BELL LABORATORIES
RECORD

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The AMA Reader

F. C. KUCH
Facilities Development

For each of the successive operations in an AMA Accounting Center*—assembling†, computing, sorting, summarizing, and printing—a reader is required to transform the information perforated on the input paper tapes into equivalent electrical information that may be properly processed. Each reader has a drum—similar in general construction and arrangement to that of the perforator‡—and a set of twenty-eight reading fingers properly lined up with the holes in the drum. The input tape is fed over the drum through guides from the front in such a way that the small paper cones forced out in perforating the tape at the central office fit into the holes in the drum. Sixteen times a second, the reading fingers move in toward the drum and each finger will either be stopped by unperforated tape or will pass through a perforation in the tape. Each finger has associated with it a pair of twin contacts, and these are closed if the corresponding finger passes through the tape but are held open if the fingers meet unperforated tape. After each line is read, the fingers are withdrawn and the drum is rotated just enough to bring the next line of holes in line with the reading fingers. In rotating, the drum carries the tape along with it.

As shown in Figure 1, each reader is mounted in the upper part of a cabinet similar to that used for a perforator. In the lower part of the cabinet is space for two reels: one for the input tape and the other for the tape that has been read. The reading drum, shown in Figure 2, like that used in the perforator, has twenty-eight holes in each row along the face of the drum parallel to the axis. It differs from the perforator drum, however, in having thirty-six of these rows instead of forty-four, and is thus smaller in diameter. It differs also from the perforator drum in having cylindrical instead of conical holes, and there is a double rather than a single row of step-checking holes around the rim. Since there are thirty-six rows of holes, a ten-degree rotation of the drum is required for each advance. Provisions are made both for stopping the advance of the drum and for allowing it to be rotated freely, as may be desirable when a tape is being removed.

Besides the twenty-eight reading contacts and the two check advance contacts that are operated with them, the reader has sixty others, all twins, that are also closed and opened sixteen times a second. These sixty contacts are arranged in four groups: one of thirty for controlling the operation of a perforator, designated the P contacts, and three of ten contacts each for control purposes, designated the H, K, and J contacts respectively. The twenty-eight read-

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* RECORD, *January*, 1952, *page* 70.
† RECORD, *May*, 1952, *page* 227.
‡ RECORD, *November*, 1951, *page* 504.

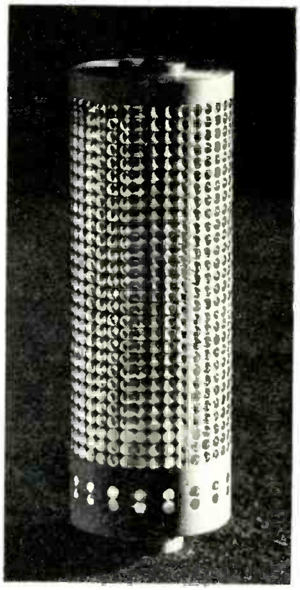


Fig. 2—The reader drum has thirty-six rows of twenty-eight cylindrical holes each. The two rows of holes in the rim are for checking the advance of the drum.

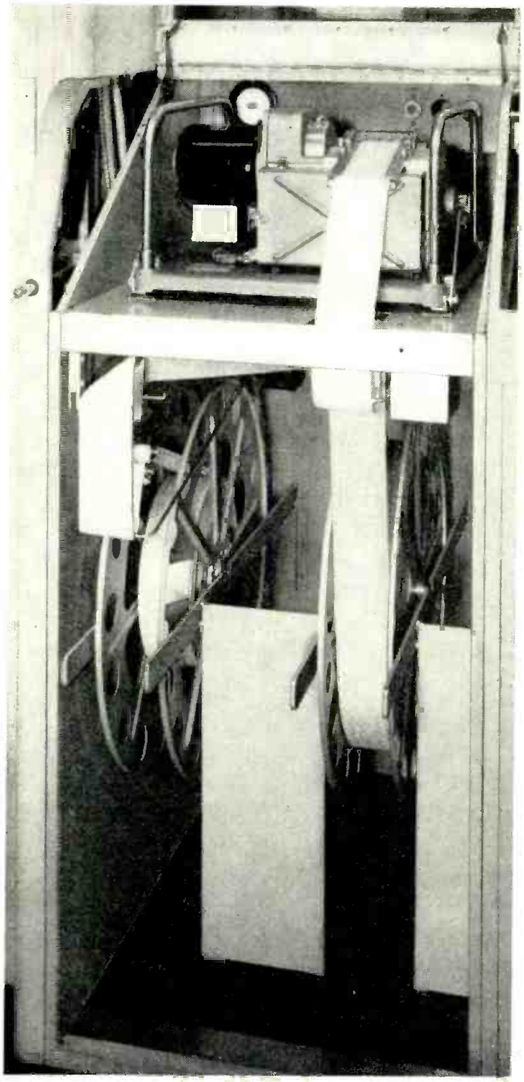


Fig. 1—Each reader cabinet includes a reader in the upper compartment and reels for the input and output tapes in the lower.

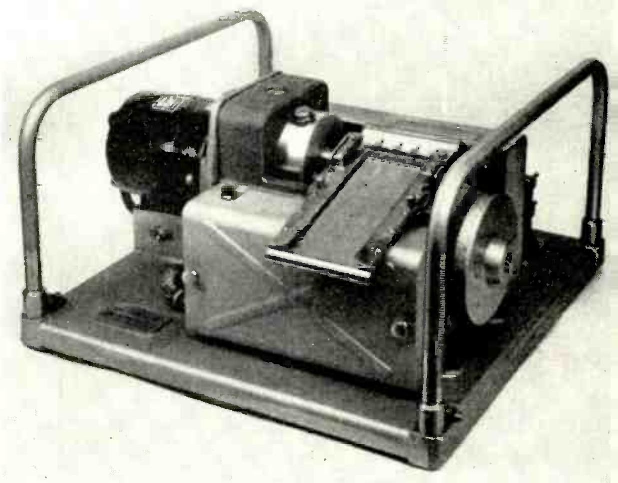


Fig. 3 (above)—The AMA reader. Input tape enters through the chute, passes over and around the drum, and then down to the takeup reel.

ing contacts, and the two advance-check contacts, close at the same time, if not restrained by blank tape or the drum, and they all open at the same time. All the perforator contacts open and close together, while in each of the H, K, and J groups, six contacts are closed while four are open, and vice versa. The P, H, K, and reading contacts are all in phase: the contacts opening and closing at the same time. The J contacts are phased to operate about fifty-two degrees later than the others. All ninety contacts, however, are operated once for each revolution of the cam shaft.

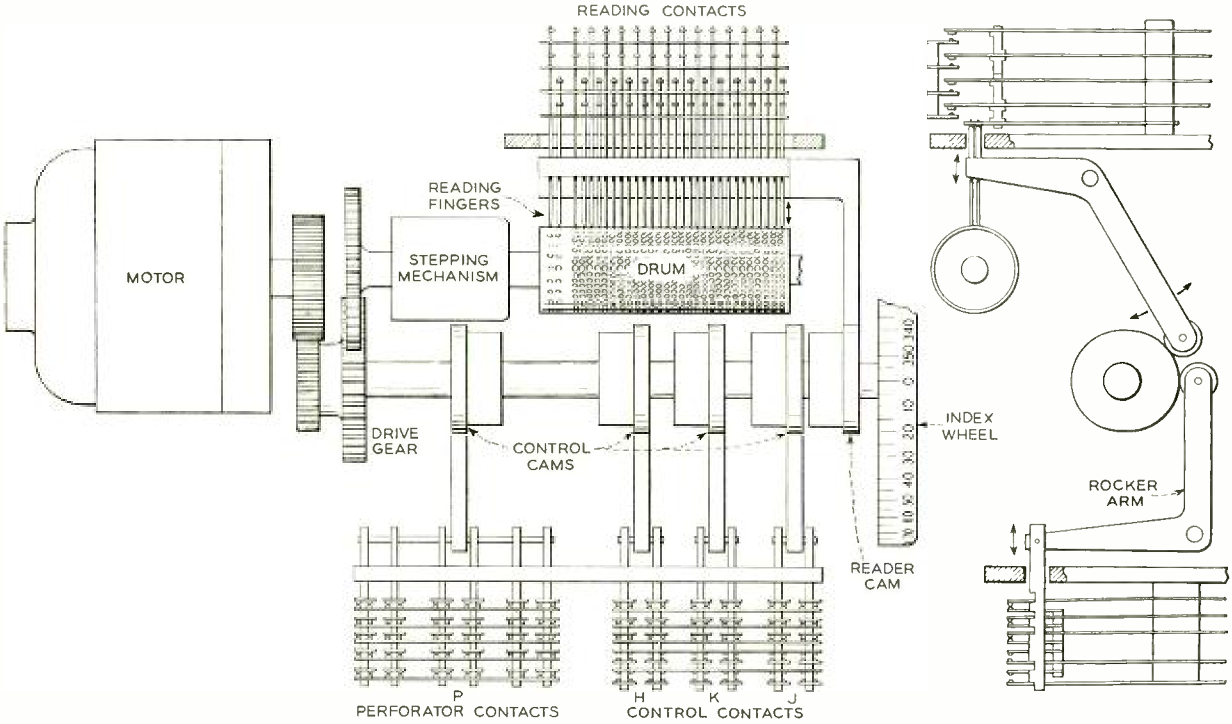


Fig. 4—Diagram of the reader showing the relationships between the major components.

The reader is shown in Figure 2, and a diagram indicating the arrangement of the various components is shown in Figure 4. A small ac motor that runs continuously drives the cam shaft of the reader at 960 rpm. There is a reduction gear between the motor and the cam shaft, and the latter, through another set of gears, drives the stepping mechanism, whose input shaft also runs at 960 rpm. On the cam shaft are five cams, which, through rocker arms with rollers riding on the cams, operate the reading fingers and the four sets of contacts already referred to. One rocker arm operates the group of thirty perforator contacts, three of them operate the three groups of control contacts, while the fifth, at the right-hand end of the cam shaft, operates the reading fingers and their associated contacts.

The cam shaft runs continuously, and thus the reading fingers move in and out and the contacts close and open sixteen times a second. The motion of the drum, however, depends on actions in the stepping mechanism. Advance of the drum is under control of the reader circuits, and is at the rate of sixteen lines per second continuously or intermittently as required for the proper processing of the tape. The timing of the advance, when it is made, is always properly phased with the cam shaft so that the advance is made while the reading pins are fully withdrawn.

The stepping mechanism, shown in Fig-

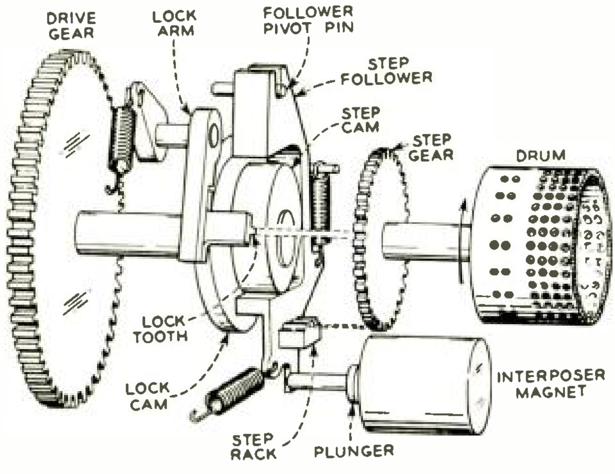


Fig. 5–Over-all view of stepping mechanism.

ure 5, has an input shaft driven through 1:1 ratio gearing from the cam shaft, and an output shaft that carries the reading drum and a thirty-six tooth gear. In the actual machine, the gear on the output shaft is directly above the step rack, but in Figure 5 it is shown moved away from it to reveal more detail of the mechanism.

Stepping is brought about by the action of the step cam on the step follower, to which the step rack is fastened. Its action can be seen more clearly in Figure 6. The follower is U-shaped, and pivots on the follower pivot pin. Two of its inner surfaces, marked A and B, are held against the step cam by the engage spring and the step spring. The step cam, which is mounted directly on the input shaft, is so designed that in rotating, it first pushes the follower down so as to disengage the step rack from the step gear, then moves the follower to the right, then allows the engage spring to pull the follower up so that the rack engages with the step gear, and finally, allows the step spring to pull the follower to the left and thereby rotate the drum just enough to bring the next row of holes in line with the reading fingers. This cycle is repeated each revolution of the step cam, and thus a total of sixteen steps of the drum are made every second.

To secure this type of cycle, the step cam has two opposite 135 degree (3 times 45 degrees) sectors of constant radius, and two opposite 45-degree sectors of changing radius. The constant-radius sectors are A and C in Figure 6. Sector A has a greater radius than sector C; the difference between them is just enough to allow the rack to move the drum one line. Sectors B and D make the transition from large to small and small to large radius. When sector D reaches surface B of the follower, it forces the follower down and disengages the rack from the gear. This requires one-eighth of a cycle, or forty-five degree rotation of the cam. For the next one-eighth cycle, the follower remains still because its A and B surfaces are riding on constant radius sectors of the cam. At the beginning of the

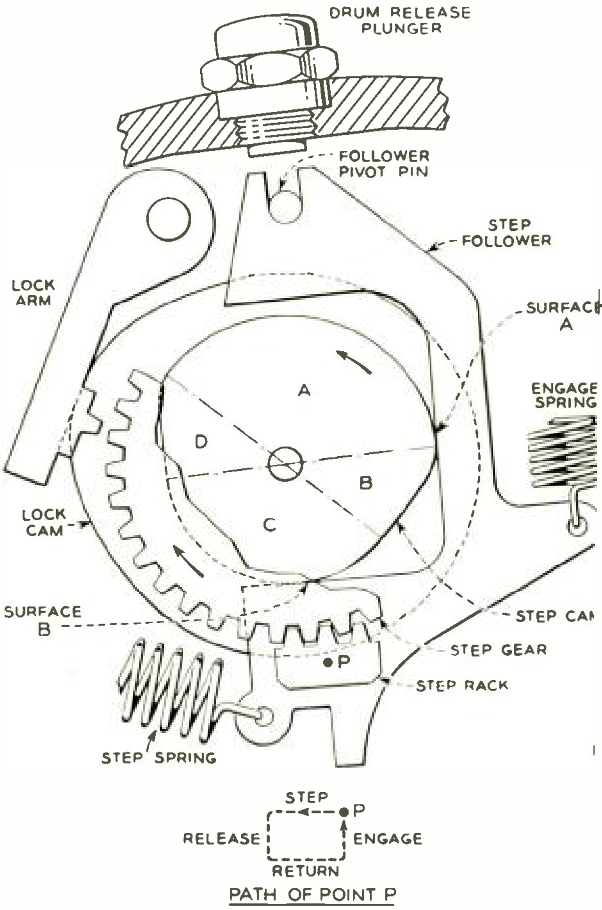


Fig. 6–Step cam and follower from drum end.

next one-eighth cycle, however, sector D has reached surface A and moves the follower to the right. After another one-eighth cycle of no motion of the follower, sector B reaches surface B and allows the follower to move up so that the rack engages the teeth of the step gear. Another one-eighth cycle of rest follows, and then sector B, having reached surface A, allows the follower to move to the left under the pull of the step spring, and advances the drum one line. The motion of the step follower, as illustrated by point P, is produced at practically constant acceleration and deceleration by the shape of the step cam. The performance is quiet and free from shock and thus long life is received.

In proper phase with the step cam, another cam, marked LOCK CAM in Figure 6, holds a lock tooth in mesh with the step gear except during the one-eighth cycle while the drum is being stepped. This prevents any possible motion of the drum while the reading fingers are in the drum.

The interposer magnet, shown in Figure 5, provides the means by which the control circuit can prevent the drum from stepping. When this magnet is released, its plunger moves forward behind a finger on the follower and prevents the follower from being pulled to the left by the step spring. When the interposer magnet is released, therefore, the follower will move up and down following the step cam, and the lock tooth will move in and out in the proper phase, but the follower will remain in its extreme right-hand position, and the drum will not be stepped.

A non-locking tape-feed key mounted at the left end of the control contact housing permits the interposer magnet to be operated by the attendant, thus allowing the drum to advance continually. This key is used principally when a new tape is being inserted in the reader.

Just above the follower and passing through the housing of the stepping mechanism is a drum-release plunger by which the follower may be pushed down to disengage the step rack from the step gear. If this is done at the middle of the step period, while the lock tooth is disengaged, the drum is left free to turn. This is taken advantage of in inserting and removing the tape.

Mounted on the cam shaft at the extreme right is a flywheel, evident in Figure 2, marked along the inner edge of its periphery with a degree scale from 0 to 360 in five-degree steps. This is used during adjustments and tests to set the cam shaft to any position of the operating cycle. Built into this flywheel is a ratchet which prevents the reader from turing backwards as the reader comes to a stop. This ratchet is of the centrifugal throw-out type, and is disengaged when the reader is running. It thus produces no noise or wear under operating conditions. It may also be disengaged by inserting special pins in the flywheel to permit the reader to be turned by hand in either direction for servicing.

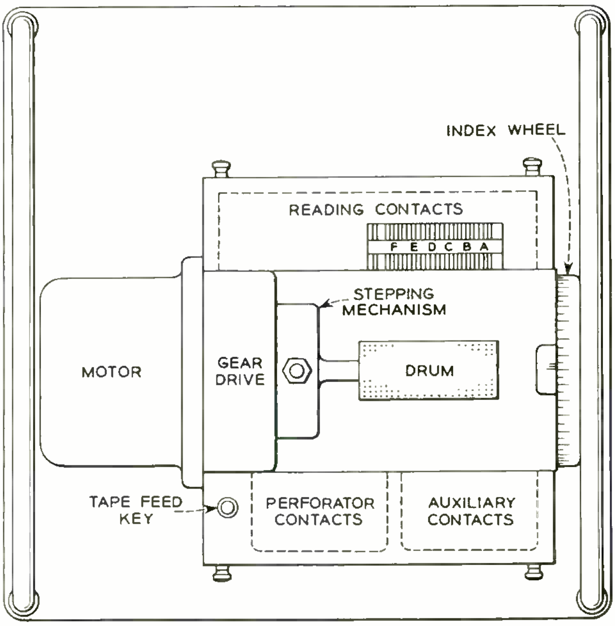


Fig. 7—Simplified diagram of the reader.

All of the contacts of the reader must be adjusted to close and open within fairly narrow limits. With the drive motor stopped, the opening and closing positions of the various contacts may be checked at any time by rotating the dial and reading its position as the various contacts operate. The relationships between the markings on the dial and the mean values for the closing and opening of the various sets of contacts are shown in Figure 8. The zero position on the dial corresponds to the middle

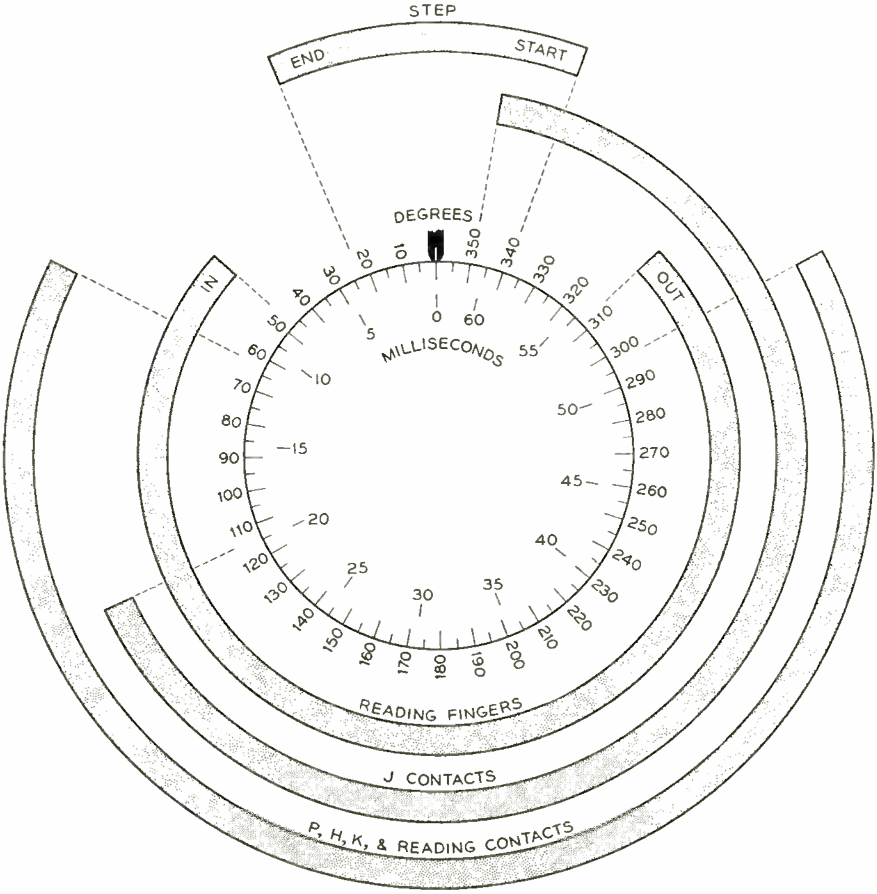


Fig. 8—Time-angle diagram for the reader shown in relation to the degree scale on the flywheel.

THE AUTHOR: F. C. KUCH, a member of the Facilities Development Department, is currently engaged in a project for the Navy. Since 1918, when he joined Western Electric's Engineering Department, now Bell Telephone Laboratories, Mr. Kuch has been occupied with a variety of assignments. He analyzed shop orders during World War I, prepared apparatus specifications, and for twelve years before World War II he designed relays, buzzers and other electromagnetic apparatus. During the war he was engaged in the design and development of radar equipment for the armed forces. From 1946 to 1950 he was associated with the development of AMA apparatus, and from 1950 to 1951 he was engaged in the design and investigation of relays for military applications. Mr. Kuch received a B.S. degree in E.E. from Cooper Union in 1925.

of the stepping period. Inside the degree scale of Figure 8 a time scale in milliseconds is marked—each revolution of the cam shaft requiring 62.5 milliseconds.

The contact assemblies, shown in Figure 7, are mounted to the frame of the reader with four screws and in addition are doweled in place with locating pins so that they are readily removable and can be remounted without disturbing the adjustment. Easily removable sheet metal covers protect the contacts from dirt. The cover for the reading contacts has a lucite window through which the positions of the reading figures can be observed. An adjacent scale, marked A to F to designate the six digit-positions on the tape, permits the code being read to be directly observed.

The reading, perforating, and control contacts and the interposer magnet are connected by local cable to a plug mounted at the rear of the reader as may be seen in Figure 9. This plug contains terminals on two levels, and is designed to plug into a jack in the reader cabinet to which the associated circuits are connected. The motor is separately connected in its own switch box to a power receptacle to which 110-volt ac supply is connected under control of the reader circuit.

There are three additional versions of the basic accounting center reader. Two of these are used as test readers for maintenance of both the central office and accounting center perforators. They are geared to operate at twenty-four cycles per second, and are equipped with only one group of control contacts. The fourth is a maintenance recorder reader used in the No. 1 crossbar central office. It operates at the same speed as the accounting center reader but is equipped with the same contacts as the test reader. These readers are manufactured by the Teletype Corporation, and their basic design was carried out at Bell Laboratories by F. M. Thomas formerly a member of the technical staff.

Since the reader is in use many hours each day, it is necessary that the adjustments be held over long periods of use. Tests have shown that the reader is stable in adjustment, and that substantially trouble-free operation can be expected with occasional lubrication and maintenance.

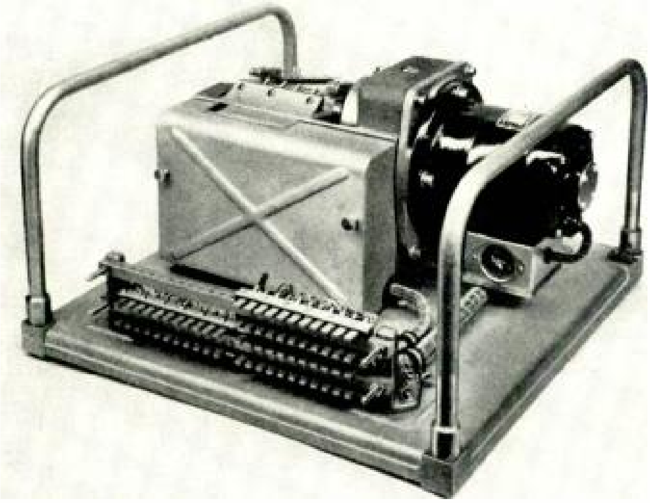


Fig. 9—A rear view of the reader.

Lee de Forest and William Shockley Discuss Electronics

Dr. de Forest (right) is the inventor of the audion from which the modern vacuum tube in its many forms and types has sprung. Dr. Shockley is the leader of the research group at Bell Telephone Laboratories whose members invented the transistor. Standing side by side these two men seem to epitomize the basic change in the pattern of our technical life which has taken place during the first half of the present century—the change from the struggling individual inventor to the great industrial scientific laboratory as the source of much of our technological advance.

This photograph was taken during a visit of Dr. de Forest to the Laboratories on April 7. The following day a testimonial dinner was given him by the De Forest Pioneers in cooperation with a number of other organizations.

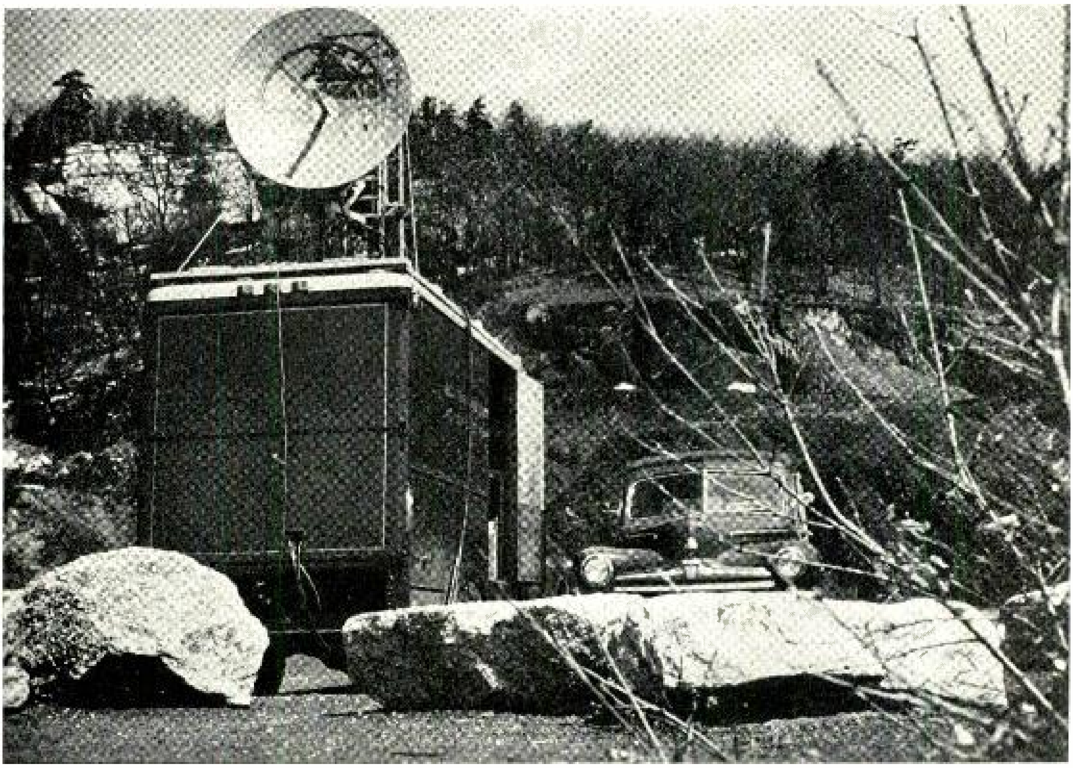
Transmission Beyond the Horizon at Frequencies Between 40 and 4000 Mc

One of the commonest assumptions in radio theory has been challenged as the result of a series of experiments conducted by the Laboratories during the past few years. These experiments have indicated that the very high and super high radio frequencies, such as those used for television, radar, and microwave relay systems are not necessarily limited to approximately line of sight distances, but that signals can consistently be obtained at distances of 200 miles or more beyond the horizon.

Lower frequencies, reflected between the ionosphere and the earth's surface, can carry signals hundreds and thousands of miles beyond the horizon. Very high frequencies, on the other hand, are not ordinarily reflected by the ionosphere but continue through it, merely undergoing some refraction as they pass through atmospheric areas of varying density. Thus, the natural tendency throughout radio history has been to assume that, in general, the higher frequencies would not be useful for transmission much beyond the horizon.

Scientists from Bell Telephone Laboratories, compiling the results of their observations, have reported that VHF signals have consistently demonstrated far greater strength at points beyond the horizon than had been expected from existing knowledge of very high frequency radio signals. The loss of power in going from within the horizon to slightly beyond is, as was expected, considerable, but accepting this loss, VHF signals were shown to decrease much more slowly with increasing distance than was predicted by existing theories.

In the series of experiments carried on by the Laboratories, the median signal levels recorded are 50 to 90 db below the intensity expected in free space but are



A truck mounted antenna used by Bell Telephone Laboratories for beyond the horizon reception.

hundreds of decibels in excess of the computed value based on the classical theory of smooth spherical earth with a standard atmosphere.

Reception of high frequency signals far beyond the horizon had been reported occasionally by previous investigators but dismissed as an irregular and undependable phenomenon. Such reception was assumed by some to be due to unusual weather conditions bringing about the presence of large volumes or "ducts" in the atmosphere having a markedly different density than the surrounding atmosphere, hence, a different refractive value. A later theory was that the normal turbulence in the atmosphere was sufficient to scatter the signal over relatively wide areas.

However, the median signal levels recorded by scientists of the Laboratories are relatively independent of meteorological conditions, indicating that the over-all reliability is much greater than would be expected from the "duct" theory. In addition, the experimental evidence on the effectiveness of directional antennas is contrary to what would be expected from the "scattering" theory.

A most significant conclusion to be derived from the tests by the Laboratories relative to free-space transmission is that the received power is substantially independent of frequency, antenna height, and weather effects at points beyond the horizon. These factors have a substantial effect at or near the horizon but their importance decreases gradually with increasing distance. The decrease in signal power in going from within the horizon to slightly beyond is greater at frequencies in the thousands of megacycles (SHF) than it is at 100 mc (VHF), but once this loss is accepted the signal decreases much more slowly with increasing distance than the extremely rapid decrease predicted by the classical smooth earth theory.

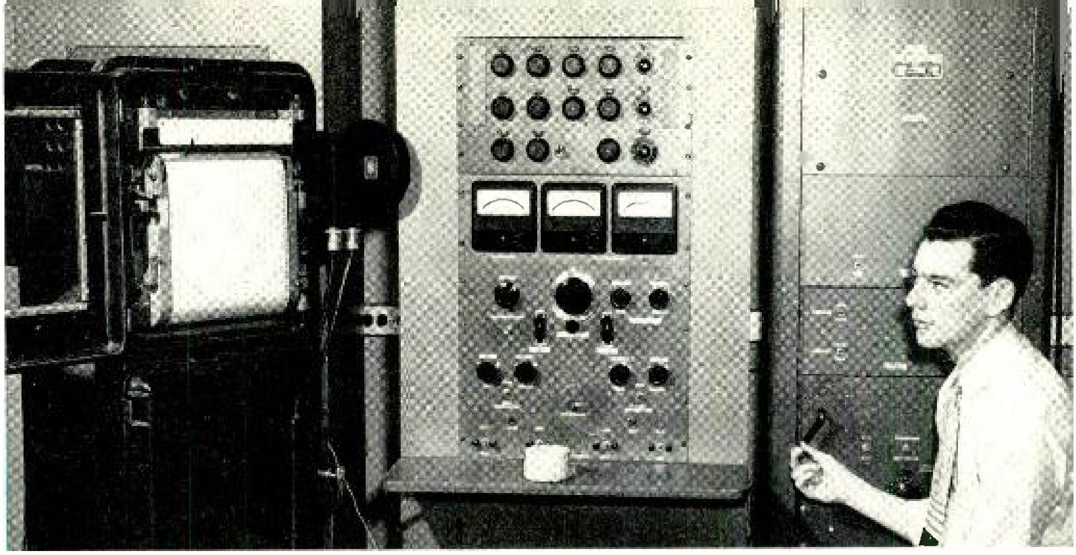
In tests at 3700 mc, made in the Spring of 1950, an experimental transmitter at Whippany, New Jersey, generated 1.5 microsecond pulses with a peak power of about 300 kw. This energy was fed through 250 feet of wave guide to a 10-foot paraboloid antenna mounted on top of a 150-foot tower. The receiving antenna was a 57-inch "dish" mounted on top of the truck that carried the receiving and recording apparatus. Measurements consisted in recording the received signal from several days to a week at each of eight general locations from 22 to 285 miles northeast of the transmitter. These sites were on high ground relative to the local terrain but were all beyond the optical line-of-sight. The most distant site was at Mt. Washington, N. H., where, in spite of the natural elevation, the optical line-of-sight from the transmitter was nearly eight miles above the receiving antenna.

A second series of tests during the same year made use of the 534.75-mc sound channel of an experimental television transmitter operated by National Broadcasting Company at Bridgeport, Conn. These measurements lasted from several hours to several days at most of the receiving sites previously used for the 3700-mc test. The longest path was about 325 miles to a point near Bar Harbor, Me., and was half over land and half over water. Other paths tested included a 225-mile path entirely over land to Mt. Washington, and a 125-mile path almost entirely over sea water to Gay Head on Martha's Vineyard.

As a result of the tests in New England on 535 and 2700 megacycles, a 1-kw transmitter operating at 459.8 megacycles was set up at Holmdel, N. J. Two principal receiving sites were selected along the microwave relay route between New York and Chicago, one near Chambersburg, Pa., (183 miles) and the other in Pittsburgh.

A series of tests on antenna beam widths and gain were conducted on the 183-mile path to Chambersburg. These tests indicated that the signals were coming from the horizon along the great circle route, and that the antenna beam widths were not widened by more than 1 or 2 degress in either azimuth or elevation, indicating the effectiveness of directional antennas for beyond-horizon reception.

A paper giving some of the results of the Laboratories' studies and summarizing data from other published reports was presented by Kenneth Bullington at the annual convention of the I.R.E. last March and will be published in the Proceedings.



A Recording Fluxmeter of High Accuracy and Sensitivity

P. P. CIOFFI
Magnetic Studies

Magnetization curves and hysteresis loops of magnetic materials reveal important characteristics affecting their performance in coils, transformers, and other electromagnetic apparatus. Since, in turn the characteristics are affected by a great many variables—heat treatment, impurities and alloying elements—a great many such curves must be obtained in developing magnetic materials.

For many years the only method which offered sufficient accuracy was that of the ballistic galvanometer with points on the curves laboriously measured, calculated, and plotted, by hand on a point-by-point basis. With the new recording fluxmeter the mere turning of a crank causes the measurements to be made and their magnitudes plotted on standard coordinate paper. Magnetization curves and major and minor hysteresis loops of ring and bar samples, which formerly required several hours of measurements and plotting can now be traced in a few minutes, with a sensitivity many times greater than that of the conventional ballistic galvanometer.

By turning a crank F. J. Dempsey measures and plots a hysteresis loop for the ring sample shown on the shelf of the flux integrator (center). The unit at right supplies power.

The setup for measuring a magnetic material in the form of a ring is shown in Figure 1. The ring is wound with two coils. A direct current flowing in the magnetizing coil produces a magnetizing force H, proportional to the current. The magnetizing force causes a flux of density B to interlink the search coil. The flux interlinkages are converted by the B-integrator into a current proportional to B. As H is varied, there is a corresponding change in B. The new fluxmeter obtains the desired curves by measuring and recording two currents, one proportional to B and the other to H.

The principle of operation is illustrated in Figure 1. The search coil and the secondary winding of a mutual inductance (M) coil are connected in series opposition to a galvanometer. A light beam reflected from the galvanometer is split between two photocells by reflection from the right angle faces of an aluminized prism. Applied to

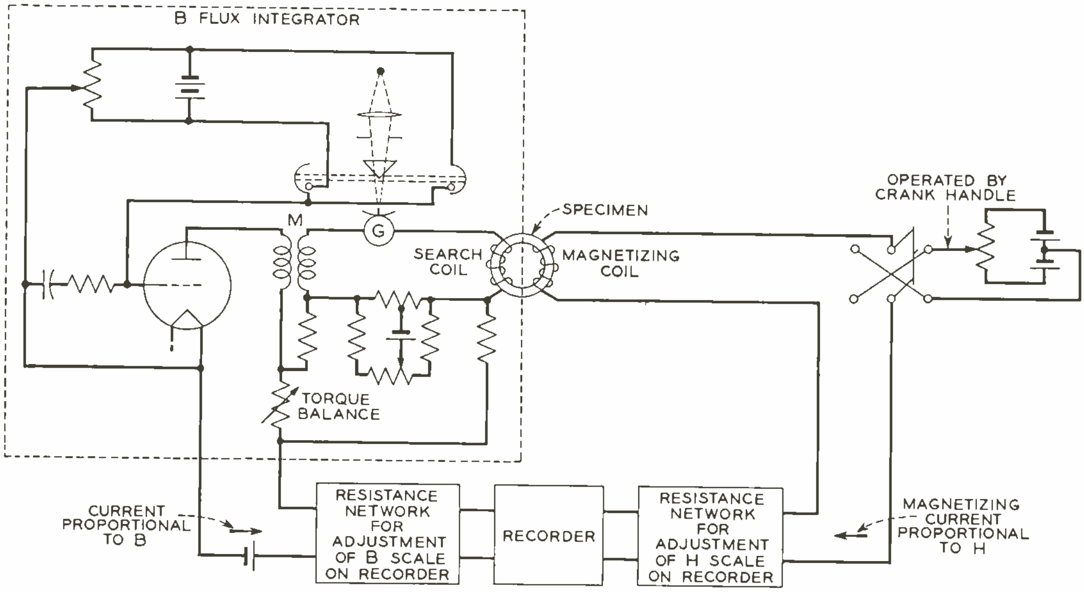


Fig. 1—Simplified schematic of the recording fluxmeter arranged to measure a ring specimen.

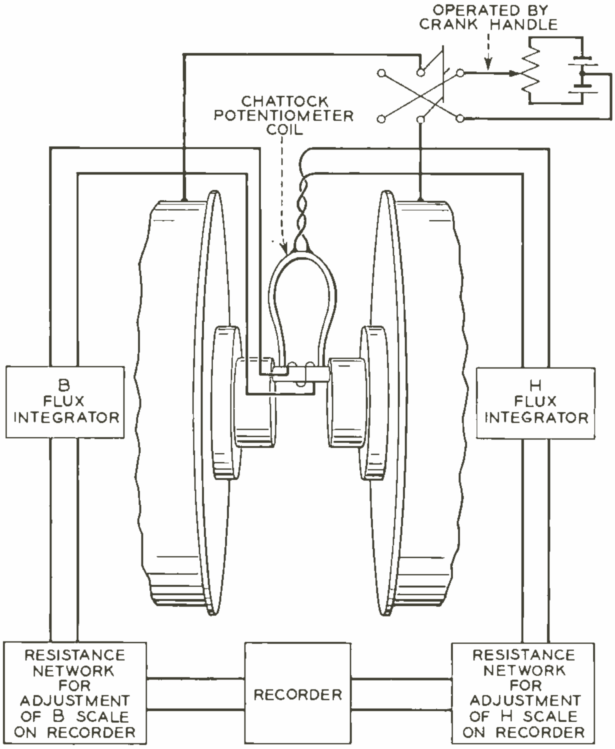


Fig. 2—Circuit for measuring a bar sample.

the grid of the tube, the voltage unbalance between the photocells, caused by a change in light distribution produces a change in current in the primary of the mutual inductance. When the crank is moved, changing H, there is a corresponding change in the B flux interlinking the search coil. The galvanometer begins to deflect, and the current change in the primary of the mutual inductance produces flux interlinkages in the secondary opposition to those from the search coil. This action tends to keep the galavnometer deflection small. If the galvanometer deflection is negligibly small, the change in primary current will be an exact measure of the change in search coil interlinkages. The high gain in the electronic and optical system reduces the maximum galvanometer deflection in a hysteresis loop traversal to about 0.0005 inch at the light dividing prism, 8 inches from the galvanometer. Compensating current proportional to the angular deflection, to prevent drift due to the restoring torque of the galvanometer suspensions, is provided by feedback from the tube's plate circuit, to the galvanometer. A balancing circuit connected to the galvanometer circuit provides a fine adjustment for the initial correction of other causes of drift.

From the tube circuit and the magnetizing circuit, currents representing B and H pass, through resistance networks, to drive a recorder equipped with two independent mechanisms. One of these, the H element, causes the drum to rotate proportionally to the magnetizing current, which, for a ring core specimen, is proportional to H. The B element drives the pen proportionally to B. By continuously increasing the magnetizing current from zero to a positive value, followed by a cyclic reversal to the

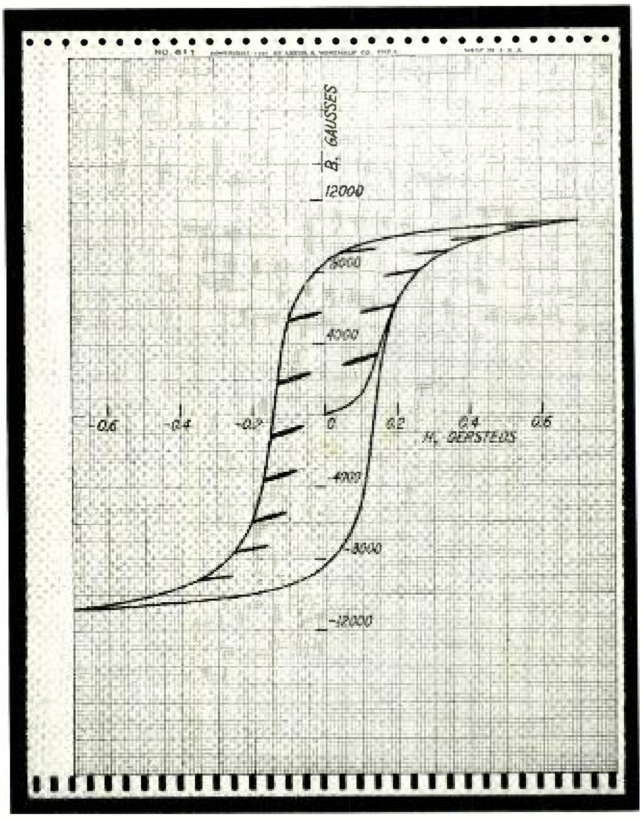


Fig. 3—Magnetization curve and hysteresis loop for a ring sample of 45 permalloy as plotted by the recording fluxmeter.

same value, the pen and the paper drum of the recorder are simultaneously driven proportionallly, respectively, to B and H in the specimen, and the magnetization curves and hysteresis loops are traced. The minor loops illustrated in Figure 3 are obtained at any point of the curve by appropriately decreasing, then again increasing the magnetizing current. The resistance networks permit adjustment to provide directly calibrated curves for wide ranges of B and H.

When the specimen is in the form of a bar the magnetizing force H is not proportional to the magnetizing current, and so must be independently determined. The setup for testing a bar specimen, Figure 2, involves, as compared with the circuit in Figure 1, a second flux integrator for H, and an electromagnet. The bar specimen is wound with a search coil only, and it is magnetized between the poles of the electromagnet, the current through which is controlled by the hand crank.

To evaluate the magnetizing force H, use is made of a flexible, elongated double-layer coil known as a Chattock magnetic potentiometer coil. When the ends of this coil are laid on the bar specimen spanning the search coil, as shown in Figure 5, the magnetizing current produces in the coil a flux linkage proportional to H. Through the H integrator, this flux linkage is made to control the rotation of the recorder's drum proportional to H. As in testing ring specimens, the flux from the search coil, which is around the bar, again controls the motion of the recorder's pen. By causing a slow cyclic change in the current through the electromagnet, the magnetization curve and hysteresis loop (Figure 4) may be obtained as simply and accurately as for a ring specimen.

The galvanometer and its optical system are mounted on a heavy brass plate. The plate is hung from a single point spring suspension, to prevent the transmission of

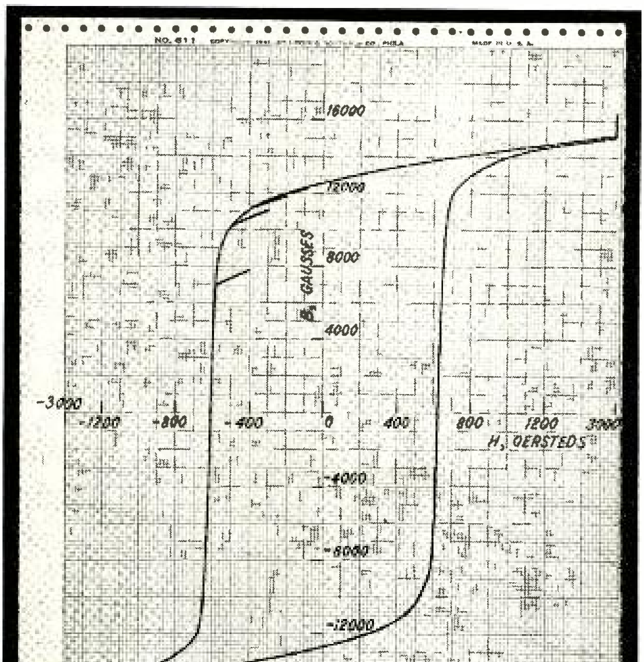


Fig. 4—Hysteresis loop for a cylinder of Alnico V.

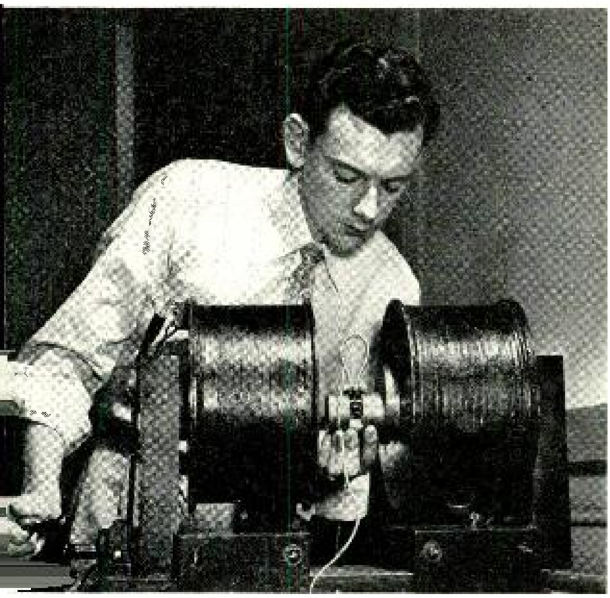


Fig. 5—Bar sample is clamped between poles with search and Chattock coils in position.

mechanical vibrations, and keep the galvanometer system level. The incoming leads are independently supported so that they do not affect the plate's level. To avoid setting the galvanometer system into vibration during manual adjustments, provision is made to anchor the plate rigidly. This is accomplished by an elevator platform, directly below, which picks up the plate on three adjustable screw supports, without changing the plate level. The elevator platform is attached to the shaft of a pneumatically operated piston. The operation is smooth and gentle; no perceptible disturbance is imparted to the suspension system when it disengages from the plate. Any residual motion of the plate is damped out magnetically by means of copper disks which are attached at each end of the plate, and move freely in the airgap fields of strong permanent magnets.

High accuracy and sensitivity—four interlinkages with the search coil give a deflection of one millimeter—were obtained by minimizing causes of drift. Since parasitic currents in the galvonometer circuit are a cause of drift, the galvanometer circuit had to be thoroughly insulated against leakage currents from neighboring circuits at higher potentials. Within the galvanometer circuit, thermoelectric junctions likely to generate extraneous potentials were either eliminated or isothermally enclosed.

M. A. Logan developed the remedy for large residual drift which he had traced to the tube circuit. Ordinarily variations in the minute grid current of a tube are not a source of objectionable instability. But, here, with the photocells presenting an input impedance of many thousands of megohms, the voltage variations built up to troublesome magnitudes. The cure was to introduce an impedance-transforming cathode follower (not shown in Figure 1) between the photocells and the tube.

THE AUTHOR: Since World War II, P. P. Cioffi has been concerned with the development and application of magnetic materials and the study of magnetic circuits in telephone apparatus. He joined the Laboratories in 1917, and after preliminary work in electronics, his efforts were devoted to fundamental investigations in magnetics; the study of strain-sensitivity, magnetostriction, and magnetoresistance properties of magnetic materials. During World War II, he was occupied with the investigation of magnetic circuits, the design of permanent magnets for magnetrons, and the development of the recording fluxmeter. He received the B.S. degree in E.E. from Cooper Union in 1919 and the E.E. degree in 1922, and, from Columbia, the M.A. degree in 1924.

Centralized Automatic Message Accounting

Development of new message Accounting Equipment, called Centralized Automatic Message Accounting (CAMA), is nearing completion at the Bell Telephone Laboratories. With CAMA the recording of message information for accounting purposes is done at a centralized tandem switching point rather than at a local dial central office as is the case with present AMA equipment.* Thus information on messages originating in a number of local central offices and passing through the centralized tandem switching point for completion is recorded efficiently at the tandem point without requiring AMA recording equipment at any of the local central offices. Scheduled for trial in the last half of 1953, the initial installation will permit metropolitan customers to dial their own message unit calls within a metropolitan area as well as certain short-haul toll calls to nearby points.

The CAMA recording equipment is located at a crossbar tandem switching center. An operator also located at this center is brought into each connection momentarily to obtain the calling customer's number and in turn cause this number to be recorded in a manner to insure a proper charge for the call. With this method of identification, all customers, including four-party and rural, can dial their own charge calls, whereas in the case of local AMA equipment now in service, such dialing is limited to individual and two-party customers. To further mechanization of CAMA, the Laboratories is planning the development of a means of automatically identifying the calling station.

Telephone Service for Carrizo Plain Area of California

On March 14 The Pacific Telephone and Telegraph Company placed in service three radio circuits between Paso Robles and points about 45 miles southeast in the Carrizo Plain area of Central California. Open-wire service lines, the longest being about 15 miles, are being built by the customers to connect 18 toll stations to the Carrizo Plain radio terminals. At present, only three toll stations are in service; no telephone service was previously available in this area. The new radio circuits, employing General Electric 60-watt equipment, operating in the 152 to 162-mc range, were installed at an estimated cost of $18,000, exclusive of the wire-line extensions.

Type-O Carrier System Goes Into Service

The first type-O carrier telephone system, known as OB1, has been placed in commercial service in southern West Virginia between Richwood and Sutton, about 90 miles east and northeast respectively of Charleston, the state capital. As described briefly in the March Record, page 138, type-O carrier is a new short-haul open-wire toll system that will ultimately furnish sixteen channels in both directions on one pair of wires. These channels are divided into four-channel groups, designated OA, OB, OC, and OD, each group providing four two-way channels. At the present time, the OB group is the only one in manufacture. This group employs a frequency range from 40 to 76 kc.

Installation of this system was begun January 7 and was virtually completed by January 28 when acceptance testing began. Commercial service started February 5. The addition of the four channels raised the number of circuits from six to ten between the two towns. Increased traffic caused by the opening of a new coal mining field near Richwood made these circuits necessary.

Interest in the installation and operation of this new system brought representatives to Richwood from Western Electric Installation Headquarters in New York, the O & E Department of the A T & T, the Chesapeake & Potomac Telephone Company of Baltimore City, and the Chesapeake & Potomac Telephone Company of West Virginia, besides those from the Laboratories. G. T. Cindric and T. W. Thatcher from the Laboratories participated in the acceptance testing of the terminals and line-up of the system.

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* Record, *February,* 1952, *page* 70.

Fig. 1—*The first step in microscopy, a cursory examination, is made with a low-power binocular microscope.*

Fig. 2—*The microtome in use, slicing a thin section of polyethylene tubing.*

Optical Microscopy:

An Adjunct to Engineering and Research

F. G. FOSTER
Chemical Laboratories

As science has progressed, new and far more sensitive analytical instruments have been developed within the past relatively few years, giving a degree of accuracy unknown a short time ago. Among the newer instruments are the mass spectrometer*, the infrared spectograph, and equipment utilizing electron optical methods, the electron microscope being perhaps the most familiar. In addition, the optical microscope, while being the oldest of these analytical instruments, also has been developed to a greater degree of refinement.

In Bell Telephone Laboratories, an optical microscopical laboratory is one of the facilities of the analytical chemistry group. It is used in a programed approach to problems requiring visual analysis greater than that which may be made with the unaided eye. Here are found the reasons why apparently sound metal parts fail, or what sometimes prevents contacts from closing, or how filler material may cause variations in properties of molded compounds.

Analytical problems can rarely be solved completely by a single instrument; frequently the results of several examinations must be pooled and correlated. As an example of a coordinated approach to a simple typical problem, a chemical examina-

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* RECORD, *February*, 1952, *page* 64.

tion of a specimen of iron or steel will provide qualitative and quantitative data as to the various elements contained in the sample. The manner in which these elements are combined, however, requires the microscope, the use of which will determine whether the material is wrought iron, gray cast iron, malleable iron, or steel. From this inspection, much can be determined in regard to hardness, strength, brittleness, and malleability.

Telephone research and development requires extensive application of the microscope. Almost limitless are the materials that find their way to the microscopical laboratory—metals, woods, textiles, ceramics, various powders, fibers, plastics, paints, corrosion products, sludges—even dust particles collected from the contacts of switching apparatus.

Examinations for engineering purposes usually fall into one or more of three groups —those made on (1) new materials, (2) processing operations, such as forming, bending, forging, riveting, and welding, and (3) failures of the manufactured part in service.

In the examination of failures, microscopy attempts to place the responsibility for the failure at the proper door—is it the fault of the supplier of the material, the manner in which the part was fabricated, or is the user the one to be blamed? For example, microscopic examination of a forged eyebolt that had failed in service will indicate whether the material initially was satisfactory, whether the forging operation had been done at a damaging temperature, or if the installer of the bolt had overstressed it, or if failure had occurred due to fatigue of the metal.

In performing a microscopical examination, a cursory survey or low power inspection is generally the first step (Figure 1). From this, an over-all viewpoint is gained, whereby the method of approach to the problem can be visualized. For this initial study, a strong magnifying glass or jeweler's loupe, having a magnification of 10 diameters, is used; if this is not sufficient, a wide field inspection binocular microscope with magnification range of 15 to 40 diameters is employed. By restricting the magnifying power in this preliminary examination, more area and greater depth of focus are obtained.

With the general nature of the problem understood, preparation of the material for

Fig. 3—Pouring bakelite powder into the mold to mount a step-by-step bank terminal.

Fig. 4—Preliminary preparation—Clarice Lovell is grinding a specimen on abrasive paper.

higher power microscopy falls into one of two general classifications of techniques—transparent or opaque. The first classification is concerned with materials that may be either sliced very thin, or dispersed or smeared in such a manner as to render them relatively transparent. This class includes wood sections, rubber, the softer plastics, textiles, paper, and finely divided particles. The second contains principally metals and some of the harder plastics.

Thin sections of materials are obtained by slicing on a microtome, a sturdy instrument carrying a carefully ground and honed blade and a means of transporting the specimen to the blade so as to cut sections of 2 to 5 microns in thickness (0.000078 to 0.000195 inch). A microtome, with its blade slicing a section of polyethylene tubing, is shown in Figure 2.

Some transparent sections are treated in various ways to bring out the features to be studied. Transparency of some specimens is increased by treating in xylene, oil of cloves or other clearing agents, while the contrast of many delicate structures may be increased by staining with a dye—methylene blue, gentian violet, safranin—among many others.

The section under study is then mounted in a resinous medium of suitable refractive index*, between a 25 by 75 mm glass slide and a very thin cover glass. The medium used for mounting must be chosen as to whether contrast in the resulting image, or maximum light transmission is desired. Thus, if a group of artificial yarns were to be examined, a medium having a refractive index vastly different from that of the yarn would be required for contrast, since, in a medium of refractive index approximately equal to that of the yarn, the specimen would virtually disappear if free of color. If, on the other hand, small inclusions were suspected, a refractive index equal to that of the yarn would be advantageous because it would allow the light to be transmitted through the relatively transparent yarn and thus emphasize the inclusions.

Contrasted to the thin, relatively transparent specimen or dispersion of fine parti-

Fig. 5—Final lapping is done on a rotating cloth covered wheel charged with alumina.

Fig. 6—The specimen is finally etched to develop grain structure.

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* Refractive index is the ratio of the velocity of light in air to that in the given medium.

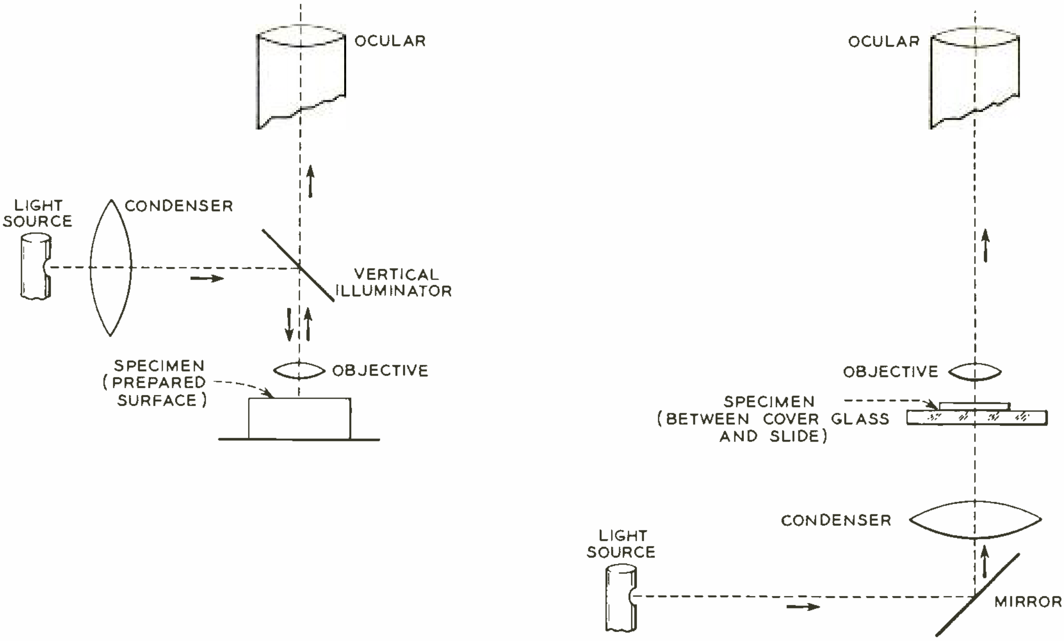

Fig. 7—Schematic drawing of light paths through microscopes. Left, path of light illuminating opaque specimen; Right, path of light illuminating transparent specimen.

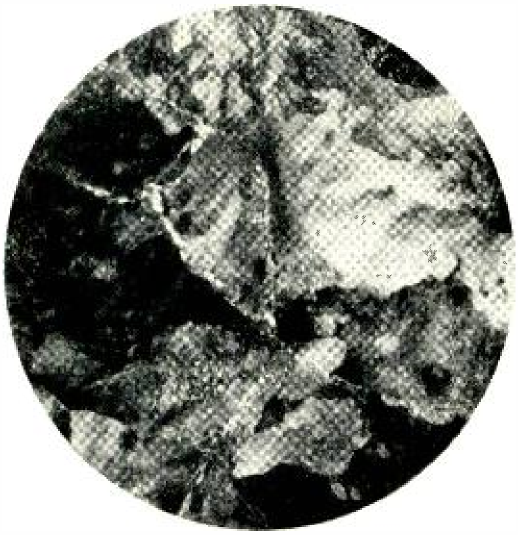

Fig. 8—Structure of Pearlitic steel resulting from use of a lens capable of resolving to a magnification of only 150 diameters, but photographed at a magnification of 500 diameters.

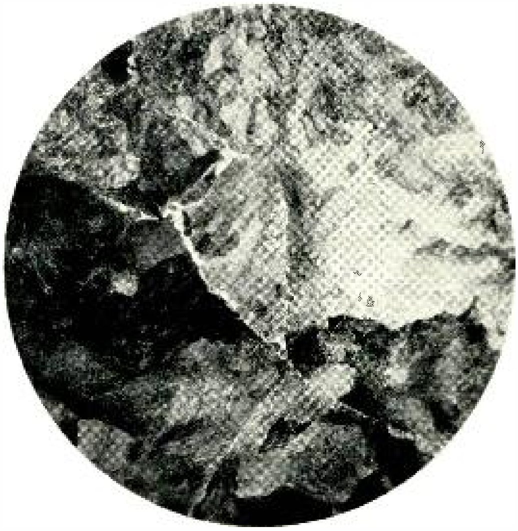

Fig. 9—The same area of specimen shown in Figure 8, but photographed with a lens capable of resolving to a magnification of 500 diameters.

cles on glass slides are the opaque materials, generally comprising the metal group. Prior to the examination of this class, it becomes necessary first to prepare the surfaces of small blocks or sections. Since exceptionally small metal sections would be difficult to handle in preparation, they are first mounted in plastic molding compounds for support (Figure 3). These specimens are given a preliminary preparation by grinding on successively finer abrasive papers, the final one being a specially prepared, extremely fine abrasive paper (Figure 4). The specimens are next lapped on two cloth-covered polishing wheels charged with alumina, the first having particles 0.3 micron in size, and the second or finishing lap, 0.1 micron. See Figure 5.

With this newly developed, mirror-like finish, a specimen is ready for its final preparatory step of etching (Figure 6). Etching has a two-fold purpose—first, to remove any amorphous material that may have been cut away from the specimen and redeposited on its surface; secondly, to emphasize grain boundaries and other physical features. Etchants are many in number and vary widely in composition. Among the common ones are nital and picral, coined names indicating respectively very dilute alcoholic solutions of nitric and picric acids that are used for many of the alloys of iron. For the copper base alloys, solutions of ammonium hydroxide and hydrogen peroxide, or potassium dichromate with sulfuric acid, are used. Many of the aluminum alloys are readily etched with a one-half per cent aqueous solution of hydrofluoric acid, but other alminum alloys, as well as the different stainless steels require stronger and more complex etchants.

Examining specimens of the two general classifications of materials, i.e., transparent and opaque, requires two distinctly different types of microscopes, the instruments themselves differing principally as to illuminating systems. For thin specimens, light from a controllable source is directed to the mirror of the microscope and transmitted through a condenser that can critically focus the illumination on the specimen. This is indicated by the right hand drawing of Figure 7. With the compound magnifying system, that is, with an objective lens next to the specimen and an ocular lens next to the eye, the magnified image becomes visible to the eye, ultimate magnification being the product of the magnifications of the objective and the ocular. Since in microscopy, resolution or the ability to see finely divided particles or closely spaced lines and not just magnification is the criterion, it then becomes necessary to employ the finest optical systems in the most judicious manner. Thus, excessively magnifying an image will gain no further resolution, but produces only "empty," or indistinct magnification. An example of this is illustrated in Figures 8 and 9 in which pearlite, an alternate layer structure of iron carbide and iron, is shown. Both of these pictures are at a magnification of 500 diameters, but Figure 8 shows the effect of using a lens capable of magnifying, with consistent resolution, to only 150 diameters In Figure 9, the lamellae are clearly defined.

Fig. 10—The metallograph used in the examination of opaque specimens.

Fig. 11—Micrograph of annealed pure nickel shows the influence of oblique illumination on resolution (750 diameters).

Fig. 12—Micrograph of a section of cloth backed adhesive coated cork-neoprene (50 diameters).

Fig. 13—Chlorinated napthalene and thymol magnified to 75 diameters and photogrpahed with ordinary light.

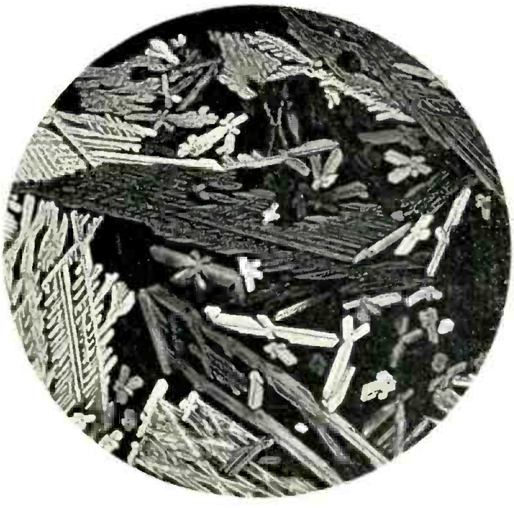

Fig. 14—The specimen of Figure 13 photographed at the same magnification, using polarized light.

It is readily apparent that similar illumination to that used for transparent specimens cannot be used for thick opaque specimens. In this case, it is necessary to resort to what is known as incident, or surface lighting. For very low powers of magnification, it is possible to illuminate obliquely in a manner similar to photographing some object on a table using a spot light. Higher power microscopic objectives with short focal lengths work at very close distances, making it impossible to direct a beam of light at a suitable angle. Devices known as vertical illuminators are employed to overcome this difficulty. Essentially, they consist of some form of mirror device, mounted in the optical path of the microscope between the objective and ocular, directing light rays from the lamp source along the optical axis toward the specimen, as shown in the left hand view of Figure 7. Thus, the rays received into the path travel through the objective lens, which is in reality a condenser, forming a spot of light. These rays are returned in varying degrees, depending upon surface reflectivity and scattering, through the image forming objective, and are further magnified by the ocular. The image may then be studied by eye or recorded photographically; a metallograph designed for this is shown in Figure 10.

Oblique illumination, emphasizing contrast through shadowing effects and relief, is accomplished by bending the rays of light before they reach the specimen. With a carefully controlled, narrow pencil of light rays, it is possible to gain up to twice the resolution. A micrograph showing this interesting and advantageous effect in annealed pure nickel is shown in Figure 11.

Darkfield illumination, developed extensively in early biological microscopy, is a method of lighting with the rays of the illuminant impinging on the edges of a specimen, thereby outlining the subject against a strong dark background. Such technique finds many uses in both microscopy of transparent and opaque studies, ultimately yielding contrast sufficient to delineate structures too delicate to see or photograph satisfactorily otherwise. An example of this type of illumination is shown in Figure 12, a micrograph of a section of cloth backed adhesive coated cork-neoprene.

A recently developed technique of specimen illumination, applicable to both transparent and opaque materials, has been designated "Phase Microscopy." This method, capable of varying contrast in the image, utilizes absorption and optical path differences. While some work has been done in the metals field employing phase microscopy, the technique has been exploited to a larger degree in biological research, the

THE AUTHOR: F. G. Foster came to the Laboratories as a draftsman in 1929, but subsequently became interested in microscopy. While engaged in drafting and later in the microscopical laboratory, he continued his studies at Newark College of Engineering, where he received his B.S. in M.E. degree. He also took courses in metallurgy at the Polytechnic Institute of Brooklyn, graduate courses in electron microscopy at Stevens Institute, and is a graduate of the New York Institute of Photography. He has recently taught metallography at the Newark College of Engineering, and is currently teaching industrial microscopy at Stevens.

Mr. Foster has been active in a number of societies and has received honors from several of them. He is a member of A.S.T.M., Past Treasurer and Editor of the Yearbook of the American Society for Metals, Fellow and Vice President of the New York Microscopical Society, Fellow of the Royal Photographic Society of Great Britain. (See Record, September, 1951, page 430), and Fellow of the Royal Microscopical Society. The American Society for Metals has granted him four awards for his microscopical work, and A.S.T.M., two.

particular advantage being the ability to resolve low contrast organisms without killing, fixing, and staining.

The examination of many birefringent substances (those possessing double refraction) or birefringent inclusions in some materials may be benefited by the use of polarized light. Either the transparent or opaque type of microscope may be used, the light entering the instrument being intercepted by a polarizing prism, and further intercepted between the specimen and ocular with an analyzing prism. By rotating these prisms, the degree of birefringency may be observed, measured, or photographed. With the addition of polarizing equipment, substances nearly invisible with ordinary illumination are revealed in a gorgeous display of color. As the prisms are rotated, varying the degree of polarization of the light, colors in varying shades and intensities are completely changed. The effectiveness of this, even in black and white, is shown in Figures 13 and 14.

Akin to many of today's scientific fields, microscopy, the study and use of the microscope, had its beginning in the hands of the amateur. Many historians give credit to Anthony van Leeuwenhoek, (1632-1723), a Dutch merchant in Amsterdam for the origin of microscopy. He early devoted himself to building simple, home-made magnifiers, which he used in the study of the minute structure of organized bodies, especially in the field of aquatic life. His researches were not conducted on any definite scientific plan, but his powers of careful observation enabled him to make many interesting discoveries about insects, the higher animals, and in the anatomy of man.

Before the early 1920's, microscopy was confined principally to medical and biological studies, but in more recent years, it has entered nearly every field of research, development, and manufacture. Today, all progressive organizations, including hospitals, research laboratories, and industrial plants, recognize the value of microscopy and have specialized laboratories and personnel for the work.

New Books by Laboratories Authors

Two new books, representing a complete study of the field, *Antennas–Theory and Practices,* and *Advanced Antenna Theory,* have been published by John Wiley & Sons.

*Antennas – Theory and Practices**, by S. A. Schelkunoff and H. T. Friis, is a comprehensive treatise on antennas of various types in various frequency ranges. It combines fundamental antenna principles and the theory of radiation with practical applications. Beginning with a broad survey of the entire field, it then discusses the various problems of antenna phenomena, including the essentials of field theory, the principles of direct radiation, and their application to antenna arrays. Essentials of field theory, an explanation of Maxwell's equations, spherical waves, antenna current, impedance, reciprocity and equivalence, self-resonance, and slot antennas, horns, reflectors, and lenses, are included in the new volume.

Advanced Antenna Theory†, by Dr. Schelkunoff, presents in rigorous fashion the theory behind antenna behavior and broadband antenna design. It is devoted to recent important work in advanced antenna theory, spherical and cylindrical antennas, integral equations, and natural oscillations. In addition to a comprehensive study of Hallen's methods of obtaining asymptotic solutions for thin antennas and Stratton and Chu's solutions for spheroidal antennas, the author includes his own theory of conical antennas and thin antennas of arbitrary shape.

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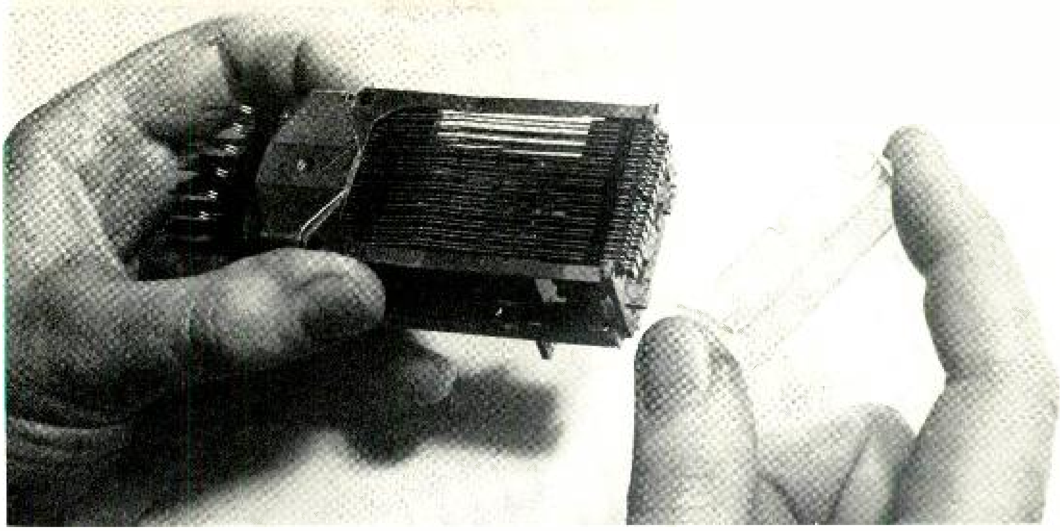
* *Antennas–Theory and Practices*, S. A. Schelkunoff and H. T. Friis, 639 pages, $10.00, John Wiley & Sons, Inc., New York.

† *Advanced Antenna Theory*, S. A. Schelkunoff, 216 pages, $6.50, John Wiley & Sons, Inc., New York.



A New General Purpose Relay

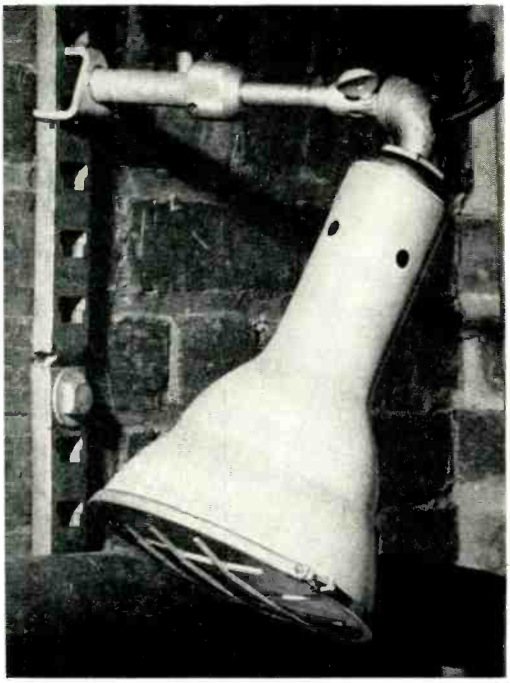
A major development of Bell Telephone Laboratories is the new wire-spring relay. It is now in production in the Western Electric plant, and by the end of this year will begin to be available for use in telephone central offices. Over one hundred thousand will be manufactured during the next eighteen months, and it is expected that production in 1954 will exceed one million. The annual production in future years may approach three million.

In its present form, the wire-spring relay is the result of extensive research and development in the Laboratories and close cooperation with the Western Electric Company, who have had to devise new manufacturing methods and to secure many new tools and machines to accommodate the novel constructions involved. The initial suggestion for this development was made by H. C. Harrison, but the extensive studies, tests, and redesigns that have been required to produce a relay to meet the high standards set for Bell System operation have resulted in many changes in the original design. As a result of this large amount of effort by both the Laboratories and the Western Electric Company, a relay has been achieved that will cost considerably less to produce in large quantities than the relays it will ultimately replace. In addition, the new relay can be operated with half the power or in half the time required for the relays at present used in crossbar switching. Over and above these advantages, it is expected to have a nearly maintenance-free life of forty years. The increased speed of operation is particularly important, since it will permit a shorter holding time for such complex circuits as markers, and thus reduce the number of them required. The savings from faster operation and lower operating current will result in economies as great as those arising from lower production costs.

Up until the advent of this new relay, flat metal strips have been used as the operating springs of Bell System relays. This new relay, on the other hand, employs small wires for the springs, and the groups of wires comprising a relay are firmly and accurately secured in plastic blocks by a molding process. This method of construction avoids all clamping screws and the many separating and insulating parts of former relays. The design is such that the relay requires almost no adjustment after assembly. It is largely this simplicity in construction that has made possible such a low-cost relay. Twin wires are employed for each contact spring to provide the advantages of double contacts. The complete independence of the two contacts of each pair has contributed to the great freedom from open contacts found in laboratory tests and field trials.

The first application of the new relay will be to No. 5 crossbar and the automatic message accounting systems, but other applications will follow. Further descriptions of this new relay will appear in subsequent issues of the RECORD.

Spot Heat for Splicers



Splicing in winter time is going to be much easier on the splicer because of this new heat lamp reflector developed by Outside Plant. Conveniently attached to a cable rack, the new reflector efficiently focusses a 250-watt or 375-watt industrial infra-red heat lamp right on the splice where it serves the dual purpose of furnishing heat and light. Power to run the lamp is supplied by a portable generator outside the manhole. The scene in the illustration above of the lamp's use was posed by instructor K. Gjertsen in a model manhole at the New York Telephone's splicing school at 44 Clarkson Street, New York.

Birth of the Loading Coil

R. B. HILL
General Staff

At the turn of the century, long distance telephony had become a substantial business, but line costs were high and the maximum speech range—even with very heavy open wires—was only about a thousand miles. How to extend this range had become a pressing problem, but even more pressing was the need to extend the speech range of cables so that underground cable could be used in place of the vulnerable overhead structures then required to carry the long-distance and the suburban toll circuits into the larger cities. Not only did the congested open-wire circuits require expensive supporting structures, but they were subject to serious and frequent interruptions from storms. Coil loading seemed to be the preferred solution to these problems, since it could extend the talking distance for both open-wire lines and cables. The successful and immediate application of the then recently invented coil loading was thus of paramount importance.

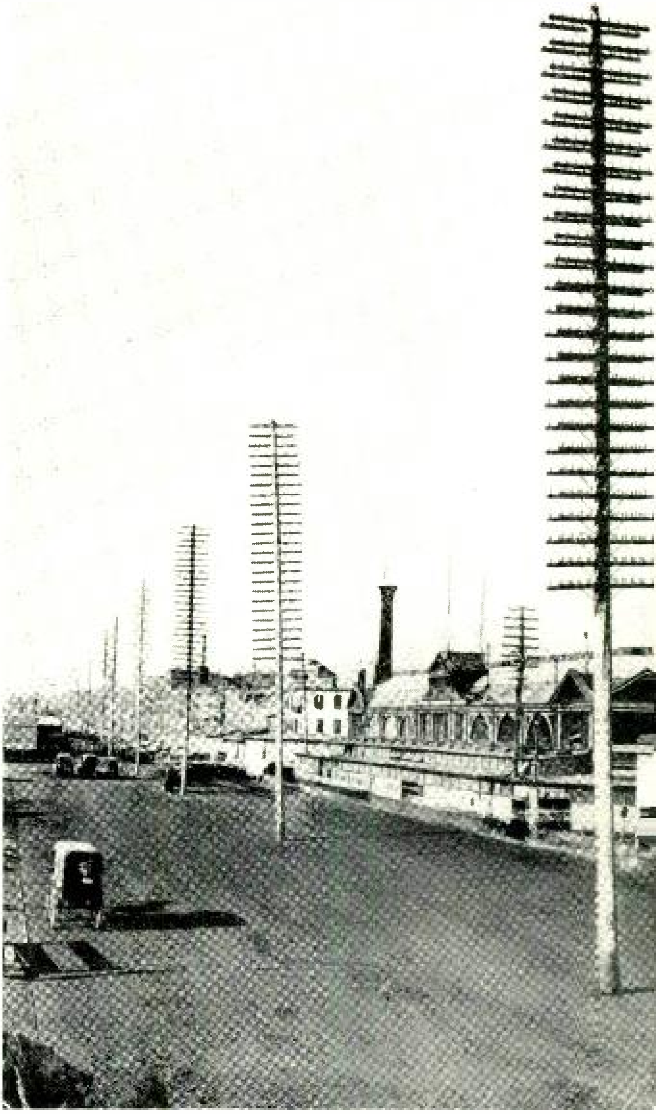


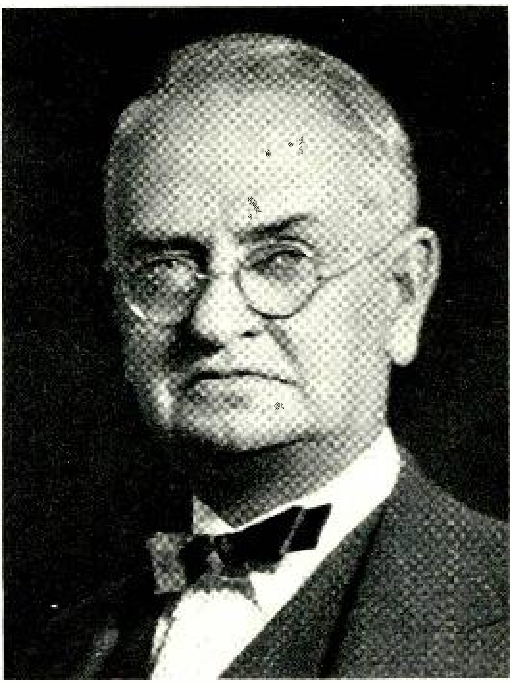
Fig. 1—West Street pole line in New York City over which long distance circuits from the North and East were brought in to the downtown long-distance office. It was such structures as this that in the early years of this century were made unnecessary by the development of loading.

The conception of loading dates from the theoretical studies of Heaviside and Vaschy, reported during 1887, showing that inductance added serially and uniformly along a telephone line could reduce the attentuation and improve the quality of transmission. Several years later they pointed out that improvements in transmission could also be obtained by inserting the series inductance in the form of discrete coils. Although it was fairly obvious that very closely spaced inductance coils would simulate the beneficial effects of continuously distributed inductance, the important question from the standpoint of cost was how far apart the inductance coils could be spaced and still give the desired results. The theoretical studies previously referred to, which comprised the first step toward the achievement of loading, stopped short of this solution, nor were suitable coils developed.

The second important step in the evolution of loading occurred during 1899, when rules for spacing the coils in terms of transmitted wave length were independently worked out by Professor M. I. Pupin of Columbia University and Dr. George A. Campbell of the American Bell Telephone Company. Pupin's patent application was filed ahead of Campbell's, and patents were issued to Pupin in June, 1900. The patent interference proceedings resulted in a final award to Pupin during April, 1904, on the basis of a few days earlier disclosure. Meanwhile, the Telephone Company had purchased Pupin's rights, and was free from restrictions in its commercial development of the new art.

The third step in the evolution of loading was much more time consuming than the creation of the underlying basic theory. It required the determination of suitable coil inductances and spacings to meet the different transmission needs, and particularly the design and manufacture of coils of sufficiently low energy losses.

The provision of the first satisfactory loading coil was largely the work of Howard S. Warren, who had joined the American Bell Telephone Company as an assistant to Campbell in September, 1899. Upon Warren fell the responsibility not only of designing a satisfactory coil, but also of devising or improving many of the manufacturing procedures required to produce it in satisfactory form. Within a little over a year after he began this work, he had provided coils for both open-wire and cable loading. His open-wire coil remained standard for many years, and although his initial cable coil was used only for the circuits between New York and Newark, beginning in 1902, it had established methods and techniques that were easily adapted to the immediately following cable coils.


H. S. WARREN

Prior to the completion of Warren's work on the initial commercial designs, experimental coils had been used in Campbell's laboratory tests (September, 1899) which verified his loading theory, and in temporary installations of experimental loading on two 24-mile Boston exchange area cable circuits in May, 1900, and on a 670-mile 104-mil open-wire circuit between Bedford, N. Y., and Brushton, Pa., in July, 1900. The 1899 laboratory tests used a circuit looped back and forth in several reels of standard nineteen-gauge cable. All of the coils used in these tests were of the air-core, solenoidal type. Time was very important, and the air-core solenoids could be produced much more quickly than iron-core designs.

The success attained in these temporary installations had a very important result in building up a large demand for commercial loading, which, however, had to be deferred pending the development of satisfactory types of loading coils. Design studies of loading coils and studies of magnetic materials had been under way to a moderate extent following Campbell's laboratory investigation. E. H. Colpitts, who had joined the American Bell Telephone Company's staff in February, 1899, assisted Campbell in these tests and for several years was closely identified with the development work on loading. Late in 1900, after the Bedford-Brushton line tests, the work was taken up with renewed vigor. Campbell, Colpitts, W. L. Richards and others worked on the problem, and scores of experimental coils of different kinds, with different arrangements of various types of iron, and of windings, were constructed in the Telephone Company's model shop.

At this time, the engineering staff dealing with transmission problems was small, as may be seen from the accompanying organization chart of December 31, 1900, for the Headquarters Technical Staff of the American Telephone and Telegraph Company, which succeeded the American Bell Telephone Company as parent company of the Bell System in December, 1899. Moreover, much of the measuring apparatus available at that time would be considered crude by present day standards. One of the most pressing needs was for current supplies of better wave shape for use with the inductance balance. In December, 1900, therefore, Warren was assigned the task of designing and constructing a series of alternating-current generators for this purpose. He designed several of them to furnish sinusoidal currents of 500, 1000, 1500, 2000 and 3000 cycles, which were completed and placed in service in February, 1901. They proved indispensable in loading coil design, since without them it would have been impossible to make sufficiently accurate measurements of the losses in the various experimental coils. Late in December, 1900, after the designs of the high-frequency generators were completed, Warren was assigned to the job of designing a satisfactory loading coil.

By this time a decision had been reached to give priority in development to open-wire loading coils, and to concentrate on a toroidial iron-core design. The toroidial coil was not a new design conception, since it was related to the "endless" solenoid suggested by Faraday, and it had been considered by Campbell and by Pupin in their early studies. The difficulties in designing and constructing toroidial coils, and in obtaining suitable core material, however, had been important factors in choosing air-core solenoids for the early laboratory and field tests.

Important advantages of the toroidial structure over the solenoidal structure result from its substantially negligible external magnetic leakage field, thereby permitting the use of relatively close fitting iron cases without having the effective resistance of the coil objectionably increased by eddy current and hysteresis losses in the case. Also, in multi-coil potting arrangements, the small magnetic leakage field is an important factor in the control of cross-talk between adjacent coils. This was especially important in cable loading.

There was no "prior art" to guide Warren in his work in designing toroidial coils. A fundamental objective was to keep the effective resistance of the coil low. This is important since the attenuation in a coil-loaded circuit is approximately proportional to its total resistance. By increasing the circuit resistance, high resistance coils could thus offset to an objectionable degree the reduction in attenuation resulting from the beneficial effect of the added inductance.

Obtaining low effective resistance of the coils throughout the transmitted frequency band required much more than merely obtaining low copper resistance. Although iron cores make it feasible to obtain lower copper resistance than would otherwise be possible in a given size coil, the total effective resistance is raised by energy losses in the cores caused by eddy currents and hysteresis effects. Thus the magnetic and electrical properties of the core material were of critical importance in the design of the loading coil. The degree of subdivision of the magetic material, and the effectiveness of the insulation of the strands in the iron core were especially important in the control of eddy current losses. Because they are proportional to the square of the frequency, these losses can readily be the dominant component loss at telephone frequen-

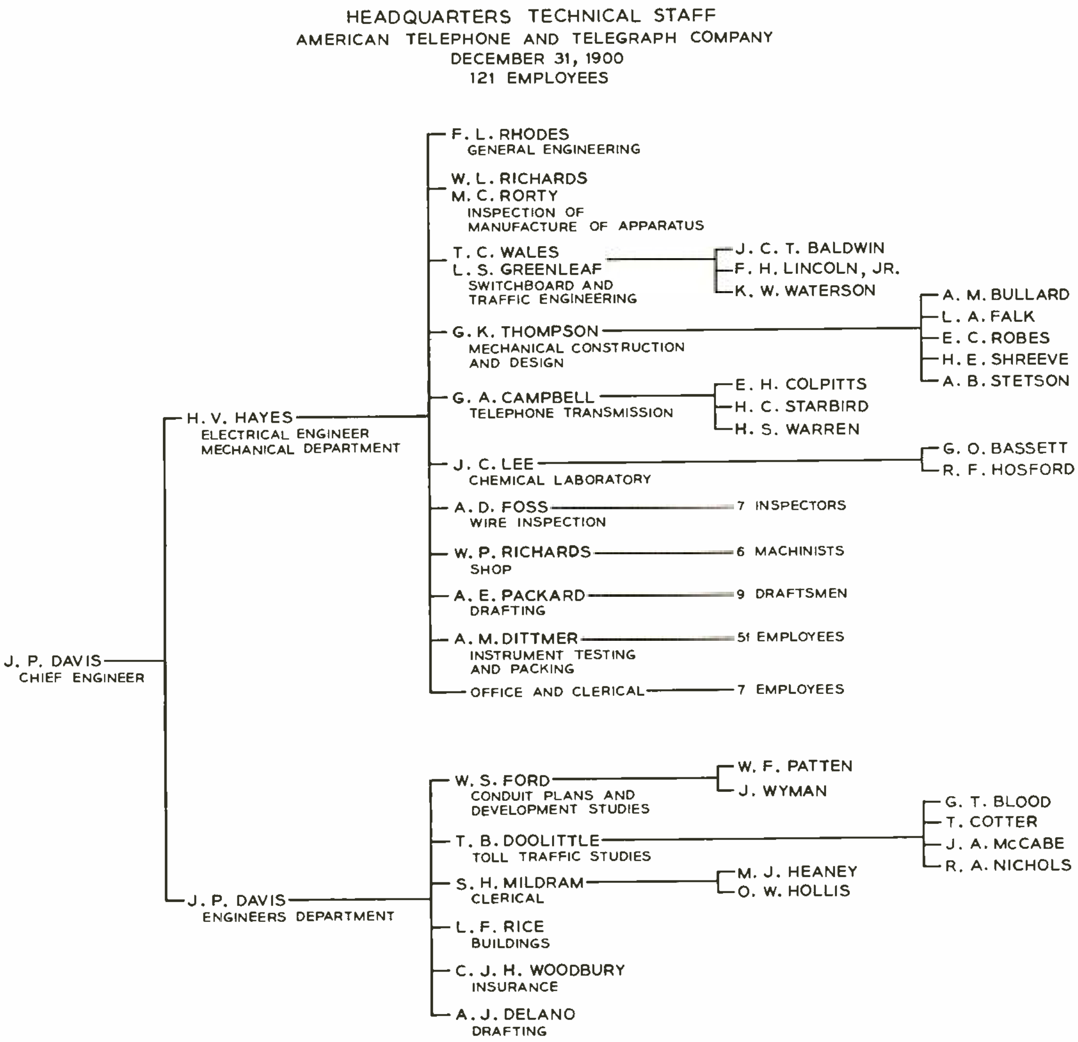


Fig. 2—Organization chart of the Headquarters Technical Staff in December, 1900.

cies. The number of turns required in the winding to obtain the desired inductance is a function of the effective permeability of the core material, and of the core dimensions. The core dimensions must, of course, be such as to provide adequate winding space for a sufficiently low resistance winding. Stranded conductors, suitably insulated, were required to avoid excessive eddy current losses at high frequencies.

Warren worked on the design problems during January and February, 1901. He devised methods of bringing the characteristics of the coils into equations which would permit him to solve for minimum energy losses. Having determined by analysis the best values for the important design factors, it was next necessary to construct model coils to incorporate the values required. So many variables enter, however, that it was a long "cut and try" procedure. Iron wire for the core, from different sources, and of different sizes, varied in its characteristics. Not only the materials employed, but the methods of winding both core and coil affected the final product.

A long series of experimental coils were produced. Each would be extensively tested, and when the over-all results were found to be not quite what was wanted, more changes would be made. All these coils were given "T", or experimental, numbers. Coil T-242, which was ready by March 1st, was about right except that the resistance of the winding was a little too high. Further changes were made and more coils produced. Before the end of that month the goal had been achieved; it was the T-300 coil. Its outside diameter was about 9 inches, and its axial height about 4 inches. Its inductance was 0.265 henry. The core was made up of about 93,000 turns of No. 38 B & S gauge mild steel wire insulated with a celluloid shellac compound, and processed to have a nominal permeability of 65. The winding was seven-strand insulated copper, each strand being 22 gauge. The average dc resistance of the complete winding was 2.5 ohms; the total effective resistance at 1000 cycles was slightly over 5 ohms.

After two T-300 coils had been made in the Boston laboratory, and found by careful tests to be satisfactory in all respects, specifications were drawn up and sent to the Western Electric Company in New York in April, 1901, with an order for 450 of the coils for use on existing 165-mil circuits between New York and Chicago.

The T-300 coil, which became the Western Electric 501 coil, was entirely different from any previous coil manufactured by the Western Electric Company, and tests made of the first few coils produced at the factory showed serious losses. In June, 1901, Warren was assigned to help in getting the coil into production. R. F. Hosford of the Chemical Department took part in the work of determining the best insulating material for the iron wire used in the cores. One of the first steps was to set up testing apparatus, including an inductance balance, so that reliable measurements of the coils and cores could be made as they were constructed. As a suitable source of high-frequency current was also necessary, two of the recently constructed alternating current generators were brought from the laboratory for this purpose.

In the core assembly process, a bundle of forty wires was continuously wound on a special collapsible core form until the desired total number of turns was reached. A film insulation was applied to the individual wires while enroute to the core form.

Before applying the commercial winding, temporary windings of relatively few turns were used to determine whether the cores were satisfactory for commercial use. In the beginning, the individual wires of the stranded copper winding were insulated with a coating of celluloid or copper sulphide. This proved unsatisfactory, and at Warren's suggestion the individual conductors were covered with a layer of cotton, with a single cotton covering over the strand. This removed the difficulties at some sacrifice of space. After the copper winding had been put on by hand, the completed coil would be baked in the cable-drying oven for two or three days, and then treated with wax or other sealing compound to keep out moisture.

Core losses of the first coils produced were found to be excessive. Experiments revealed, however, that better cores could be obtained by running the core winding machines more slowly, and by impinging a hot blast on the core while it was being wound. These changes, together with more thorough vacuum drying of the completed cores, resulted in satisfactory cores by the latter part of July, 1901. By the middle of August, three coils had been assembled in their iron cases, sealed with Bermudez

Fig. 3—One of the 501-type loading coils designed by Warren and first used on the open-wire circuits between New York and Chicago.

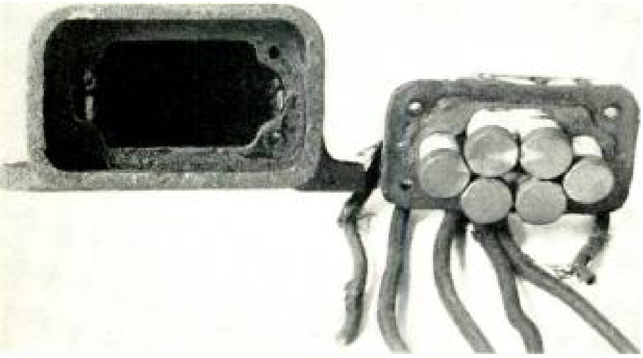


Fig. 4—The T-451 lightning arrester. The two electrodes at opposite ends of arrester are the ground electrodes. The leads to the other four electrodes were spliced to the bare open-wires close to the leads from the terminals of the associated loading coil. The breakdown gaps between the winding terminals and ground were shorter than those between the terminals of the windings.

asphalt, equipped with terminals, and were ready for shipment.

Troubles in manufacturing the coil were not over, however. It soon developed that a large proportion of the output had an effective resistance higher than the limit set for their use on the circuit between New York and Chicago. Warren therefore resumed his studies of manufacturing techniques. After a thorough examination of all the steps involved in constructing the cores, and in winding, baking, waxing, and mounting the coils, it was found that the excessive loss was due to the coils not being sufficiently dry at the time they were sealed with wax, largely because of the non-uniform oven temperature and the weather and moisture conditions during the waxing process. The optimum temperature for baking the coils was determined, and methods for drying and sealing them effectively were adopted. As the result, production was speeded up, and by the end of October, 1901, a sufficient number of coils had been made, tested, and shipped to load one eight-gauge circuit to Chicago.

Due to the delay in getting the T-300 coils into production, and to the pressure of the operating people to get the three eight-gauge circuits between New York and Chicago loaded, only one circuit could be equipped with T-300 coils. For the two other circuits, T-350 coils were used temporarily. These were very large air-core solenoidal coils previously designed by Colpitts and manufactured by the Western Electric Company to be available in case of emergency. They were not so good as the T-300 coils, and did not remain in service long. The loading of these three circuits was completed on November 2, 1901, the coils being spaced at intervals of 2½ miles.

With the successful achievement of a satisfactory open-wire loading coil, Warren, late in December, 1901, undertook to design a loading coil for use on cable circuits; the work order read "to develop as nearly as

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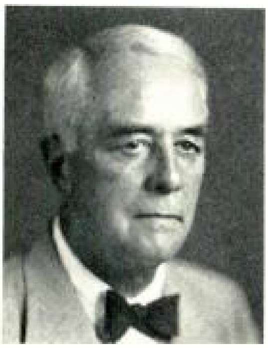

THE AUTHOR: ROGER B. HILL received a B.S. degree from Harvard University in 1911 and entered the Engineering Department of the American Telephone and Telegraph Company in August of that year. For several years thereafter he was engaged principally in appraisal and depreciation studies. When the Department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

possible the ultimate loading coil for standard nineteen-gauge cable." The immediate demand, however, was for a coil with which to load a nineteen-gauge cable between New York City and Newark, N. J., a distance of ten miles. By virtue of the experience gained in designing the open-wire loading coil, this task was not too difficult, and by the middle of February, 1902, a toroidal coil with an iron wire core, known as the T-420 (Western Electric No. 502) had been developed for this service. It had an outside diameter of 5 inches, an axial height of 2¼ inches, and an inductance of about 0.3 henry. The loading of this cable—the first commercial installation of cable loading—was completed in August, 1902. Prior to the development of loading, a relatively expensive No. 13-gauge cable had been planned for this route.

With the successful completion of the design of these two coils, the 501 for open-wire lines, and the 502 for cables, the basic foundation for the design of later coils had been laid. Loading is a complicated art, however, and many factors besides the reduction in attenuation must be considered. These became more pronounced as the transmission was improved in the following years. They are beyond the scope of this article, however, which is concerned only with the production of the first commercial types of loading coil. Warren's capable handling of the development and production of the first loading coils was recognized in the reorganization of the Engineering Department in 1905. He was placed in charge of the Mechanical, Electrical, Chemical and Switchboard Departments, reporting directly to H. V. Hayes, Chief Engineer.

Loading is one of the great landmarks in the history of telephony. Until the advent of the electronic repeater in 1915, loading was the dominating factor in improving long distance telephony over open-wires and cables and in reducing its cost and extending its range. It is still an important factor in the design economy of short haul toll facilities. Moreover, for nearly five decades, it has made possible great economies in the exchange area cable plant by permitting the extensive use of smaller conductors; present indications are that it will continue to be very important in this field of use.

Telephone Service for Train Passengers

Mobile telephone service for passengers on crack railroad trains will pass the five-year mark next summer. It was introduced on New York-Washington trains in 1947, extended to Buffalo, Boston, and Harrisburg in 1948, and installed on a train between San Francisco and Los Angeles in 1949.

Land stations for all these systems are mostly part of the Bell System's highway network—a few urban stations are used also. The channels use two frequencies but because few railroad passengers would be accustomed to "press-to-talk"*, and separate antennas were feasible, it was decided to use the familiar handset instead of "press-to-talk" sets as used on vehicles. Antennas† for the two frequencies are at opposite ends of the car.

At first, service on the train was handled by the secretary or club car attendant, but later the Laboratories developed a coin box system which is in use on about half of the trains. The patron listens to be sure the channel is available, then presses a locking button which puts his transmitter "on the air." The mobile service operator answers, takes the details of the calls, and gives the rate for the services. When the called telephone is ready to talk, she asks the patron to deposit coins to the amount of the toll.

At present calls to and from train range between 800 and 1000 a week. Service is available to two sections each of the *Congressional*, *Broadway Limited* and *Senator* of the Pennsylvania Railroad; four sections of *Merchants Limited* of the New York, New Haven and Hartford; the *Royal Blue* of the Baltimore and Ohio; and two sections of the *Lark* of the Southern Pacific.

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* Record, *January*, 1948, *page* 9.

† Record, *May*, 1949, *page* 72.

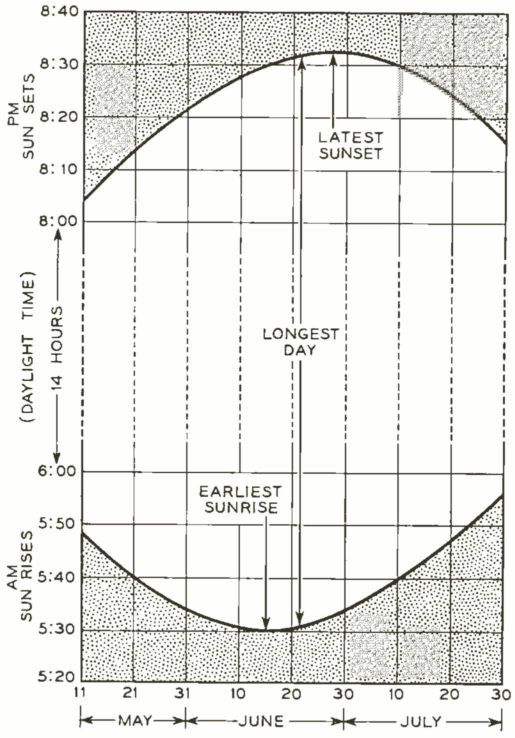
The Sun in June

On the twenty-first of this month the sun will be above the horizon longer than on any other day of the year. An obvious conclusion would seem to be that on this day the sun will rise earlier and set later than on any other day. As often happens, however, the obvious conclusion is not the correct one. The day of earliest sunrise is June 14, while the day of latest sunset is June 28—a week earlier and a week later, respectively, than the longest day. This is illustrated on the accompanying diagram, which in its essential features is similar to that published previously*.

This anomaly in the occurrences of sunrise and sunset arises because standard time is not based on the position of the true sun but on the position of a hypothetical object known as the mean sun. Since the earth travels an elliptical orbit in a plane inclined some 23 degrees to the plane of the equator, the apparent motion of the true sun is not uniform. If we used a time based on the position of the true sun, the days would be of unequal length. Such a reckoning is called apparent time, and is used only for certain special purposes. Instead, we use standard time. This is based on the position of the mean sun, which is assumed to travel at uniform speed in the plane of the earth's equator. The difference between the positions of the apparent and mean suns is known as the "equation of time," which varies from nearly minus 14 minutes to over plus 16 minutes, and is zero four times during the year.

Between June 14 and June 28 the equation of time is decreasing rapidly, and its change is greater than the change in the time—during the same period—that the sun is above the horizon. It is this variation in the equation of time during this period that causes sunrise in terms of mean time to be earlier on the 14th than on the 21st, and that similarly causes sunset to be later on the 28th than on the 21st.

In using sunrise and sunset figures, one should be careful to determine just what events are meant by the times given. Astronomically, sunrise and sunset are taken as the instant when the center of the sun is in the plane parallel to the horizon through the center of the earth. Because of the large refraction for objects near the horizon, however, the sun at these times as actually seen is well above the horizon. The times in the accompanying diagram are those when the upper edge of the visible sun is at the horizon as seen from sea level. From a higher point of view, of course, the sun would rise earlier and set later than the times indicated. A correction must be made also for longitude east or west of the standard meridians and for latitude north or south of 40 degrees N. These were discussed in the article already referred to.



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* Record, *January*, 1945, *page* 11.

Matter of Small Weight

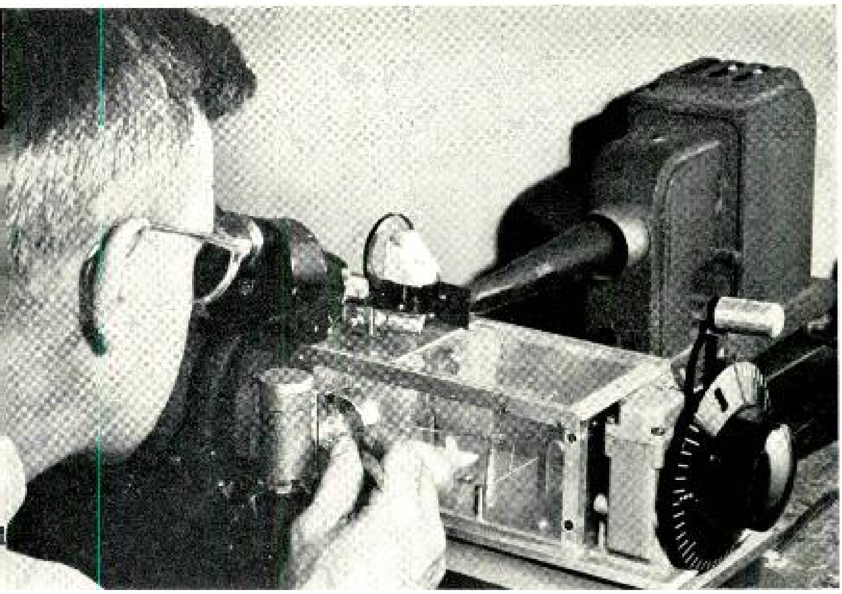

Fig. 1—G. E. Reitter loads a scale pan with the aid of a stereomicroscope.

Among recent additions to instrumentation at Murray Hill is a microbalance sensitive enough to determine the weight of a fragment of lint caught floating in the air. The instrument, shown in Figure 1, has been developed to weigh traces of metal transferred between relay contacts during arcing—amounts too small for conventional balances. These minute weighings help in the search for ways to make contacts work better and last longer.

As shown in Figure 2, two scale pans are suspended from the ends of a crossbar, the center of which is attached to a torsion fiber. The fiber is a tungsten wire about as fine as spider's web, and the crossbar is a rod of quartz a few hairbreadths thick. The scale pans are made of thin glass bubbles and are cemented to tungsten hooks which in turn are attached to quartz fibers hanging from the crossbar. The fibers act like hinges; as the crossbar deflects, the fibers bend so as to suspend the scale pans directly under the ends of the arm, and thus keep constant the balancing torque relationship. A mirror at the point of intersection of the torsion fiber and the crossbar reflects a light beam which registers deflections on a scale; both crossbar and scale pans are electrostatically shielded.

To calibrate the instrument, a length of fine aluminum wire is weighed in a chemical microbalance. From this wire a minute fragment of known length and hence, calculable weight is snipped off and placed in a scale pan. The resulting twist indicates the torsion constant of the fiber expressed in millionths of a gram per scale division.

The specimens used in the contact studies weigh about five milligrams each. A counterweight, usually another specimen of comparable weight, rests in the other pan and the device is brought to a balance by turning the torsion adjuster. The amount of metal transferred to a specimen is measured by the difference in dial readings before and after exposure to arcing. In this way changes up to 250 millionths of a gram are measured with a probable error of seven hundredths of a millionth of a gram. The instrument was designed and constructed by F. E. Haworth and G. E. Reitter.

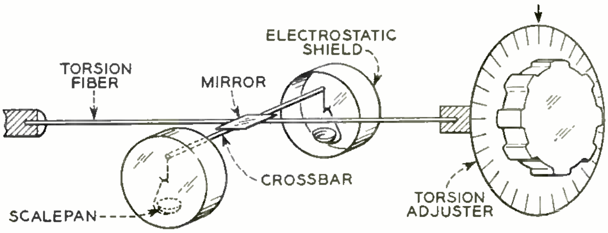

Fig. 2—Simplified diagram of torsion balance.

M. J. Kelly Elected to American Philosophical Society

Dating from the middle of the Eighteenth Century, the American Philosophical Society is the oldest learned society in this country and one of the oldest in the world. Its interests encompass four major fields: mathematical and physical sciences, biological sciences; social sciences; and the humanities. Dr. Kelly was elected to membership at the Annual General Meeting of the Society on April 26 of this year. Limited to 500 in this country and 75 residents of foreign nations, its membership is considered one of the highest professional honors of the world. Among the Society's distinguished members were fifteen signers of the Declaration of Independence and thirteen presidents of the United States.

Physical Electronics Conference Held at M.I.T.

At the Physical Electronics Conference held at Massachusetts Institute of Technology from March 26 to 29, the following papers by Laboratories engineers and scientists were presented: *Mobilities of Ions in Kryton, Xenon, and Nitrogen* by R. N. Varney; *The Sticking Probability of Nitrogen on Tungsten* by J. A. Becker and C. W. Hartman; *The Reduction of Alkaline Earth Oxide in Gases* by G. E. Moore; *Radiation Produced in Germanium and Silicon by Electron-Hole Recombination* by J. R. Haynes; *Mobility of Electrons in Germanium at Low Temperature and High Field—Experiment* by E. J. Ryder; *Mobility of Electrons in Germanium at Low Temperature and High Field—Theory* by Mrs. E. M. Conwell; *Tests of Transistor Equations* by M. B. Prince; and *Probing the Space Charge Layer in a p-n Junction* by G. L. Pearson.

Deal-Holmdel Colloquium

J. A. Becker addressed the meeting held at Holmdel on April 11. The subject of his talk was *The Field Emission Electron Microscope*, with which magnification of the order of a millionfold has been obtained. This device consists of a highly evacuated glass envelope resembling a cathode ray tube and containing, in place of the conventional electron gun, a very sharply pointed tungsten wire mounted about three inches from the phosphor coating on the face of the tube. The tungsten point is so sharp that the tip is composed of a part of a single crystal of tungsten.

When a high potential is applied to the tungsten wire a very concentrated electric field is produced at the point so that electrons are drawn from it. The electron density from different parts of the tungsten point varies with the work function of the exposed crystal planes. This varied current density creates a greatly magnified pattern on the phosphorescent screen.

Such a magnifier was used in a study of the "Rocky Point Effect," a trouble in high power amplifier tubes that had occurred in the early days of transatlantic radio transmission and which had been overcome, but remained unexplained, until recently.

The talk was supplemented with a series of slides illustrating adsorption effects.

Talks by Members of Technical Staff

W. H. Brattain spoke on *Surface Properties of Germanium* at the Physics Department Seminar, University of Pennsylvania, March 5. H. W. Lewis presented a paper on *Present Status of the Theory of the Equation of State of Matter at High Pressures* at the Department of Terrestrial Magnetism, Washington, March 6. R. M. Bozorth gave a talk on *Recent Developments in Ferro-Magnetism* at the Physics Colloquium of Iowa State College, March 12. A similar talk was presented to the Basic Sciences Division of the Chicago Section, A.I.E.E. C. L. Hogan spoke at a seminar at M.I.T. on one of the Federal Government projects, March 10. The title of his talk was *Applications of Ferrites to Microwave Transmission*. C. Herring spoke on *Creep at Elevated Temperatures* at the Physics Colloquium of the University of Missouri on March 24. On March 28, he also spoke at the Metals Research Laboratory Seminar, Kearny Institute of Technology, on the subject of *Thermo-Etching and Related Phenomena on Clean Metal Surfaces.*

Organization Changes in the Laboratories

At a meeting of the Board of Directors on April 21, G. N. Thayer, Director of Transmission Development, was elected Vice President of the Laboratories, effective May 1. He succeeded T. E. Shea, Vice President, who resigned on May 12 to become Vice President of the Sandia Corporation. Mr. Thayer has responsibility in the Laboratories for the military program and for the supervision of the Patent and the Military Electronics Departments.

Effective May 1, M. B. McDavitt, Director of Switching Development was appointed Director of Transmission Development and A. J. Busch, Director of Switching Systems Development was appointed Director of Switching Development, both reporting to J. W. McRae, Vice President.

A native of Colorado, Mr. Thayer holds a degree in engineering from Stevens Institute of Technology. When he first joined the Laboratories in 1930, he was concerned primarily with the development of mobile radio communications equipment and systems. In 1940 he became affiliated with a group developing radar systems, and later turned his attention to microwave radio relay systems. Since 1949 he has been concerned with the development of communications systems, including the cross-country radio relay system, the Key West-Havana submarine cable, and overseas radio projects. He was appointed Assistant Director of Transmission Systems Development in 1949 and Director of Transmission Development in 1951.

G. N. Thayer

Mr. McDavitt has been associated with the Bell System since receiving degrees from the University of Virginia and Massachusetts Institute of Technology in 1925. As Director of Switching Development since 1949, he has been responsible for all phases of local and long distance switching development. During the war he was concerned with communications systems projects for the armed forces.

Mr. Busch has been associated with the Bell System since 1922, and has devoted virtually all his efforts to dial switching sys-

M. B. McDavitt

A. J. Busch

tems. Since 1948 he has been in charge of the group responsible for all manual and dial switching equipment developments in the Bell System. During the war he, too, was concerned with communications developments for the armed forces. He holds an electrical engineering degree from the Polytechnic Institute of Brooklyn.

Book Review

W. Shockley's book, *Electrons and Holes in Semiconductors,* was reviewed in the March 15, 1952, issue of *Nature* (London). Commenting on this recent addition to the Bell Telephone Laboratories Series, the reviewer states that the "book gives evidence throughout of careful planning, the diagrams are excellent, the mathematical results are amply illustrated by numerical examples, and a pleasing feature is the setting of problems at the end of most of the chapters. This book can be unreservedly recommended to all who are concerned with semi-conductors and to those who wish to gain an appreciation of the present status of the transistor and of future trends in this increasingly important field."

Technical Societies' Activities

W. E. Campbell has been elected President-Elect of the American Society of Lubrication Engineers. He will assume office as President at the annual meeting of the society to be held in Boston, April, 1953. The American Society of Lubrication Engineers is a national technical society whose objective is to advance knowledge of the science of lubrication and to promote the use of more effective means for its application and dissemination.

W. H. Doherty presented a paper entitled *Research in Broad-Band Transmission* at the annual Broadcast Engineering Conference sponsored by the National Association of Radio and Television Broadcasters in Chicago, March 31 to April 2.

R. W. Sears spoke before the Communication Division of the New York Section, A.I.E.E., on April 16, on *Electronic Memory Tubes.* A number of types of electronic storage tubes have been developed and disclosed in recent technical literature for use as rapid digital memory elements in high-speed computers and signal amplitude memory for signal translation.

K. K. Darrow spoke on *Atomic Fission* before the Montclair Society of Engineers on March 7. He also spoke on *The Atom From Lucretius to the Present* at Hofstra College on March 15, and on *Magnetic Resonance* at Case Institute of Technology on March 24. He has been elected to the Governing Board of the American Institute of Physics for the four-year term commencing 1952.

V. E. Legg represented the Laboratories at a meeting of the A.S.T.M. Committee on Magnetic Testing in Wheeling, West Virginia on March 24. Discussion included preparations for new standards for testing magnetic materials of use in the telephone system and elsewhere.

At the 50th anniversary of the American Society for Testing Materials, to be held during the week of June 23, several papers by Laboratories engineers will be presented. A. P. Jahn will speak on *Atmospheric Corrosion of Steel Wires;* W. E. Campbell on the *Present Status of the Problem of Fretting Wear* (part of the symposium of *Fretting Corrosion*); K. G. Compton on *Outdoor Exposure Testing on Racks and Fences* (part of the symposium on *Conditioning and Weathering*); and M. E. Fine on *Dynamic Methods for Determining Elastic Constants and their Temperature Variations in Metals* (part of the symposium on *Determination of Elastic Constants*).

Besides J. R. Townsend, who is Chairman of the General Arrangements Committee of the A.S.T.M., and G. R. Gohn, Chairman of the Technical Program Committee, I. V. Williams is a member of the Committee on Plant Visitations, F. G. Foster, a member of the Photographic Exhibits Committee and Co-chairman of the committee arranging a symposium on *Light Microscopy,* and R. Burns, Chairman of the Symposium Committee on *Conditioning and Weathering.*

Members of the Laboratories active on the various standing committees of the A.S.T.M., include J. R. Townsend, Chairman of Committee B-6, on *Die-Cast Metals and Alloys* and Committee E-1 on *Methods of Testing;* A. P. Jahn, Vice-Chairman of

Dr. Ovid W. Eshbach (left), Dean of the School of Engineering at Northwestern University and National President of Eta Kapppa Nu, together with Alton B. Zerby, National Secretary of that society, confer a Professional Membership in the society on Dr. M. J. Kelly, President of Bell Telephone Laboratories, following the installation of the Gamma Theta Chapter at the Missouri School of Mines and Metallurgy on April 26. He was elected to this membership by the National Executive Council of Etta Kappa Nu. At the ceremony of the installation of the chapter Dr. Kelly spoke on "The Contribution of the Electrical Engineer to National Defense."

Committee A-5 on *Corrosion of Iron and Steel; K. G. Compton*, Chairman of Committee B-3 on *Corrosion of Non-Ferrous Metals and Alloys;* I. V. Williams, Chairman of Committee B-7 on *Light Metals and Alloys;* C. M. Harris, Vice-Chairman of Committee C-2, on *Acoustical Materials;* H. F. Dodge, Chairman of Committee E-11 on *Quality Control of Materials;* A. Mendizza, Chairman of Subcommittee XVI of Committee A-5, on *Hardware Testing.*

J. A. Becker presented a paper by himself and C. D. Hartman entitled *Field Emission Microscopy and Filament Flash Techniques for the Study of Structure Adsorption of Metal Surfaces* at the American Chemical Society meeting in Buffalo.

D. Slepian spoke before a joint meeting of the Basic Sciences and Communications Divisions, New York Section, A.I.E.E. May 1, on *Information Theory and the Geometry of Signal Space.* The central theme of Mr. Slepian's lecture was the problem of efficient signaling over a band-limited channel in the presence of white Gaussian noise. For the purpose of treating this problem by information theoretic means, the fundamental concepts of n-dimensional geometry and function space were explained. The meaning of C. E. Shannon's capacity formula for the band-limited channel was discussed, and a survey of attempts to realize the ideally efficient signaling systems predicted by this formula was presented.

At this meeting, election of officers for both divisions of the New York Section were announced. These included, in the Communication Division, W. T. Rea, incoming Chairman, and M. A. Townsend, the incoming Secretary-Treasurer. R. H. Van Horn has been elected Vice-Chairman of the Basic Sciences Division.

Patents Issued to Members of Bell Telephone Laboratories During January and February

2,580,439 Directional Acoustic System, W. E. Kock.

2,580,446 Harmonic Generator, C. A. Lovell and D. B. Parkinson.

2,580,672 Saw-Tooth Generator and System Utilizing It, R. E. Graham.

2,580,673 Saw-Tooth Generator and System Utilizing It, R. E. Graham.

2,580,685 Color Television with Reduced Band Width, R. C. Mathes.

2,580,697 Image Dissector Tube, B. M. Oliver.

2,580,757 Alarm Sending Circuit, C. E. Germanton.

2,580,875 Tube Circuit, C. H. Young

2,581,184 Reperforating Apparatus, H. W. Goff.

2,581,251 Telephone Booth, A. Glazer, N. R. Stryker and H. F. Hopkins.

2,581,266 Brush Contact Device, G. R. Lum.

2,581,305 Detection of Electrically Charged Particles, A. M. Skellett.

2,581,308 Controlling and Indicating Device. H. J. Smith.

2,581,847 Radiant Energy Object Locating System, L. Espenschied and J. G. Chaffee.

2,582,474 Gun Computer Having Target Rate Integrating Means for Determining Target Position, D C. Bomberger, W. E. Ingerson and H. G. Och.

2,582,480 Register Circuit, T. L. Dimond.

2,582,498 Negative Impedance Repeater and Loading System, J. L. Merrill, Jr.

2,582,510 Polyethylene Stabilized with Sulfur Plus a Vulcanization Accelerator, B. A. Stiratelli.

2,582,691 Impulse Testing and Test Impulse Generating Set, W. W. Fritschi.

2,582,959 Electron-Tube Controlled Switching System, E. Bruce and N. I. Hall.

2,583,009 Asymmetric Electrical Conducting Device, K. M. Alsen.

2,583,000 Asymmetric Electrical Conducting Device, K. M. Alsen.

2,583,029 Method of Preparing Glow Discharge Devices, M. A. Townsend.

2,583,086 Tape Perforating Machine, W. W. Carpenter.

2,583,088 Alarm Signaling System, C. E. Clutts, G. E. Pullis, A. K. Schenck and L. A. Weber.

2,583,102 Counting System, W. H. T. Holden.

2,583,328 Circuit for Controlling the Release of a Relay, T. L. Dimond.

2,583,542 Vibratory Reed-Controlled Oscillator, L. G. Bostwick.

2,583,562 Cathode-Ray Device, F. Gray and R. W. Sears.

2,584,261 Ground Trainer for Aircraft Crew, R. C. Davis, E. J. Fogarty and R. O. Rippere.

2,584,990 Transistor Counting System, T. L. Dimond.

2,585,010 Wire Connecting Tool, C. N. Hickman, R. F. Mallina and F. Reck.

2,585,077 Control of Impedance of Semiconductor Amplifier Circuits, H. L. Barney.

2,585,078 Negative Resistance Device Utilizing Semi-conductor Amplifier, H. L. Barney.

2,585,545 Signaling System, D. K. Gannett.

2,585,562 Directive Antenna System, W. D. Lewis.

2,585,563 Wave Filter, W. D. Lewis and W. W. Mumford.

2,585,571 Pulse Repeater, M. E. Mohr.

2,585,582 Electron Gun, J. R. Pierce.

2,585,722 Frequency Divider, J. A. Baird.

2,585,772 Method and Circuit for Pulsation Welding, A. D. Hasley and F. H. Hibbard.

2,585,841 Bridged T Phase Shifter, P. H. Richardson.

2,585,842 Bridged T Phase Shifter, P. H. Richardson.

2,585,866 Antenna Mechanism, C. F. Spahn, Jr.

2,585,904 Crossbar Telephone System, A. J. Busch.

2,586,080 Semiconductive Signal Translating Device, W. G. Pfann.

2,586,534 Private Branch Exchange Trunk Circuit, P. R. Gray.

2,586,540 Torsion Meter, W. H. T. Holden.

2,586,597 Oscillation Generator, J. Bardeen and W. H. Brattain.

2,586,821 Selective Signaling System Using Rectifiers Back to Back, W. H. T. Holden.

2,586,901 Two-way Trunk Circuit Arranged for Dial-Back Operations, S. W. Allison.

2,587,014 Charge and Tax Determining Equipment for Telephone Systems, E. Vroom.

2,587,036 Process and Apparatus for Semi-Continuous Plating, L. H. Germer and G. E. Reitter.

2,587,043 Preparation of 1, 2, Di-Primary Amines, W. L. Hawkins.

2,587,055 Electrical Cavity Resonator for Microwaves R. W. Marshall.

2,587,458 Contact Spring, M. Fritts.

2,587,482 Piezoelectric Type Switching Relay, A. C. Keller.