November 1959

Bell Laboratories RECORD

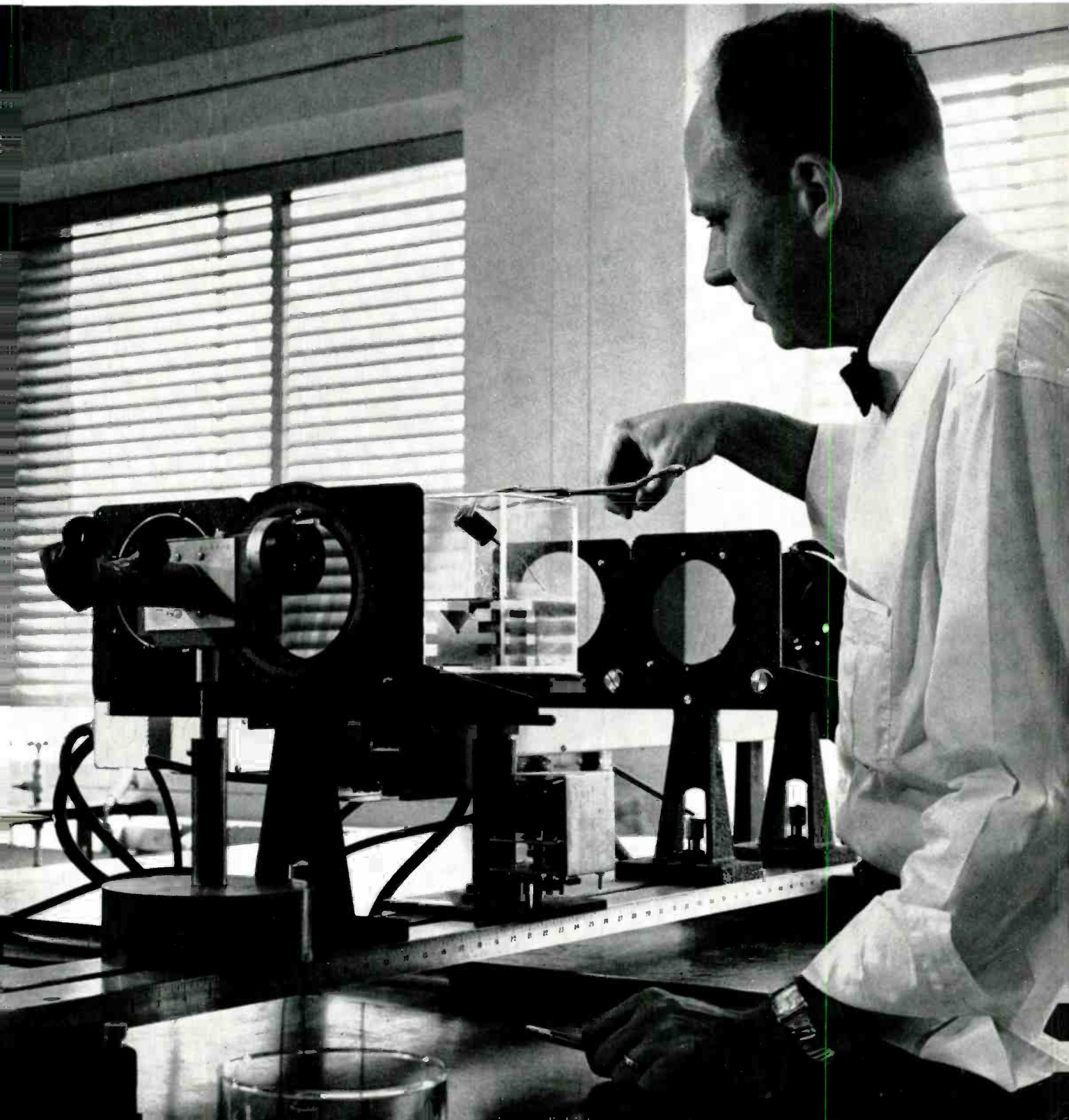
The Twistor: A New Memory Element

Compatible Stereophonic Sound System

Glass Seals For Undersea Cables

The Teletrainer

Automatic Control Of A Pipeline



THE BELL LABORATORIES RECORD is published monthly by Bell Telephone Laboratories, Incorporated, 463 West Street, New York 14, N. Y., J. B. FISK, President; K. PRINCE, Secretary; and T. J. MONTIGEL, Treasurer. Subscription: $2.00 per year; Foreign, $2.60 per year. Checks should be made payable to Bell Laboratories Record and addressed to the Circulation Manager. Printed in U. S. A.

Bell Laboratories **RECORD**

Volume 37 • Number 11 • November 1959

Contents

Cover

D. R. Oswald places a glass seal for an undersea repeater in a polarimeter. This unique test was used to insure reliability of the seals *(see p. 415)**.*

The author (left) and A. J. Munn inserting a mylar sheet containing twistor wires into solenoid frames. The completed assembly contains ten such frames which are folded accordion-like to make a complete memory module. Final assembly yields a compact 500-word, 112-bit per word module.

In a "twistor" memory device, information is stored on hair-like magnetic wire in the form of spirally-polarized magnetic zones. Because of its versatility the twistor memory cell can be used as the storage element, the input selection wire, and the output "sense" wire in electronic circuits.

A. H. Bobeck

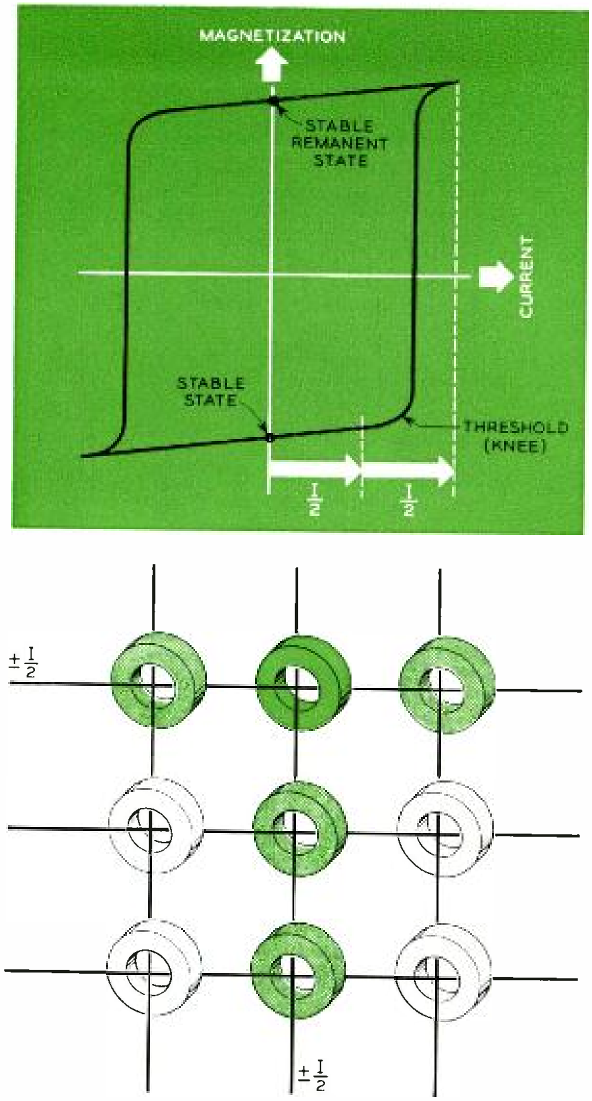
THE TWISTOR: A New Magnetic Memory Element

Developmental activity in the field of high-speed memory devices has been very rapid in the past decade, and perhaps the most important advances have come in the solid-state device area. These advances include such memory elements as the small bead-like ferrite core, the multi-apertured ferrite sheet, the multipath ferrite structure, the ferroelectric storage cell, and, more recently, the "twistor." All of these devices have one feature in common: for storage they rely on a class of materials which are characterized by a pair of stable states.

An ordinary light switch has two stable states, and by its position "remembers" a manual command. It is capable of storing a single binary digit, often abbreviated a "bit." A relay, properly connected, will remember an electrical command. We note, however, that the storage properties of these devices are mainly the result of a skillful mechanical assembly rather than a basic property of the materials from which they were constructed. Mechanical devices fall short of meeting the reliability and high speed of operation demanded in modern computing facilities, whether Bell System or military.

Of the many solid-state memory devices investigated here and at other laboratories, only those that are magnetic in nature have had significant usage. We know that the compass needle and the horseshoe magnet are permanent magnet configurations, but there is nothing really permanent about a permanent magnet, since its direction of magnetization may readily be reversed electronically. The twistor is a highly sophisticated and novel form of the permanent magnet.

Before undertaking to describe the twistor in any great detail, we will discuss one additional property of storage devices that cannot be overlooked. Present system requirements call for



Magnetization curve (above) and one type of solid-state memory device — ferrite cores (below). Simultaneous horizontal and vertical current pulses select one core from a matrix of nine; action depends on shape of the magnetization curve which permits a 2:1 discrimination level.

storage capacities which run into the millions or even tens of millions of bits of information. To be compatible with transistorized arithmetic units, each bit of stored information must be available in a few millionths of a second. This access problem is a formidable one. Fortunately, however, metallurgists and ceramicists have been able to process magnetic materials in such a way as to obtain a "square-looped" magnetization or hysteresis curve. It is possible to utilize the threshold or "knee" of such a characteristic to permit selection of a particular memory cell within a matrix composed of many such cells. The drawing on this page illustrates this point. In particular, if a 2:1 discrimination is possible in the levels of current used to select a particular cell, then we may use a coincident selection system much like that employed as an aid in finding a city on a road map. Thus, a million-bit matrix (1000 x 1000) will require just two thousand access points.

Magnetization Requirements

Magnetic materials which are useful, then, must possess not only stable remanent states but also have a well-defined switching threshold. Let us consider a magnetic material which has been heated to a rather high temperature — a temperature at which thermal activity prevents organized behavior of the spinning electrons which contribute to magnetization. As we reduce the temperature, the thermal activity lessens until the interactions between neighboring spins begin to restrict their movements. The temperature at which this occurs is called the Curie temperature. A further reduction in temperature results in small domains of spontaneous magnetization in which all the spins are more or less parallel to each other. With an external field we next switch the direction of magnetization of these domains into one of two conditions — the stable remanent states previously referred to. For example, in a ferrite core the paths are clockwise and counterclockwise around the circumference of the device.

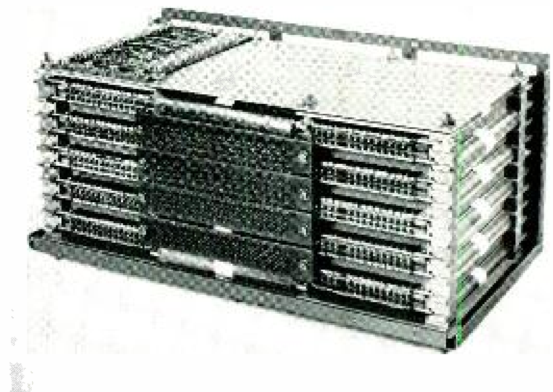
In the twistor the paths are along a helix or spiral. We may establish the helical flux path by twisting a suitable magnetic wire. A more attractive variation consists of a magnetic tape or flat wire wrapped on a nonmagnetic center conductor (such as copper) as shown in the illustration at the bottom of the next page. The flat wire is wrapped so that it follows a helical path inclined at an angle of 45° with respect to the axis of the central wire. A rather simple machine performs the wrapping. Continuous electrical tests serve to check the finished product.

The magnetic flat wire consists of a flattened one-mil diameter, special molybdenum-permalloy wire. Our studies indicate that this magnetic material is well suited for the twistor application. It combines the desirable features of high resistivity, strain insensitivity, low coercive force, low saturation flux density, and high ductility.

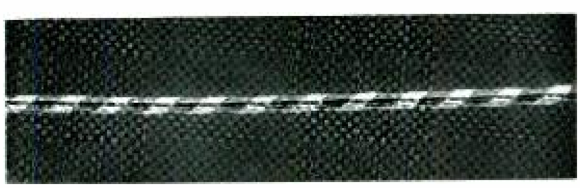
The wire is flattened to reduce the eddy-current losses associated with reversal of magnetization. In addition, this flattening tends to reduce the strains induced by the wrapping process. Because of its many fabrication advantages, the wrapped-wire twistor is used almost exclusively, and our interest will now center on this form.

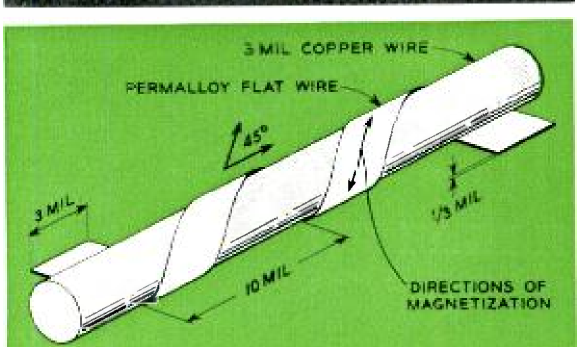
Information and Current

Information is stored in a twistor in the form of a helically polarized magnetization. The polarization, of course, is determined by the magnitude and direction of the selection fields or currents *(see drawing on the next page)*. Both axial and circular fields are possible. The former may be generated by current passing through a solenoid which is concentric with the twistor wire. The latter is generated by passing current down the twistor wire itself. We may adjust either field so that it alone is insufficient to affect the direction of magnetization. If both fields are applied in coincidence, however, their resultant vector sum exceeds the threshold required, and reversal of the direction of magnetization is possible. Of course, if either the axial or the circular field is made large enough, it alone can be used for flux reversal. This property is of importance since in most twistor memories designed to date, the reading of the stored information — as contrasted to the writing of the information — is performed by a single large axial field. The twistor is used as both the storage medium and as one of the access wires. In addition, the twistor also serves as the sense wire. That is, the central copper conductor "senses" a change in the direction of the magnetic flux, and the voltage thereby induced is propagated to the sensing amplifiers.



This is the largest twistor constructed to date. It has a 56,000 variable twistor memory unit with a 500-word storage capacity at 112 bits per word. All of the terminals are of the wire-wrapped type.



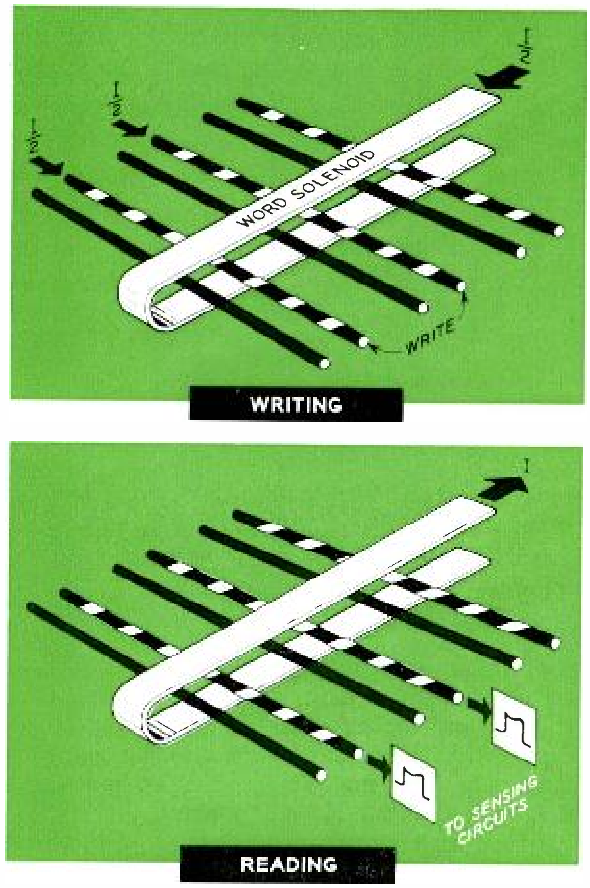


Present twistor memory arrays use a wrapped-wire structure. Magnetization tends to follow the helical path defined by permalloy flat wire. Ten or fifteen wraps make a basic storage segment.

When used as a sense winding, the twistor acts as though it had a built-in voltage step-up transformer. This is extremely fortunate since the volume of magnetic material in a twistor memory cell is very small indeed — only about one-one thousandth that of a conventional ferrite memory core. Typical signals for the wrapped twistor wire are 6-8 millivolts for a 100-mil storage length and a one microsecond switching time. Another memory design gives a 60-millivolt signal. This is an example of the flexibility possible in the design of twistor arrays. Complete read-write cycle times of 3-4 microseconds have been realized in small arrays.

Bit Storage

Many bits of information are stored along each twistor wire in a typical memory array. The density of such storage zones is limited for present material at five to ten per linear inch. This storage density represents a compromise between drive currents, output signals, and demagnetizing factors. The minimum allowable separation between adjacent parallel twistor wires in a three-dimensional array may be readily determined by a summation of dipole fields. For the wrapped twistor wire described above,



Coincident pulsing of a solenoid and twistor wire "writes" into a twistor memory. More than a single bit may be inserted if desired. The actual reading is common to many twistor wires.

a spacing of 100 mils is indicated. This represents a storage density of 500-1000 bits per cubic inch.

The ease of fabrication of twistor arrays is perhaps one of the most important advantages of this device. Its construction is especially adaptable to automatic techniques. The twistor wire may be fabricated and tested continuously. Multi-turn solenoids may be applied with multiple-coil winding machines, while single-strip solenoids can be obtained with printed-circuit techniques. Other assembly techniques, such as a weaving process, may also be considered.

The twistor memory cell is a competitor to the ferrite toroid and sheet in the field of large-capacity, random-access, memories. Its widest use will probably be in relatively large-size arrays of the order of one million bits or more, since the cost of the memory element itself becomes important at these sizes.

F. K. Becker

A Compatib

The new "concert-hall realism" and "living presence" of modern sound reproduction and transmission are really not new at all. But these terms are descriptive of the great strides that have been made in recent years in the mass reproduction and broadcast transmission and reception of high-fidelity, stereophonic sound. Actually, techniques for transmitting stereophonic, or two-dimensional, sound were developed some years ago at Bell Laboratories.

Because the transmission and reception of sound is basic to communication, telephone engineers since the days of Alexander Graham Bell have studied in detail the physical and subjective aspects of speech and hearing. Specifically, in 1933 a group at Bell Laboratories directed by Dr. Harvey Fletcher, undertook a series of such studies designed to further our understanding of "auditory perspective" — how and why we hear spatially. Later that year, these tests culminated in a demonstration of the long-distance transmission of stereophonic sound (RECORD, *May* and *June*, 1933; *March*, 1934).

Under the auspices of the National Academy of Sciences, a concert of the Philadelphia Orchestra was transmitted from the Academy of Music

Broadcasts designed for stereo listening frequently sound distorted to the single-channel listener. Recently, however, Bell Laboratories has demonstrated a compatible stereo system that assures balanced, high-quality reception for these listeners, along with the full stereo effect for those equipped to receive it.

...tereophonic Sound System

in Philadelphia to Constitution Hall in Washington, D. C. The orchestra was conducted by Associate Conductor Smallens, while the Director, Dr. Leopold Stokowski, manipulated controls from his position in the rear of Constitution Hall.

To reproduce a perception of dimensional sound, three microphones were placed before the orchestra, one at each side and one in the center. The output of each microphone was transmitted over a separate Bell System circuit specially "tailored" for the experiment. At Constitution Hall, the loudspeaker associated with each microphone was placed on the stage in a corresponding position. Many of these who heard the reproduced concert proclaimed the development of a system that promised even greater emotional appeal than "live" music. Much of this reaction was undoubtedly due to the enhanced volume range of the reproduced sounds.

One of the latest developments in the field of stereophonic sound is a "compatible" stereo system, which means that listeners who have only one receiver, or who prefer to use only one receiver, can also enjoy broadcasts intended primarily for stereo reception. The system was demonstrated earlier this year on a portion of the "Perry Como Show" television program, broadcast by the National Broadcasting Company over its nationwide network. This article will be principally concerned with some of the concepts underlying the development of this system.

The broadcasting of radio and TV programs in stereo, over two separate channels, became popular about 1952. To a large extent, this popularity was created and enhanced by the widespread acceptance of high-fidelity recordings and sound equipment. In various experimental arrangements, the two channels required for stereo are selected from different combinations of the AM, FM, and television broadcast bands. The listener spaces the receivers in his home in the proper way to get stereo sound. Listeners' reactions have been so favorable that more broadcasters are considering offering additional stereophonic sound programs.

The major obstacle to an increase in this type of broadcasting, however, is the majority of the potential audience, who have or prefer to use only one receiver. If the broadcaster tries for the full stereophonic effect, the sound the single-channel listener hears comes from only one of two widely spaced microphones. Thus, he misses a portion of the program. In many cases, this effect is similar to listening to one-half of an orchestra or to one side of a two-way conversation. And what the single-channel listener does receive is poorly balanced, because of the placement of the microphone in relation to the sound sources.

Broadcasters, in order to protect the investment of their sponsors, must dilute the stereophonic effect to preserve satisfactory reception for the single-channel listener. If the broadcaster does this — by moving the microphones closer together or intentionally blending the signals electrically — he spoils the true stereophonic effect.

Single-Channel Systems

For this reason, some effort has been made by broadcasters and others to develop a compatible stereo system: one adaptable to the broadcast of high-quality signals for both stereo and monaural listeners. Most of this effort has been directed at single-channel transmission systems. Such arrangements generally use either frequency-division or time-division multiplexing — that is, the two or three signals necessary for stereo are sent over a single channel that uses carrier transmission. Multiplexing schemes like this have been used for many years on Bell System toll trunks to send many telephone conversations over a single carrier channel. Most of the stereo multiplex systems are indeed compatible with present day single-channel receivers. But to reproduce stereophonic sound, they require additional equipment not ordinarily found in standard AM and FM receivers. In effect, the receiver must have a "de-multiplexer" in addition to its normal components.

The proposed stereophonic transmission circuit invented at Bell Laboratories offers a solution to this compatibility problem on both two- and three-channel broadcasts. Successful compatibility in this circuit depends on a psychoacoustic phenomenon known as the *precedence effect.* Before discussing this phenomenon and how it is used to achieve compatibility, it would be well to review some of the fundamentals of how we localize sound.

To locate the source of a sound, we require some perception in the three spatial coordinates — radial distance, altitude, and azimuth. These three coordinates and some other important localization concepts are shown in the drawing on this page. Man's auditory perception of distance seems to be primarily governed by loudness and the ratio of direct to reverberant sounds. As a result, distance perception is poor. We have little or no altitude perception, but azimuth perception is extremely good. An average listener can localize a sound source to within about 2° in azimuth.

The mechanisms for detection in azimuth are: (1) phase differences between the sound waves at the two ears; (2) interaural differences in the time of arrival of transient sounds; and (3) differences in intensity of sound at the two ears due to "shadowing" by the head. These intensity differences also depend on frequency, and thus

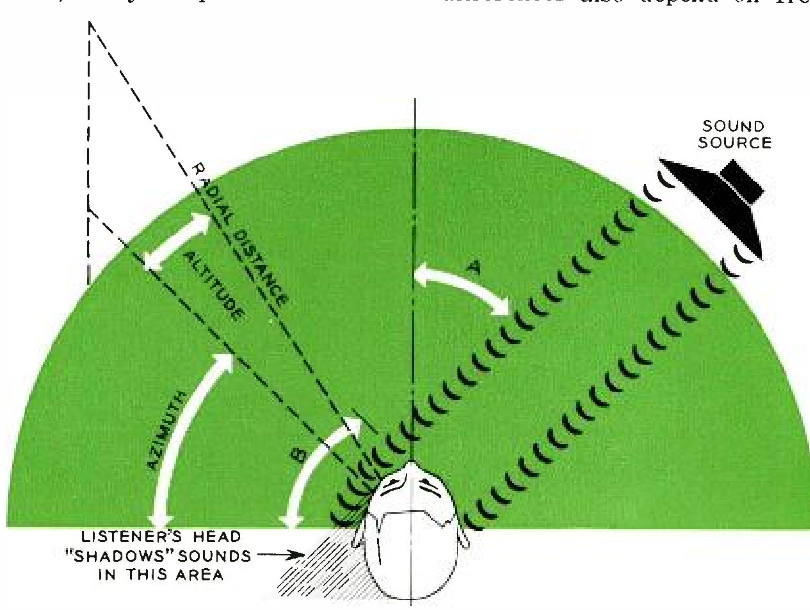


Diagram showing how we localize sound. Sound coming from azimuth angle A reaches the two ears with a time difference of $T = B/C$ where C is the velocity of the sound. If A is 45° and the interaural distance is 20 centimeters, the time difference is about $5x10^{-4}$ second, or 0.5 milliseconds. The sound wave that bends around the head is also weakened at the higher frequencies.

result in an interaural difference in "quality."

In reverberant rooms, even those with an optimum reverberation time for the reproduction of music, the "standing-wave" patterns tend to destroy our sense of directivity for prolonged pure tones. Hence, in ordinary listening environments, the interaural differences in arrival time and the intensity of the transient sounds assume the predominant roles in azimuth localization.

Psycho-acoustic experiments have shown that it is possible to trade loudness differences for arrival-time differences. For example, a listener seated equidistant from two in-phase loudspeakers separated by several feet will have the impression of a single, centrally located source if the two loudspeakers have the same intensity. If the intensity of one speaker increases while the other correspondingly decreases, the apparent source of the sound will shift toward the more intense loudspeaker. The amount of the apparent shift depends on the correlation of the sound pressures at the two ears and that which a single sound source at some azimuth angle would produce.

A subjective shift in sound source can also be achieved by holding the sound levels constant in both speakers and by introducing a time delay in one of them. In this case, the apparent source will shift toward the undelayed speaker. Delays as short as 0.25 millisecond will produce a substantial shift in the apparent source. The sound source seemingly shifts because delays of this order are about equal to the difference in the time it takes for transient sounds to arrive at the two ears when a single sound source is displaced 20° to one side of the listener. If the delay in one speaker is increased to two or three milliseconds, the undelayed speaker becomes the apparent sound source. The power of the delayed source must be increased by a factor of ten over the undelayed source before a listener will judge the two speakers to have the same loudness.

Precedence Effect

This dominance of the undelayed source prevails for delays up to about 35 milliseconds. At this point, the average observer begins to detect a distinct echo. In the 1- to 35-millisecond-delay region, then, the mechanism of azimuth localization determines the source of a sound by the direction of the first-arriving sound and virtually disregards the later-arriving echoes. This reaction of our azimuth perception facilities is called the *precedence effect*. Basically, it is our natural acuity for the preceding sounds in locating a sound source. Succeeding sounds only contribute to loudness.

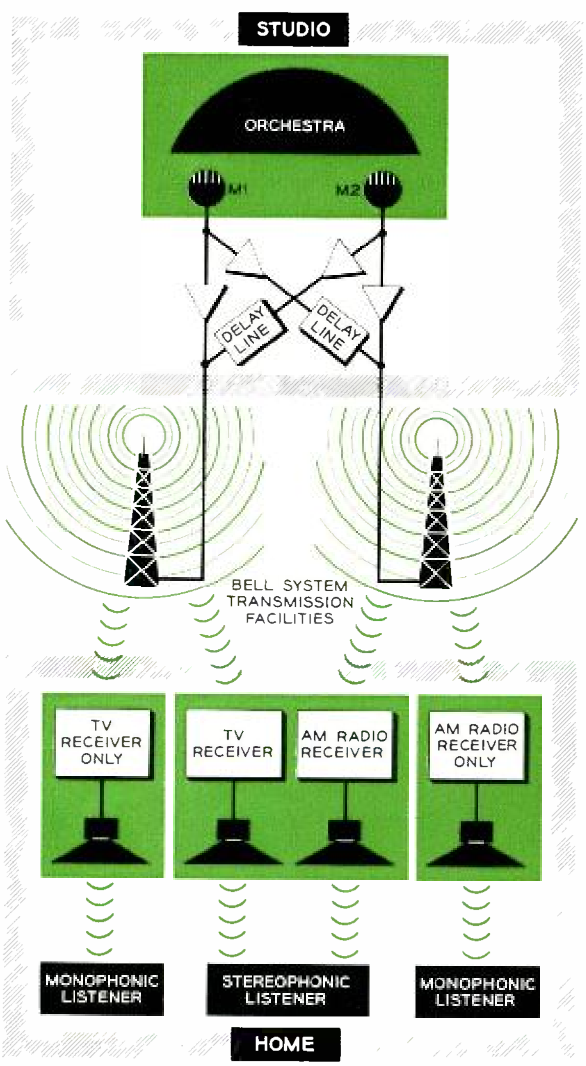
Dr. Leopold Stokowski, then director of the Philadelphia Orchestra, manipulating special controls for historic stereophonic broadcast demonstration in April, 1933. This control arrangement for blending stereo signals was set up in a box at the rear of Constitution Hall in Washington, D. C.

The precedence effect may seem amazing, but it is an everyday experience. In the average indoor environment, the bulk of the sound we hear arrives by way of reflections or echoes. Yet, in this same environment we have no difficulty localizing the source of various sounds.

As mentioned, the precedence effect is the basis of the compatibility arrangement for the proposed stereophonic system. The circuits between the two microphones and their corresponding FM-radio and TV transmitters are cross-connected through two delay lines. This arrangement is shown in the diagram on page 414. Each circuit and cross connection also has its own buffer, or one-way, amplifier. With these cross connections, music or voice signals from the left (M1) microphone are transmitted directly to the left (TV) loudspeaker in the listener's home, while the same signal is slightly delayed before reaching the (AM) speaker to his right. Because of the precedence effect, a listener with a stereo setup will hear the sound as if it came only from the left (TV) loudspeaker.

Conversely, the sound from the right (M2) microphone goes directly to the right speaker but is delayed before reaching the left (TV) speaker. It is therefore "unheard" in the left speaker. Thus, the stereo listener localizes the total sound he hears just as he would in the theater — as coming directly from each of his two speakers, or sides of the stage. For him, the full stereophonic effect is maintained.

With this arrangement, monophonic reception is completely compatible because a person listening to either single channel hears the total sound from both microphones in a "balanced" reproduction. The slight delay of one signal does not affect his reception at all.



The new compatible stereo circuit for a two-channel broadcast, showing transmission facilities and alternative receiving arrangements. Broadcast circuits can vary from local to transcontinental.

A three-channel system would operate in a similar manner. The direct signal travels only in the primary channels, while a delayed replica of the other two direct signals is added to it to achieve the balance necessary for compatibility.

Both prior to and following its demonstration, this new stereo system has been tested to determine the subjective reactions of listeners. With a two-channel system broadcasting music, the test results indicate that most listeners prefer a time delay of about ten milliseconds, with the intensity of the delayed signal equal to the direct signal. A different set of parameters appears optimum for speech, however. Here, the results show a preference for a five-millisecond delay, with the intensity of the delayed signal three db less than the direct signal. For variety programs, a compromise using a ten-millisecond delay with three db of attenuation in the delayed signal was very well received in the tests.

Additional Advantages of the System

In addition to compatibility, a stereo system based on the precedence effect has two interesting and desirable side advantages. For many listeners, this effect may eliminate two *subjective* reactions to stereophonic sound — "the hole in the middle" and the inadequacy of a three-cubic-foot box to the task of reproducing the music of a full orchestra.

The "hole in the middle" is an effect that some people experience when listening intently to stereophonically reproduced sound, generally orchestral music. After a time, one becomes aware that the speakers are the only sources of sound present, and there appear to be virtually no sound sources between them. The use of the precedence effect for channel separation enlarges the area of the apparent sound sources, however, and the listener is less aware of any hole.

This apparent enlargement of the sound sources is also more suggestive of the large loudspeakers generally associated with the reproduction of orchestral music. And for many stereo listeners, this phenomenon may overcome their reaction to small-speaker reproduction.

Most importantly, the proposed compatible stereophonic system should make it possible for broadcasters to offer stereophonic programs that do not dilute the full stereo effect or penalize the single-channel listener. In turn, this may make possible more two- and three-channel stereo programming on both local and national networks.

Submarine cable repeaters have the most carefully engineered housings of any unit in the Bell System. One of the many experiments designed to guarantee their reliability was a test of the possible effects of high voltage on the glass seals that serve as insulators for the passage of power into the repeater housings.

D. R. Oswald

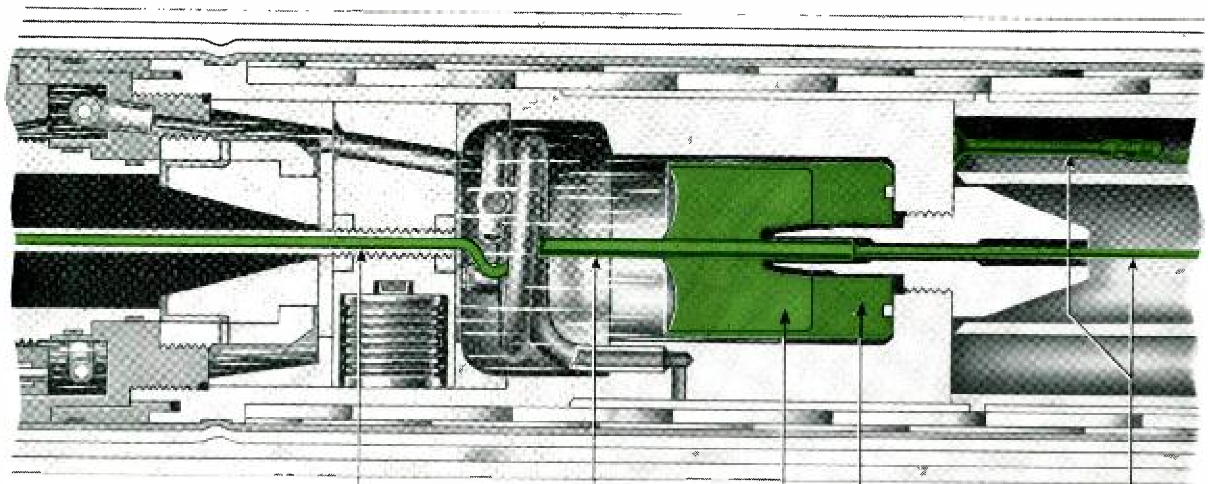
Reliability Of Glass Seals For Undersea Cables

The installation of the first transatlantic cable in 1956 made possible for the first time intercontinental voice communications free from the atmospheric interference that occasionally affects radio transmission. Overcoming this drawback in radiotelephony over long expanses of water is complicated by the impracticality of having repeaters in the transmission path to reshape and amplify the voice signals. In modern undersea cables, however, compact electronic repeaters can be inserted periodically to insure faithful and reliable voice transmission.

These undersea repeaters have already become classic examples of controlled design and manufacture for the ultimate in dependability (RECORD, *January*, 1959). In designing for such a high degree of reliability, Bell Laboratories engineers realized that the tubular, protective covering for the repeaters was just as important as the electronic elements that comprise the repeater itself. This protective structure prevents the extreme pressures at the ocean bottom from forcing water or water vapor into the repeater.

Because these repeaters are electronic devices, certain elements inside the container must be electrically connected to an external source of power. The required connection here is to the coaxial, center-conductor wire that runs the length of the cable. Metallic electrical conductors must be passed through the ends of the repeater enclosure in a way that insulates them from the electrical return path near the cable sheath.

The actual arrangement for doing this is shown in the simplified cross-sectional view on page 416. This diagram of the end portion of a repeater housing shows the location and details of the feed-through insulator; the shaded assembly in the center of the drawing is commonly referred to as the "glass seal." The metal center rod and the metal outer cup are connected to, and are at the



Sectioned view of the end portion of a repeater housing showing the glass seal and the important elements of the repeater connection. The glass cylinder of the feed-through insulator is continuously subjected to the total operating voltage of the submarine cable repeater at this point.

same electrical potential as, the inner and outer conductors of the cable, respectively. The glass that separates them is therefore continuously subjected to the total operating voltage of the repeater. To insure both the mechanical and electrical reliability of these glass seals, device development engineers at the Allentown, Pa., location of Bell Laboratories devised some interesting and unique test methods. This article will describe some of the basic concepts underlying these tests and will give a brief analysis of the results.

Glass is generally considered a near-perfect insulator, but with increasing temperatures its effectiveness falls off rapidly. Specifically, the electrical conductivity of some glasses increases by a factor of 10^5 with a temperature rise from 50° to 250°C. This so-called "volume conductivity" is electrolytic in nature and must be distinguished from the "surface conduction" that can result from adsorbed films of moisture or other contaminants on the surface of the glass. Because the glass seals discussed here are always clean and dry, surface conduction is negligible. In volume conduction, current is carried by ionic migration of certain elements within the glass, as opposed to the free-electron conduction usually associated with metals.

If this electrolytic conduction occurs to an appreciable extent, there is the possibility of a progressive change in the uniformity of composition of the glass. The rate of this change is related to temperature in exactly the same way that the volume conductivity is. Briefly, the higher the temperature, the shorter the time required for a given applied voltage to produce detectable changes in glass composition. This relationship was basic to the tests devised for the glass seals.

There was one complicating factor, however —the glass in the seals is not entirely pure and homogeneous. In making the hermetic glass-to-metal bond, the surface of the metal is first oxidized by heating in air, and the glass is then melted and made to flow onto the oxidized surfaces. Some of the metallic oxide is absorbed by the glass, and it is through this medium that the bond is produced. The composition of the glass near the metal surfaces is thus altered from its basic state by the absorption of the oxide. The proportion of oxide contained in the mixture diminishes with the distance from the metal.

Unfortunately, no data are available on the electrical characteristics of such an inhomogeneous combination of glass and oxide, and the extent of electrolytic action at a given voltage and temperature cannot be predicted. But it is logical to speculate that even at temperatures as low as 4°C — the estimated operating ambient of a submarine cable seal — the effects of electrolytic conduction might be significant over the long design life of the cable.

The reliability tests for the seals thus resolved into this general problem: to determine the effects of electrolytic conduction over a long period of time. Since the time interval could not reasonably be duplicated, "accelerated" testing had to be used. For these tests, representative seals were subjected to dc voltages of the same magnitude as those encountered in the cable, with the temperature of the seals elevated to between 175° and 250°C. Under these conditions, the conduction rate could be increased to the point where indications of the effects of electrolytic conduction could be obtained in a reasonable time. The results of these accelerated tests were then extrapolated to give an estimate of the time required for the same effects to occur at ocean-bottom temperature.

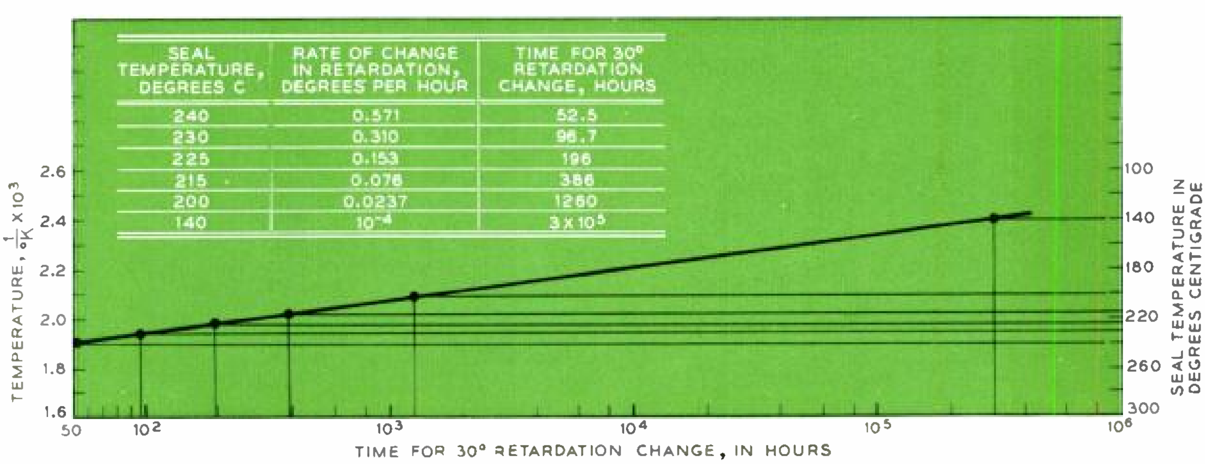
Optical Retardation

An important step in the test procedure was to devise a method of detecting changes in the composition of the glass seals. To do this, the "optical retardation" (defined below) of the glass immediately surrounding the center-conductor rod was measured. In this area, the glass exhibited the measurable retardation characteristic because strained glass is birefringent — that is, it can refract light in two directions. And the glass in the submarine cable seals, as is generally the case with glass bonded to metal, is slightly strained because of a differential in the rates at which the glass and the metal contract as the bonded assembly cools during manufacture.

When a plane-polarized ray of light passes through strained, birefringent glass, its unidirectional vibration is resolved into two components by the double refraction. The difference in velocity of these components as they emerge from the glass is the optical retardation. The magnitude of this retardation depends on the thickness of the birefringent material, the magnitude of its stress, and its stress optical constant, or retardation per unit stress and unit thickness. It can be readily measured with an optical instrument called a polarimeter *(see photograph on front cover)*. Measured changes in optical retardation therefore reflect changes in either the magnitude of stress or in the stress-optical constant. It is reasonable to assume that the residual cooling-stress remains constant; therefore, subsequent changes in optical retardation can be interpreted as representing changes in the composition of the glass.

The designers of the test arrangement first discovered practical evidence of a correlation between the effects of electrolytic conduction and optical retardation when they observed a change in the general retardation pattern in a seal that had been subjected to 4000 volts dc at an ambient temperature of 200°C, for 1600 hours. This seal, as viewed in a polarimeter, is shown *(top left in the illustration on the next page)*, alongside a similar view of a normal, untested seal. The most important difference between the two, although the photographs do not clearly illustrate it, is that the region immediately surrounding the center-conductor rod appears brighter in the tested seal than in the untested seal. A significant difference in the magnitudes of retardation in that region is indicated.

In quantitative tests that followed this initial observation, the rates at which the retardation changed for a given applied voltage were found



SEAL TEMPERATURE, DEGREES C	RATE OF CHANGE IN RETARDATION, DEGREES PER HOUR	TIME FOR 30° RETARDATION CHANGE, HOURS
240	0.571	52.5
230	0.310	96.7
225	0.153	196
215	0.078	388
200	0.0237	1260
140	10^{-4}	3×10^5

Plot of rate of change in retardation for varying degrees of temperature. The curve has been extrapolated to lower temperatures and made into a straight line for convenience. Inset table shows test temperatures, rates of change in retardation, and times for a 30-degree retardation change.

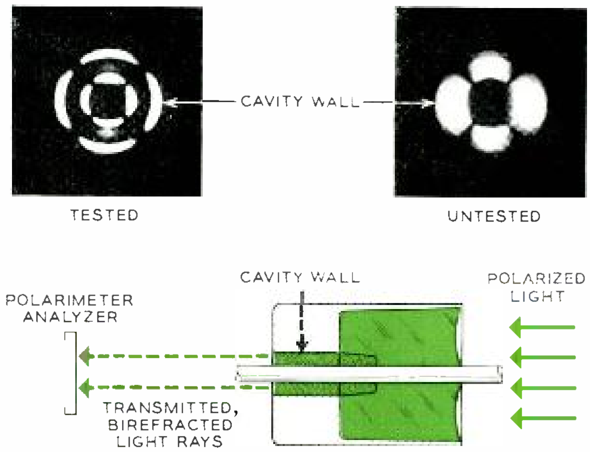
to be related to glass temperature in exactly the manner predicted by a consideration of the principles governing electrolytic conduction in glass. The most significant relationship is that the rate of change in retardation, like conductivity, is related exponentially to temperature. This rate of change in retardation, described earlier, is actually a measure of the rate at which the composition of the glass near the center-conductor wire is changing.

The drawing on the preceding page summarizes some of the observed data on rates of change in retardation at varying temperatures. These data were obtained from seals maintained at the indicated temperature for up to 1400 hours, with 4000 volts dc applied between the cup and the center-conductor rod. This voltage, which is somewhat higher than the 2500-volt maximum encountered in the operating cable, was used to give an adequate safety factor. The test temperatures were necessarily limited to the range between 175° and 250°C. At the lower temperature, there was no change in retardation after 1400 hours on test, so the test at that temperature was discontinued. At 250°C, on the other hand, the change was so rapid that its rate could not be accurately determined.

When retardation is measured with a polarimeter, its value is expressed in degrees of rotation of the "analyzer" — a light-polarizing disc on the instrument. At the highest test temperatures, changes in measured retardation, represented by as much as a 60° change in analyzer position, were observed after the seal had been under test for a number of hours and had again been cooled to room temperature. The electrical conductivity of these seals at room temperature, however, was still negligible enough to be barely measurable by ordinary instruments. Electrically, then, the seals were still acceptable. Hydrostatic pressure tests showed them to be mechanically reliable as well.

In the illustration just mentioned, the rate of change in retardation and the resultant time required for a 30° change in retardation are tabulated for each of the temperatures used. The tabulated times are also plotted against temperature to illustrate the extrapolation of the test data to lower temperature.

The 30° change in retardation, shown in the right-hand column of the table, was chosen as an arbitrary criterion for the following reason: Since a 60° change, as mentioned earlier, did not appreciably affect the mechanical and electrical reliability of the seal, a 30° change will certainly not affect them, and an added factor of safety is introduced by using the lower value as the criterion.



Polarimetric views of retardation patterns in tested, left, and normal seals. The seals were viewed parallel to their longitudinal axes. Only a narrow ring of glass, with the diameter of the center conductor as its inside diameter and the base of the metal cup as its outside diameter, is visible (see cross-section view on page 416). Light rays are everywhere else obstructed by metal. The dark area in the visible glass ring of the tested seal indicates a change in optical retardation, an effect caused by electrolytic conduction.

As the data plot and its extrapolation show, even at temperatures as high as 140°C the time on test required for a 30° retardation change to occur is 3 x 10^5 hours, or 34 years. The design life of the cable is less than this, so further extrapolation to lower temperatures is obviously unnecessary. For this experiment, the reliability of the seal had already been proven.

These tests and the careful interpretation of their results have strengthened the confidence of cable engineers in the reliability of the glass seals developed for submarine telephone cables. More explicitly, the tests demonstrated that the effects of electrolytic conduction in a glass-to-metal seal can be evaluated by using a retardation measurement as the criterion. Along with many other elaborate tests devised for designing reliable undersea cables, the retardation technique has helped development engineers to predict long-range cable performance on the basis of short-term accelerated tests.

Because of the expanding interest in good telephone techniques, a portable "Teletrainer" unit has been developed at Bell Laboratories. It gives students and other groups experience in getting the most value from their telephones.

G. R. Frost and W. W. Grote

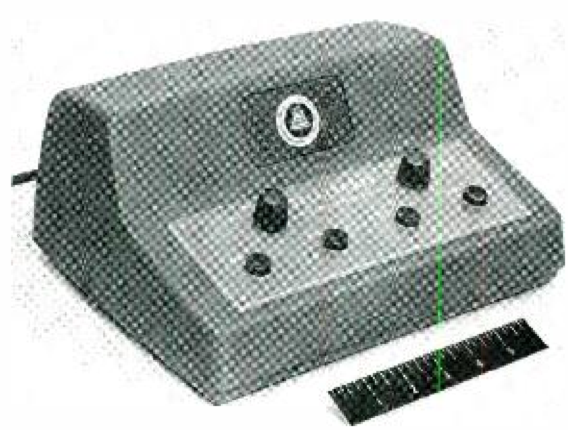
THE TELETRAINER

Sometimes the final use of a device far exceeds that for which it was originally intended. Such was the case with the "Teletrainer," a unit upon which practice telephone calls can be made.

The Teletrainer was developed under the direction of G. I. Robertson of the Publication Department to fill a need for an audio-visual aid to assist Bell System lecturers in public demonstrations of good telephone techniques. It allows the lecturer to demonstrate such actions as listening for dial tone, correct procedure in dialing, interpretation of informative signals, and the proper method of answering an incoming call.

The aid consists of two dial telephones connected to a control cabinet. This control cabinet has circuits for furnishing dial tone, busy and ring-back tones, and for ringing and interconnecting the telephones for conversation. A built-in amplifier and loudspeaker, and a take-off jack for connection to an external amplifier and speaker, allow the audience to hear all tones and both sides of the telephone conversation during demonstrations. A suitcase-type carrying case assures portability and ease of handling.

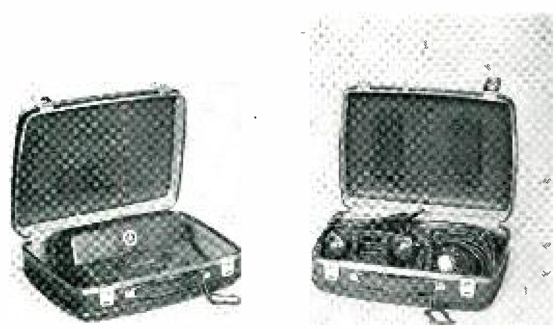
Several years ago, one hundred of these aids were made available to Bell System lecturers in the Operating Companies. Large numbers of Teletrainer demonstrations were conducted before service groups, engineering societies, social organizations and school classes.



The control unit of the newly developed Teletrainer. Emphasized in the design were attractiveness, ease of handling, safety and low cost.

Coincident with the introduction of the Teletrainer, a few Companies began pioneering in "Good Usage" telephone-training programs in secondary schools as part of the regular school curriculum. Because of the tremendous volume of business and social contacts being made over the telephone today, these companies felt that the principles of good telephone usage had an important place in education. Through such training, students can quickly acquire the necessary abilities and thus enhance their value as employees and as members of society.

Results obtained from these initial efforts stimulated a demand for similar training programs throughout the country. School administrators and Operating Company officials were quick to see the benefits of such training. As a result of this demand, the American Telephone and Telegraph Company initiated a country-wide program in Teletraining.



In its carrying cases, the Teletrainer equipment units are easily carried to different locations.

Experience with the original Teletrainer developed by the Publication Department led to its adoption as the standard device for this program. A formal course in telephone training, complete with teacher's manual and student's booklet, was prepared to accompany the equipment.

To satisfy the demand for this course in secondary schools, 3100 units were placed in service during the 1954-1958 period. Demand for additional courses still continues, and units are continually being placed. Consequently, the Teletrainer was recently redesigned for quantity production. Present plans call for the manufacture of about 10,000 units over the next five-year period.

The new version has a more pleasing appearance, is somewhat easier to operate, and is packaged for easier handling. It is also designed for more economical quantity production.

The photograph on the preceding page shows the new Teletrainer. The base has a smooth coating of blue-gray enamel, and the cover has a fine-wrinkle finish of red enamel which matches the cherry red color of the telephones associated with the unit. The front panel is gray with white lettering, and is covered with a scratch-resistant, clear-plastic plate. This protects the panel and lettering from wear in normal use and handling. For ease of operation, the panel is sloped at an angle similar to that of the new Call Director (RECORD, *February,* 1959).

A Bell System medallion is mounted in the vertical portion of the cover adjacent to the front panel. This section of the cover is grilled so that sound can radiate from the internal loudspeaker toward the front of the unit, where the teacher or instructor will normally be. A similar grill in the back of the cover permits sound from the loudspeaker to be directed out into the main portion of the classroom.

Commercial ac powers the Teletrainer, and the illuminated Bell System medallion lights to indicate when the power switch is turned to ON. There are four other switches on the panel, and these are used by the instructor to control dial tone, busy signal and individual ringing of the two telephones. These switches are of the push-button type constructed to operate on light pressure, with the buttons contoured to fit the finger. The remaining control on the front panel is a knob for adjusting the level of sound output from the loudspeaker.

From an engineering standpoint, the design requirements of the Teletrainer were severe. The units had to be rugged to withstand the rigors of portable usage, and lightweight to permit easy transportation. Simple controls to allow operation by non-technical people were a must. Another requirement was to meet Bell System standards in telephone transmission, ringing signals and informative tones, using standard telephone sets. Important parts of the design are the safeguards against accidental electrical shock and fire. Both earlier and new units have fully met the requirements of the Underwriters' Laboratories and are so listed by them.

Weight requirements were met by minimizing the number of components and carefully selecting these on the basis of weight. The total number of parts was kept small by assigning more than

This photograph shows an early model of the Teletrainer in use in a high-school class in business practice. Teletrainer is on the teacher's desk, and two students (left and right) use the telephones.

one function to each wherever possible. Some components were made to perform their multiple functions simultaneously, while others perform them on a sort of time-division basis.

An example of simultaneous performance of different functions by single components is the line-to-grid transformer, which is used as a retard coil, as an amplifier input transformer, and as a takeoff for a public address system.

An example of time sharing is the use of the amplifier output tube for ringing the telephones. Normally, this tube is an audio amplifier feeding speech signals to the loudspeaker. Since the audience can hear the ringing of the telephone sets directly, however, the use of the loudspeaker is not required at this time. Instead of providing a separate source of ringing current, the output tube is at this time converted to a 20-cycle oscillator. This oscillator is interrupted by a motor-driven timer to give the proper time cycles for ringing.

The weight of the Teletrainer was further reduced by using magnesium for die-casting the base and cover, and by using aluminum for the internal chassis construction. To increase portability, two lightweight carrying cases are provided. One is for the Teletrainer and the other is for the two telephone sets and connecting cords. Each weighs less than 4 pounds empty and less than 15 pounds when equipped.

The carrying cases are standard pieces of tested and proven luggage with slightly modified interiors. Plastic inserts and felt padding were added to hold the equipment firmly in place. The cases are molded from material with a glass-fiber base, to which an outer surface of scuff-resistant vinyl is applied. Different colors were chosen to aid identification. The Teletrainer case is silver gray, while the telephone case is blue. The use of standard luggage, made in quantity for other uses, has resulted in a considerable saving in cost.

The new design of the Teletrainer not only provides a "new look" but also has advantages of ruggedness, ease of handling and cost. This should result in greater use and wider distribution, thereby training more future customers in the proper use of the telephone.

In No. 4-type toll offices, data needed for billing long-distance calls will soon be recorded with Centralized Automatic Message Accounting (CAMA) equipment. If the call originates in local step-by-step offices, means must be promptly provided at the toll office for recording the digits of the called numbers as the customer dials them. The newly developed ten-digit dial pulse register performs this function.

R. F. Dusenberry

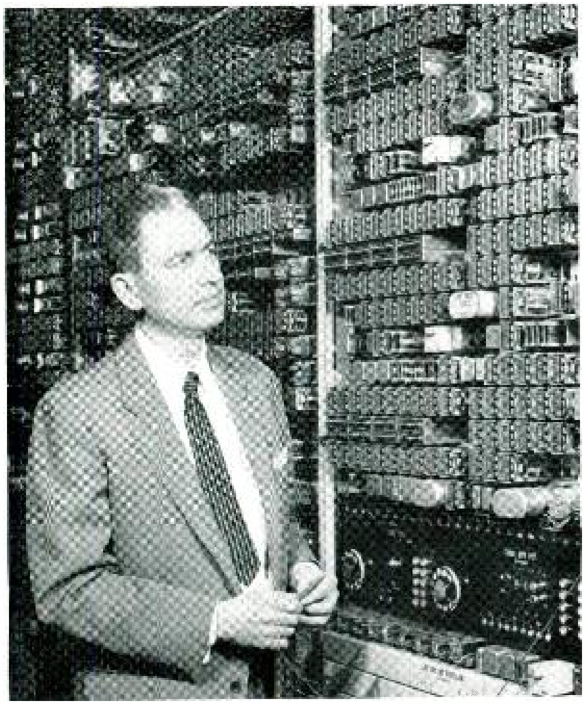
NEW DIAL-PULSE REGISTER FOR No. 4-TYPE CAMA

For several years now, Direct Distance Dialing (DDD) has been made available to telephone customers in localities where local central offices include the necessary switching features and equipment for the automatic recording of billing data (RECORD, *July*, 1954). Many existing telephone central offices, however, have a relatively low volume of toll traffic and therefore cannot economically justify equipment for automatically recording billing data on toll messages. The alternative is to locate the data-recording equipment at a centralized point through which the call would normally be routed. This has been done for crossbar tandem offices and is now available for No. 4A and 4M toll offices (RECORD, *September*, 1959).

One of the circuits included in this development for No. 4-type toll crossbar Centralized Automatic Message Accounting (CAMA) is the ten-digit incoming dial-pulse register, which was developed specifically to handle calls from step-by-step originating offices.

The direct dial control employed by step-by-step does not provide for the storage of information as the customer dials it; instead, the connection is set up as each digit is dialed. To dial a toll call, the customer first dials the digits of a directing code, which establishes a connection through the step-by-step office to the toll office. Here a registering device records the remainder of the digits. Dial tone is provided in local offices as a signal that the equipment is ready to receive dial pulses, but the use of an additional tone to indicate that the toll office is ready is regarded as undesirable for standard telephone service.

To avoid this second dial tone, it was decided to furnish registering devices in the toll crossbar office capable of being selected and connected during the interdigital interval — that is, during



The author standing before the CAMA incoming dial pulse register frame in the toll switching laboratory. Each prototype register seen in the background occupies six relay mounting plates.

the short space of time between digits as the customer dials the number. Sender and sender-link arrangements, however — which provide such registration conventionally — cannot meet these requirements for the interdigital interval economically. It was therefore necessary to furnish fast-acting connectors which would promptly connect the incoming trunk circuit to a register capable of recording the digits as the customer dials them.

Most of the interdigital interval may be consumed in establishing the connection to the toll office, so the fast connector or "bylink" (RECORD, *October*, 1959) must provide a path between the incoming trunk and the incoming register within 50 milliseconds. This avoids mutilating the succeeding digit dialed by the customer. A bylink feature of extending control and pulsing connections to the register through the link-control relays (even before the link has operated its own crossbar switch) is the principal means of establishing the connection in such a short time. The bylink used in No. 4-type toll CAMA systems is similar to one employed in crossbar tandem, but the register is somewhat different.

The incoming register, seen in the block diagram, is capable of registering all the digits the customer is expected to dial, the maximum being ten. By recording all the digits in the register, the holding time of the comparatively complex and expensive sender is reduced to a minimum since it is not connected while the customer dials. The register is much simpler than the sender, for it only registers the digits as they are dialed, initiates a sender seizure when they are almost all received, and rapidly outpulses all digits to the sender in multifrequency form over a path established through the trunk and sender-link circuits.

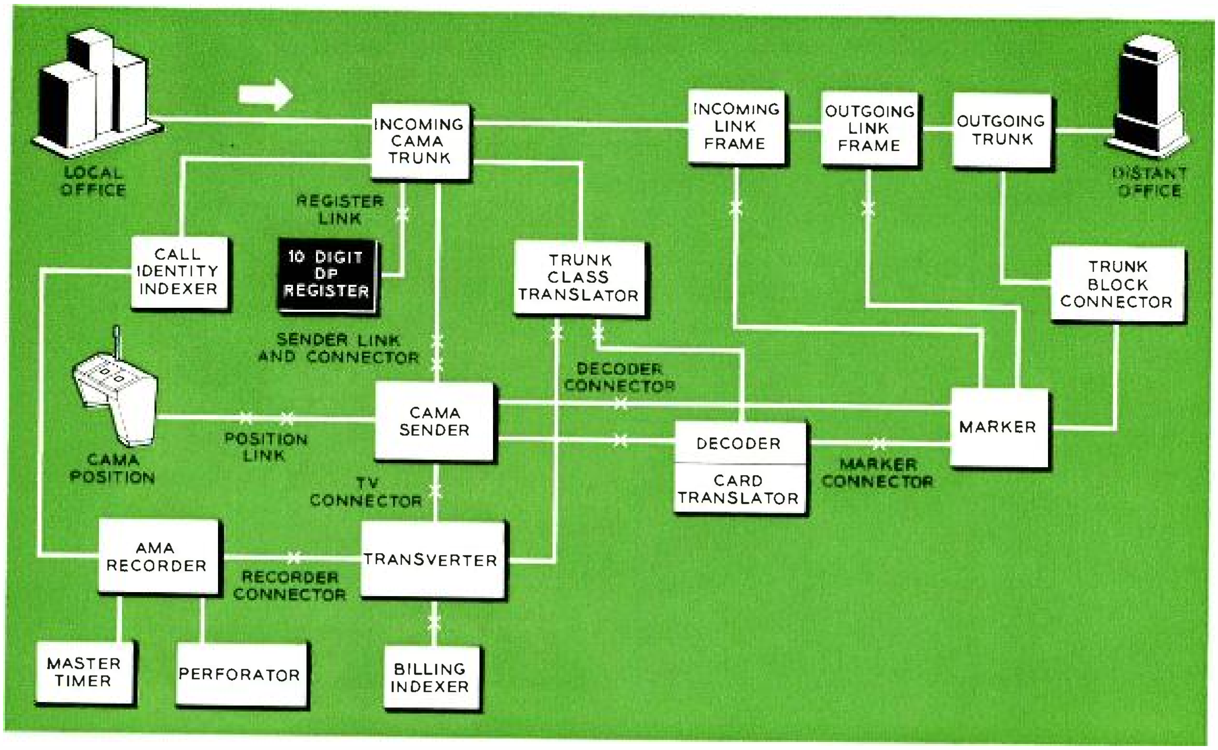
Anticipation Features

Multifrequency pulsing from the register to the sender, in addition to saving sender holding time, permits the use of only MF-type CAMA senders. This occurs because the register serves as converter from the step-by-step office dial pulsing to the multifrequency form.

The DDD numbering plan requires the use of seven digits for office code and line number, prefixed where necessary by a three-digit area code. The incoming register is arranged to receive either seven or ten digits, recognizing an area code by the appearance of a "0" or "1" for the second digit dialed. Thus, the register knows how many digits to expect on any given call, and it anticipates the end of pulsing by seeking a sender before inpulsing is quite completed. In the average case, it is able to establish the connection to a sender, outpulse most of the digits already registered, and be ready to outpulse the last digits when they are received. The actual amount of "anticipation" used for seeking a sender varies with the expected number of digits. A seven-digit call will seek a sender just before the last digit, but a ten-digit call will seek a sender before the next-to-last digit. Greater outpulsing time is thereby allowed for the case where there are three more digits to outpulse.

The register also cooperates with the sender in another anticipation feature. On certain calls, a CAMA operator has to be connected briefly so that she can identify the calling number for billing purposes. The sender will seek a CAMA operator's position when the next-to-last digit has been received from the register, but it should do so only if the register has received all of the digits. This is to avoid calling in an operator on a call that has been abandoned. To do this, the register withholds the outpulsing of the last two digits until the very last dial pulse has been registered.

In the process of performing its functions,



Block diagram showing the new design for 4A CAMA and the position of the new register in the system. Three hundred registers are assigned to serve all of the trunks in a transverter group. The incoming register receives either seven or ten digits and it detects an area code by the appearance of a "0" or "1" for the second digit dialed. The register then knows how many digits to expect on any call, and it anticipates end of pulsing by seeking sender before end of inpulsing.

the register counts dial pulses by a set of counting relays, shifts each number into a dry-reed relay register package, and, when ready to outpulse, translates the number into multifrequency form for outpulsing. Translating relays are also used to register the first dialed digit to save register packages. Similarly, the tenth digit dialed is retained in the counting relays, since no additional dialed digits will be forthcoming.

Several features are included in the register to help it recognize and act when customer delays or circuit troubles threaten to affect the register's availability for serving calls. Gas tube timers monitor the entire interval from the moment the register is selected until it releases upon completion of outpulsing. If the circuit or the customer fails to perform the next expected step within a reasonable length of time, the timer will initiate a circuit release. In cases where the circuit, rather than the customer, is at fault, alarm indications are provided. On the other hand, if there is a time-out during the dialing interval, the customer is considered to be responsible for the delay, and no alarm is indicated. In either case, the incoming trunk circuit is set into a reorder condition, which returns interrupted tone to the customer to inform him that he should reinitiate his call.

As an aid for trouble shooting, a limited number of faulty registers are held under key control, instead of releasing them. The trunk may also be held under certain conditions with interrupted tone being returned to the customer.

Incoming registers are mounted on three-bay frames, which hold twenty registers and the associated register-link equipment. Nominally, the twenty registers on the frame will serve a maximum of 140 trunks, with each trunk having access to ten of the twenty registers. A maximum of 300 registers is provided to serve all of the trunks in a transverter group, the basic CAMA office unit. This number is a function of the amount of traffic, the holding time of the register, and the size of the register group.

Communication is a very important factor in automation. For automatic operations like those of utility companies, where equipment in widespread areas is remotely controlled, Laboratories engineers have developed the SC2 Selective Control System which offers integrated yet flexible communication and control.

P. J. Gayet

Automatic Control Of A Pipeline

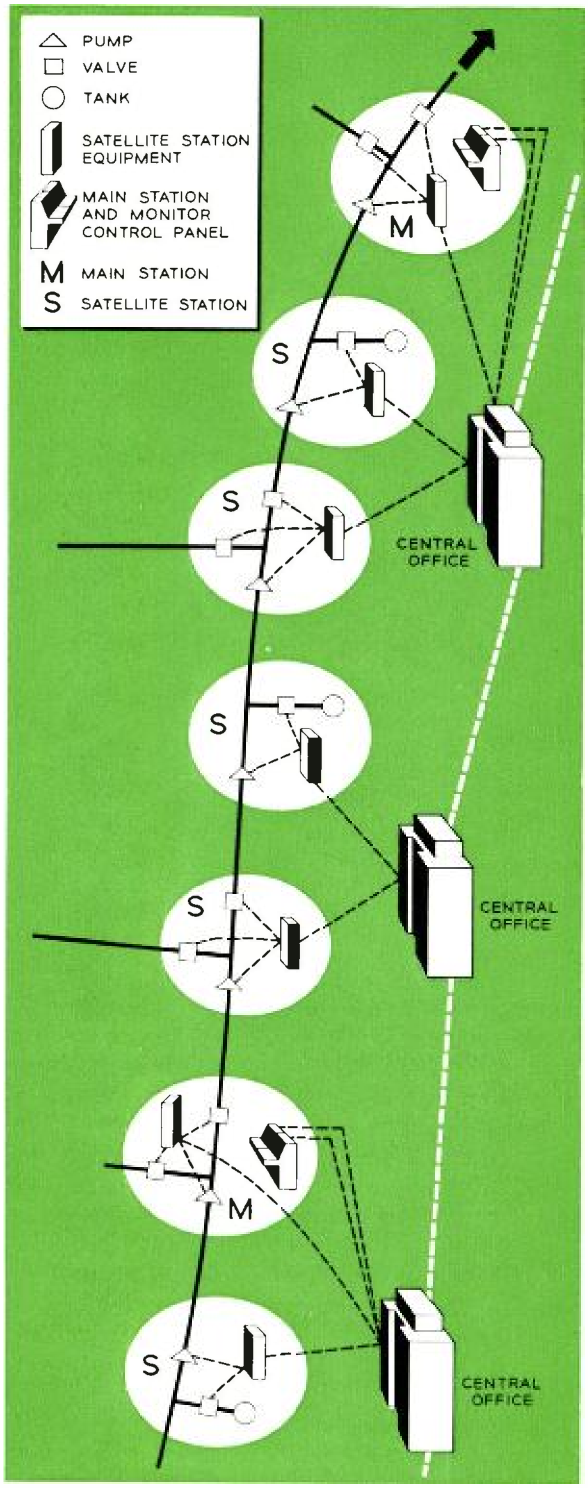
The large industrial growth in the United States since World War II has brought about problems in obtaining adequately qualified manpower. The answer to such problems, in many cases, has been the development and use of automated processes for achieving more economical and reliable operations. But as more and more complex equipment is installed in more and more locations, the result is an ever-increasing need for coordinating activities at these various, scattered points.

Problems of coordinating widely separated activities have been kept to a minimum in utility and other "right-of-way" companies by selective-control systems. These systems give one operator finger-tip control of large networks of electrical distribution systems, railroad signaling and switching systems, pipeline pumping stations, and the like.

Selective remote-control systems of this kind have usually consisted of communication equipment at the remote terminals owned by the utility company, and inter-connecting line facilities leased from the Bell System. As the use of such systems became widespread, however, it became apparent to the utility companies that there would be definite advantages in having an integrated control system. Such a system would include both the communication equipment at the terminals and the line facilities for linking this equipment together. It would not include, however, the devices such as circuit breakers, signals, pumps and valves which are operated by the actual control system. These devices would continue to be owned and maintained by the utility company.

The Early Trial System

Experience showed that an integrated system of this type would be advantageous to both the customer and the Bell System. A complete, well-defined communication network would be established, and would be maintained with undivided responsibility. Several utility customers in various parts of the country requested such a service, and after careful consideration, the Bell System entered the field of selective control systems.



Sketch showing in some detail one section of the control system and how it ties into adjacent sections. The main stations and monitor stations do not connect to pumps or valves. Satellite-station equipment is operated entirely by remote control.

The first steps that Bell Laboratories took in this new field were studies of the areas in which such systems could be used, and of the features of control systems already available. Arrangements were then made with the Philadelphia Electric Company to install a small, trial system for controlling six breaker switches at four locations on their power-distribution network (RECORD, *August*, 1955). For this trial installation a system known as the SC1 Supervisory Control System was developed and installed.

From experience gained during this trial, and as a result of subsequent discussions with prospective customers, systems engineers at Bell Laboratories, in cooperation with the A.T.&T. Company, formulated requirements for the development of a new arrangement. This arrangement was designated the SC2 Selective Control System. While the new scheme incorporates the features of the earlier system, it has additional options which make it more versatile, and consequently make it applicable to a larger variety of situations.

The first full-scale installation of the SC2 System was made on 1200 miles of the "Little Big Inch" Pipeline owned and operated by the Texas Eastern Transmission Corporation. The general route of the pipeline is shown on the accompanying map. When the Texas Eastern Company decided to go ahead with plans to convert the pipeline from gas transmission to the transmission of petroleum products, it requested the Bell System to provide a selective control system.

Oil pipelines, in general, pump fluid in one direction only. Pumping stations are located at intervals along the pipeline, and the velocity of flow can be regulated by varying the number of pumps operating at any one time. At each pump location there is also a pressure or suction setting that allows an adjustment of the pressure on the fluid. Maintaining the correct pressure is necessary to prevent vaporization during transmission.

In addition to the main, or "backbone" route of the pipeline, there are lines feeding off to the side, called "laterals." Valves are located at points both in the main line and in the lateral line.

When one product is pumped behind another in the pipeline, the two must of course be separated. Various types of special devices are used for this purpose. In this article, they will be called "scrapers." As a scraper moves through the pipe it closes lever-type switches located in the wall of the pipeline at points just preceding pumping stations. These switches provide a means of generating signals that record the progress of flow of the liquid.

For control purposes, the Little Big Inch Pipeline was split into six sections. Texas Eastern also established certain selective, remote-control requirements. At the head of each section, an operator would control from one to nine pumping stations, located "down-stream," or north of him. This meant that for the stations under his control, the operator would turn pumps on and off, regulate their suction setting, operate valves, and recognize the passage of scrapers. In addition, this control operator had to be able to alert an attendant at any pumping station in his section.

Along with control, the operator needed an up-to-the-minute record of the status of all devices under his control, and of all devices under the control of the adjacent upstream operator. And above all, the system had to be "fail-safe" — any mutilation of control signals or spurious signals could not produce an unwanted operation.

In addition to controlling each pump individually, the operator must be able to turn on or off all pumps in his section with a single control-action. Furthermore, if an emergency condition requiring a complete shutdown of the pipeline developed, an arrangement had to be made for what Texas Eastern calls "crash stop." This enables any control operator or pumping station attendant to initiate an action which turns off all pumps and closes all lateral valves in the entire pipeline.

Operation of the SC2 System

When the specific requirements for the selective control system for the Texas Eastern installation were studied, the proposed SC2 System appeared suitable for the job. In the basic plan of SC2, a control operator seated before a modern-styled console at the control point, or "main" station, can send control signals to any of a number of "satellite" stations. These satellites automatically respond to the signals, and return reply or confirmation signals to the main station. The customer's equipment for actuating pumps and valves is in turn controlled at outlying points by the satellites.

Red and green lamps on the main-station console display a continuous record of the status of all devices under the operator's control. A "monitor" station, which may be installed at any desired location, also displays an identical continuous record. The monitor and satellites are connected to the main station through the Bell System network by a single, low-cost channel which requires only a narrow frequency band. This could be a telegraph channel. For the pipeline, six complete systems were used — each consisting of a main station, a number of satellites and a monitor station. A main station was located at each control point, satellite stations were located at the pumping stations, and a monitor station was located at the end of each section, adjacent to the next main station. The sketch on page 426 shows this arrangement and the relationship between SC2 equipment and customer equipment.

For a better understanding of the important features of the SC2 System, and how Texas Eastern is using it, let us pretend to watch a control operator as he goes through some typical control operations. We will take as an example the main station at El Dorado, Arkansas. The operator at the console, which is shown in detail on page 428, controls equipment at nine satellite locations. The main part of the control panel is mostly keys (push buttons) and lamps, which are associated with individually controlled devices such as pumps and valves. A common-control section in the lower portion of the panel has keys and lamps which relate to general system functions.

Perhaps the first thing we notice about the console is that for every pump and valve which the operator controls, either a red "CLOSE" lamp or a green "TRIP" lamp is lit. Thus, he is able to tell at a glance the state of the pumps and valves under his control. Associated with each set of lights are keys to send control signals that order the actuating devices to one state or the other.

Let us assume that the pump at satellite station 6 (Bald Knob) is running as indicated by the

Map showing the route of the Little Big Inch Pipeline. Squares are main stations of SC2 System, as it was originally conceived, and circles are satellites. The direction of flow is north.

Control console for a typical main station. Operator is demonstrating how "master operate" key and an individual order button must both be pressed to send an order. Keys and lamps for "roll call" are located at the bottom.

red lamp under "STA" (the customers designation for pumps). To turn the pump off, the operator simultaneously presses the "TRIP" key associated with the pump, and the "MASTER OPERATE" key located at the bottom of the console. Since this key must be operated to send any order code, accidental operation of one of the order keys alone will not send a code.

When the two keys have been pressed, a code is transmitted to all satellite stations. The satellite at Bald Knob then takes action to shut down the pump. After receiving an indication from contacts on the pump that it has stopped, the satellite sends an acknowledgment signal back to the main station. We notice at this time that the red lamp associated with the pump goes out and the green lamp lights.

The self-checking code transmitted to the satellite stations is of the 2-out-of-5, pulse-length type. In such codes, of the five pulses that make up a digit, two are always long and three are always short. The code must appear as such to the satellite, or it will reject it and take no action. This coding of orders insures fail-safe reliability, because it would be impossible for one valid code to change into another valid code as a result of unwanted noise or voltage surges on the transmission line.

The 2-out-of-5 arrangement permits 10 possible combinations for each digit of the code, and the three-digit codes which are used allow for a total of 1000 codes. As an additional check, the system used on the pipeline is arranged for automatic "double" transmission on important codes. In this case, the satellites must receive both transmissions identically to take action.

Return signals from the satellite stations consist of only a single long or short pulse, representing the two conditions a device may have. Thus, simplicity in the satellite-station sending equipment and main-station receiving equipment is achieved with no sacrifice in reliability.

Suppose, now, that the operator wants to operate the pump at station 7 (Egypt) to the "on" or closed condition. The operation in this case is somewhat different because a pump, while it will shut down in a few seconds, requires several minutes to come on and operate at the proper speed. To avoid tying up the entire control system for this length of time, an order to close a pump is immediately answered by a single pulse, showing that the control equipment at the satellite has functioned to start the pump mechanism.

We notice this action at the main-station console by the lighting of a white "DEL ANS" (delayed answer) lamp in addition to the green lamp that is already on. The operator is now free to use the system for other control functions.

Before proceeding with this discussion of the operation of the pump, it will be helpful to discuss first another important feature of the SC2 system — "roll call." Roll calls are used in various ways to meet several of the important system requirements.

Up to now, we have not seen how the operator may tell if one of the devices under his control changes condition without an order — that is, by self operation, failure of the equipment, or for some other reason. In such an unordered operation, the associated satellite sends in a single "uninvited" pulse to its main station. The main station then automatically sends codes to all of its satellite stations in sequence. These codes are similar in nature to order codes, and are known as "inquiry" codes.

This series of inquiry codes is the roll call. When a satellite receives an inquiry code, it returns a single long or short pulse to verify the condition of a pump or valve at its location. The main station then automatically directs an inquiry to the next device, and this continues until all devices in all satellite locations are polled.

From the discussions so far, we can see that all order and inquiry codes are acknowledged. Note, however, that if a trouble condition causes either an order signal or an inquiry signal not to be acknowledged, an amber "NO REPLY" lamp lights on the main-station console.

Now, when a device which has changed its condition without a direct order is interrogated, the return pulse will not agree with the lamp indication on the main-station console. In this case, the lamp changes to a flashing indication of the correct condition, and an audible alarm sounds. Keys are provided on the console to retire these alarms. If the operator wants to make a periodic check of the line facilities, he can do it manually by pressing the "ROLL CALL START" key at the bottom of the console.

Checking Line Facilities

For check purposes, without the roll call, each pump and valve has an associated "INQ" key on the main-station console. Operating one of these keys sends out an inquiry code to only that device.

Let us go back now to the pump which the operator has ordered to the "on" condition. The pump at station 7 was getting up to proper speed and had indicated this by sending a delayed-answer signal to the main console. When the pump gets up to the proper speed, it sends an "uninvited" pulse to the main station, starting a roll call. As the roll call starts, we can note its progress by the "ROLL CALL" lamps on the lower-right side of the console. When the roll-call reaches the console lamp associated with the pump at station 7, the white and green lamps (indicating "delayed answer" and "off" respectively) extinguish and the red lamp lights. Thus, this roll call has served to indicate to the operator that the pump is "on" and operating at proper speed.

A few minutes later another roll call alerts us by an audible alarm. And we notice a flashing red lamp in the console position associated with a scraper for one of the stations. Here, the roll call indicates that a scraper is arriving at that station and has sent in a signal. This feature may be also used for alarms other than the passage of the scraper.

As we continue to observe, another roll call starts, an alarm sounds on the first inquiry signal transmitted, and the "CRASH-STOP SIGNAL" lamp lights. In this case, the roll call indicates that an operator at a main station or an attendant at a satellite station somewhere along the pipeline has had reason to request a complete shutdown, perhaps because he has observed a pressure reading outside of normal limits.

To initiate a crash-stop order, a satellite attendant operates a crash-stop key located on the wall in the satellite station. This sends in a single uninvited pulse which starts a roll call. As soon as the main-station equipment realizes that the change was a request for crash stop, the roll call stops, and the main station sends a crash-stop order down the line. The monitor station at the end of the section primes the next section to do the same, and so the signal passes on "down" the pipeline. "Down" in this case is north — the direction of transmission.

When the first crash stop order is sent, the main station also causes its adjacent "upstream" (to the south) monitor to request a roll call in that section. In the first step of this roll call, the monitor informs the upstream main station of the crash condition. This action continues all the way up-stream, so that no matter where the request for a crash stop was initiated, signals are passed all the way up and down the pipeline to effect a complete shutdown.

At our location, we soon notice from the main and monitor consoles that the lamps indicate that all pumps have been turned off and all lateral valves have been closed in both our section and the one adjacently upstream. When the emergency condition is cleared, the dispatchers can start the pipeline again.

With a single SC2 Selective Control System (one main station and its satellites) such as the one we have been watching, as many as 300 individual devices may be controlled from a single control point. Building-block design permits easy expansion, and helps to make the system easy to maintain. Codes are wired into the system by means of cross connections. Most of the equipment is mounted in relay racks which may be placed in an out-of-the-way location on the customer's premises. Only the operating consoles need be placed in the control operator's office. The SC2 system is usually operated from a power supply with sufficient reserve to hold over for a reasonable time in case power is lost.

The system has a number of optional features which, although not used by Texas Eastern, are valuable for other control applications. These include: control of telemetering either on the control channel or on auxiliary channels; raising and lowering the voltage of generators; and control from alternate main stations.

This new system now makes it possible for the Bell System to offer integrated control systems to utilities and other businesses and industries in all parts of the country.

Coin-disposal mechanisms for pay telephones have always presented interesting challenges to Bell Laboratories designers. A new slow-release coin relay, now being manufactured, lowers the minimum operating voltage from 60 to 50 volts and handles twenty instead of eleven coins.

W. D. Goodale, Jr. and K. E. Voyles

A New Coin-Disposal Mechanism For Pay Telephones

When a customer uses a coin telephone he activates an important unit known as the "coin-disposal" mechanism. It consists of a hopper to accept coins, devices to collect or return them, and various electrical and mechanical controls.

Briefly, this is what happens when a customer places a coin call: He inserts a coin or coins in a slot, from which they pass into a device that rejects slugs and then drop into the hopper — a vertical, cylindrical tube. As it enters the hopper, a coin passes over a small "finger" or trigger which causes a signal to be sent to the central office. If the call is manually controlled, this signal brings in the telephone operator, who asks for the number. If the call is to be dialed, the signal causes the automatic equipment to return dial tone.

At the bottom of the hopper a coin comes to rest on a type of "trap door," and under this is a vertically oriented vane. Later, when the operator or the automatic equipment knows the correct disposition of the coins, a signal is sent from the office to the telephone. This signal will be of either positive or negative polarity—one polarity causes the vane to deflect in one direction, and the other causes the vane to deflect in the opposite direction. The trap door opens and, depending on the position of the vane, the coin or coins fall into the cashbox or into the refund receptacle.

The present coin-disposal mechanism was introduced in 1912. Over the years, as with most Bell System apparatus, it has gone through many modifications and improvements. But again like many telephone items, a number of factors sometimes combine in such a way that a major revision or a completely new design is called for. In the case of the coin-disposal mechanism, one of the chief factors was the incorporation into the coin telephone of certain transmission components of the 500-type telephone set. These provide speech transmission beyond the capability of existing coin-disposal units. In particular, the improved efficiency of these components offered the possibility of using coin telephones over higher-resistance loops — which result from the use of smaller gauge, less expensive wire, or from the placing of coin telephones at greater distances from the central office.

There were a number of other important considerations for a new design, however. The central-office signal which operates the mechanism should be of a certain duration, but there is always a possibility of this signal being too short to operate the mechanism properly. It was very desirable, therefore, to ease this requirement with a design that would insure operation even with a very brief signal. Further, with the increased use of coin telephones for long-distance calls, the hopper needed a larger coin capacity. In addition, many details of the electrical and mechanical functions were capable of improvement as insurance against sticking of coins or jamming and excessive wear of the trap and vane.

Another electrical requirement was that the coil of the relay which operates the mechanism should have a high impedance to voice frequencies. By this means the amount of "ground noise" reaching the telephone set is held to an acceptable value. The use of the G-type handset with its more efficient receiver has made an increase in this impedance desirable. Finally, a new design had to be interchangeable in existing coin telephones.

The new slow-release coin relay (*see drawing on page 433*), was designed to meet these requirements. It is basically a nonpolar relay with a polarized preselector mechanism. The principal element in the preselector is a nylon card, which is moved in a vertical plane by a lever attached to the armature. Molded into the card is a small permanent alnico magnet whose ends are located in close proximity to two magnetic flux leads extending from the upper end of the electromagnet.

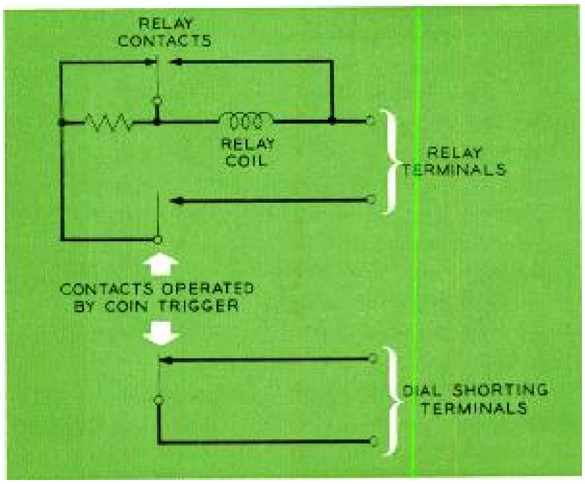
This mechanism operates as follows: When the electromagnet energizes the two flux leads with a "North" polarity, they respectively repel and attract the "North" and "South" ends of the permanent magnet embedded in the selector card. The resulting torque tilts the selector card as the main armature starts to move it downward, so that it can engage one side of a nylon cam. The cam thus turns the hopper vane to the "collect" position.

The opposite direction of current flow through the electromagnet polarizes the two flux leads "South," thereby tilting the selector card in the other direction and causing the vane to turn to the "refund" position. In this manner, the polarity of the voltage sent out by the central office determines whether the coins waiting on the trap are to be collected or refunded. In other words, the nylon card responds to polarity, even though the armature of the relay always acts in the same direction regardless of the polarity of the energizing pulse. This type of action eliminates the problem of controlling and balancing large differential forces — a problem which has made the older type of coin relay difficult to adjust.

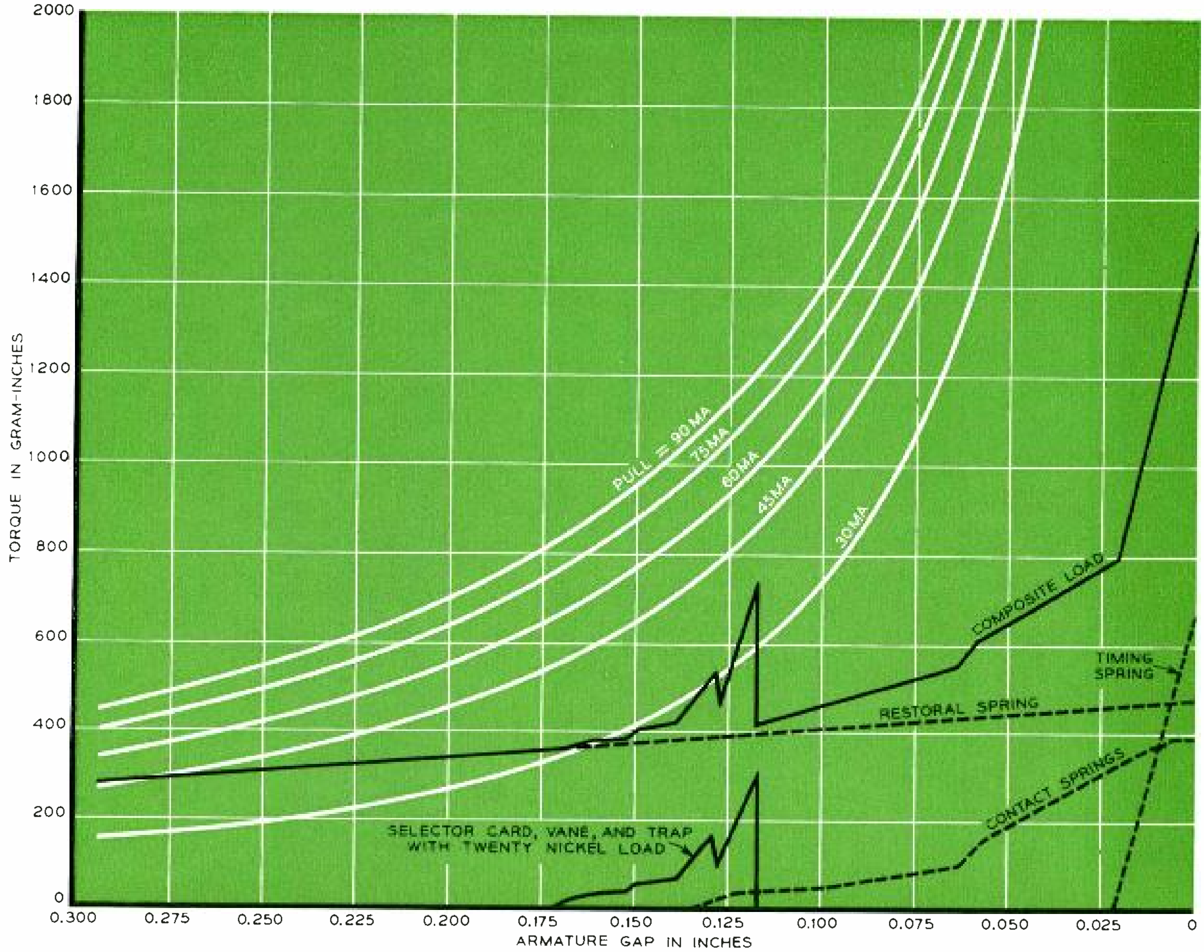
The card also controls the motion of the trap. After the vane has turned part way from its vertical rest position, the card engages a small tab attached to the trap-support arm, moves it from under the nylon trap, and permits the trap to fall open. In the last part of the armature stroke, the complete opening of the trap is insured by the final drive of this arm against a cam surface projecting from the bottom of the trap.

All mechanical load forces have been matched to the magnetic pull curve of the armature (*see the graph on page 432*) so that as much work as possible can be performed by the relay with assurance that the operation will be completed after it is once started. Except for a small amount of pivot friction, the initial resisting force (*left-hand portion of graph*) is due to the adjustable restoral spring, which determines the minimum operating voltage. Since the magnetic pull increases inversely as the square of the armature air gap — whereas the change of the restoral spring force is linear and relatively small during the stroke — excess force becomes available to perform other functions as the gap closes. First, the light mechanical load caused by the rotation of the vane is undertaken. Then the trap support lever is rotated to release the trap. Contact springs are operated near the end of the stroke. Last of all, the load of an adjustable release timing spring is picked up. None of these extra loads is great enough to stop the armature motion once the initial pull overcomes the force of the restoral spring.

One disadvantage of the older mechanism is that its "holding time" depends directly on the duration of the pulse sent out from the central office. In the case of manual operation at the central



Schematic circuit drawing to show position of the resistor substituted for the coil of the relay. This resistor extends the life of the limiting lamp at the central office and maintains needed supervisory functions while the relay is operated.



The measured pull and load characteristics of the new coin-disposal unit (read from left to right).

office, it is possible for an operator to produce such a short pulse that some coins will fail to pass through the trap and vane area and may jam in the mechanism as it restores to normal. Even automatic exchanges produce a small percentage of pulses which are below the 0.3-second minimum design limit. The new coin relay circumvents this problem with contacts which short circuit the coil on the electromagnet as the armature nears the end of its "operate" stroke. After the winding is short circuited, the collapsing magnetic field tends to maintain current flow through these contacts. Since the magnetic gaps are of large area and very short length when the armature is in the operated position, the magnetic pull is sufficient to hold the armature until the current fades to a small fraction of the minimum operate current. The point on the current-time decay curve at which the armature is released can be adjusted by the release timing spring. Normally this is set at 0.60 second for reasons we will now consider.

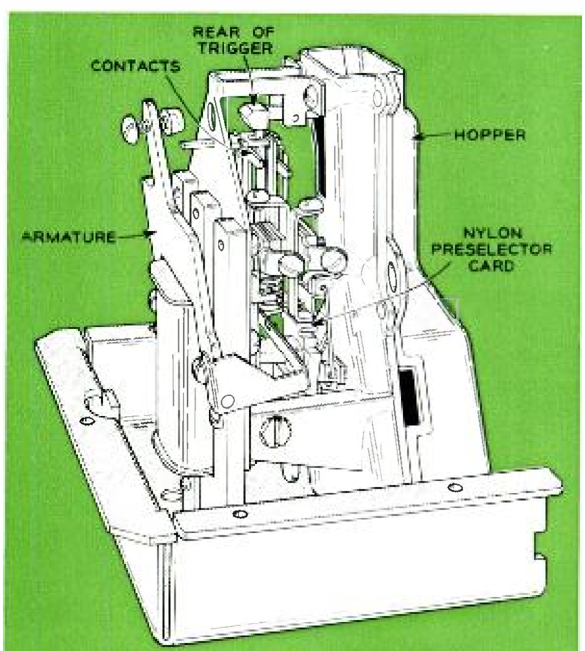
High-speed photographs show that a full load of assorted coins will fall clear of the trap and vane in 0.2 second. A 0.40-second margin must be available to allow for variations due to manufacturing tolerances, temperature changes, changes in the properties of the magnetic material in the armature and core, and operation of a coin pilot lamp at the central office. On the other hand, it is important that the release time should not be too long, because in some types of automatic exchanges the equipment sends out a check pulse 0.8 second after the actuating pulse, to verify that the relay has operated and reset itself. This check will be satisfied if the ground contacts at the mechanism unit are open when this pulse arrives. If not, the central office equipment takes steps to clear the difficulty.

Placing a short circuit on the relay coil will cause large current surges to flow through a series current-limiting lamp at the central office when the loop has a low resistance. Since the life of the lamp is greatly reduced by such treatment, it is desirable to avoid this condition. Also, supervisory functions must be maintained while the relay is operated. Hence, by using a set of contacts on the coin relay, a resistor *(see circuit drawing, page 431)* is substituted for the coil just before the short circuit contacts are closed.

The shorted-winding method of obtaining slow release also obviates the need of voltage-release requirements. As the relay is held operated by the short circuit on the winding, the trigger resets itself, and during the release stroke the ground contacts open before the short is removed. This is an important feature, because voltage may exist between line and ground under certain conditions of earth potential and circuit voltage following the coin pulse sent from the central office.

The first requirement of the redesign is met by the new relay because the operate voltage can now be set at 50 volts instead of 60; this permits operation on loops having about 550 ohms, or 50 per cent more resistance, yet the present nonoperate value of 40 volts — imposed to meet circuit and earth potential conditions — can still be maintained. The spread between the operate and nonoperate voltages can readily be held to these narrower limits. This is true because the pull on the armature is proportional to the square of the current and inversely proportional to the square of the gap; also, the greater work capacity makes frictional effects of less relative importance. We expect that the new units will be much simpler to adjust originally at the factory and will require much less adjustment in the field as they age and wear.

W. D. Goodale, Jr. dropping a coin in the hopper of the new coin-disposal mechanism. This unit takes twenty instead of the previous eleven coins.



This drawing presents the major components of the new coin-disposal mechanism. These include: coin relay armature, hopper, and nylon card.

Other requirements for the operation of the trap and vane are met by the design of the selector mechanism. Also, the new relay can handle a load of twenty coins instead of eleven, and the relay will operate on pulses which are approximately half the length required for the older mechanism. In addition the impedance of the relay coil has been increased substantially.

Finally, new materials and manufacturing processes in the design have reduced costs and repair. For instance, the switch is card-actuated to permit closer control of its operation, and it requires few adjustments during manufacture. The hopper is a zinc alloy diecasting rather than a part formed from flat stock. This provides more economical parts having closer dimensional tolerances. In combination with molded nylon traps, vanes and the parts of the preselector mechanism, we expect less trouble from manufacturing variations and changes caused by wear.

Performance data indicate that laboratory models on trial at the Buffalo, New York, airport for more than two years are very reliable and that trouble-free life expectancy should be many times that of the old unit. It is expected that the new unit, which is completely interchangeable with the old, will result in improved performance and important savings for the Bell System.

President Kappel Speaks To Pioneers on Growth Of Telephone Industry

By 1975 the telephone industry may well be serving 69 million households in the United States and Canada, compared with 42 million today, A.T.&T. President Frederick R. Kappel told the General Assembly Meeting of the Telephone Pioneers of America in Cleveland on October 1.

This statement followed a list of four major factors that Mr. Kappel said are bound to have a tremendous impact on communications in the next 15 years:

- The combined populations in the United States and Canada will very likely increase by nearly 65 million.
- The prospect that standards of living will continue to rise. More people will have the means to buy not only basic telephone service, but the particular service arrangements that meet their individual needs and tastes.
- Communications technology is advancing rapidly so that we shall have new and improved services to offer.
- Other businesses are advancing and changing rapidly also — in their technology, their organization, and in their ability to furnish new products and services.

Mr. Kappel mentioned several of the challenges and opportunities that lie ahead for the telephone industry, such as growth of extensions, DDD service, ocean cables, mobile service, and electronic switching.

"Also," he continued, "I think we have to become more imaginative in figuring out how to get the most value from our technical progress. Will we realize all the possibilities to the limit? Only if we explore our markets — only if we learn what people want and organize ourselves to meet these wants."

Mr. Kappel further explored the question of earnings and competition in the telephone industry. "Why should we try to come up with new ideas and instruments and systems that will serve our customers better? Why undertake new ventures? Why accept new risks?

"My own answer is that we simply must do all these things to be a progressive industry—one that makes important contributions to the economy and to society, that is well regarded by the public, and that competent, forward-looking people want to work in.

"But I also believe that certain factors which are fundamental to the progress of other businesses cannot be absent from ours. I mean specifically the profit incentive — the drive for financial progress — the expectation of reasonable reward."

Mr. Kappel spoke directly to the point of what we ought to earn: "I think telephone earnings broadly comparable with the earnings realized by other well-managed, progressive businesses in competitive industry are necessary to produce the very best in telephone service."

Mr. Kappel said he believed such earnings are necessary to provide, in the long run, the best service at the lowest price.

"Why? Because they will give investors the incentive to provide the great sums of capital we need. Because they will allow us to spend money to effect long-run economies. Because they will stimulate and spur us to use our inventiveness and energy in this competition I was talking about. Because they will encourage us to take the risks that will benefit our customers. Because they will give the business the vigor and vitality it must have to attract top-grade people who will have both the desire and the ability to make this industry of ours contribute more and more to the world."

"Over a period of years," Mr. Kappel said, "experience and reflection have produced some very clear and consistent basic principles." He said he would stress all these aspects of Bell System policy:

"It makes service paramount. It emphasizes constant improvement. It recognizes that progress and prosperity go hand in hand. It calls for prices no higher than they need be to assure the financial health of the business and continuing service betterment. It is always alert to the risks the business faces. It brings out that this is a business of people who need the incentives of good pay and opportunity. It takes the long view.

"Looking ahead, it seems to me our opportunities to improve and enlarge communication services are probably greater than they ever have been."

"In this endeavor," Mr. Kappel concluded, "I firmly believe that the Pioneers, by their abilities and leadership in the business, and also by their thoughtful participation in public affairs in their communities, will make a contribution of first importance to the whole future of communications, and to all the people serving in, and served by, this great industry of ours."

NEWS

Plates for ESS Memory Processed Automatically

Photographic plates used in the permanent memory system of the experimental electronic switching system designed at Bell Laboratories are now being exposed and developed automatically. M. B. Purvis and G. V. Deverall of the Switching Systems Development Department described the photographic problems associated with the construction of a large computer memory at a meeting of the Society of Photographic Scientists and Engineers held in Chicago on October 30. D. C. Koehler of the same department discussed the automatic processor. This equipment was developed by R. K. Eisenhart and R. F. Glore, also of the Switching Systems Development Department.

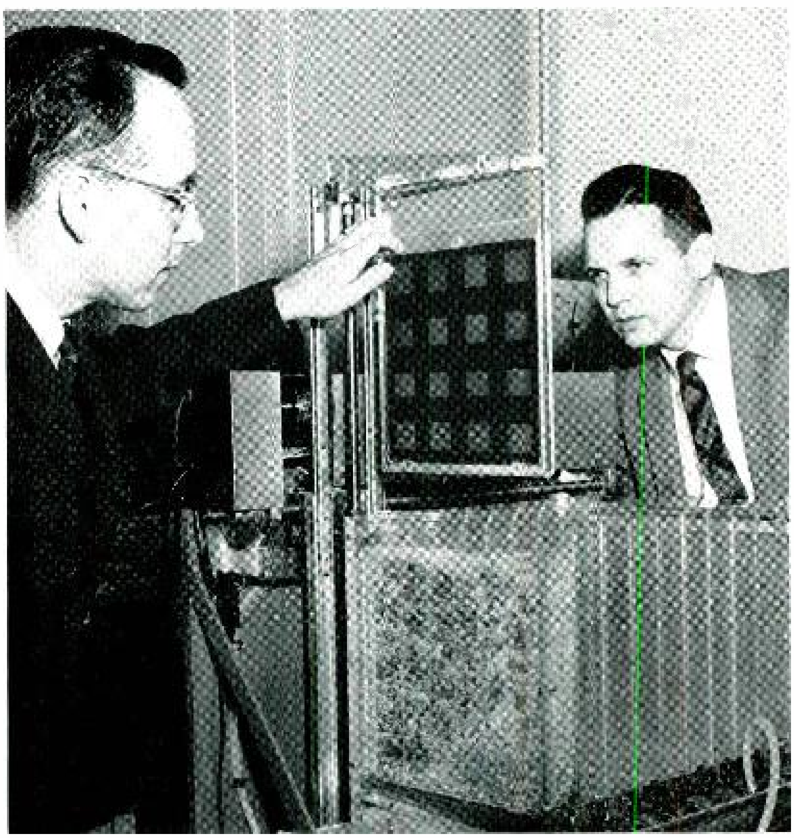
The permanent memory—called the Flying-Spot Store (RECORD, *October*, 1959) — stores such data as directory information and instructions for the electronic switching system. This information is in the form of thousands of tiny clear dots on an otherwise opaque photographic film area two inches square. Seventeen areas are used together to make up a complete photographic plate, and the entire megabit memory is comprised of four such plates.

A beam generated by a cathode-ray tube and focused by a system of lenses scans the spots of clear and opaque film. The movement of the beam is controlled by an intricate optical positioning system which must be accurate enough to pick out a particular spot only five thousandths of an inch in diameter, and separated from its neighbor by only two and a half thousandths of an inch.

Because of the critical accuracies required, the store itself is used to expose the plates, as well as to read them. This ensures that no slight mechanical variations between lenses and other parts will disturb the close tolerances. The moving beam from the cathode-ray tube is focused through an objective lens and a condenser lens on the photo-sensitive area. It moves over the entire two-inch-square area rapidly, pausing briefly at positions where a spot exposure is desired. Engineers selected a positive film, photographically "slow" enough to be insensitive to the passing of the beam alone, but fast enough so that a brief pause will make an exposure.

Each of the seventeen small areas is exposed individually, in sequence, while the sixteen others are covered by a system of shutters. Automatic control of this operation permits an entire plate of seventeen areas, containing 550,000 spot positions, to be exposed in less than three minutes.

After exposure, the plates are withdrawn from the flying-spot store in a dust- and light-proof



R. K. Eisenhart, left, and D. C. Koehler with bench model of an automatic processor for photo memory plates used in ESS. A plate is suspended from the traveling arm, and is dipped automatically into the various tanks according to a predetermined cycle.

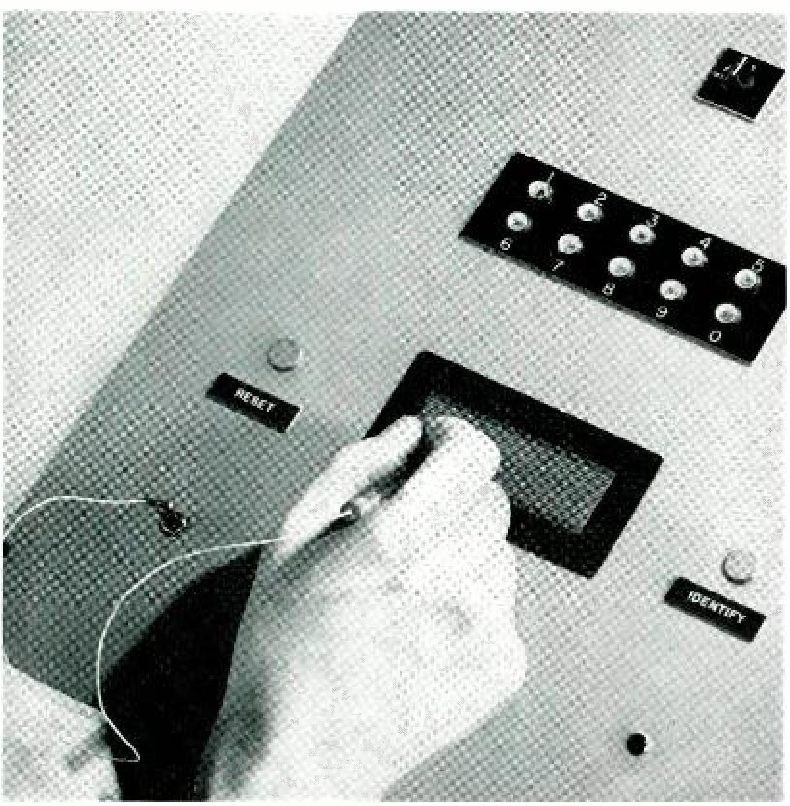
container and inserted into the automatic processor for developing and "fixing". Two 10- by 12½-inch plates can be processed at the same time.

Once the plates enter the processor, they are automatically carried through a number of steps. They are dipped into one tank after another, depending on a predetermined schedule. As many as fifteen steps may be involved in a typical "reversal" processing schedule, and appropriate "dwell" times are set for each to allow proper processing. Periodic bursts of air through the tanks agitate the solutions.

After developing, reversal, and fixing operations have been completed, the plates are rinsed and dried in filtered air, and put back into their container for reinsertion into the memory unit. Extreme care is essential to avoid picking up lint or dust spots, which might be mistaken for bits of information by the cathode-ray beam.

The time required for a complete developing schedule varies somewhat, depending on the steps involved. Once the machine has been put in operation, it will continue through its sequence without interruption. The machine was designed to be easy to operate because it may be used by personnel unfamiliar with photographic procedures.

New Reading Machine Has A Ten-Word Vocabulary



Electrically wired stylus is pressed to "Reset" button before word is written on the electrically-connected writing surface. When stylus is touched to "Identify" button, light appears above digit written.

An experimental device that reads handwritten words has been built at Bell Laboratories. Invented by L. D. Harmon of the Visual and Acoustics Research Department, the device has a ten-word vocabulary — the spelled-out words "zero" through "nine". The handwriting reader, about the size of a briefcase, demonstrates methods which might eventually be applied in machines designed to read a wider variety of material.

To use the reader, one moves a metal stylus over a special surface just as if he were writing with a pen or pencil. After completing the word, he touches an "Identify" button with the stylus and a light appears beside the numeral, corresponding to the word he has just written.

The stylus, which is wired, makes electrical contact with 15 horizontal metal strips alternately sandwiched between strips of insulating material in the writing surface. Up-and-down movements of the stylus cause electrical connections to be made with the metal strips in sequence. The sequence and number of connections tell the word-reading device which of the ten words has been written.

"Reading machines" could be valuable in any business or industry for information presently translated into machine language by punched cards, by tape, and by pressing adding-machine or typewriter keys. In the Bell System, reading machines could help in translating toll tickets, in processing bill stubs and orders for change in service and in other commercial applications. The handwriting reader is an early experimental step in the study of how such machines can be made.

Machines are already in use that can read individual letters and numbers, but most require printing in a rigid type style and specific size. Among these are machines for reading the codes that appear on some credit cards.

The Laboratories device is believed to be the first which actually reads cursive script — connected handwritten material — despite variations in individual style. It also explores machine reading by entire words rather than letter-by-letter. It does this by picking out features of the over-all shape of the word. These include the length of the word, dotting the "i's" and the number and position of vertically extended letters such as "h" and "g".

Current research in "pattern recognition" aims to eliminate or limit constraints — to find practicable, efficient ways for machines to read any reasonably legible material. Many methods have been proposed and are under study. The handwriting reader has one minor constraint. The user must write within vertical limits indicated on the special surface.

Although the device has enough flexibility to recognize most individual styles of cursive writing, it has limitations. The writer must not print the words nor lift the stylus between letters. And he must dot his "i's" punctiliously in the words "five", "six", and "nine". However, the handwriting reader has a high degree of accuracy, scoring 97 per cent in a test of 1,000 words written by 20 persons. Most of the errors can be eliminated by minor improvements.

Four Named Fellows of the A.I.E.E.

Four Laboratories men were recently named Fellows of the American Institute of Electrical Engineers in recognition of their outstanding contributions to the electrical art.

They are: L. G. Abraham, Director of Transmission Engineering I, "for contributions to the engineering and development of long distance television transmissions systems"; A. C. Dickieson, Director of Transmission Systems Development I, "for contributions to long distance multi-channel communications and to underwater guidance systems"; P. G. Edwards, Director of Development, Merrimack Valley Laboratory, "for contributions to the development of carrier, cable, and microwave communications systems"; and John Meszar, Director of Switching Systems Development II, "for contributions in the field of automatic telephone interconnecting technology."

New Patent Document

The United States Patent Office recently announced the publication of a new pamphlet entitled, "Patents and Inventions — An Information Aid for Inventors." the pamphlet will aid in disseminating information concerning the patent system.

Laboratories Woman Elected Secretary Of Women Engineers

Miss Eileen Cavanagh, of the Military Systems Studies Department, has been elected national secretary of the Society of Women Engineers. She previously served as corresponding secretary, chairman of the Boston section, a member of the national board of directors, and chairman of the national admissions and procedures committees.

Vice Presidents Bode and Tinus Attend Army Panel

H. W. Bode, Vice President — Military Development and Systems Engineering, and W. C. Tinus, Vice President — Military Development Programs, were among a group of fifty scientists and industrialists who attended the Fall meeting of the Army Scientific Advisory Panel. The meeting was held in Fort Monroe, Va., during the week of October 5.

J. W. McRae, A.T.&T. vice president, formerly of the Laboratories, was chairman of the panel.

H. C. Harrison Receives Franklin Institute Medal

Henry C. Harrison, who retired in 1952 after 38 years in the Bell System, was awarded the Franklin Institute's Elliott Cresson Medal at ceremonies held October 21 in Philadelphia.

Mr. Harrison, credited with more than 100 patents, was cited for a lifetime of outstanding invention. In particular, the citation covered his work in the application of "matched impedances" to acoustic, mechanical and electrical devices and to combinations of them. It also mentioned his work on switching apparatus.

The gold Cresson Medal is awarded annually for discovery or original research adding to the sum of human knowledge. One of its early recipients was Alexander Graham Bell.

Cable Opened to European Mainland

The first telephone cable system to link North America directly to the mainland of Europe was inaugurated on September 22. Inaugural ceremonies in this country were held in the third floor assembly room of the A.T.&T. Company headquarters at 195

Broadway. European government officials and partners to the enterprise participated from Paris.

The 4,400-mile, high-fidelity system connects the telephone networks of the United States with those of France, Germany, Belgium, The Netherlands, Switzerland and Italy.

This new transatlantic cable system is owned by A.T.&T., the French Ministry of Posts and Telecommunications and the German Federal Ministry for Posts and Telecommunications. It can carry 36 simultaneous conversations. However, the new TASI system now under development (RECORD, *March*, 1959) should approximately double this capacity.

Twin cables make up the deep-sea portion of the system, which stretches across the bottom of the Atlantic between Clarenville, Newfoundland, and Penmarch, France. This cable is similar in design and construction to the first transoceanic telephone cable, which was laid from Newfoundland to Scotland in 1956.

Transatlantic calls to the mainland of Europe increased from 282,000 in 1956 to 340,000 in 1957; this heavy demand for telephone service to the Continent prompted the construction of the new cable system to France.

A.T.&T. President Frederick R. Kappel, speaking at the ceremonies, said he could "never adequately describe" the successful effort that had been made to open the cable system on schedule. Referring to the difficulties, he mentioned that the deep-sea segment of the system was begun March 14, much earlier in the spring than ever before attempted in the 102-year history of transatlantic cable laying. As a result, the moody and often turbulent North Atlantic constantly threatened operations. On two occasions laying was halted — once by huge ice fields that formed off the coast of Newfoundland, and again when fire razed one of the two cableships engaged to do the job.

Laboratories Men Participate in Lecture Series

Two Laboratories engineers have participated in a Fall Lecture Series on "Reliability and Components" sponsored by the Northern New Jersey Section of the I.R.E. in cooperation with the New Jersey Division of the A.I.E.E. The six-lecture series is being held during October and November at the Hillside School in Montclair, New Jersey.

On October 13, J. H. Hershey, of the Electro-Mechanical Development Department, discussed "The Reliability Concept." J. H. Bollman, also of the Electro-Mechanical Development Department, spoke on October 20 on the "Prediction of Reliability."

Compatible Stereo Demonstrated at Hi-Fi Music Show

An electronic circuit permitting two-channel stereophonic sound programs to be received monophonically on single sets without loss of balance was publicly demonstrated by Bell Telephone Laboratories last month. The demonstration took place at the 1959 New York High Fidelity Music Show held in New York City the week of October 5.

The circuit, developed at the Laboratories (*see page 410*), takes advantage of the "precedence effect" — a psychoacoustic phenomenon involving transmission. With this, one signal, reproduced through two separate loudspeakers but slightly delayed in one, sounds as if it came only from the first speaker. The system enables both channels to act as single channels.

In addition to the stereo demonstration, the Laboratories exhibited the highlights of research in stereophonic sound. These included a 1933 stereo concert — the first transmitted over wire — by the Philadelphia Orchestra. The concert, performed in Philadelphia, was picked up by three microphones and transmitted over telephone lines to Washington, D.C.

Another exhibit was the "tailor's dummy" that appeared at the Chicago World's Fair in 1933. Microphones in each "ear" of the dummy were connected to right and left earphones worn by the audience. Speaking into each of the dummy's ears, the demonstrator showed the binaural-hearing importance of localizing sounds.

Construction Begun on New Western Electric Research Center

Construction of a permanent home for Western Electric's Engineering Research Center near Princeton, New Jersey, is now underway. This Center was established early in 1958 to undertake fundamental research and development studies in manufacturing processes for Bell System products. It has been temporarily housed in an existing building, part of the 192-acre site.

Two new structures will be built — a three-story laboratory with 77,000 square feet of floor space, and a one-story, high-ceilinged building providing 30,000 square feet of floor space. This will house a laboratory, power plant, and storage area for essential company records. The buildings will be rendered in modern glass-wall architecture.

Over 100 people will be assigned to the Engineering Research Center by the end of this year, including more than 50 scientists and engineers. Initial occupancy of the smaller of the two new buildings is expected about mid-1960, while the larger structure is scheduled for occupancy during 1961.

It is expected that the new W.E. Center will facilitate close coordination of various work with that of Bell Laboratories, thus expediting technical progress.

TALKS

Following is a list of speakers, titles, and places of presentation for recent talks presented by members of Bell Laboratories.

NATIONAL ULTRASONICS SYMPOSIUM, Stanford University, Stanford, Calif.

May, J. E., Jr., *Wire-Type Dispersive Ultrasonic Delay Lines.*

Mason, W. O., and Thurston, R. N., *A Compact Electromechanical Bandpass Filter for Frequencies Below 20 kc.*

Meeker, T. R., *Dispersive Ultrasonic Delay Lines Using the First Longitudinal Mode in a Strip.*

Meitzler, A. H., *Ultrasonic Delay Lines Using Shear Modes in Strips.*

Thurston, R. N., see Mason, W. O.

1959 WESTERN ELECTRONIC SHOW AND CONVENTION, San Francisco, Calif.

Baker, A. N., Goldey, J. M., and Ross, I. M., *Recovery Time of p-n-p-n Diodes.*

Bangert, J. T., *Practical Applications of Time Domain Theory.*

Barney, H. L., *Unitary Transistorized Artificial Larynx.*

Classon, H. T., see Melroy, D. O.

Cook, J. S., and Louisell, W. H., *Fast Longitudinal Space Charge Wave Parametric Amplifiers.*

D'Asaro, L. A., *A Stepping Transistor Element.*

Early, J. M., *Stored Charge Analysis of Transistors* (Presented by Baker, A. N.).

Flanagan, J. L., *A Resonance-Vocoder and Baseband Complement: A Hybrid System for Speech Transmission.*

Foulkes, J. D., *A Class of Machines which Determine the Statistical Structure of a Sequence of Characters.*

Goldey, J. M., see Baker, A. N.

Kinariwala, B. K., *Synthesis of Driving-Point Impedances Using Active RC Networks.*

Louisell, W. H., see Cook, J. S.

Melroy, D. O., and Classon, H. T., *Measurement of Internal Reflections in Traveling-Wave Tubes Using a Millimicrosecond Pulse Radar.*

Ross, I. M., see Baker, A. M.

A.I.M.E. SEMICONDUCTORS TECHNICAL CONFERENCE, Boston, Mass.

Atalla, M. M., *Semiconductor Surfaces and Films — The Silicon-Silicon Dioxide System.*

Benson, K. E., *Experimental Results with Large Area Floating Zones.*

Ditzenberger, J. A., see Whelan, J. M.

Kaiser, W., see Reiss, H.

Reiss, H., and Kaiser, W., *Solid-State Reactions of Oxygen in Silicon.*

Struthers, J. D., see Whelan, J. M.

Wernick, J. H., *Metallurgy of Some Ternary Semiconductors and Constitution of the $AgSbSe_2$ — $HgSbTe_2$ — $AgBiSe_2$ — $PbSe$ — $PbTe$ System.*

Whelan, J. M., Struthers, J. D., and Ditzenberger, J. A., *Distribution Coefficients of Various Impurities in Gallium Arsenide.*

AMERICAN PSYCHOLOGICAL ASSOCIATION MEETING, Cincinnati, Ohio.

Deininger, R. L., *Human Factors Studies of Push-Button Characteristics and Information Processing in Keyset Operation.*

Gerard, H. B., *Social Influence and Time Perspective.*

Holt, H. O., *The Research of the Communications Social Science Research Department, Bell Telephone Laboratories, Inc.*

Jenkins, H. M., *Effect of Learning to Discriminate on Resistance to Extinction.*

Shepard, R. N., *Application of I.P.L. V to the Simulation of Perceptual Learning.*

CONFERENCE ON QUANTUM ELECTRONICS, Bloomingburg, New York

Fox, A. G., *Generation and Amplification of Microwaves by Ferromagnets.*

Gordon, J. P., *Beam-Type Masers.*

Javan, A., *The Possibility of Obtaining Negative Temperature in Atoms by Electron Impact.*

Schawlow, A. L., *Infrared and Optical Masers.*

Schulz-Du Bois, E. O., *Generation of Coherent Radiation from Heat.*

OTHER TALKS

Anderson, O. L., *Applications of Calorimetry Measurements to Glass Problems*, Fourteenth Calorimetry Conf., Yale Univ., New Haven, Conn.

Blair, R. R., Knox, W. P., and Easley, J. W., *Transistor Circuit Behavior at Exposures Greater than 10^{15} Fast Neutrons per cm^2*, Second Conf. on Nuclear Radiation Effects on Semiconductor Devices, Materials and Circuits, N. Y. C.

Brady, G. W., *Research in the Structure of Solutions*, Symposium on Aqueous Solutions, Am. Chem. Soc., Atlantic City, N. J.

Buchsbaum, S. J., *Plasma Conductivity*, Third Biennial Gas Dynamics Symposium, Northwestern Univ., Evanston, Ill.

Buchsbaum, S. J., *Experimental Study of a Plasma Column in a Microwave Cavity*, International Plasma Symposium, Seattle, Wash.

Clogston, A. M., *General Principles of Magnetism*, Case Institute of Technology, Cleveland, Ohio.

Cutler, C. C., *Radio Communication by Means of Satellites*, Fourth Symposium on Ballistic Missile and Space Technology, Los Angeles, Calif.

Darlington, S., *Guidance and Control of Unmanned Soft Landings on the Moon*, Fourth Symposium on Ballistic Missile and Space Technology, Los Angeles, Calif.

Dworkin, S., *Films for the Adult Trainee Audience*, University Film Producers Assoc. Annual Conf., Purdue Univ., Lafayette, Ind.

Easley, J. W., see Blair, R. R.

Easley, J. W., *On the Neutron Bombardment Reduction of Transistor Current Gain*, Second Conf. on Nuclear Radiation Effects on Semiconductor Devices, Materials and Circuits, N. Y. C.

Engelbrecht, R. S., see Mumford, W. W.

Frisch, H. L., see Lebowitz, J. L.

Frisch, H. L., see Lundberg, J. L.

Fuller, C. S., *Chemical Equilibria and Reactions in Semiconductors*, Seventeenth Int'l Cong. for Pure and Applied Chem., Munich, Germany.

Hellman, M. Y., see Lundberg, J. L.

Herring, C., *Phonon Drag Effects*, Gordon Research Conf., Meriden, N. H.

Honaman, R. K., *The Forward Look in Communication Technology*, The Rotary Club of Wilmington, Wilmington, Del.

Igleheart, J. D., *Effects of Frequency Cutoff Characteristics on Spiking and Ringing of TV Signals*, I.R.E. Nat'l Convention, Session 52, N. Y. C.

Knab, E. D., *Flat-Flanged Eyelets in Printed-Circuit Applications*, I.R.E.-P.G.P.T. Meeting, N. Y. C.

Knox, W. P., see Blair, R. R.

Kuebler, N. A., see Nelson, L. S.

Landau, H. J., and Pollak, H. O., *Energy Relations Between Functions and Their Fourier Transforms*, Am. Math. Soc., Salt Lake City, Utah.

Lebowitz, J. L., Frisch, H. L., and Reiss, H., *The Equation of State of a Fluid*, Copenhagen Refrigeration Conf., Copenhagen, Denmark, (Presented by Frisch, H. L.).

Lloyd, S. P., *On Conditional Independence*, Am. Math. Soc., Salt Lake City, Utah.

Lundberg, J. L., Hellman, Molly Y., and Frisch, H. L., *The Study of the Polydispersity of Polymers by Viscometry*, Am. Chem. Soc., Atlantic City, N. J.

Mason, W. P., *Measurements of Shear Elasticity and Viscosity of the Tobalsky-Leaduman-Ferry Reduction Formula at High Frequencies*, British Society of Rheology, London, England.

Morin, F. J., *Electronic Energy Bands in the Transition Metal Oxides*, Gordon Conf. on Inorganic Chem., New Hampton, N. H.

Mumford, W. W., *Technical Aspects of Microwave Radiation*, Regional Conf. of Bell System Operating Companies, Denver, Colo.

Mumford, W. W., *Microwave Noise Figures*, Nat'l Bureau of Standards, Boulder, Colo.

Mumford, W. W., *Technical Aspects of Microwave Radiation Hazards*, A. T. & T. Company Regional Conf. on Radiation Hazards, N. Y. C.

Mumford, W. W., and Engelbrecht, R. S., *Historical Background and Recent Results with Traveling-Wave Amplifiers using Diodes*, Boston Chapter, I.R.E.-P.G.M.T.&T., M.I.T., Cambridge, Mass.

Nelson, L. S., and Kuebler, N. A., *Heterogeneous Flash Pyrolysis of Hydrocarbon Polymers*, Conf. on Phys. Chem. in Aerodynamics and Space Flight, Philadelphia, Pa.

Pearson, A. D., *Low Melting Glasses*, Bell Laboratories, Allentown, Pa.

Pearson, G. L., *Domain Dynamics in Ferroelectric Crystals*, Dept. of Elec. Eng., Stanford Univ., Stanford, Calif.

Pollak, H. O., see Landau, H. J.

Reiss, H., see Lebowitz, J. L.

Sobel, M., *Acceptance Sampling with Life Test Objectives*, New York University, N. Y. C.

Storks, K. H., *X-ray Absorption for Chemical Analysis*, General Electric X-Ray Diffraction School, Milwaukee, Wis.

Unger, S. H., *Pattern Processing with the Spatial Computer*, Conf. on Frontier Research in Digital Computers, U. N. C., Chapel Hill, N. C.

Van Bergeijk, W. A., *Hydrostatic Balance in Xenopus Larvae*, Am. Inst. of Biological Sciences, Pennsylvania State Univ., University Park, Pa.

Wood, D. L., *Infrared Spectroscopic Methods for Characterizing High Polymers*, Gordon Research Conf. on Anal. Chem., New Hampton, N. H.

PATENTS

Following is a list of the inventors, titles and patent numbers of patents recently issued to members of the Laboratories.

Andersen, J. R. — *Anti-backlash Gear Assembly* — 2,902,879.

Andersen, J. R. — *Ferroelectric Storage Array* — 2,905,928.

Ault, C. F. — *Electron Beam Control System* — 2,904,721.

Bachelet, A. E. and Entz, F. F. — *Electronic Signaling Circuit* — 2,906,996.

Boyle, W. S. — *Intermittent Discharge Pulse Generators* — 2,905,820.

Bozorth, R. M. — *Methods of Treating Single Crystal Cores of a Ferrite Including Cobalt and Inductances Using Same* — 2,906,979.

Brolin, S. L. — *Current Supply Apparatus* — 2,906,941.

Burns, F. P. — *Piezoresistive Semiconductor Microphone* — 2,905,771.

Chase, F. H. — *Current Supply Apparatus* — 2,904,742.

Costa, J. F. — *Signaling System* — 2,906,998.

Crawford, R. V. — *Radiant Energy Highway Communication System with Controlled Directive Antenna* — 2,904,674.

Cutler, C. C. — *Impedance Matching by Means of Coupled Helices* — 2,905,858.

Cutler, C. C. — *Traveling Wave Tube* — 8,906,914.

Edson, J. O. and Feldman, C. B. H. — *Derivation of Vocoder Pitch Signals* — 2,906,955.

Entz, F. S., see Bachelet, A. E.

Feldman, C. B. H., see Edson, J. O.

Flint, E. W. — *Translator* — 2,905,934.

Goodale, W. D., Jr., Pferd, W. and Thompson, R. K., Jr. — *Telephone Pay Station* — 2,906,823.

Graham, R. E. — *Method and Apparatus for Reducing Television Bandwidth* — 2,905,756.

Harris, J. R. — *Binary Counter* — 2,906,894.

Hasley, A. D. — *Hard Tube Modulator Pulse Transformer* — 2,903,583.

Hoover, C. W., Jr. — *Beam Positioning System* — 2,903,598.

Kelly, H. P. and Nichols, R. L. — *Broadband Balanced Amplifier* — 2,904,643.

Ketchledge, R. W. — *Modulating System* — 2,902,659.

Kowaleski, C., Pferd, W. and Walker, R. K. — *Coin Testing Mechanism* — 2,903,117.

Kretzmer, E. R. — *Method and Apparatus for Reducing Television Bandwidth* — 2,906,816.

Lovell, C. A. — *Electric Voltage Multiplier* — 2,906,459.

Mallina, R. F. — *Wiring System* — 2,905,400.

Mason, W. P. and Thurston, R. N. — *Torsional Vibrational Wave Filters and Delay Lines* — 2,906,971.

Mason, W. P. — *Electrostrictive Ceramics Comprising Barium Titanate* — 2,906,973.

Mattson, R. H. — *Transistor Blocking Oscillator* — 2,906,893.

McKim, B. and Stapleton, R. J. — *Telephone Circuit Using Magnetic Cores* — 2,904,636.

Merlin, H. R., Jr. — *Code Translator* — 2,907,019.

Meszaros, G. W. — *Current Supply Apparatus* — 2,903,639.

Morgan, S. P. — *Mode Conversion in Wave Guides* — 2,904,759.

Nichols, R. L., see Kelly, H. P.

Nickerson, C. A. — *Cycle Measuring Means* — 2,903,059.

Ostendorf, B., Jr. — *Binary Counter Transistor Circuit* — 2,903,676.

Peek, R. L., Jr. — *Laminated Core Dry Reed Relay* — 2,902,558.

Pfann, W. G. — *Suspension of Liquid Material* — 2,904,411.

Pferd, W., see Kowaleski, C.

Pferd, W., see Goodale, W. D., Jr.

Robertson, G. H. — *Virtual Cathode Stabilization Means* — 2,903,580.

Robertson, George H. — *Electron Discharge Device* — 2,905,852.

Rosenfeld, J. L. — *Magnetic Core Circuit* — 2,906,887.

Scanlon, J. J. — *Transistor Pulse Transmission Circuits* — 2,906,891.

Soffel, R. O. — *Variable-Frequency Oscillator* — 2,902,656.

Spring, C. H. F. — *Circuit Controller* — 2,904,662.

Stadler, H. L. — *Displacement and Speed Measuring Apparatus* — 2,906,953.

Stapleton, R. J., see McKim, B.

Thompson, R. K., Jr., see Goodale, W. D., Jr.

Thurmond, C. D. — *Recovery of Silicon from Silicon Dioxide* — 2,904,405.

Thurston, R. N., see Mason, W. P.

Walker, R. K., see Kowaleski, C.

Weisbaum, S. — *Nonreciprocal Circuit Element* — 2,903,656.

Williams, R. D. — *Telephone System Employing Line Hunting* — 2,904,637.

PAPERS

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

Abrahams, S. C., see Prince, E.

Baker, A. N., Goldey, J. M., and Ross, I. M., *Recovery Time of p-n-p-n Diodes*, Wescon Convention Record, 3, Part 3, pp. 43-48, Aug., 1959.

Bangert, J. T., *Practical Applications of Time Domain Theory*, Wescon Convention Record, 3, Part 2, pp 29-38, Aug., 1959.

Barney, H. L., *Unitary Transistorized Artificial Larynx*, Wescon Convention Record, 3, Part 8, pp. 26-34, Aug., 1959.

Boyle, W. S., see Weinreich, G.

Brailsford, A. D., see Galt, J. K.

Cetlin, B. B., see Galt, J. K.

Clogston, A. M., *Optical Faraday Rotation in Ferrimagnetic Garnets*, J. Phys. Rad., 20, pp. 151-154, Feb., 1959.

D'Asaro, L. A., *A Stepping Transistor Element*, Wescon Convention Record, 3, Part pp. 37-42, Aug., 1959.

Douglass, D. C., *The Fine Structure of the Cl_2 Quadrupole Resonance Spectrum*, J. Chem. Phys., 31, pp. 504-505, Aug., 1959.

Douglass, D. C., and McCall, D. W., *Self Diffusion in Water*, J. Chem. Phys., 31, p. 569, Aug., 1959.

Dunn, H. K., Sivian, L. J. (Deceased), and White, S. D., *Absolute Amplitudes and Spectra of Certain Musical Instruments and Orchestras*, I.R.E. Trans. Prof. Gp. Audio, AU-7, pp. 47-75, May-June, 1959.

Flanagan, J. L., *A Resonance-Vocoder and Baseband Complement: A Hybrid System for Speech Transmission*, Wescon

PAPERS (CONTINUED)

Convention Record, 3, Part 7, pp. 5-16, Aug., 1959.

Foulkes, J. D., *A Class of Machines which Determine the Statistical Structure of a Sequence of Characters*, Wescon Convention Record, 3, Part 4, pp. 66-73, Aug. 1959.

Galt, J. K., Yager, W. A., Merritt, F. R., Cetlin, B. B., and Brailsford, A. D., *Cyclotron Absorption in Metallic Bismuth and Its Alloys*, Phys. Rev., 114, pp. 1396-1413, June 15, 1959.

Geller, S., see Wernick, J. H.

Goldey, J. M., see Baker, A. N.

Hittinger, W. C., *Transistor Types 1959*, Electronic Design, 7, pp. 36-37, July, 1959.

Holmes, E. F., Jr., *Relay Circuit Parameter Nomograph*, Electrical Design News, 4, pp. 65-67, Sept., 1959.

Kinariwala, B. K., *Synthesis of Driving-Point Impedances Using Active RC Networks*, Wescon Convention Record, 3, Part 2, pp. 53-64, Aug., 1959.

Kolb, E. D., and Tanenbaum, M., *Uniform Resistivity p-Type Silicon by Zone Leveling*, J. Electrochem. Soc., 106, pp. 597-599, July, 1959.

Lloyd, S. P., *A Sampling Theorem for Stationary (Wide Sense) Stochastic Processes*, Trans. Am. Math. Soc., 92, pp. 1-12, July, 1959.

Loomis, T. C., see Sinclair, W. R.

McCall, D. W., see Douglass, D. C.

Merritt, F. R., see Galt, J. K.

Pierce, J. R., *Relativity and Space Travel*, Proc. I.R.E., 47, pp. 1053-1061, June, 1959.

Prince, E., and Abrahams, S. C., *A Single Crystal Automatic Neutron Diffractometer*, Rev. Sci. Instr., 30, pp. 581-585, July, 1959.

Riney, T. D., *Coefficients in Certain Asymptotic Factorial Expansions*, Proc. Am. Math. Soc., 10, pp. 511-518, Aug., 1959.

Rodgers, K. F., see Weinreich, G.

Ross, I. M., see Baker, A. N.

Sinclair, W. R., and Loomis, T. C., "Measurements of Diffusion in the System TiO_2-SnO_2," *Kinetics of High-Temperature Processes*. Technology Press and John Wiley & Sons, 1959, pp. 58-61, 1959.

Sivian, L. J., see Dunn, H. K.

Tanenbaum, M., see Kolb, E. D.

Weinreich, G., Boyle, W. S., White, H. G., and Rodgers, K. F., *Errata: Valley-Orbit Splitting of Arsenic Donor Ground State in Germanium*, Phys. Rev. Letters, 3, p. 244, Sept. 1, 1959.

Wernick, J. H., and Geller, S., *Transition Element — Rare Earth Compounds with the Cu_5Ca Structure*, Acta Crys., 12, pp. 662-665, Sept. 10, 1959.

Whitcomb, D. L., *Cathode Temperature Measurements by Infrared Photography*, Proc. Fourth Nat'l Conf. on Tube Technique, pp. 117-120, July, 1959.

White, H. G., see Weinreich, G.

White, S. D., see Dunn, H. K.

Yager, W. A., see Galt, J. K.

Zajac, E. E., and Flugge, W., (Stanford U.), *Bending Impact Waves in Beams*, Ingenieur Archiv., 28, pp. 59-70, March, 1959.

THE AUTHORS

A. H. Bobeck was born in Youngstown, Ohio, and received his M.S. (E.E.) degree from Purdue University in 1949. After joining the Laboratories and completing the Communication Development Training Program Mr. Bobeck worked on the design of both communication and pulse transformers. Since 1952 he has specialized in the design of magnetic logic and memory devices. This work includes magnetic shift registers, magnetic access switches, transistor-driven core memories, and most recently, the twistor—the latter item being the subject of his article in this issue. He is a member of the I.R.E.

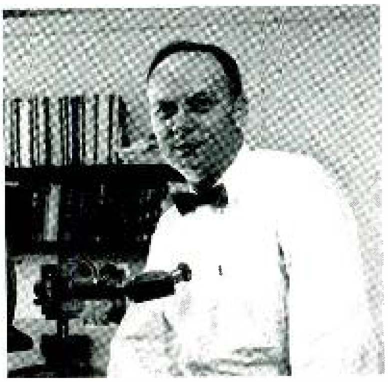
A. H. Bobeck

F. K. Becker, a native of Denver, Colorado, received the B.S. (E.E.) degree from the University of Colorado in 1945, and after a tour of duty as an electronics officer in the Navy, he received the M.S. (E.E.) degree from the California Institute of Technology in 1947. He then joined the Mountain States Telephone and Telegraph Company in Denver, Colorado, where he worked as a dial equipment engineer. He transferred to the Laboratories in 1951, and after a short stay was recalled by the Navy for a two-year tour of duty at the Office of Naval Research in Washington, D. C. He rejoined the Laboratories in 1954 as a member of the Transmission Research Department assigned to acoustics and

F. K. Becker

underwater sound projects. More recently, he has been concerned with the development of experimental picture-transmission systems using narrow bandwidth circuits. Mr. Becker is senior member of I.R.E., a member of the Acoustical Society of America, Tau Beta Pi, Sigma Tau, Eta Kappa Nu and Pi Mu Epsilon. He wrote the article, "A Compatible Stereophonic Sound System," in this issue.

D. R. Oswald, ("Reliability of Glass Seals for Undersea Cables") was born near Reading, Pennsylvania, and is a graduate of Wyomissing Polytechnic Institute in Reading. He is currently attending evening courses at Lafayette College. Since joining Bell Laboratories at the Allentown, Pa., location in 1952, Mr. Oswald has worked on mechanical problems associated with electron devices, with emphasis on glass-to-metal



D. R. Oswald

seals and device enclosures. He has also engaged in the measurement of stresses in glass and thermal expansivity of metals and ceramics, and is presently investigating techniques for economical cutting of semiconductor raw materials and other problems connected with the fabrication of semiconductor devices.

G. R. Frost, a native of St. Louis, joined the Western Electric Co. in 1921 as an Educational Methods Engineer, and in 1923 he transferred to Illinois Bell, where he was concerned with central office maintenance work and training. In 1930 he accepted a position with Electrical Research Products, Inc., as an Acoustical Engineer, taking part in talking motion picture installation and maintenance pro-

G. R. Frost

cedures. In 1936 Mr. Frost joined the Ohio Bell outside plant group, and in 1942 he came to Bell Laboratories as an instructor in the School for War Training. Subsequently his responsibilities have included development of railroad radio transmission systems, formation of text material and instruction in the first switching school, and design of the first semi-automatic traffic study machine. He became a member of the staff of the Communications Development Training Program, specializing in switching training. At present Mr. Frost is concerned with the development of lecture-aid devices used by Bell

W. W. Grote

System lecturers in demonstrating the developments of Bell Laboratories. In this issue, he is co-author of the article on the Teletrainer.

W. W. Grote, who was born in Brooklyn, New York, attended Brooklyn Polytechnic Institute and studied Mechanical Engineering. Shortly after joining the Laboratories in 1936, he transferred to the Specialty Products Department, where he worked on Battle Announcing Equipment. He served during World War II as an Electronic Technician for the United States Navy, and upon returning from service was engaged in the development of audio amplifiers. He has participated in the mechanical design of apparatus used in the Nike Missile project, and he also engaged in the development of Telephone Answering Sets and the Distant Talking Subscriber Sets. More recently he has been engaged in the design of new audio amplifiers, both vacuum tube and transistorized, volume indicators and a new transistorized loudspeaker amplifier unit. Mr. Grote was responsible for the redesign of the Teletrainer, described in this issue of the RECORD.

Paul J. Gayet, a native of Mount Vernon, New York, received the B.E.E. degree from Rensselaer Polytechnic Institute in 1952 and joined Bell Laboratories on graduation. After he completed the CDT program, he

Paul J. Gayet

was assigned to the Systems Engineering III Department and engaged in special systems studies, including selective-control systems, and remote control of air-ground radio stations. Prior to his resignation earlier this year, he was working on a selective signaling system for use on private lines and telephone order wires. Mr. Gayet is the author of the article "Automatic Control of a Pipeline" in this issue.

R. F. Dusenberry, author of "No. 4-Type CAMA—New Dial-Pulse Register" in this issue, was born and raised in Ridgewood, N. J. In 1948 he received his B.S. in E.E. degree at Lafayette College and joined the Laboratories in the same year as a student in the Communications Development Training Program. Since 1949 he has been in the Switching Systems Development Department, where he has worked on circuit design, first for the Automatic Message Accounting Center and then for the Tandem Office CAMA project. Later he worked on the design of a portable traffic-usage recording circuit, and has recently completed work on circuits required for the toll-office CAMA project. He also served as Communications Development Training Program instructor in "Human Engineering." Mr. Dusenberry is an Associate Member of the American Institute of Electrical Engineers and a member of Tau Beta Pi and Phi Beta Kappa.

R. F. Dusenberry

W. D. Goodale

W. D. Goodale, Jr., born in New York, was graduated from Lehigh University in 1928 with an E.E. degree. In 1937 he received a M.E.E. degree from Brooklyn Polytechnic Institute. As a member of the D and R Department of the A.T.&T. Co. from 1928 to 1934, he was concerned with transmission studies of operators' and station telephone sets. After joining the Laboratories in 1934, he continued to work on transmission problems, particularly those arising from operating-room noise and panel contact noise. The war years were devoted to testing and evaluating underwater sound equipment. Subsequently, he has been engaged in station transmission and signaling studies, and coin collector development. During the past three years his primary interest has been speakerphone design. Mr. Goodale is co-author of the article "A New Coin-Disposal Mechanism for Pay Telephones," in this issue.

K. E. Voyles

K. E. Voyles, co-author of "A New Coin-Disposal Mechanism for Pay Telephones," was born and raised in Indianapolis, Indiana. He attended Purdue University, receiving his B.S.E.E. degree in 1945. After his release from the Naval Reserve in 1946, he performed design engineering work for the Cornell Dubilier Electric Corp., Civil Aeronautics Administration, Industrial Development Engineering Associates, and served as Chief Engineer of the Jackson Electrical Instrument Co. These areas of work dealt with respectively, broadcast radio and vibrator power supplies, V.H.F. antennas and monitors, U.H.F. television converters, and color television test equipment. Joining the Apparatus Development Group at the Indianapolis Branch Laboratory as a Member of Technical Staff in 1957, Mr. Voyles has worked with various coin collector problems.