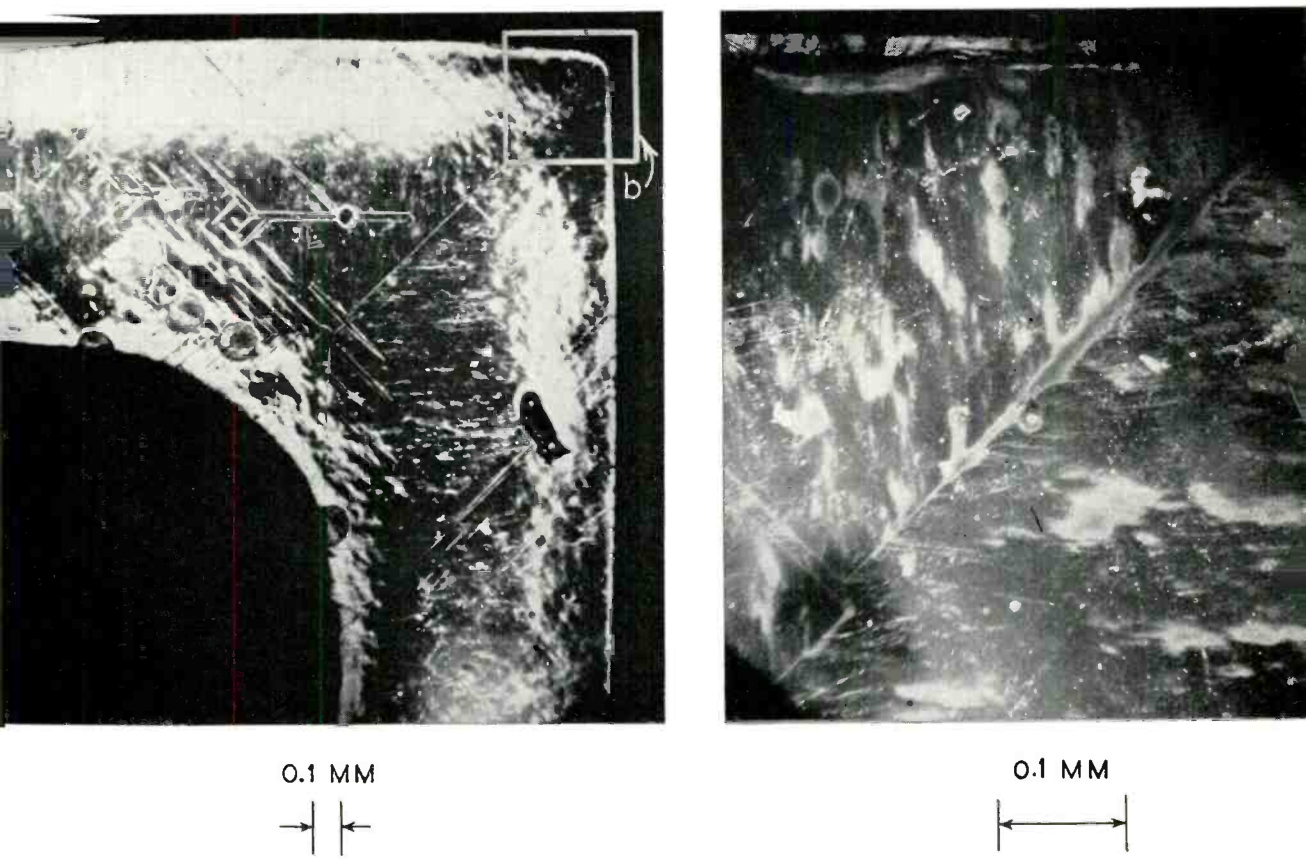
* H. J. Williams, R. M. Bozorth, and W. Shockley, "Magnetic Domain Patterns on Single Crystals of Iron," *Physical Review*, Vol. 75, *pages* 155-178, *January* 1, 1949. See also C. Kittel, *Review of Modern Physics*, Vol. 21, pages 541-583, October, 1949.

the atom may be divided when the atom is separated from its neighboring atoms – such as in a gas. Some of these shells are subdivided as indicated in Figure 5. When the atoms come close together as they do in a solid, the fourth or outermost shell of each becomes disrupted and the two electrons which comprise it wander from atom to atom, and are the "free" electrons responsible for electrical conduction. The electrons in the outer part of the third shell are those responsible for the distinctive kind of magnetism found in iron, cobalt and nickel. Some of these electrons spin in one direction and some in the opposite, as indicated, so that their magnetic moments neutralize each other partially, but not wholly, and the excess of those spinning in one direction over those spinning in the other causes each atom as a whole to behave as a small permanent magnet. It is these "uncompensated electron spins" which are the elementary magnets responsible for ferromagnetism.*

In a domain, all of the spins are parallel. The region of parallel spins on the left side of Figure 6 represents a domain with the spins pointing up, and the region on the right is a domain with the spins pointing down. The transition region between the two domains is the domain boundary, which is about 300 atomic layers in thickness. In each successive atomic layer the orientation of the spins gradually changes from the alignment in one domain to that in the other. In doing so, some of the spins are directed normal to the surface, so that flux emerges from the surface along a boundary. It is this flux escaping along a boundary that attracts the particles of magnetite, and thus forms the patterns. When a magnetic field

* *Bell System Technical Journal,* Vol. 19, *page 2, January,* 1940.

Fig. 3—Powder pattern formed at the corner of a hollow rectangle, showing the domain boundary. The enlargement of (b) is shown at the right.



is applied, it causes the boundary to move so that one domain increases in size while the other decreases. The model of Figure 7 illustrates this – the direction of the arrows changes as the force on the rod (representing the applied field) is applied to simulate movement of the domain boundary.

Using the recording fluxmeter*, the hysteresis loop shown in Figure 8 was obtained. Each point on the loop corresponds to a certain position of the boundary. As the boundary moves across the crystal under the application of a magnetizing force, one side of the loop is traced, and, on reversing the field, the boundary moves back and the other side is traced.

* RECORD, *June*, 1952, *page* 247.

Suppose that the boundary is in a central position, corresponding to the point A on the left hand vertical portion of the hysteresis loop as shown in Figure 9. Now imagine the magnetizing force to be decreased slightly from A to B. No corresponding motion of the boundary occurs. It is quite likely that this is because slight crystal imperfections restrain the motion of the boundary. When the restraining force of the imperfection is overcome by a larger decrease in the applied field, the boundary starts to move back toward the side from which it came even though the field is tending to force it in the opposite direction. When the field is decreased to zero, the boundary returns all the way; this is shown by the minor hysteresis loop CABC in Figure 9.

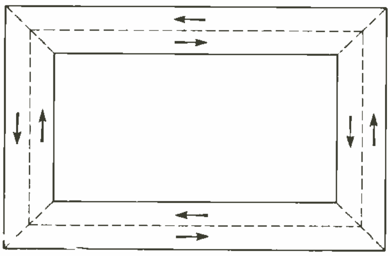


Fig. 4—Drawing of the domain boundary extending completely around the hollow rectangle.

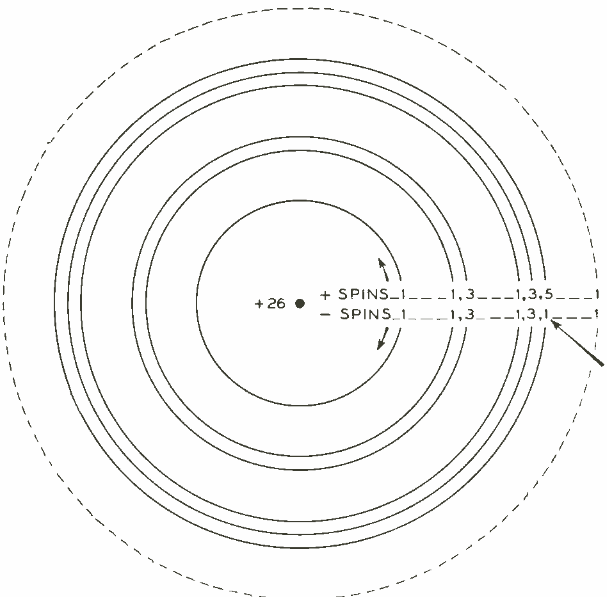


Fig. 5—Electron shells in an atom of iron. The arrow, right, indicates the "uncompensated" electron spins that are responsible for ferromagnetism.

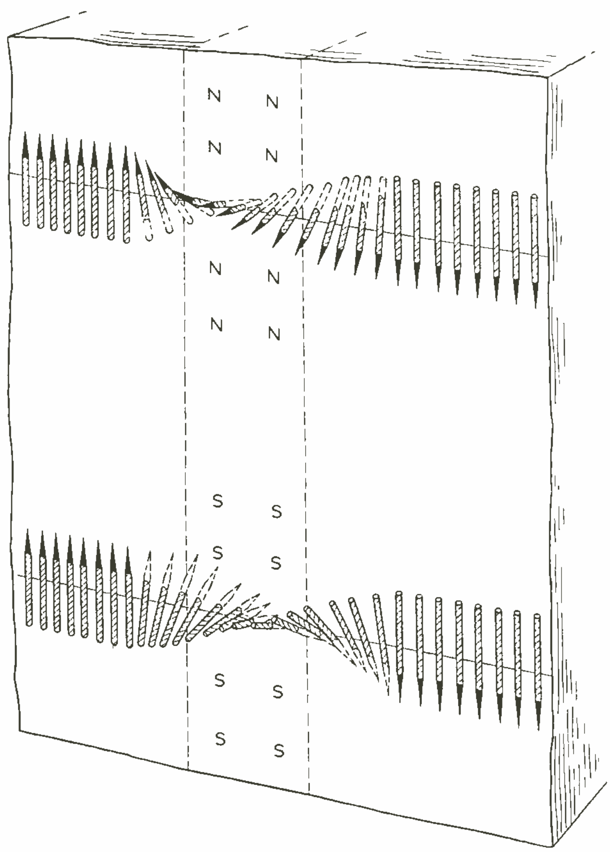


Fig. 6—Schematic of a domain boundary showing electron spin orientations that occur on either side of the boundary.

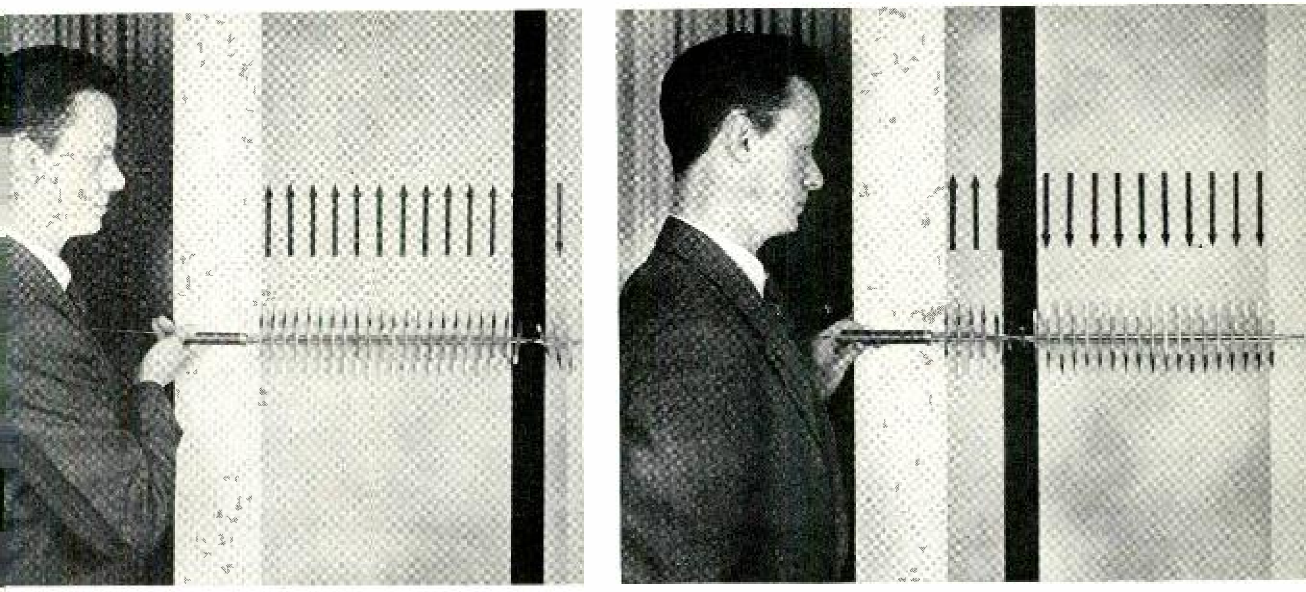


Fig. 7—J. G. Walker illustrates the manner in which a domain boundary moves under the influence of a magnetic field, with the corresponding "electron spins" that produce powder patterns at the boundary. In Figure 7(a), the boundary is at the right; (b) indicates the boundary position near the left hand side.

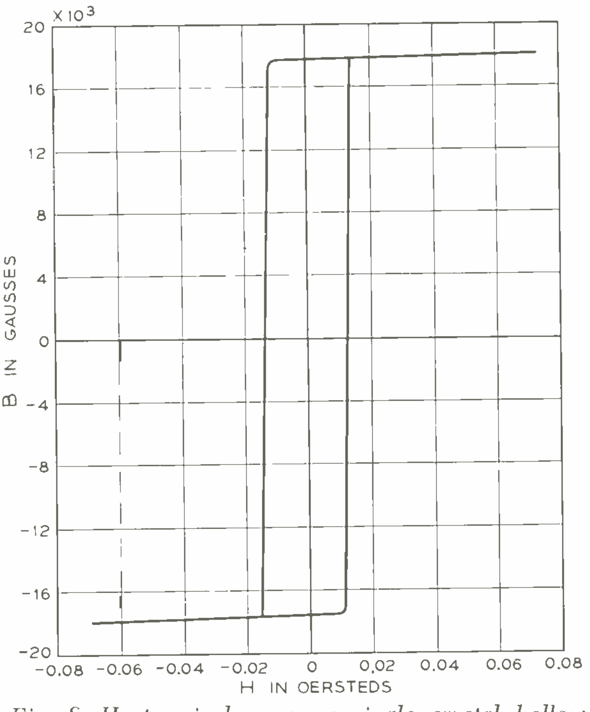


Fig. 8—Hysteresis loop on a single crystal hollow rectangle having its sides parallel to the easy directions of magnetization.

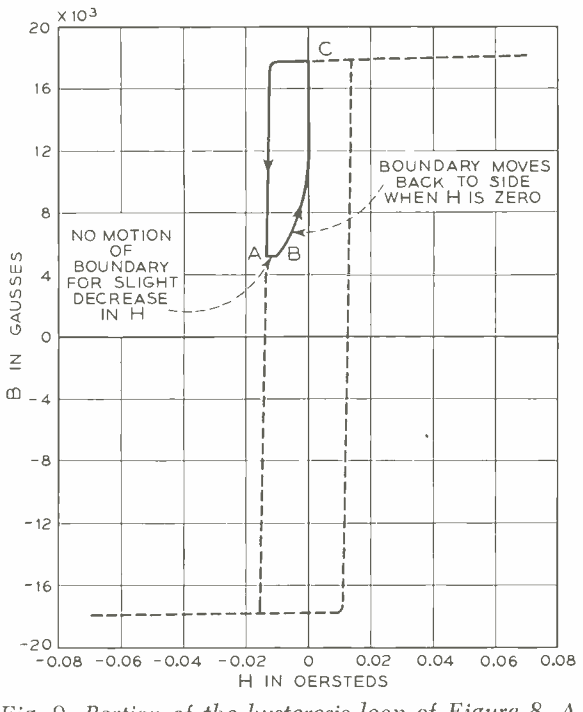


Fig. 9—Portion of the hysteresis loop of Figure 8. A slight reduction in magnetizing force produces no motion of the domain boundary, but reducing the field to zero causes the boundary to move to its original side position.

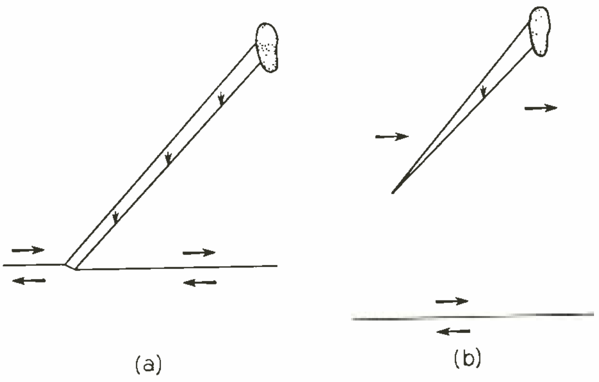


Fig. 10—A secondary domain boundary forms at a crystal imperfection, as indicated in (a); when the applied field is increased, and the main boundary moves, the secondary boundary stretches until it finally snaps off, as shown in (b).

This tendency of the boundary to return to the side where it was previously, is sometimes spoken of as the "magnetic memory." The boundary "remembers" which side it came from and tends to return. The memory is due to small, spike-like domains that form at crystal imperfections. When the boundary moves, due to a change in the applied field, these secondary domains tend to cling to it; the spike-like domains then stretch and finally snap off. This process is shown by the drawing of the powder patterns in Figure 10, and the actual pattern in Figure 11.

Domain boundaries have a surface energy similar to a soap film – they tend to contract and so the spikes exert a force on the main boundary. It is these spike-like domains that cause the magnetic memory by clinging to the moving wall and stretching, in some cases, as much as half-way across the crystal. When the field is removed, the spike-like domains pull the boundary back.

They are also responsible for the major part of the coercive force. Calculations by W. Shockley of coercive force, based upon the estimated number of imperfections throughout the volume, have produced good agreement with the observed value.

When a spike snaps, there is a sudden jump in part of the boundary, and it is these sudden jumps in the boundary, or sections of it, that cause the Barkhausen effect.* By connecting a secondary winding on the specimen to an amplifier and a loudspeaker, the Barkhausen noise can be heard while the boundary movement is observed with the microscope. This experiment gives new

* H. J. Williams and W. Shockley, *Physical Review*, Vol. 75, page 170, 1949.

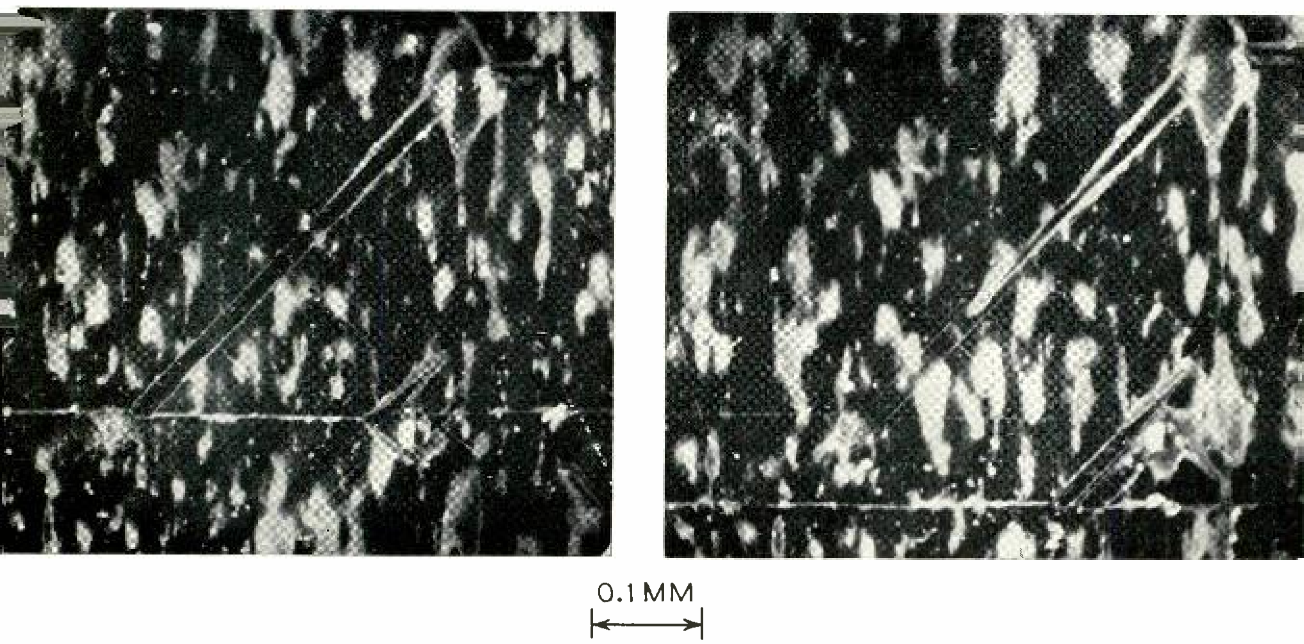


Fig. 11—Photomicrograph of the secondary domain boundary represented schematically in Figure 10.

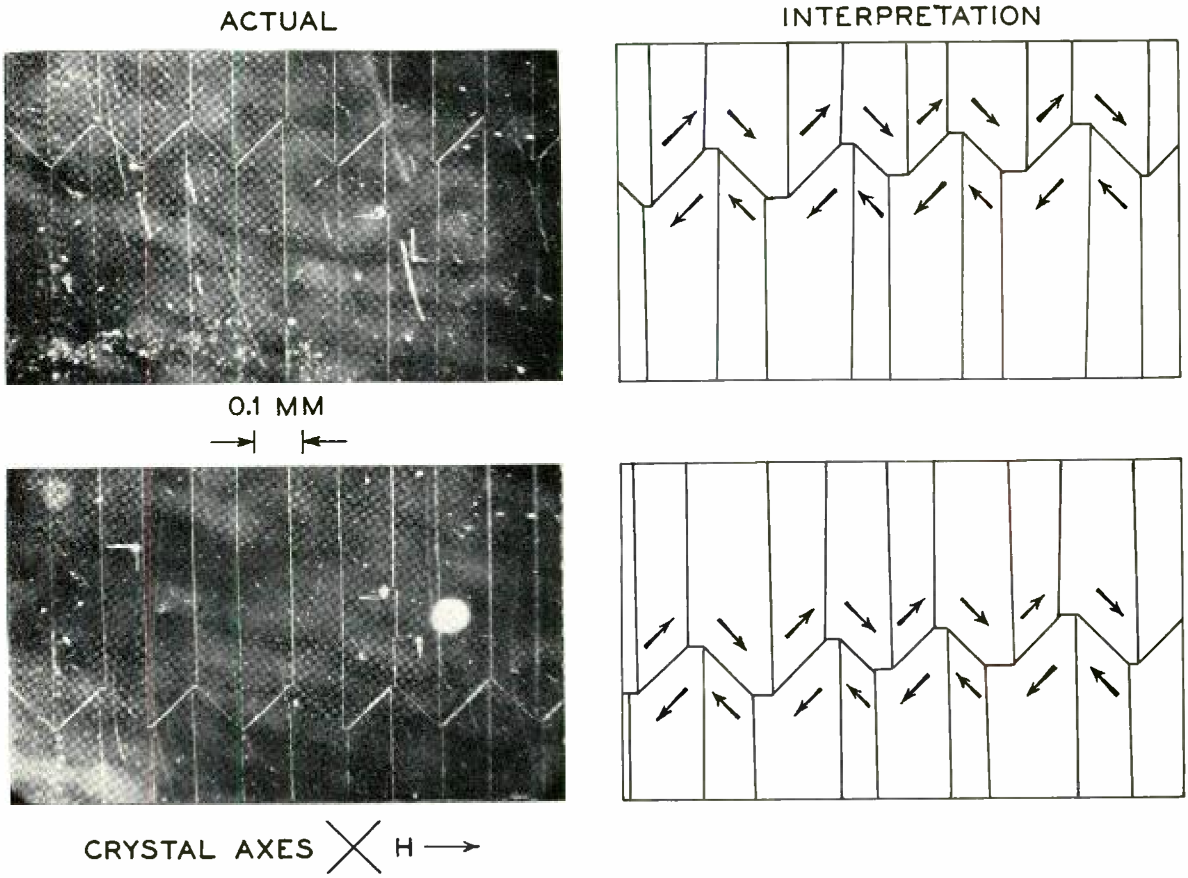


Fig. 12—Domain patterns showing displacement of the zigzag boundary due to an applied field for the crystal of Figure 12.

information concerning the Barkhausen effect, since it definitely shows that each Barkhausen pulse is not necessarily due to a reversal of an entire domain, as was formerly thought to be the case.

A more complicated domain structure is shown in Figure 13. This crystal has the length of each side of the hollow rectangle inclined at an angle of 45 degrees to two directions of easy magnetization. The magnetization in each domain is parallel to one of the directions of easy magnetization. There is a zigzag boundary, extending along the length of the crystal, that separates two sets of domains. One set carries flux in a zigzag manner clockwise around the crystal, while the lower set carries flux in a counterclockwise manner. Figure 12 shows an enlarged view of a section of Figure 13.

A hysteresis loop, Figure 14, traced on the fluxmeter as the boundary moves from

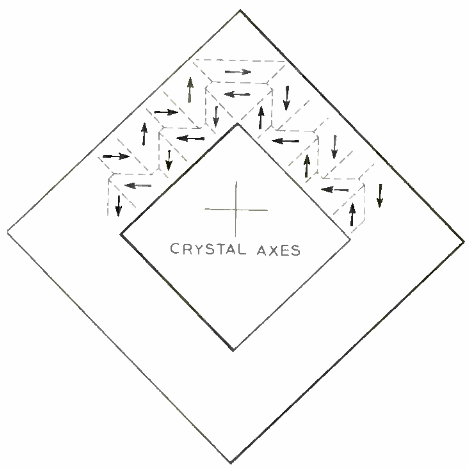


Fig. 13—*A single crystal cut to an angle of 45 degrees to two directions of easy magnetization, showing the domain structure.*

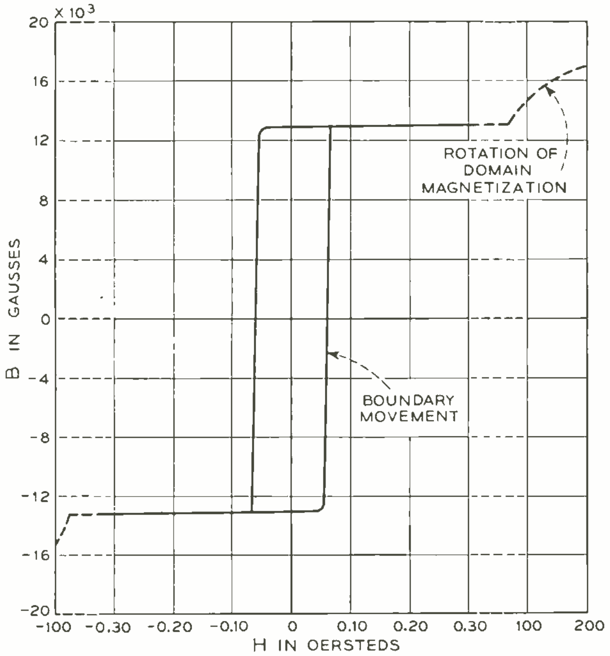


Fig. 14—*Hysteresis loop traced by the fluxmeter as the zigzag boundary of Figure 13 moves from one side to the other and back; the dashed line shows the magnetization curve at high fields.*

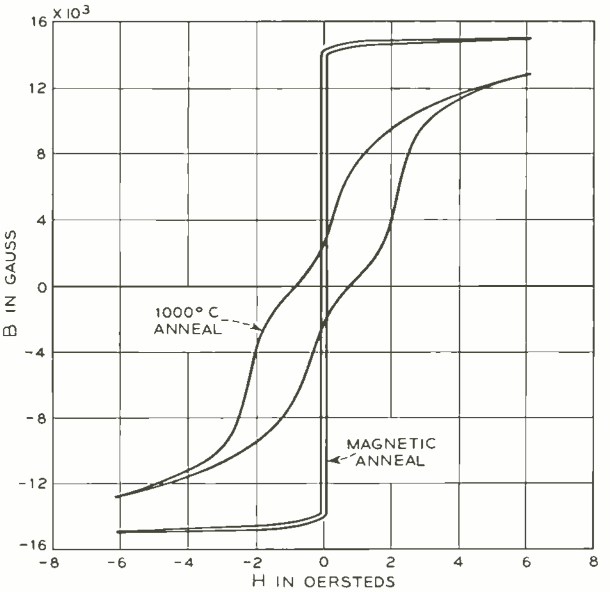


Fig. 15—Comparison of hysteresis loops of a polycrystalline Perminvar ring 3.8 cm outside diameter, 3.2 cm inside diameter, 0.04 cm thick, (a) after ordinary 1000 degree C anneal, and (b) after a subsequent magnetic anneal.

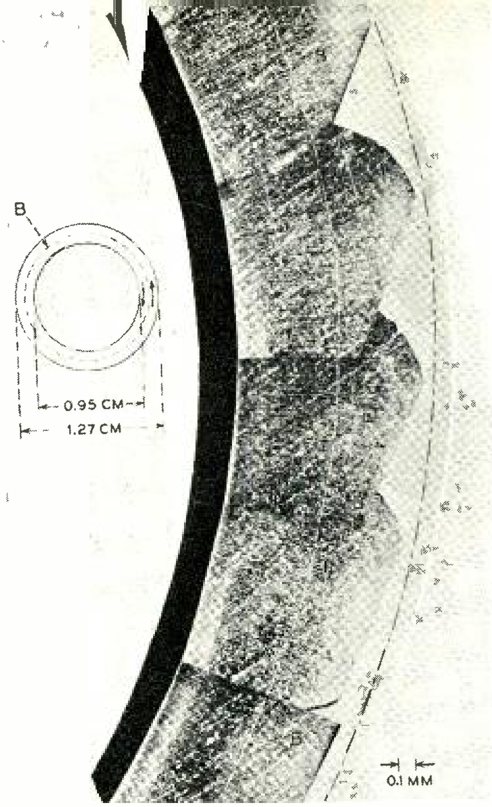


Fig. 16—Polycrystalline Perminvar specimen (left) on which a series of adjacent magnetic domain boundary patterns were observed (right), showing a single domain boundary extending around the ring.

one side to the other* shows that the movement is accomplished with a relatively weak field, but magnetization does not change from saturation in one direction to saturation in the other, as was the case for the first crystal. Magnetization of the second crystal reaches seven-tenths of saturation, because the magnetization in the domains is inclined at an angle of 45 degrees to the sides of the specimen. Saturation of the specimen requires rotating the magnetization in the domains into a position parallel to the field, and this requires very high magnetizing forces. This dynamic behavior of the domain structure in this crystal illustrates very clearly the two fundamental processes by which changes in magnetization may occur. One is domain boundary movement that occurs at relatively weak fields and the other is domain rotation, in which a higher field is required to rotate the domains from the easy direction

* Motion pictures of many of these experiments have been made in collaboration with F. M. Tylee.

of magnetization into the hard direction.

More recent studies have been made to observe the domain structure of polycrystalline perminvar having rectangular hysteresis loops*. Specifically, this has been done on a sample containing 43 per cent nickel, 34 per cent iron, and 23 per cent cobalt, after heat treatment in a magnetic field. Some idea of the effectiveness of this treatment can be obtained from the hysteresis loops of Figure 15. The "wasp-waisted" loop is that obtained on a ring sample after a 1,000 degree C anneal, while the vertical-sided loop is from the same sample after a

* H. J. Williams and Matilda Goertz "Domain Structure of Perminvar Having a Rectangular Hysteresis Loop," *Journal of Applied Physics*, Vol. 23, No. 3, *pages* 316-323, *March*, 1952.

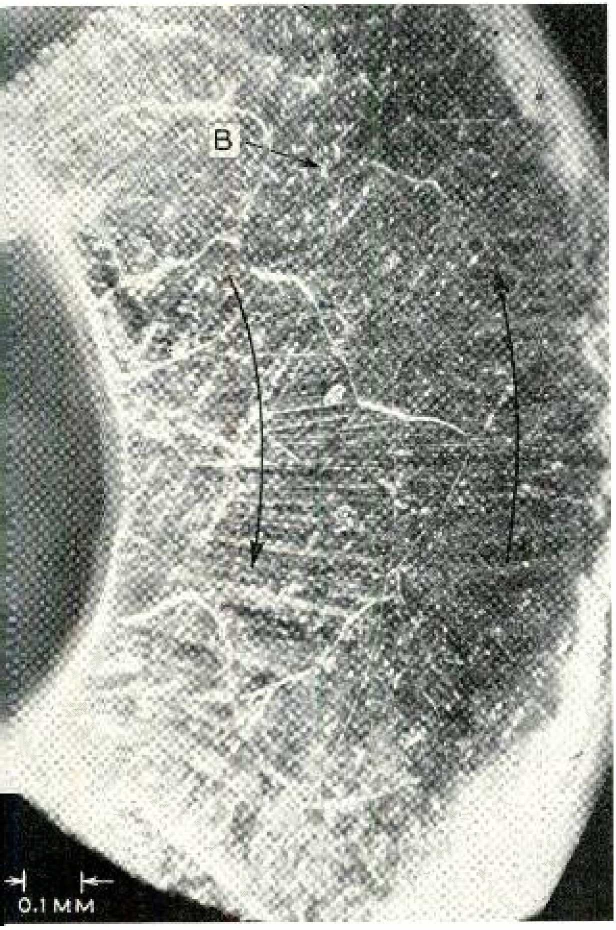


Fig. 17—Domain pattern showing crystal boundaries and a circumferential domain boundary B crossing them.

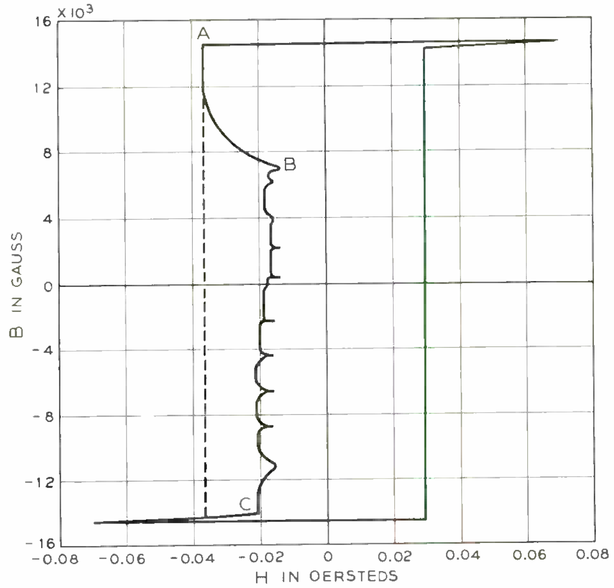


Fig. 18—Hysteresis loop of Perminvar after magnetic anneal. A—Starting field; A-B—Rapid decrease of applied field; B-C—Hysteresis loop traced under equilibrium conditions. Dotted line indicates path if the applied field had not been reduced.

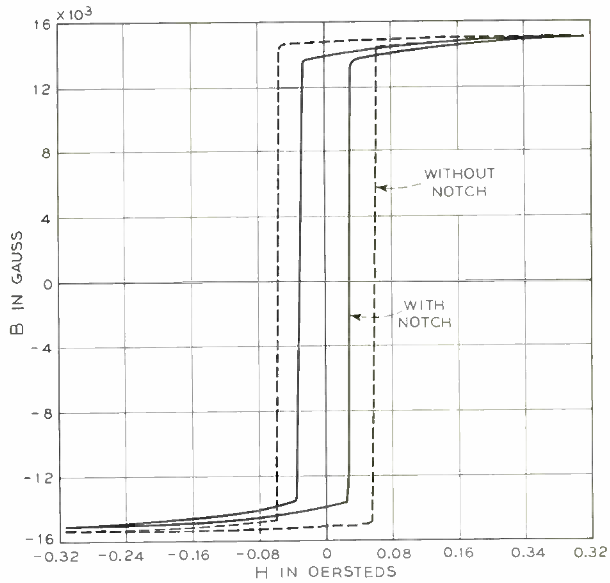
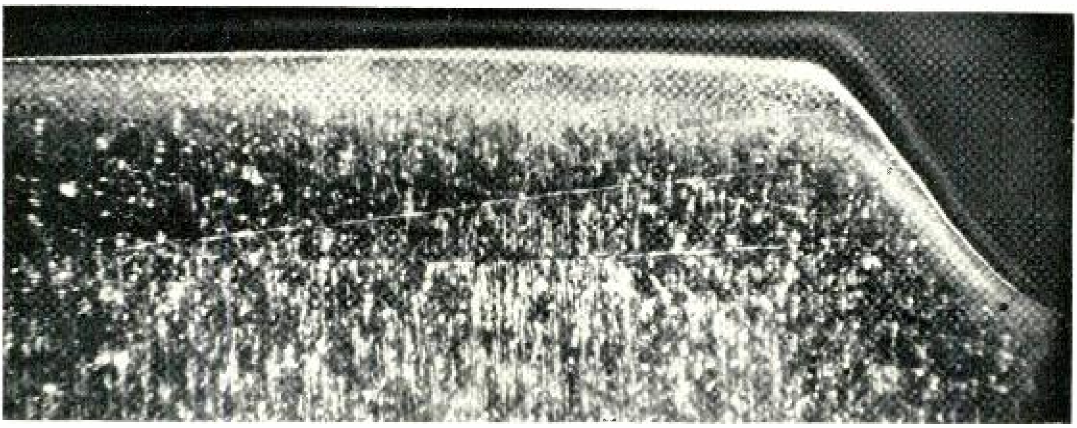
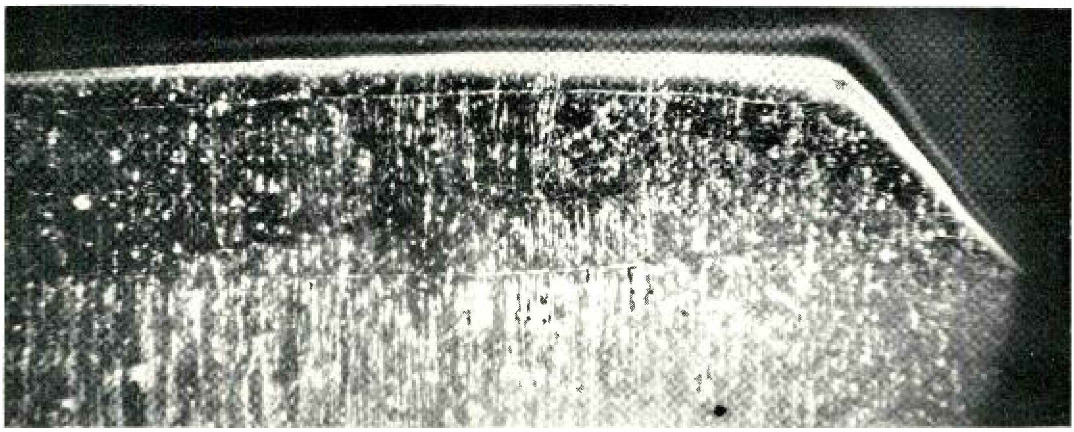


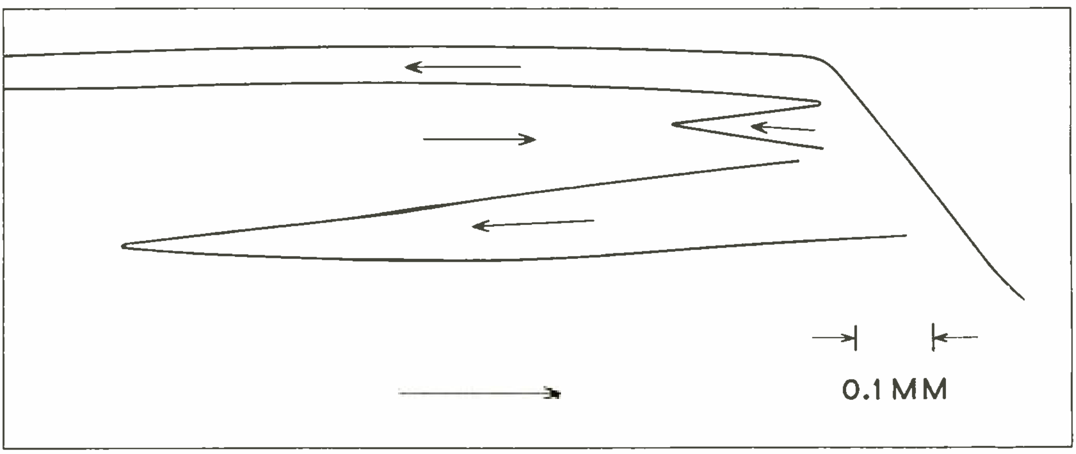
Fig. 19—Effect of notching the specimen to create an artificial nucleus of reverse magnetization.



(a)



(b)



(c)

Fig. 20—Domain patterns showing nuclei of reversed magnetization at a notch. (a) Positive vertical field applied (b) Negative vertical field applied (c) Interpretation.

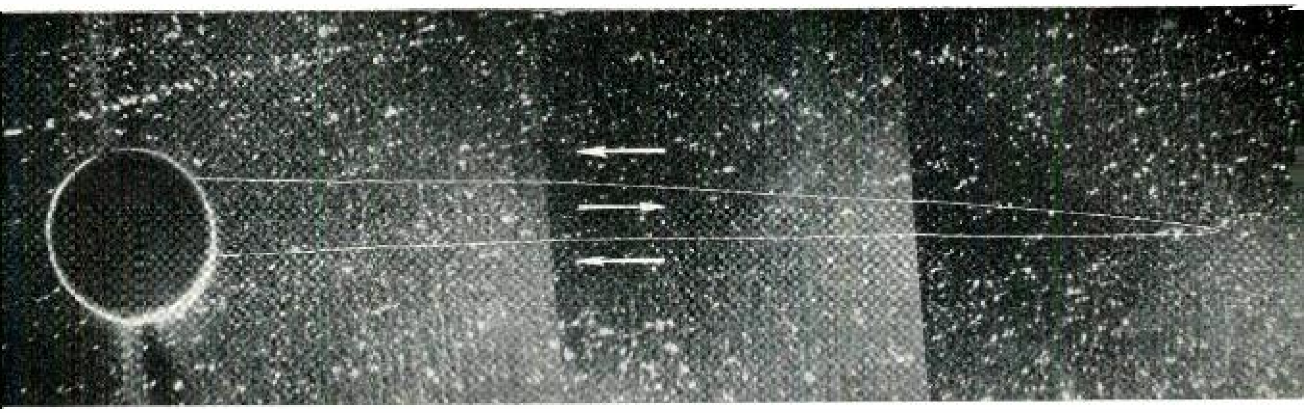


Fig. 21—Domain pattern of a nucleus of reversed magnetization at a 0.2 mm hole in a Perminvar ring. Arrows indicate direction of magnetization.

0.1 MM

1,000 degree C anneal for one hour, followed by cooling from the Curie temperature (about 700 degrees C) in a magnetic field of 15 oersteds. The practical value of magnetic materials having rectangular hysteresis loops lies in their application to mechanical contact rectifiers and memory storage devices.

Using a polycrystalline ring sample of the size shown at the left in Figure 16, heat treated in a magnetic field, a series of adjacent magnetic domain boundary patterns, right, shows a single domain boundary extending part way around the polycrystalline ring, and forming two oppositely directed circular flux circuits. These patterns show the expected direction of easy magnetization; this direction follows closely the direction of the heat treating field across crystal boundaries and along a curved path. A closer view, Figure 17, shows the crystal boundaries and a circumferential domain boundary crossing them.

Application of a magnetizing force, just as in the experiments with the single crystal specimens, causes the circumferential domain boundary to move, so that one type of flux circuit grows at the expense of the other. The net flux flowing around the ring is, of course, the difference of the clockwise and counterclockwise flux circuits.

After saturation in one direction, when the magnetization begins to reverse, a *nucleus of reverse magnetization* forms at some favorable point in the ring and then grows until it spreads over the entire specimen. A higher field (starting field) is required to form a nucleus than to continue its growth once it has started.

In Figure 18, at the point A, the starting field has been reached and the magnetization starts to decrease rapidly; if the applied field had not been decreased, the curve would have followed the dotted line, giving a vertical side of the hysteresis loop similar to the one on the right hand side. A decrease of the field, however, to a value slightly less than the value of the critical field, stopped the change in magnetization. Along most of the section from B to C the loop is being traced under equilibrium conditions. The short horizontal lines show that when the strength of the field is decreased slightly, there is no change in magnetization.

One method of establishing a nucleus is to use an auxiliary winding to produce a higher field in one part of the specimen than in the rest of it. This causes an elongated nucleus to form in this region. The exact manner in which a nucleus forms is not completely understood, but previous work on domain patterns has shown nuclei of reverse magnetization occurring at crystal imperfections. This suggested making an artificial imperfection in the specimen. A notch about 0.1 mm deep was filed in the outer circumference of the ring specimen; hysteresis loops taken before and after notching are as shown in Figure 19. The coercive force and the hysteresis loop are decreased by a factor of two. The domain pattern obtained with the notched specimen, illustrating the nucleus of reversed magnetization, is shown in Figure 20. A nucleus of reverse magnetization occurring at a small hole drilled in a specimen is also shown in Figure 21.

Fundamental studies on magnetic materials, while seemingly of little immediate practical value, eventually result in important contributions to our engineering achievements. Although many of the successes in our understanding of magnetic phenomena have been due to the application of our knowledge of the structure of atoms in solids, in many ways the magnetic studies have in turn contributed to our understanding of atomic structure. Studies of the domain structure of magnetic materials are, and will continue to be, of major importance in the understanding of magnetic materials that are used in the communication field.

THE AUTHOR: After spending two years at Ohio State University, H. J. WILLIAMS transferred to the University of Wisconsin, where he graduated in 1925 with an A.B. degree, majoring in physics. He then spent a year in the Magnetics Development Group at Hawthorne, Western Electric, returning to Wisconsin for graduate work for the next two years. In 1929, he came to the Laboratories, where he went directly into magnetics research. His entire career at the Laboratories has been devoted to magnetic studies; these have involved effects of tension on magnetic properties, investigation of grain oriented alloys, aluminum iron alloys, phosphorous iron, silicon iron, and single crystal studies of nickel, cobalt, and other alloys of iron. During World War II, he made investigations of various alloys for transducers to be used in underwater sound (Sonar) devices. Toward the end of the war and subsequently, he was concerned with aging effects in magnetic iron. For several years recently he has concentrated on domain pattern studies. Mr. Williams is a Fellow of the American Physical Society and has published many articles on magnetic topics in several different technical societies' publications.

Professional Papers

During the past month, papers have been presented by several members of the Laboratories before professional and educational groups.

At the Gordon Conference on Non-Stoichiometric Compounds in New Hampton, N. H., J. A. Burton spoke on *Semi-Conductors from the Chemical Point of View.*

R. M. Burns discussed the *Corrosion of Metals* before a meeting of the Northeastern Association of Chemistry Teachers at Burlington, Vt.

W. P. Mason and S. D. White traveled to Istanbul, Turkey, to present a joint paper, *New Techniques for Measuring Forces and Wear in Telephone Equipment,* at the Eighth International Congress of Applied Mechanics.

The I. R. E. Convention in Long Beach, California, heard papers presented by six members of the Laboratories. The authors and titles were: W. R. Bennett, *Practical Significance of Information Theory in Transmission Problems;* H. M. Pruden, *The C-1 Control System in Transcontinental TD-2 Radio Relay System;* A. E. Anderson, *Transistors in Pulse Circuits;* J. A. Morton, *Junction Transistor Theory;* W. J. Pietenpol, *Characteristics of* n-p-n *Transistors;* and J. M. Shive, *Properties of M 1740* p-n *Junction Photocell.*

Extreme Cold Opens Way To New Knowledge

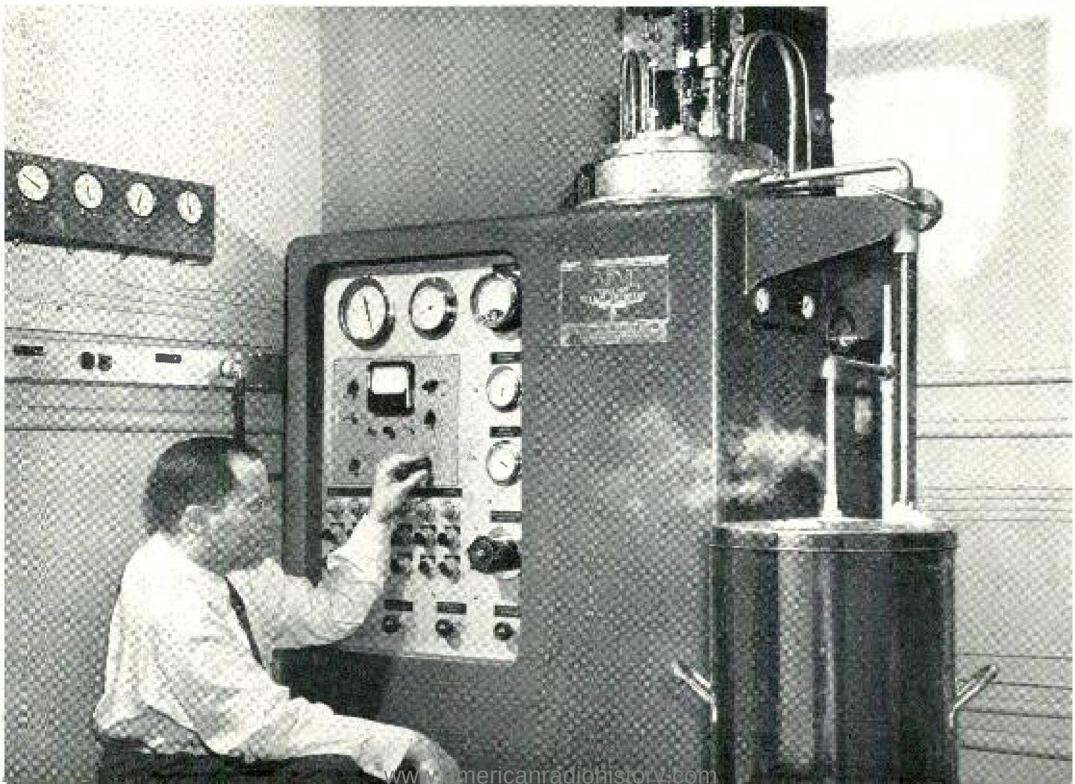
Much can be learned about the nature of materials by studying their behavior in extreme cold. Several materials of great importance to the future of the telephone system are being studied at Murray Hill with the aid of a new refrigerating unit which by liquefying helium, produces temperatures close to absolute zero.

At very low temperatures materials exhibit striking changes in behavior which remain unexplained by theory. Tin, for example, develops extremely high electrical conductivity; set in motion by induction, a current continues to flow indefinitely without perceptible diminution. Studies of this "super conductivity" may further clarify the mechanisms of conduction, hence suggest ways of producing higher conductivity at ordinary temperatures. Circuits of higher conductivity than now available would be of great advantage in reducing attenuation and power consumption.

Admixtures of alloying materials markedly affect the conductivity of germanium, and the effect is different at very low temperatures than at room temperatures. Additional data obtained in extreme cold should help explain germanium's conductive mechanisms, and thus help improve semi-conducting devices such as germanium diodes and transistors.

Another problem under attack is that of making ferro-magnetic materials more efficient at high frequencies. The properties of a ferro-magnetic material depend on what happens to electron spins within the material. In turn the behavior of electron spins is revealed by resonance absorption bands which vary both in peak frequency and band width with the material's temperature. Absorption studies at very low temperatures are expected to reveal important new information as to the electron spin process.

At Murray Hill E. Corenzwit operates a Collins Helium Cryostat producing liquid helium which is stored for transportation in the container at right. At point of use, helium is poured into an insulated chamber containing the material to be tested at temperatures near absolute zero.



A Test Unit For AMA Perforators and Readers

A. R. BONORDEN
Switching Systems Development

To simplify the testing and adjusting of perforators and readers used in the AMA system*, the test unit shown in Figure 1 was developed by the Laboratories as part of the maintenance facilities for accounting centers. It consists of a cabinet type relay bay, which houses the relay equipment of the test circuit and a rectifier for supplying 50 volt dc power, and a table carrying a control turret and mountings for a reader and a perforator. These mountings incorporate jacks through which the reader or perforator is electrically connected to the test circuit. The perforator mounting at the left, rides in a sub-base and turn table so arranged that after a perforator is plugged into the test circuit and fastened, it may be tilted and rotated to expose any face toward the attendant for adjustment purposes. The design also permits the bottom face of the perforator, which carries the paper advance mechanism, to be so exposed, as indicated in Figure 2.

Immediately behind the perforator mounting, rests an oscilloscope used to check reader contacts under dynamic conditions for chatter and phase difference. This instrument, being portable, is also available to the maintenance force for use outside of the test room. Floating fluorescent lighting fixtures are located above each of the machine mountings. The fixture over the reader carries a 5-inch magnifying lens which provides an excellent aid to vision when checking and adjusting the reader

* Record: *September,* 1951, *page* 401; *November,* 1951; *page* 504; *February,* 1952, *page* 70; *and June,* 1952, *page* 237.

Fig. 1—Perforator and reader test unit.

Fig. 2—By tipping up the perforator, sliding back and then rotating its mounting, its undersurface is exposed for inspection or adjustments.

contact springs. Below the table, provision is made for holding blank paper tape for the perforator and perforated tape for the reader, and for collecting the output tape from each machine in metal bins.

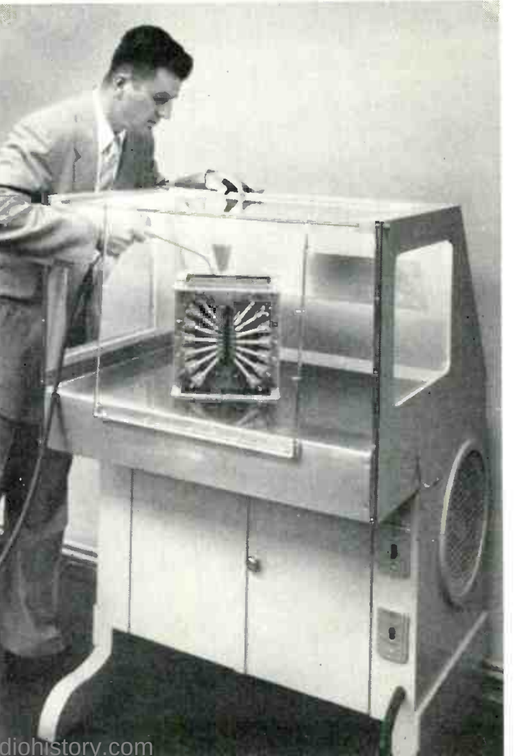
Also associated with the test unit is a cleaning cabinet, shown in Figure 3, which provides compressed air and a suction pump for removing accumulation of paper fibers and dust from the machines before adjusting, lubricating, and testing.

Each accounting center reader has twenty-eight reading pins with their associated spring contacts, two advance checking fingers also with their associated contacts, and sixty other pairs of contacts arranged in two groups: a perforating group and a control group. These three sets of thirty pairs of contact springs are driven by separate cams on the drive shaft and are phased differently.

In the lower part of the control turret there are three banks of thirty lamps on the right, and three banks of similarly arranged jacks on the left side of the turret. During a test, the lamps are associated with the three groups of contacts in the reader: thirty associated with the twenty-eight reading pins and the two advance check pins, thirty with the perforator contacts, and thirty with the control contacts. The jacks give access to the reader contacts and also to the perforator magnets. Above the lamps and jacks are two meters and a group of keys used in controlling the various tests. One of the meters is a dc voltmeter for indicating the output voltage of the rectifier; the other is a pulse-per-second meter used for indicating the running speed of the reader.

Certain sub-groups of contacts on the reader make and break at different points of the reading cycle, and one of the static tests of the reader is made to determine that each contact makes and breaks within specified angular limits of the drive shaft. In

Fig. 3—Perforator being cleaned with compressed air in the cleaning cabinet.



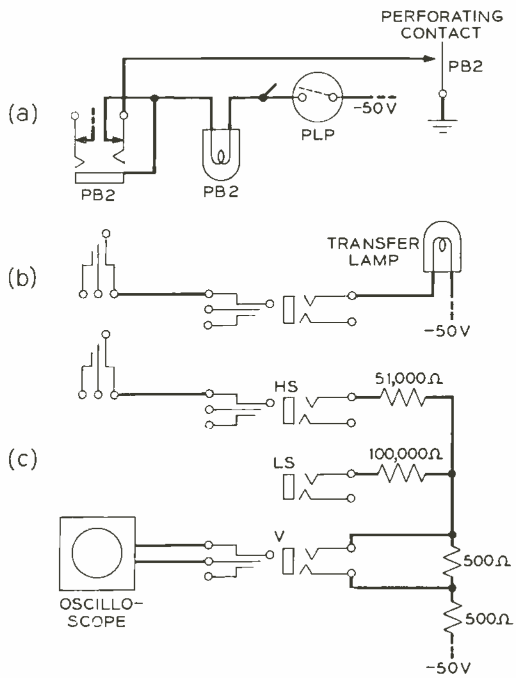


Fig. 4—Each contact of the perforator group of the reader is associated with a jack and lamp as indicated at (a) and through its jack may be associated with a lamp in the top of the test table, as at (b) or with an oscilloscope, as at (c).

in the turret by use of the patch cord indicated at (b) of Figure 4. It will be noticed that the reader contact is connected to the tip of the jack, and this is true of the equivalent circuits for all three groups.

Among the dynamic tests of the readers are those for contact chatter, phase difference of contacts, and false closure on blank tape. For the first two tests, the oscilloscope is patched through a simple jack circuit, indicated at (c) in Figure 4, to the reader contact to be tested. With the reader running, each closure impresses a small voltage across the input of the vertical sweep amplifier in the oscilloscope to cause the trace to move upward. When the horizontal sweep is synchronized with the reader speed, the two horizontal lines of the repetitive trace, representing the make and break portions of the cycle, will readily indicate any chat-

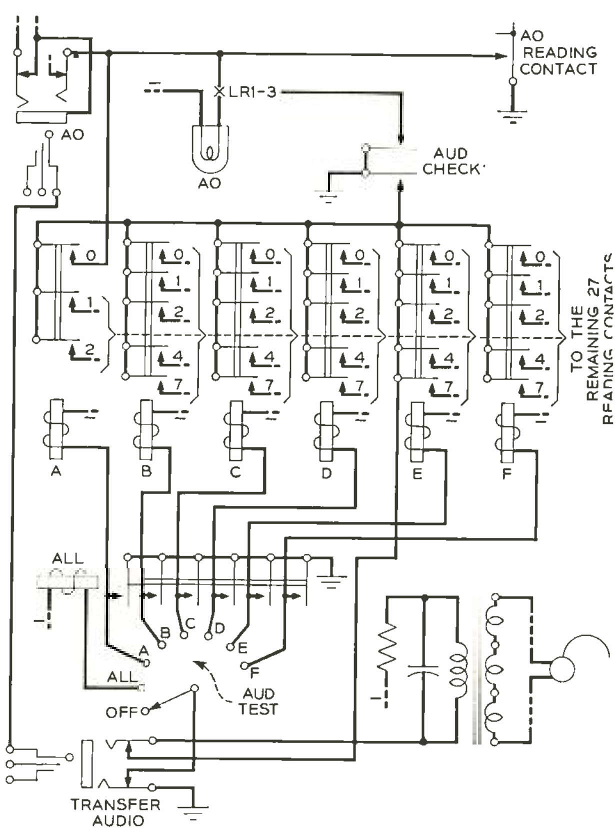


Fig. 5—Auditory test circuit employed to detect false closures of reading contacts sensing blank tape.

making this test, the index wheel of the reader* is set to precise position while watching the lamps associated with the contacts to see that all those in each group light or go out within prescribed angular settings. When it becomes necessary to work on an individual contact spring, the strain of watching one lamp in a group is eliminated by a simple patch between the jacks at the turret. This patch connects the desired contact directly to a lamp located in the table top near the reader where its condition, whether lighted or not, is readily evident even though the eye is focused on the index wheel marking.

The association of the lamps and jacks with the contacts of the perforating group is indicated by the top drawing of Figure 4. Somewhat similar arrangements are provided for the other two groups of contacts. The lamp in the table top used for checking individual contacts is also associated with a jack, and it may be substituted for the lamp

* Record, *June*, 1951, *page* 237.

ter or bounce during the cycle. By means of patching in a second reader contact to jack LS, it is possible to see the phase difference between the closure or openings of the two contacts. The second contact when closed alone provides a vertical deflection half that of the first, and when both are closed together, the deflection becomes one and one-half times that of the first alone. With one cycle of the trace spanning thirty-six divisions on the oscilloscope screen, out-of-phase conditions greater than five degrees are readily detected.

A telephone head receiver plugged into jacks in the front apron of the table is used to detect false closure of any of the twenty-eight reading contacts with the reader running and reading blank tape. Such contact closures are not necessarily cyclic and are difficult to observe on the oscilloscope screen. The telephone receiver provides a convenient method, and its sensitivity is excellent for this purpose. The usual varistor is connected across the receiver to limit the intensity of the audible clicks emitted on closure and opening of a contact.

The circuit arrangement used is shown in Figure 5. Three of the twenty-eight reading contacts are associated with the A digit of a line of perforations on an AMA tape, and five contacts are associated with each of the five remaining digits designated B to F inclusive. The contacts for each of the six digits of a line of the tape are connected to the test circuit through a separate relay, and which relay is operated depends on the position of the AUD TEST rotary switch. The first position of this switch, by operating relay ALL, connects all twenty-eight contacts to the test receiver. The lamps associated with the contacts are not connected to the circuit unless the LRI-3 relays are operated from the AUD CHECK key.

Before making the test, however, it is necessary to make sure that the test circuit itself is not defective. With the reader running without tape, the AUD CHECK key is operated and released after observing that all twenty-eight reading lamps flash, which checks the paths between contacts to the lamps. The AUD TEST switch is then turned to the ALL position and the AUD CHECK key again operated and released after observing that the same lamps light steadily, which assures that all contacts are connected to the test circuit. The receiver will now be emitting clicks. The actual test for false closures now consists in inserting blank tape into the running reader and noticing its effect on the output of the receiver. With blank tape in the reader none of the reading contacts should close and therefore all clicks should be eliminated.

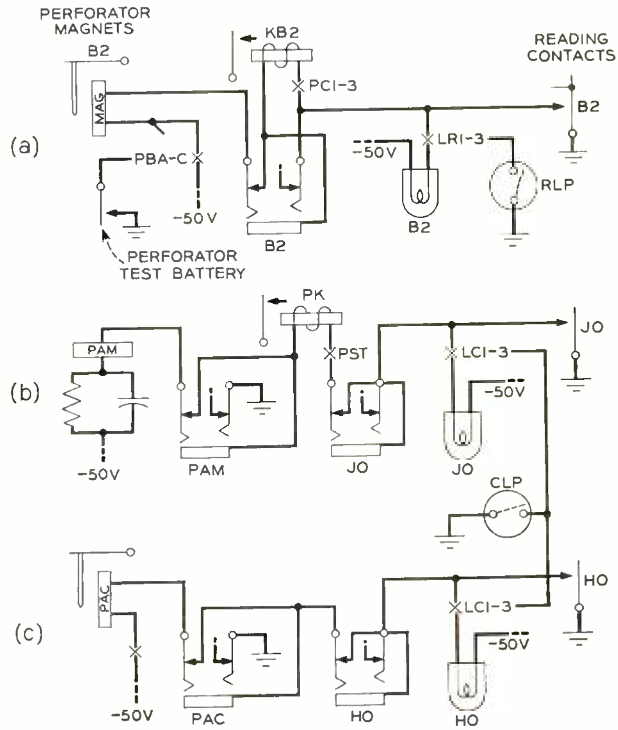


Fig. 6—Connecting paths of perforator magnets.

Should false closures be detected on the receiver with the AUD TEST switch on the ALL position, the switch is advanced step by step through the succeeding six switch positions. Each position leaves connected to the receiver one of the A to F groups of reading contacts. When the location of the contact failure has been narrowed to a particular group, the receiver circuit is then extended through a patch cord to each of the test jack tip springs individually in that group to locate the contact at fault.

For a static test of the perforator magnets, the circuit indicated in Figure 6(a) is employed. The jack indicated here is that for

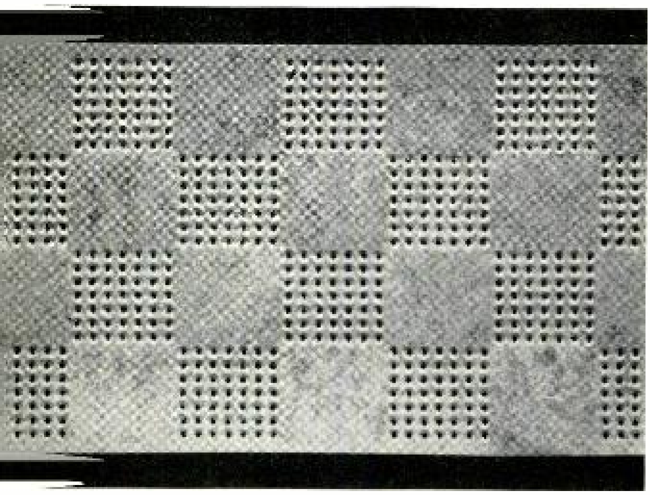


Fig. 7—Test pattern on tape used in over-all test.

one of the reading contacts, and like all the jacks has a reader contact connected to the tip. All the jacks for the twenty-eight reading contacts, however, have one of the perforator magnets connected to their ring contacts. When no plug is inserted in the jack, and relays PCI-3 have been operated for a perforator magnet test, there is a path through the winding of the check relay KB2 to the ring contact of the jack. The magnet may be operated individually by a patch from this ring contact to a ground jack or to a 35-type test set*, which permits the current flow tests.

During the adjustment of the perforator advance mechanism, it is necessary to have eleven of the perforator magnets operated. This is accomplished by rotating the reader index wheel by hand until the reading pins have completed their advance toward the drum on which has been placed a short piece of tape having a splice pattern. This allows eleven contacts to close and operate eleven magnets through check circuits like that of Figure 6(a).

Two additional jack circuits shown at (b) and (c) of Figure 6 provide electrical access respectively to the perforator advance magnet (PAM) and to the perforator advance check magnet (PAC) when equipped. As an aid in effecting and checking adjustments of the associated mechanisms, these two magnets may be conveniently operated by means of remote control keys (32A-test set) patched to jacks PAM and PAC.

A final over-all operation test is used in which the reader under test reads a test pattern test tape, shown in Figure 7*, and drives a perforator known to be in good adjustment. Similarly a perforator under test is arranged to be driven by the test reader.

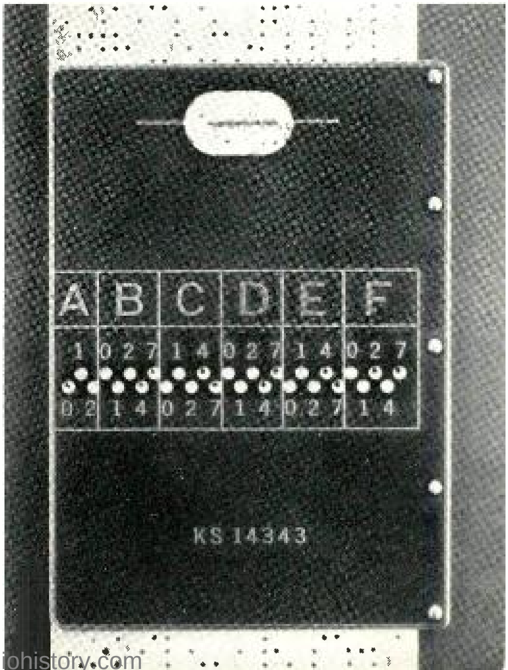
The test reader runs at a higher speed than service readers. It provides contact make and break periods which are representative of the shortest periods encountered by perforators serving in accounting center machines. The test pattern test tape provides a six foot length of "checkerboard pattern" preceded and followed by one foot of splice pattern. During the passage of this test tape through the reader the perforator is caused to perforate the pattern line by line as read, each magnet being operated from the corresponding reader contact over a test jack circuit such as Figure 6(a).

Just before the end of the test tape reaches the drum of the reader, the reader is stopped, the test tape is removed, and the leading end of the output tape from the perforator is inserted into the reader to initiate a "feedback" test. The reader is again started and allowed to run for five minutes during which time the perforator reproduces eight or nine complete test pat-

* Record, *April*, 1940, *page* 134.

* *Specification* X-64669B, *List* 1.

Fig. 8—The KS-14343 tape reader in position on a tape disclosing a good line.



tern test tapes in tandem as a continuous output tape. Inasmuch as each such test tape is derived from the preceding test tape, any tendency toward malfunctioning in reading or perforating very often provides a cumulative worsening of any defective perforation through the reproduction stages so that these conditions are readily noticed when making a visual examination and comparison of the last and first test tapes in the output. Easily noticed also are missing lines and extra lines indicative of a failure of the drum to advance in the perforator and reader respectively.

The duplication at the test table of test tapes for the processing machines of the accounting center is also an important function and is accomplished as explained above for the initial reproduction of the test pattern tape. If errors exist in such input test tapes, they must be previously located and marked with the aid of the KS-14343 tape reader, Figure 8, so that the reader may be stopped a few lines ahead of the line containing the error. Control means then permit alternately stepping to and perforating each good line, and with dummy plugs and a patch cord the error may be corrected in reproduction or the bad line may be perforated correctly hole by hole.

THE AUTHOR: A. R. BONORDEN has had almost thirty-seven years of service with the Bell System, including twelve with the Pacific Telephone and Telegraph Company and the Western Electric Company, after which he attended the University of California from which he received an A.B. degree in 1920. He then rejoined the Pacific Company.

In 1927 Mr. Bonorden transferred to the D and R which consolidated with the Laboratories in 1934. He investigated economic equipment and circuit arrangements, design requirements, and the study of possible improvements in subscriber senders and decoders of the panel dial system. He became a member of the telegraph group in 1932, and two years later became responsible for the investigation of arrangements and methods for economically supervising private wire telegraph service and for maintaining central office TWX equipment. This included the preparation of design requirements of the No. 1 telegraph service board. During World War II, Mr. Bonorden worked on the development of searchlight radar for the Marine Corps. In 1946 he became a member of the switching group. His contributions to the telephone industry include a coin box mechanism, a cordless TWX switching system, a telegraph concentration arrangement used in one of the large press association offices, and a system of telegraph and telephone trunks permitting cordless transfer of calls at telegraph test boards.

Training Program Reconvenes

The 1952 class of the Communication Development Training Program met for the first time on Tuesday, September 2. There were 139 new Laboratories members enrolled, composing the largest class yet to enter the CDT Program.

After a brief greeting from F. D. Leamer, Director of Personnel, J. W. McRae, Vice President of Bell Telephone Laboratories, presented the first in a course of orientation lectures called "The Bell System." Mr. McRae explained the part that the CDT Program has in the general policies of the Bell System and the relation of this specialized training to the professional development of each technical man enrolled in it.

The CDT Program has been organized to provide new members of the Laboratories a post-graduate course in the sciences and in the technology of telecommunications combined with practical work experience in widely differing departments as described in the article on page 404.

Communications Development Training Program

S. B. INGRAM
Director of Education and Training

Physical research during the past two decades has provided a tremendous fund of new knowledge directly applicable to electronic and communication technology. Moreover, the development and engineering of new systems and apparatus require an increasingly analytical and fundamental approach. Because the communication systems currently available are products of an already highly developed technology, some marked advance in scientific knowledge is almost prerequisite to improvements of any kind.

Engineers of Bell Telephone Laboratories engaged in communications development must be masters of the most advanced analytical and experimental techniques and of the most recent scientific information. Men entering upon such work without either advanced training or considerable specialized experience are not prepared to participate most effectively. In the Laboratories, the most recent approach to providing advanced scientific education is the Communications Development Training

Above—A. B. Clark, Vice President of Bell Telephone Laboratories, talking to the first year class on the Bell System. A student panel also faces the class, ready to discuss questions raised by the lecture. Below—H. D. Hagstrum, Physical Research Department, lecturing to the first year class in Physics I.

Program. The basic scientific concepts and methods learned in technical school or college provide a necessary background, but the advanced knowledge and specialized tools essential to communications development and engineering can best be acquired in the industry itself. While learning on the job is possible, it is slow, tedious, and uneconomical and does not provide the breadth of knowledge that an organized in-service training program does.

Training programs for personnel are not new in Bell Laboratories. As early as 1919, the Engineering Department of Western Electric Company, predecessor of Bell Telephone Laboratories, recognized the need for specialized instruction, and instituted out-of-hour courses in physics, mathematics, and manufacturing processes conducted by experts of the Engineering Department staff for its new members. As need has arisen subsequently, courses have been added for drafting room and shop personnel, as well as for members of the Technical Staff. The Laboratories, incorporated in 1925, continued and augmented the program, offering various educational opportunities through both in-hours and out-of-hours courses.

During World War II, at the request of the U. S. Army Signal Corps, a School for War Training was inaugurated to provide training for both armed service and civil service personnel. Because experienced men were not available in sufficient numbers to operate and maintain the very new and highly complex military devices developed by Bell Laboratories, practical training had to be provided. When the school was closed at the end of the war, 3600 specialists had been instructed in various phases of handling military radio, radar, and other electronic equipment.

The current program for young college graduates is a continuation of group training and an adaptation to realize the value of centralized academic education in collaboration with specialized practical training in technical departments. In 1948, the program was instituted for new members recently graduated with B.S. or M.S. degrees. Five years' experience with the plan has brought about some modifications. For students now entering the three-year curriculum, the work in the last two years will be more specialized than it has been formerly. However, the fundamental objectives of the program remain the same. Post-graduate training in the sciences and in the technology of telecommunications is combined with practical work experience. Regular members of the Laboratories who desire the advanced training and who have the prerequisites may also enroll in specific courses with the approval of their departments. The objectives of the program are to provide a better fundamental technical back-

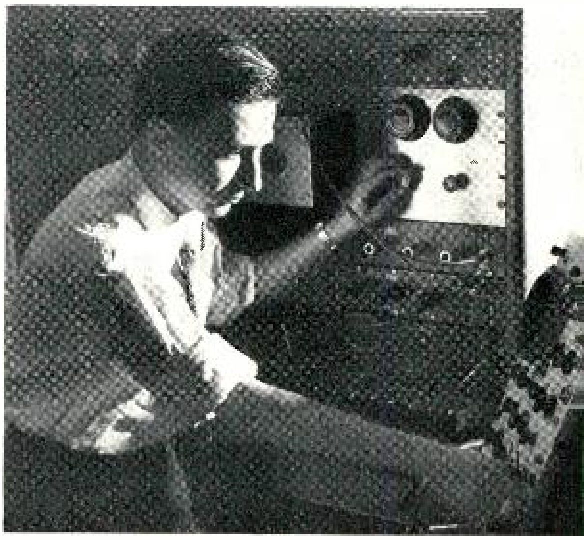
First year students clearing up a point after class with Mr. Hagstrum.

ground for all of its graduates, to provide broad orientation in the work of the Bell System and of Bell Telephone Laboratories during the first year, to provide intensive specialized training in the work of each student's department, and to provide an acquaintance with the techniques of departments related to his own. The three-year curriculum has been carefully designed to include material considerably advanced beyond the undergraduate level but fundamental to communications development and engineering. Job assignments are then integrated with the academic work to round out the complete industrial training program.

In his first year with the Laboratories, a young member is placed under the supervision of the Education and Training Department, but is "sponsored" by the development department to which he will ultimately be assigned. Three days of each week are spent in school, 4-1/3 hours in attending classes and 3-1/6 in preparing class assignments. The other two days are devoted to a "rotational assignment" in a technical department. During the first year there are three of these assignments to departments chosen because of the relation of their work to that of the sponsoring department and because they offer knowledge of Laboratories operations as widely different as possible.

R. M. Seeley, Jr., Underwater Systems Development Department, from Duke University, on his rotational assignment in Switching Apparatus Development is measuring the operate-time of a telephone relay.

For example, a new member, who, during placement interviews, seems best fitted for work in switching systems, will be temporarily assigned to the Education and Training Department and sponsored by the Switching Systems Development Department. His rotating assignments may then be in the Switching Appartus Development Department, the Transmission Systems Development Department, and the Switching Research Department, all of which are obviously related to his future work, and in each of which he will see work entirely different in character. In each of these tem-



R. Alonzo, Switching Engineering Department, comes from Harvard with an M.S. in Mechanical Engineering. In connection with his rotational assignment in the Switching Research Department, he is examining some experimental electronic apparatus studied by mechanical engineers in this department.

porary assignments he will work two days of each week at some regular and productive job with which that department is occupied. Since development work usually involves many interrelations with other departments, this introduction to the interdependence of his own work with that of others is valuable.

Although the rotational assignment is in no sense "made work," the prime concern is that the new member learn, rather than that he produce. The objectives of this part of the in-service training program are that

S. B. Ingram, Director of Education and Training, meets one of the informal discussions groups

the student learn, by practicing, the many interrelations of his department with other related ones and something of the philosophy of the departments with which he will cooperate. Moreover, the opportunity to work closely with men in these related departments is a great advantage to a new member. He thus becomes acquainted with them so that in the future, when he needs advice or assistance, he will know his colleagues well enough to go directly to the one that is most nearly concerned with his problem.

Meanwhile, the other three days of each week are spent in attending classes and studying. The first year curriculum contains three groups of science courses plus one general course. The first, a mathematics group, covers the mathematical tools basic to advanced engineering work in communications. It includes two courses in Analysis and one in the mathematics of Fundamental Circuit Theory. The second, a group of physics courses, deals with atomic physics, the physics of solids, and the physics of wave phenomena. The third group encompasses the broad concepts underlying modern communications, comprising classes in Probability and Statistics, in Communication Theory, and in Logic and Switching. The importance of these three groups of courses in fundamental theory lies in their ultimate application in telephone technology.

In addition, a fourth course, extending throughout the entire year, is designed to orient new members in the field of practical communications. Entitled "The Bell System" this course presents broadly the functional organization of the Bell System, reviews the basic principles of economics with special application to public utilities and to development problems, and then devotes the greater portion of the time to an introduction to the major transmission and switching systems in the Bell System.

In the light of his first year record, the new member reviews his assignment with a counsellor in the Education and Training Department and with his sponsoring department, and the three consider the advisability of his continuing a full academic program. If it still appears that he is both fitted for and interested in his sponsoring department, he will be formally transferred to it. If a change is desirable, a new series of placement interviews will be instituted and he will be reassigned to another department. Whether he continues in the training program depends upon his inclination and aptitude and upon the needs of his sponsoring technical department. During the past five years, 399 members of the Laboratories have enrolled in the program. Of these, 38.6 per cent have been new members taking the full curriculum and 61.4 per cent other members registered for only specific courses. Some others, who finished the first year, have transferred to the Part-time Graduate Study Plan so that they might earn advanced degrees in one of the academic institutions nearby.

In the second and third years of the Communications Development Training Program, the content is much more intensively specialized. Course work is confined to the area in which the student will work permanently, so the courses offered depend upon student needs. One day is spent in class and study, and four days at work in the department.

Newell Brown (left), Military Electronics Department, from the University of Maryland, and Pete Kelly, Military Electronics Department, from Illinois Institute of Technology, work on a problem together in one of the study rooms.

Leonard J. Weber (left), Military Electronics Department, from Oregon State College, discusses his training assignment with E. J. Thielen of the Program administration.

Both the graduates and their supervisors have judged the plan a success. Since much of the material is not available in established courses in colleges and technical schools, engineers enjoy an opportunity to learn quickly what only considerable experience could otherwise teach them. Moreover, the instruction is given by authorities in their respective fields. Mathematics is taught by men from the Laboratories' Department of Mathematics, Physics by those engaged in physical research, Switching by the Switching Department, and Transmission by members of the Transmission Department. Thus, students enrolled in the Program receive the best possible practical instruction.

In this way Bell Telephone Laboratories is provided with men quickly and thoroughly integrated into the organization, trained in advanced techniques, and provided with the most recent pertinent scientific information that is available.

THE AUTHOR: S. B. INGRAM, Director of Education and Training, joined the Laboratories in 1930. Until he became the head of our training program, he was concerned with electron tube development. He spent about eight years in the development of gas tubes and developed the cold cathode gas tube used in telephone ringing systems. Later his responsibilities included the supervision of work on various types of electron tubes, including gas, power, electron beam, and microwave tubes. During World War II, he was in charge of the development of modulator tubes for radar systems, cold cathode tubes for use in timing circuits of magnetic mines, and miniature tubes for proximity fuses.

He was graduated with a B.A. degree in Physics and Mathematics from the University of British Columbia (1925) and received a Ph.D. degree in Physics from California Institute of Technology in 1928. From 1928-30 he was a National Research Council Fellow at the University of Michigan.

Elliott Cresson Medal Awarded To E. C. Molina

Edward C. Molina, who retired from Bell Telephone Laboratories in January 1943, has been awarded the Elliott Cresson Medal "for his important contributions to the mathematical theory of probability and for his significant contributions to the improvement of telephone communications, both by the application of mathematical probability to the study of telephone traffic and by the invention of switching equipment". Among earlier recipients of the Elliott Crisson Medal were G. A. Campbell, J. R. Carson, C. J. Davisson, G. R. Elmen, L. H. Germer and R. R. Williams.

The Elliott Cresson Medal was established in 1848 by a gift from Elliott Cresson, a Philadelphia merchant and Quaker humanitarian famous for assisting emancipated slaves to recolonize Africa. In his conveyance of the gift he stated that the awards were "to be in all instances made either for some discovery in the arts and sciences, or for the invention or improvement of some useful machine, or for some new process or combination of materials in manufacture, or for ingenuity, skill, or perfection in workmanship."

Mr. Molina, who has contributed much to the science of communications, was first employed by the Western Electric Company at West Street in 1898. Transferring to A T and T at Boston in 1901, he became engaged in designing circuits for automatic telephone systems, in which one of his most important contributions was the development of a translating system that permitted lines designated on a decimal basis to be interconnected by switches functioning on a non-decimal basis. In 1919, when the Development and Research Department of the A T and T was formed, Mr. Molina took charge of applying the theory of probability to trunking problems. When, in 1934, this Department was incorporated into Bell Laboratories, Mr. Molina continued his contributions to probability theory and its telephone applications, as Switching Theory Engineer. Since his retirement he has been a special lecturer in mathematics at Newark College of Engineering.

New A.I.E.E. President

D. A. Quarles, in August, was inaugurated president of the American Institute of Electrical Engineers for the 1952-1953 term. Mr. Quarles, President of Sandia and Vice-President of Western Electric, was formerly Vice-President of Bell Telephone Laboratories.

Conference on Quality Control

The fourth annual all-day conference on Quality Control, sponsored by the Metropolitan Section of the American Society for Quality Control, was held on September 13, at Rutgers University in New Brunswick. As in the past, the program consisted of morning and afternoon sessions on the several aspects of quality control. At the session "Panel B: Applications in Electronic and Mechanical Industries," P. S. Olmstead was the presiding officer. H. F. Dodge was Chairman at the afternoon session, "Panel E: Sampling and Inspection." E. B. Ferrell, Vice-Chairman of the Metropolitan Section of the Society, and P. S. Olmstead served on the Advisory Committee for the Rutgers Conference.

New Cable in Southwest

A six-tube coaxial cable has just been installed between Oklahoma City and Amarillo. Four tubes were equipped initially, two for telephone service and two for protection and maintenance. The cable can also be used, if desired, for carrying television programs.

This new 270-mile route will provide storm-proof channels to handle the rapidly increasing traffic between the Panhandle and Central Texas and will supply additional cross-country circuits. It is jointly owned by Southwestern Bell Telephone Company and the Long Lines Division of A T and T.

Laboratories Leaders Participate in the Centennial of Engineering

Celebrating the one hundredth anniversary of the founding of the first professional engineering society in this country, the American Society of Civil Engineers, representatives of sixty-six societies gathered in Chicago from September 3 to September 12, inclusive. More than twenty-five thousand engineers and scientists from the United States and foreign countries attended this Convocation.

A series of Convocation Symposium Meetings—general meetings dealing with broad topics of engineering achievement—was held at the Eighth Street Theater on September 3, 4, 5, 8, 9, 11, and 12. At the meeting of September 4, devoted to "Education and Training," O. E. Buckley, a member of the Board of Directors of Bell Telephone Laboratories, took part in a discussion of *Looking Ahead for Engineering Education.*

The Symposium Meetings of the 11th and 12th were devoted to Communications, and J. W. McRae, Vice President of the Laboratories, addressed the meeting on the 12th on the subject of *Communications in the Future.*

As part of the Centennial Celebration of the American Society of Civil Engineers, a large number of other technical societies held their own meetings in the Congress Hotel to portray the progress in their fields during the past, and to discuss the probable future trends. Outstanding authorities in each field described the advances made during the past one hundred years of engineering work, and related these developments to the social progress of the United States.

The A.I.E.E. held technical meetings on the morning and afternoon of September 10, 11, and 12. On each of these dates a luncheon meeting was also held at which an address was given by some outstanding member of the profession.

On Friday, September 12, the morning meeting was devoted to the Communication Division, and at it A. B. Clark, Vice President of the Laboratories, presented a paper on the *Development of Telephony in the United States.* At the luncheon meeting of this day M. J. Kelly, President of the Laboratories, spoke on the subject of *Communications and Electronics—A Review of Their Contribution to Our Nation's Strength and Culture and of Significant Trends in the Evolution of Their Technology.* In his talk, Dr. Kelly reviewed the conversion of the United States from a primarily agricultural to an industrial country over a relatively short period, emphasizing the important part played by the communication art in making this conversion possible. He traced the growth in communication developments, stating that although we had gone far in the development and use of communication services, continued and almost unlimited growth could be expected in the future.

The afternoon session of the 12th was devoted to the Science and Electronics Division. At this meeting Dr. R. M. Bozorth of the Laboratories, discussed the *Behavior of Magnetic Materials* and W. H. MacWilliams, Jr., talked on *Computers: Past, Present, and Future.*

Dr. Osborne Honored

Harold S. Osborne, formerly Chief Engineer of the A T and T, has been elected president of the International Electrochemical Commission at its meeting in Scheveningen, Netherlands. This body is the international coordinating agency in the field of electrotechnical standards.

Dr. Osborne has been active in standards work. He is president of the U. S. National Committee, an affiliate of the Electrical Standards Committee of the American Standards Association.

Additional Direct Dialing

Another installation of direct dialing by long distance operators has been completed in Cincinnati, Ohio, connecting this community with more than 16,000 others throughout the country. Putting in the new equipment for automatic toll switching was a joint project of the Cincinnati and Suburban Telephone Company and the Long Lines Department of the A T and T. The new system, known as "Operator Toll Dialing" now includes eighteen cities, and two more, New Orleans and Scranton, will be added to the network early next year.

Moves to Academic Position

Harvey Fletcher, formerly Director of Physical Research in Bell Telephone Laboratories, is now Dean of Engineering and Director of Research in Brigham Young University, Provo, Utah. He will organize the newly established School of Engineering and will be responsible for promoting and guiding all research that is carried on in the University.

Well known in the field of acoustics, Dr. Fletcher holds honorary degrees of Doctor of Science from Case School of Applied Science, Columbia University, Kenyon College, Stevens Institute of Technology, and the University of Utah.

Patents Issued to Members of Bell Telephone Laboratories During the Month of July

2,602,033 – *Carbonyl Process* – J. J. Lander.

2,602,148 – *High Frequency Amplifier* – J. R. Pierce.

2,602,151 – *Triangular Wave Generator* – R. L. Carbrey

2,602,158 – *Coder for Pulse Code Modulation* – R. L. Carbrey.

2,602,180 – *Pneumatic Tool for Cleaning Switch Banks* – V. F. Miller.

2,602,211 – *Rectifier and Method of Making It* – J. H. Scaff and H. C. Theuerer.

2,602,327 – *Transducing System* – W. L. Bond.

2,602,763 – *Preparation of Semi-conductive Materials for Translating Devices* – J. H. Scaff and H. C. Theuerer.

2,602,853 – *Selective Signaling System* – H. C. Harrison.

2,602,857 – *Wave Guide Attenuator* – W. H. Hewitt, Jr.

2,602,858 – *Wave Guide Dielectric Protection* – R. V. L. Hartley.

2,602,872 – *Apparatus for Equipping Crystals with Wires* – A. W. Ziegler.

2,602,890 – *Sweep Circuit* – W. L. Gaines.

2,602,907 – *Filament Mounting for High Power Electron Discharge Devices* – E. G. Shower.

2,602,918 – *Multiplex Modulator* – E. R. Kretzmer.

2,602,919 – *Balanced Parabolic Modulator* – E. J. Drazy.

2,603,692 – *Rectifier and Method of Making It* – J. H. Scaff and H. C. Theuerer.

2,603,693 – *Semi-conductor Signal Translating Device* – R. J. Kircher.

2,603,694 – *Semi-conductor Signal Translating Device* – R. J. Kircher.

2,603,709 – *Rotatable Wave Guide Attenuator* – A. E. Bowen.

2,603,710 – *Rotatable Attenuator for Wave Guides* – A. E. Bowen.

2,603,714 – *Percentage Time Division Multiplex for Pulse Code Modulation* – L. A. Meacham.

2,603,715 – *Pulse Position Call or Dial Receiver* – H. E. Vaughan.

2,603,716 – *Decoder and Translator with Readily Changeable Translations* – F. K. Low.

2,603,718 – *Impulse Sender* – C. A. Lovell and D. B. Parkinson.

2,603,749 – *Directive Antenna System* – W. E. Kock.

2,603,772 – *Modulation System* – L. M. Field.

2,603,773 – *Modulated Oscillator* – L. M. Field.

2,604,540 – *Calling Line Identification for Automatic Ticketing Systems* – F. B. Blake.

2,604,542 – *Cross-point Switching Mechanism* – R. E. Hersey.

2,604,543 – *Equalizer Circuit* – W. D. Goodale, Jr.

2,604,545 – *Party Line Station Signaling System* – A. H. Inglis and L. E. Krebs.

2,604,596 – *Bombardment Induced Conductivity in Solid Insulators* – A. J. Ahearn.

2,604,619 – *Voltage Regulation* – J. R. Stone.

2,605,323 – *Wave Transmission* – A. L. Samuel.

2,605,347 – *Telegraph Concentration Board Spare Communication Circuit* – M. R. Purvis.

2,605,361 – *Differential Quantization of Communication Signals* – C. C. Cutler.

A.S.T.M. Director

George R. Gohn, of the Chemical and Metallurgical Research Department, has been elected to the Board of Directors of the American Society for Testing Materials. This organization, which is engaged in the standardizing of specifications and of the methods of testing materials, has just celebrated the fiftieth anniversary.

WINTHROP J. MEANS, Transmission Apparatus Development Department, has been elected second Vice-President of the Harvard Engineering Society. Newton Monk, Transmission Engineering Department, is a member of the Board of Governors.

S. B. WILLIAMS has recently been elected president of the Association for Computing Machinery. Mr. Williams, formerly switching development engineer with the Systems Development Department, is now retired. R. W. Hamming, Physical Research Department, was elected to represent the New York area on the council of the same organization.

W. E. KOCK, Director of Acoustics Research, and H. L. BARNEY, who supervises the speech communication group, have been in England to confer with British experts on acoustical problems and to observe British developments in that field.

M. E. FINE was appointed to an adjunct professorship in the graduate faculty of New York University. He will teach in a new curriculum of metallurgical studies, offered for the first time this academic year. Graduate students may earn the degree of Master of Science in Metallurgy in this Department.

H. H. BAILEY has been named to represent the Laboratories as a member of the newly-formed Technical Advisory Group for the Air Force Armament Center at Eglin Field, Florida.

R. J. NOSSAMAN, Director of Outside Plant Development, during a recent visit to Illinois Bell Telephone Company, described some of the latest developments made by his department. Before groups of engineers, supervisors, and life members, Mr. Nossaman demonstrated a combined splice closure and terminal, as well as other outside plant developments.

K. K. DARROW, on his recent Western trip, spoke at the Hughes Aircraft Corporation in Culver City, California, on *Magnetic Resonance*. He also visited the California Institute of Technology and attended the meeting of the American Physical Society at Denver, Colorado.

A. E. ANDERSON, Electronic Apparatus Development Department engineer, spoke before the Huntsville, Alabama, subsection of the Institute of Radio Engineers at the inaugural meeting of that group. He described the switching properties of the transistor which was invented in the Laboratories. Mr. Anderson has been working on the development of transistors since 1948.

L. A. WOOTEN attended the meetings of the Congress on Analytical Chemistry at Oxford University, England, September 4 through September 10. The Congress was sponsored by the International Union of Pure and Applied Chemistry. Dr. Wooten also visited research centers of chemical electronics and analytical chemistry in England, Holland, and Germany.