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Cover   *New college science film on "Physics of Polymers" uses bead models in water tank to imitate rubber molecules during vibration. See page 243.*

Lacano

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K. E. Hammer and L. E. Krebs
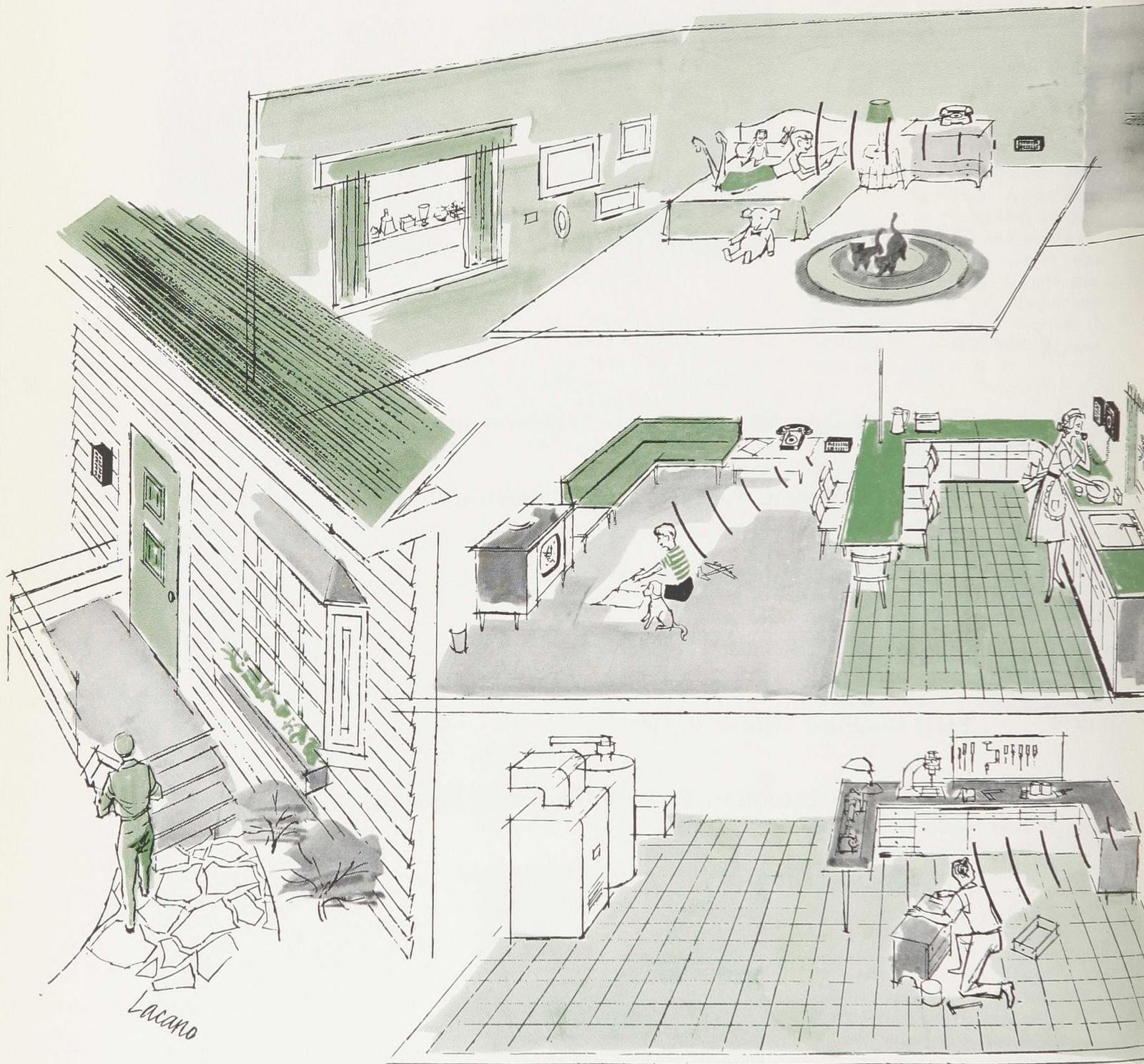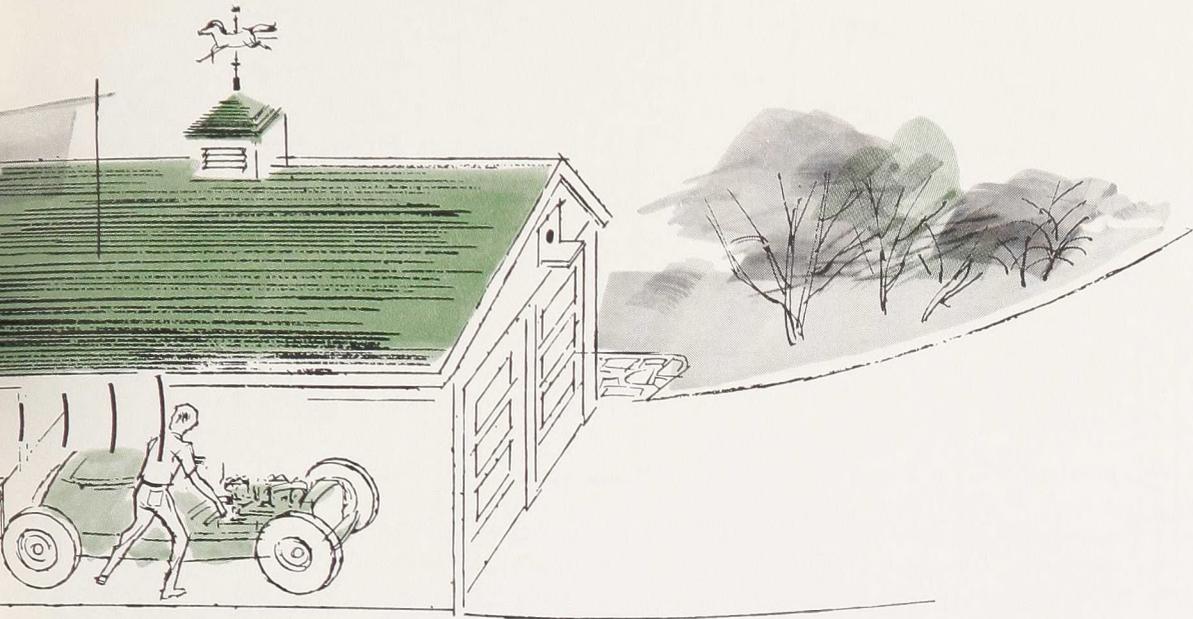
The Home Interphone System

UNTIL RECENT YEARS, almost all residential Bell System customers had only a single telephone, and their use of the instrument was limited to placing or receiving calls from distant locations. Gradually, however, extension telephones have become almost essential, until today, nearly one-third of all residential customers have one or more. Using these extensions, it is now convenient to place or receive calls from almost any point in the home. However, without additional facilities, it is impractical or inconvenient to communicate from one part of the house to another.

The Home Interphone* Residential Intercommunications System now provides Bell System customers with facilities for expanding telephone service to include in-home communications. With the Home Interphone System, each of the telephone sets in the home can be used in an interphone system, as well as to place or receive normal "outside" calls.

*Bell System service mark

Typical installation shows versatility of the Home Interphone System. Up to five inside stations and two outdoor door-answering units may be installed.

Any one of the sets can be used for calling persons in the vicinity of any of the other sets and the called person can answer without picking up a telephone handset. Also, any one of the sets can be used to answer the door and converse with visitors there.

A number of new equipment items were developed to provide this service. For example, standard two line type telephone sets are equipped with a special transmitter assembly for remote-speech pickup. Miniature loudspeakers for use with the System are packaged in two alternate ways. One of the plastic-housed assemblies incorporates a telephone station terminal block and in this form is associated with each telephone set to project the initiating caller's voice throughout the surrounding areas.

When the loudspeaker is used at an outside door location, it is associated with a transmitter so that a person there may respond to queries and carry on conversation with individuals at the telephone locations inside the house.

The control unit which completes the system is a small out-of-sight package, housing the transistor amplifiers, hybrid circuit, switch-
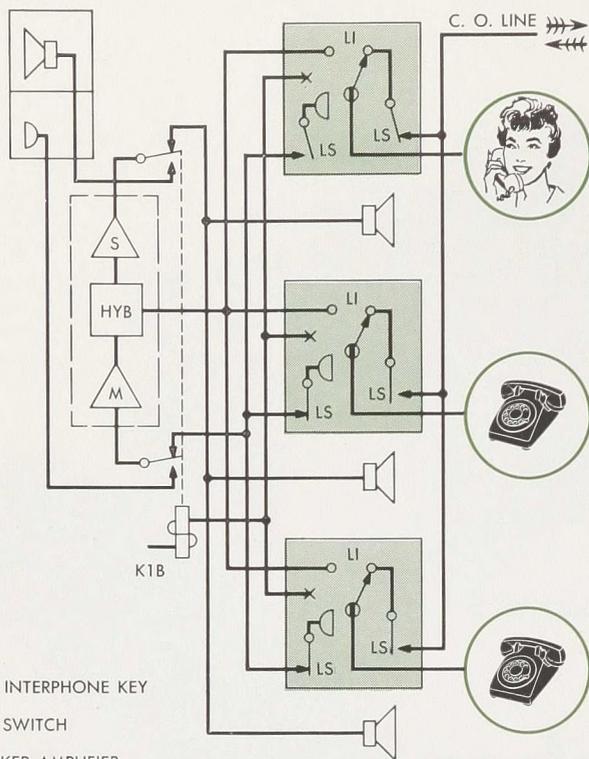
LI = LINE INTERPHONE KEY

LS = LINE SWITCH

S = SPEAKER AMPLIFIER

M = MICROPHONE AMPLIFIER

A

B

C

D

C. O. LINE

K1B

K1B

K1B

K1B
(LOCKED UP)
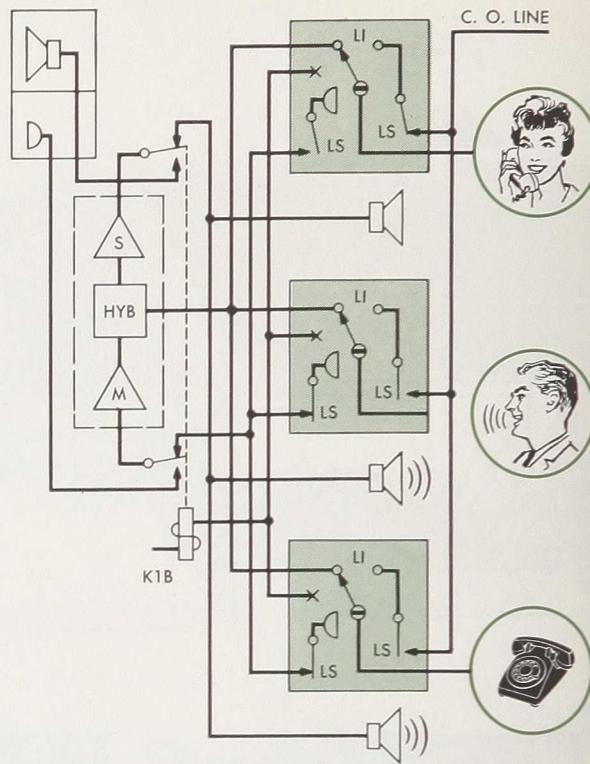
(PUSHED)

ing relays and power rectifier and filter.

Since the centralized control unit must be connected to each telephone location by a six pair inside wiring cable, there is a significant installation expense unless the home can be wired during the construction period.
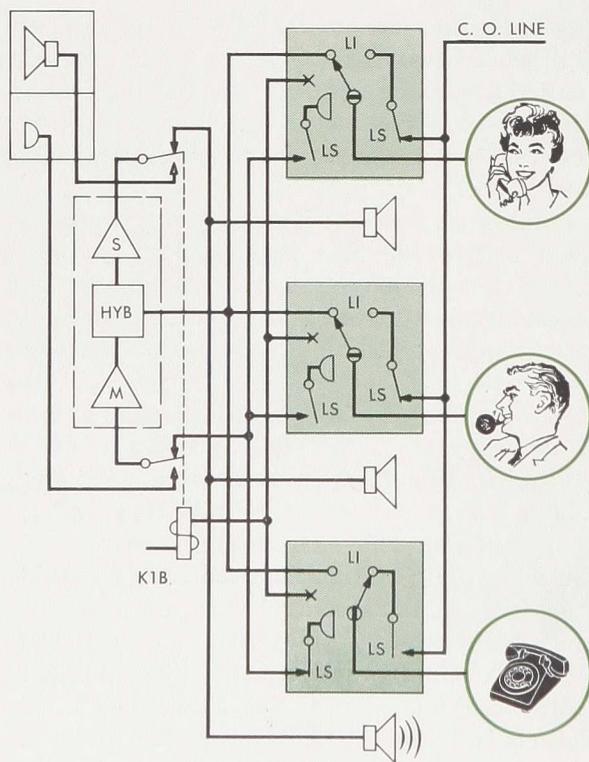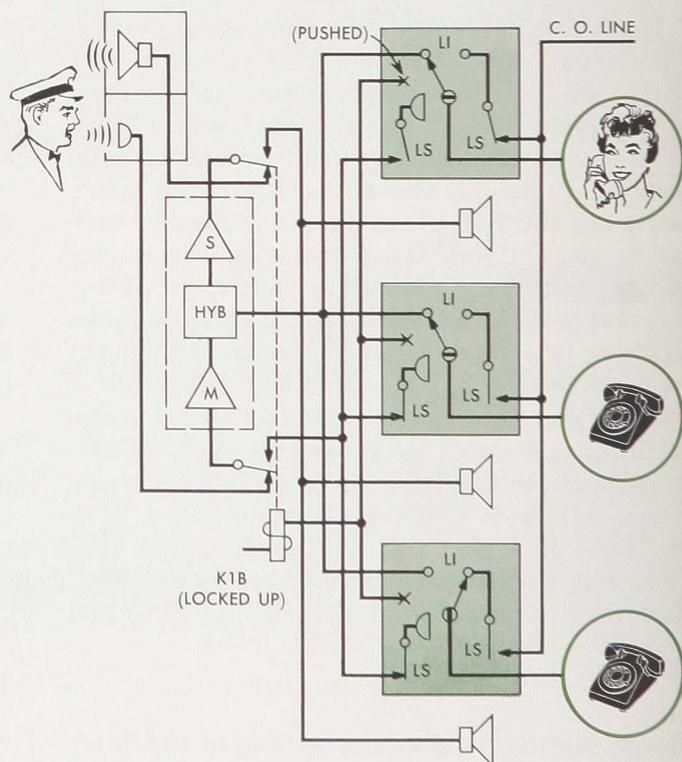
This installation cost, plus the maintenance which the customer receives with all telephone facilities, accounts for a relatively high tariff rate, which somewhat limits the number of potential customers for this service. Of course, the appeal is primarily for those who have need for and can afford more than basic telephone service.

A typical Home Interphone System installation is shown in sketch form on the frontispiece. A maximum of five inside stations and two door locations may be equipped, although the basic tariff rate is predicated on three inside and one door locations.

Normal telephone calls are handled in the conventional manner, with the turnbutton in a vertical position. More than one set can be used simultaneously on the outside line, just as extension sets are now often used in parallel. When the turnbutton is in a horizontal position and the handset is lifted, the user may speak into the handset transmitter to anyone near any of the equipped telephone locations. The person called on an interphone conversation can either respond by speaking toward the transmitter in the telephone housing and listening to the loudspeaker, or pick up the handset and talk normally over it to the other party. (Schematic diagrams of the circuits in each of the basic situations are shown opposite.) Furthermore, by listening at the handset receiver, conversation or other sounds from those areas may be monitored. The convenience of the service is readily apparent—from monitoring the children at play to asking dad how he wants his eggs fried for breakfast.

Door answering service from any telephone is available with the turnbutton in interphone position, but in this case the button must be momentarily depressed to pull up the switching relay of the control unit. This action disconnects all the speakers and transmitters associated with telephone sets and substitutes the one or two corresponding units at entrance doors. The householder can then use the telephone handset and outdoor loudspeaker to talk to visitors outside, who respond using the microphone provided for this service. When she hangs up the handset the control unit is turned off.

Perhaps most useful is the ability to call some other person to pick up a telephone call. In this case, after responding to an incoming ring and finding that someone else is wanted, the distant party is asked to hold the line; the hold button is actuated, and after turning the selector button to the interphone position, the wanted party is "called to the phone." The individual answering the phone initially should then restore the turnbutton to vertical, restore the hold button, and listen or talk with the distant party until the desired party answers.

In a similar manner, it is possible for the householder to hold the line while answering the door. In this case, she simply operates the "hold" key, turns the line-interphone key to the interphone position and depresses it momentarily to connect her telephone set to the outside loudspeakers and transmitters. She returns to her telephone conversation by turning the line-interphone key to vertical and the hold key to its unoperated position.

Most frequently, the 500-type desk and wall sets and the Princess phone are used to provide this service. A craftsman is shown on page 222 installing the small transmitter in a 500-type wall set; a completed installation is shown at right. Some other special purpose sets, such as the
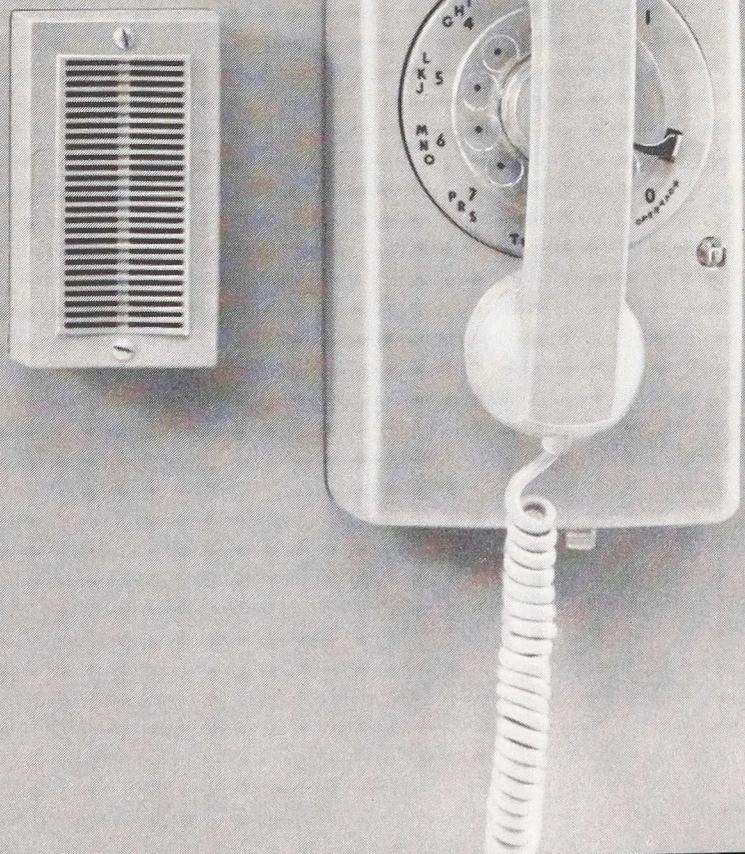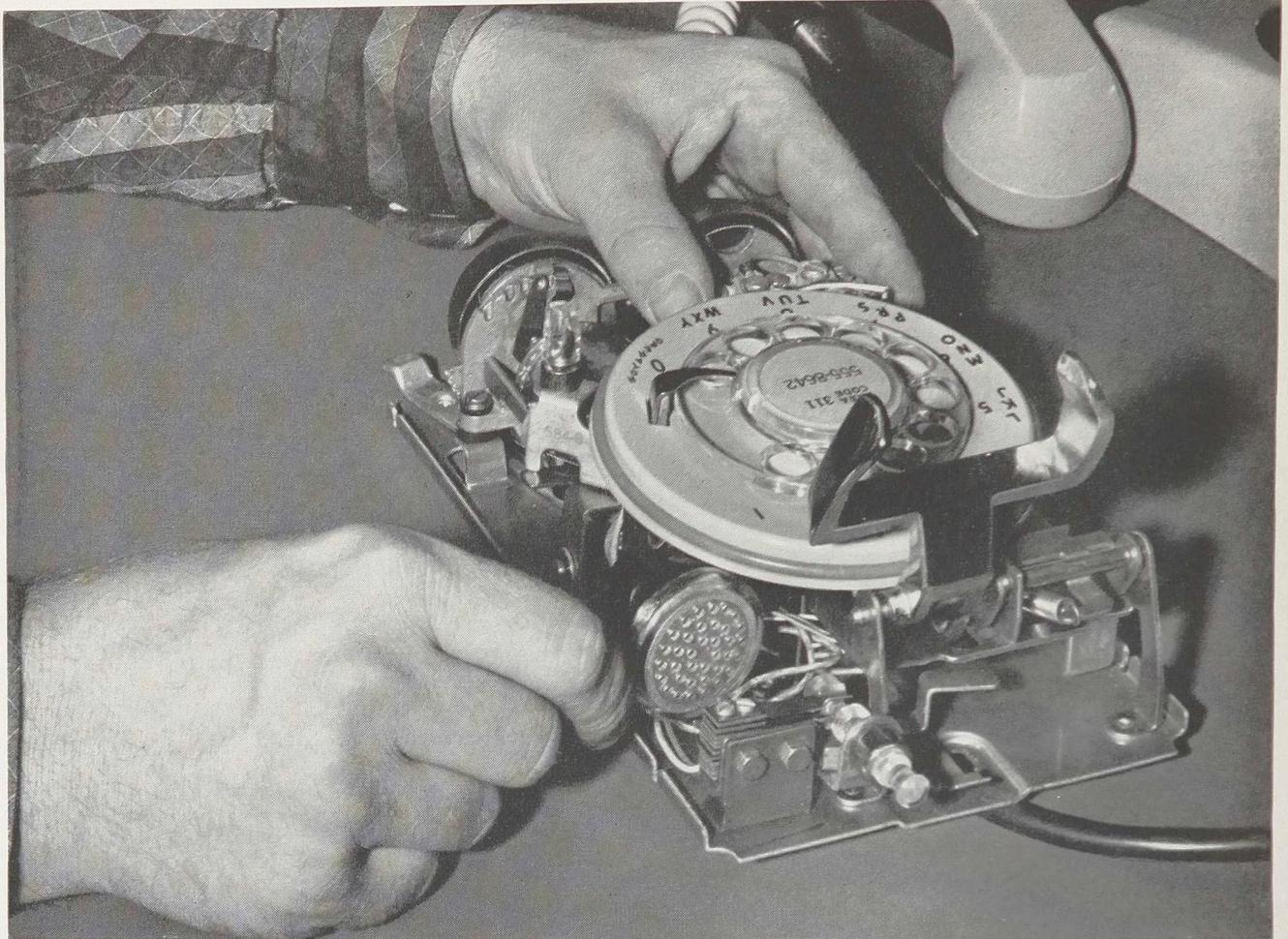
A craftsman at a Western Electric repair shop installs a transmitter in a 500-type wall set. Note the turnbutton near his left hand and the hold button in the foreground.

new panel phone, may be used with the Home Interphone System as well.

A wiring board in the control unit incorporates the transistorized transmitter and loudspeaker amplifiers. Separate controls in each permit adjustment by the installer for each installation. A hybrid transformer and balancing network also mounted on the wiring board permits interconnecting the two-wire telephone sets and the four-wire loudspeaker-microphone combination without excessive electric feedback which would otherwise result in a singing (oscillating) condition. Acoustic coupling is, therefore, the most commonly encountered limitation on the output levels to which the system can be adjusted. Judicious spacing is sometimes required between the loudspeakers and the associated telephone sets with their remote pickup microphones. A supervisory relay in the control unit activates the amplifiers whenever any handset is off the hook while the selector button is in the interphone position. The control unit also mounts a large terminal board

which is usually the interconnecting point for all the system wiring.

Power for this unit comes from the customers' conventional power outlet via a small dial-light transformer. When the system is being used as an interphone, it draws approximately one watt of power; this drops to the order of $\frac{1}{4}$ watt during the much longer standby periods. Of course, the system is designed so that power failure does not interfere with incoming or outgoing telephone calls.

Many Potential Uses

Like all such systems, there are many potential services and a number of limitations. The latter are exemplified by any high noise level near a remote pickup microphone; these tend to mask interphone conversations. However, the approximately 20,000 systems in service attest to its usefulness. After all, what is more natural, when a need arises for voice communication with another area, than to reach for the nearest phone?

The design philosophy of the T1 Carrier System stressed reduced terminal costs. This concept makes the T1 system competitive with voice-frequency circuits for short distance telephone traffic.

# T1 Carrier System Terminals

H. T. King and D. B. Penick

COMMUNICATIONS SYSTEMS, like many things in our lives, compete with each other in an economic sense. Carrier systems, for instance, save money because they can transmit a number of telephone conversations over a single pair of wires and thus use cables quite efficiently. But because of the terminal equipment they need to combine voice channels and convert switching signals for transmission, carrier systems tend to be more expensive than voice frequency circuits for short distance transmission.

The T1 Carrier System (RECORD, *November,* 1962) which is designed to carry short-haul, exchange trunk traffic in and around cities, departs from the usual analog carrier techniques. Instead, it uses the principle of time-division multiplexing. This allows a large proportion of the terminal equipment to be used in common by all the channels in the system. Therefore the cost of individual channel units, and hence of a complete terminal, is reduced and the system can compete successfully with voice frequency circuits.

For an example, take the transmission path of a frequently used type of channel — one which connects to a two-wire trunk circuit. The trunk circuit itself connects to one winding of a balanced hybrid coil. The transmitting and receiving branches of the hybrid connect — through access jacks, pads, and low-pass filters — to trans-

mitting and receiving gates (see the drawing at the bottom of page 225) which in turn connect to timing-pulse sources. Twenty-four of these circuits form the complete multiplexing and demultiplexing part of the 24-channel PCM Bank Type D1 —the T1 Carrier terminal. The channel units themselves contain only those elements shown in the drawing to the left of the dotted line. The filters and the gates are mounted in groups of six circuits on each of eight separate plug-in units, four for transmitting and four for receiving. The schematic drawing on the following page shows the channel and gate circuits in their relation to the common circuits in the terminal.

These simple filter and gate circuits convert signals from the 24 individual channels into a train of PAM (pulse amplitude modulated) pulses. The secret of their effectiveness is the high-speed precision action of the transmitting and receiving gates. Each gate (see the drawing at the top of page 225) is an assembly of four carefully matched diodes. The diodes are normally back biased, so that no current flows through the signal path. Every 125 microseconds (8000 times-per-second) each gate in turn receives a pulse of current that lasts about 2.5 microseconds. During this interval the diodes become highly conducting and a sampling of the signal current flows, producing a pulse equal in amplitude to the filtered input
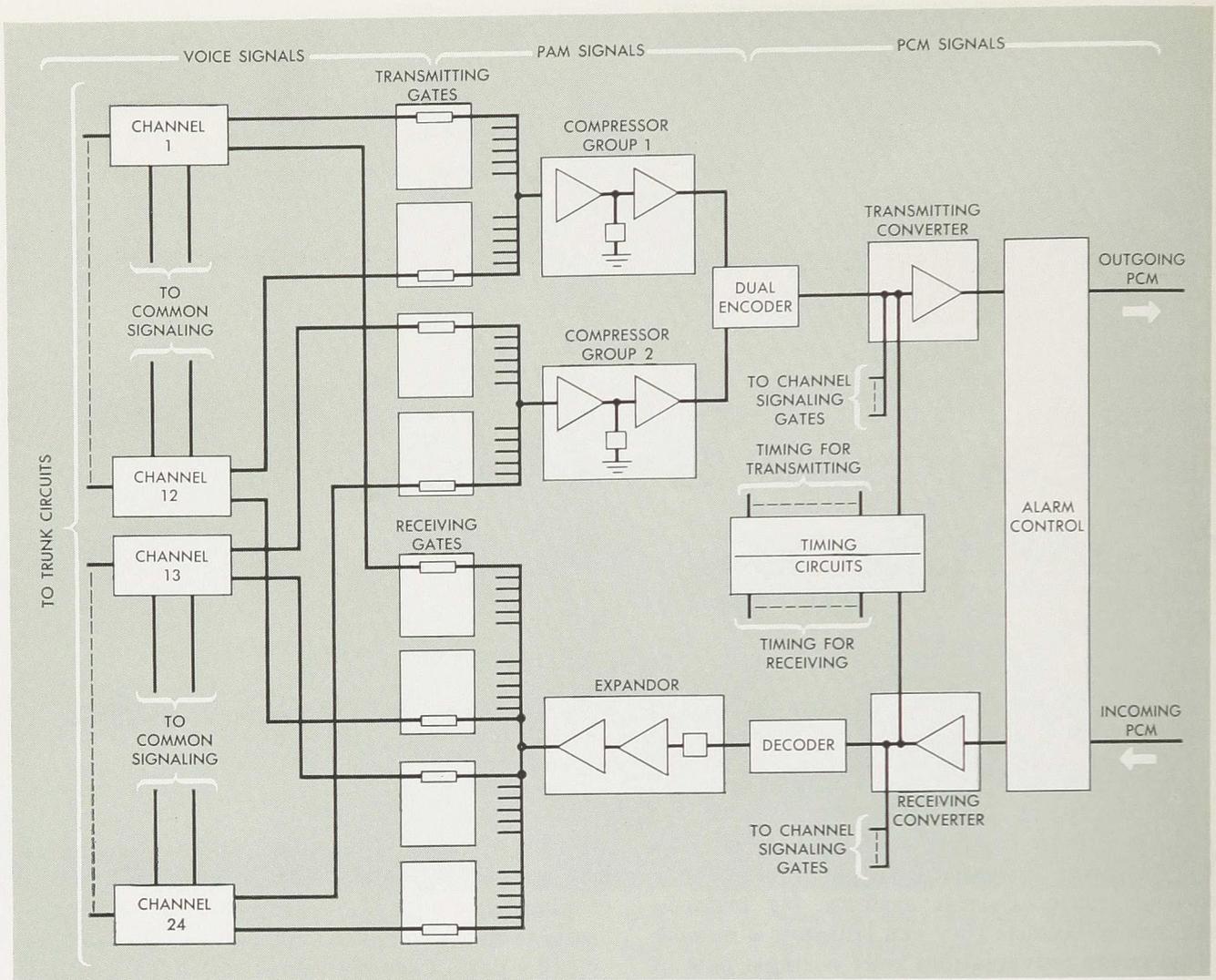
The T1 System terminal. The channel and gate circuits shown at the left are individual to each channel unit. The circuits shown at the right are common to all channels in one system terminal.

speech signal. The samples from the individual channels are added together in time sequence to form the PAM pulse train. This operation is called time-division multiplexing.

Timing Circuits

Other groups of circuits produce the timing pulses for the system and process the channel pulses before they are transmitted over the line. These circuits are more complex than the channel circuits and, therefore, more expensive. The saving factor is that they are common to all channels in a bank. Thus their cost is shared by all channels and the cost per channel of the system is kept low.

A central part of this common equipment is the master clock. It is the source of all timing pulses which control the multiplexing and demultiplexing of voice signals and of all pulses in-

volved in processing the PAM train before it goes to the line and to the far terminal. The extra processing would not be necessary if analog techniques, using amplifiers and equalizers, were used to transmit the PAM train before it goes to the line and the far terminal. This, however, requires an extremely stable transmission circuit through many repeaters and many sections of telephone cable—a formidable and expensive undertaking. Instead, to insure accurate transmission, the PAM pulses are translated into a train of binary-coded pulses which are better suited for transmission over the line. Varying combinations of binary digits represent varying amplitudes in the speech signal. This kind of transmission is called pulse code modulation (PCM).

A binary digit, or bit, in the sense of this article, is simply a pulse whose only important characteristic is its presence (ON) or absence (OFF)

at a particular time. As long as such characteristics as amplitude, duration, or shape of the pulse do not interfere with its recognition—or with the recognition of other pulses—they are not important in the system. The binary code for the T1 Carrier System uses 7 digits which yield 128 possible combinations. One of these, the "all zeros" code that represents the binary number zero, is not used. The other 127 possible combinations, or codes, are assigned to represent 127 levels of amplitude equally spaced between maximum negative amplitude and maximum positive amplitude. The center amplitude, zero, is represented by binary code number 64.

Transmitting and Receiving Circuits

Transmitting circuits (see the drawing on page 227) convert the PAM pulse train to a PCM signal. A storage capacitor retains each PAM pulse for approximately one channel time. During this interval, a number of operations are performed on the pulse. First, a non-linear amplifier (compressor) instantaneously varies the gain inversely with the amplitude of the input voltage. The compressed voltage is presented to an encoder which examines it seven times. At each examination, the encoder sends an ON (pulse) or an OFF (no pulse) signal to indicate the voltage level it has detected. The accuracy of this representation of the voltage level doubles with each examination. At the end of the encoding period, a clamp momentarily short circuits the capacitor so that it is cleared of one pulse and ready to store the next.

The receiving circuits which reconvert the PCM signal to a PAM pulse train are the inverse of the transmitting circuits. A decoder examines the seven OFF and ON signals transmitted by the encoder and sends out a PAM pulse whose amplitude matches, within one part in 127, that of the transmitted sample. An expandor amplifies the PAM
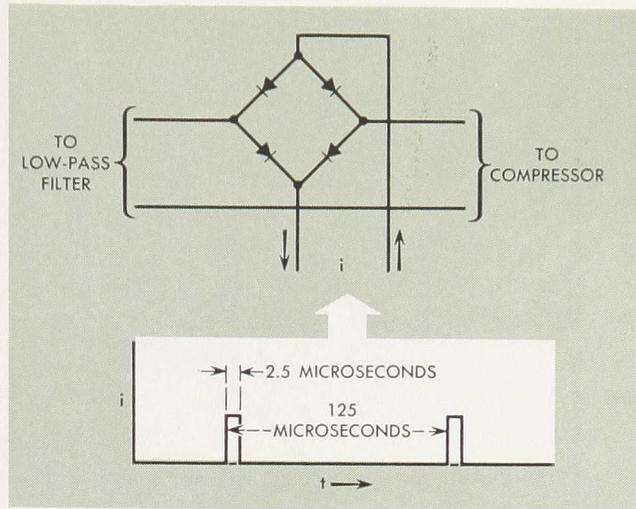
A gate circuit is included in each channel unit.

pulse by a gain which complements the compressor gain, thus restoring the original signal amplitude.

The precise, intricate logic and comparison circuits of the encoder and decoder perform, on a precise time scale, many of the functions of modern computers. In fact, these units can be considered the brain of the T1 System terminal. Two of their major features were determined by the encoding method used in the system. One is the routing of alternate transmitting PAM pulses through two separate circuits before they are encoded. Thus, the pulses are spaced two channel times apart, instead of one, in each circuit and duplicate equipment is required for the two circuits. The second feature is the use of the compandor—the combined name of the compressor and expandor.

Alternate pulses are separated because the encoder needs seven-eighths of the time allotted for a single channel to scan and encode a PAM pulse. During this time the pulse amplitude must remain substantially constant. At the end of the encoding
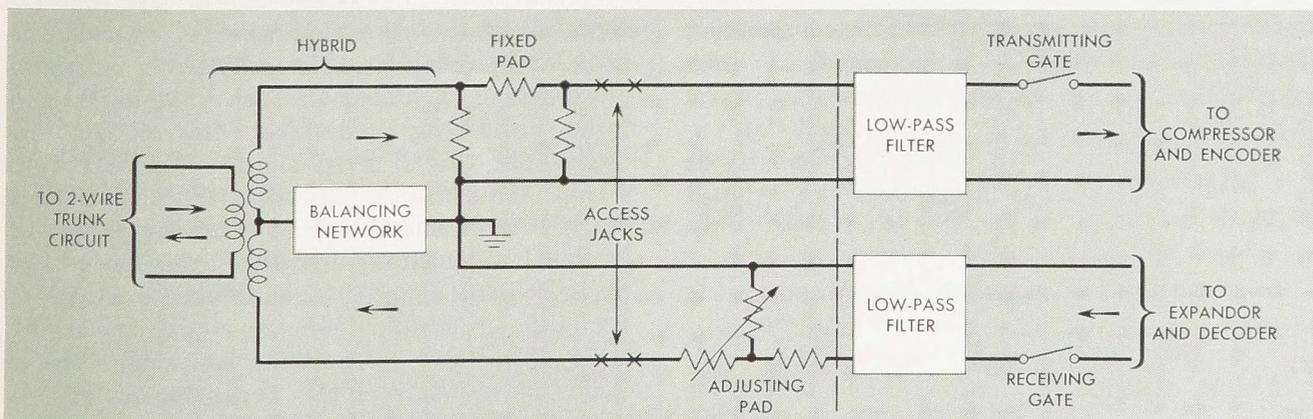
The transmission path between a T1 System terminal and a two-wire trunk circuit. Twenty four of these circuits are used in the multiplexing and demultiplexing part of a complete T1 terminal.

CODE STEPS FROM ZERO SIGNAL (y-axis)
70, 60, 50, 40, 30, 20, 10

AMPLITUDE OF SIGNAL SAMPLE IN DECIBELS FROM MAXIMUM (x-axis)
−70, −60, −50, −40, −30, −20, −10, 0
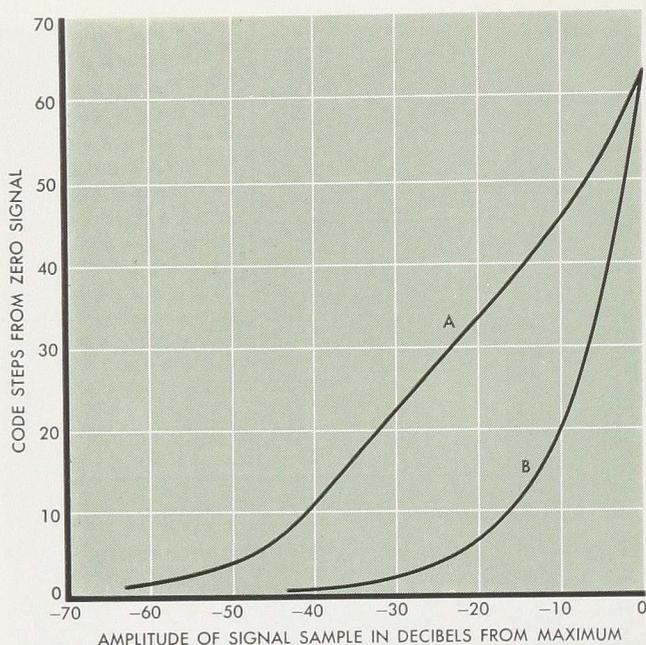
Curve A shows the characteristic of the encoded signal that is achieved with the compandor. Curve B shows the characteristic that would be achieved if this unit had not been used.

interval, and before another pulse can be encoded, several events must occur in sequence: (1) the clamp must operate to remove the encoded pulse, (2) the transient voltage that results from the operation of the clamp must die out, (3) the storage capacitor must charge to the full amplitude of the next pulse to be encoded, and (4) the transient voltage that results from the operation of the gate must die out. The additional channel time gained by routing alternate PAM pulses through separate channels is a comfortable amount of time for these actions.

Compandor Circuit

The compandor is required because of the linear response characteristic of the encoder. Actually, the system would operate without the compandor; that is, speech would be understandable. However, a very disturbing type of noise that arises from the quantizing effect of the equal-step encoder would affect speech signals, particularly at low levels. The compandor reduces this type of noise by 20 to 25 db. It does this in a rather simple way.

The response characteristic of the human ear is essentially logarithmic. At any sound level—high or low—within normal hearing range, the minimum recognizable change is about 1 db, or 10 per cent in sound pressure. The compandor converts equal ratio (or equal db) steps of speech to equal amplitude steps for the encoder, and

reconverts them to equal ratio steps at the receiving terminal. Thus, if each code step represents less than a 1 db change in speech level, the quantizing noise is almost imperceptible.

One property of almost any semiconductor diode is the nearly logarithmic relationship between the current and voltage applied to it over certain portions of its characteristic. This property can be used to get a satisfactory characteristic for the encoded signal. Therefore, the compandor circuit is arranged so that the current through the diode is proportional to the speech amplitude and the voltage across the diode is proportional to the encoded amplitude. To properly reconstruct the original uncompressed signal at the receiving terminal, it is only necessary to maintain strict proportionality between the nonlinear networks of the compressor and expandor. The central design problem here is to maintain the stability and the equivalence of all compressor and expandor nonlinear networks for both positive and negative excursions of the signal level.

Curve A in the graph to the left is typical of the performance of the compandor; it shows that less than 1 db signal variation per code step is maintained over more than a 40 db range. Curve B shows the characteristic that would be achieved without the compandor; the variation would be maintained over only about 20 db from the maximum signal. Moreover, the range of variation in properly manufactured units should spread no more than one code step at any point on the characteristic of curve A, and the spread will be substantially smaller at the three adjusted points which are approximately 0, —20 db, and —40 db with respect to the maximum signal.

Turning to another function of the terminal—signaling—we can again point to an impressively economical design. In fact, the T1 System signaling arrangement is by far the simplest and least expensive available to any carrier system. The signaling state of a channel (i.e. on-hook, off-hook, dial pulsing, etc.) is indicated by an eighth pulse which is added in each channel interval to the seven PCM pulses from the encoder. The circuit for this is even simpler than the voice signal transmission circuits. It consists of a single diode transmitting or receiving gate timed by the channel timing circuits. The gates connect to individual channel circuits and multiple directly though a simple common signaling circuit to the transmitting or receiving converter. The remarkable economy of this arrangement holds up even for revertive signaling where an additional signaling state (the revertive pulse) leads to some complications. In this case, the seventh PCM digit
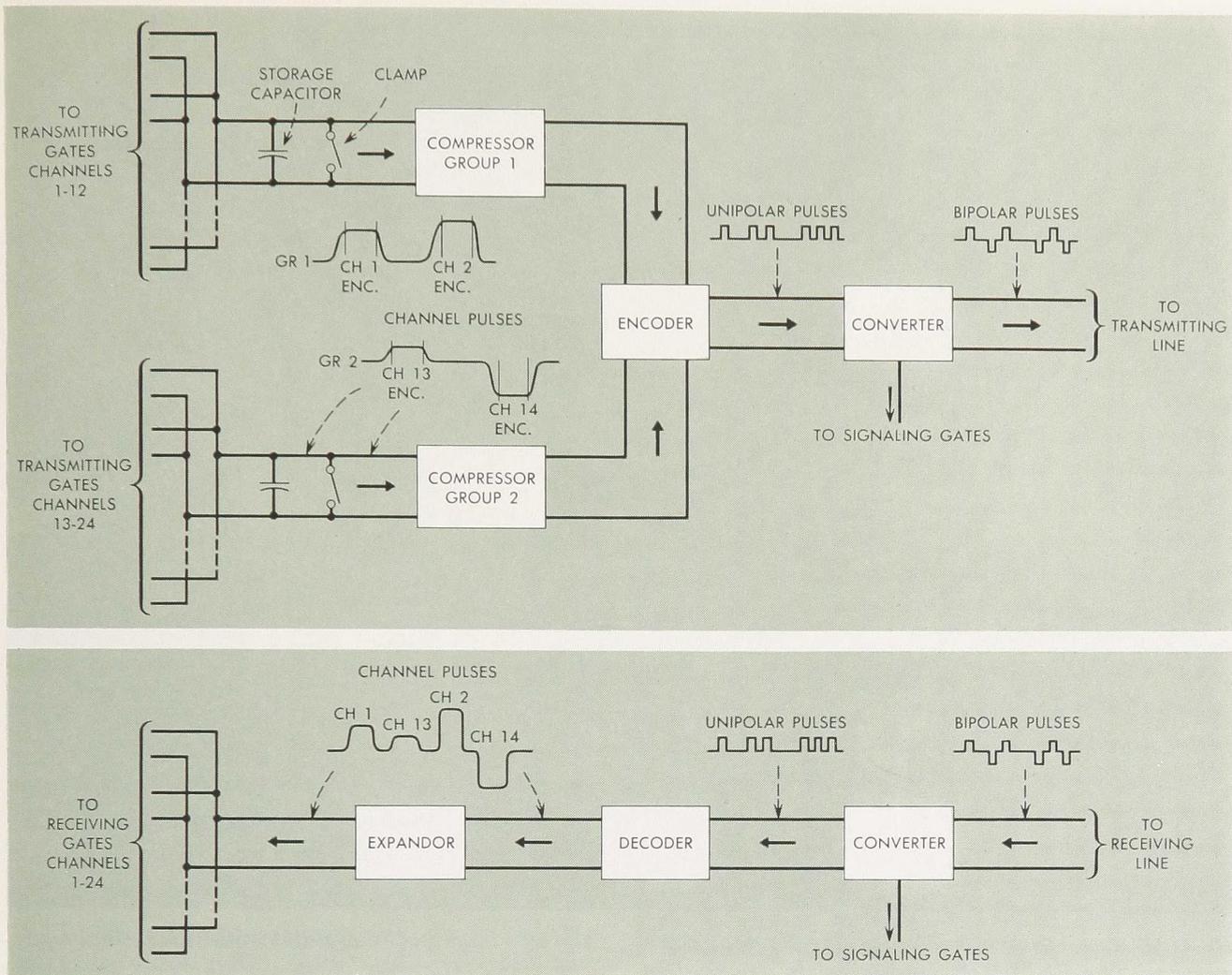
Conversion of PAM *signal to* PCM *pulse train which is transmitted over the line to the distant terminal.* PAM *pulses are routed through two separate circuits to the encoder and then combined in one train.*

is 'borrowed' during the dialing interval and used as a second signaling digit. When the connection is completed, the digit is restored to the talking path.

We have accounted for eight digits per channel —seven PCM and one signaling—a total of 192 digits. They represent one sample of the whole system. At this point the timing circuits introduce one digit to mark the end of a frame. For uniqueness, the digit is alternately ON and OFF. With the framing digit, we have a total of 193 digits per frame. That total multiplied by 8000 frames per second yields the basic timing rate of the system—1,544,000 bits per second.

As the final step in processing the PCM signal, the transmitting converter combines the three kinds of digits—framing, signaling, and PCM code. All input digits have the same polarity, nominal amplitude, and duration. The converter regenerates each digit and reverses the polarity of alternate pulses, generating a bipolar signal to be sent

to the line. The signal transmits the same code information as its unipolar counterpart, but the timing information rate is cut in half and the dc component balances out to zero. This simplifies the repeater design and reduces repeater sensitivity to crosstalk enough to permit the repeaters to be spaced as far apart as loading coils on voice lines (one of the original design objectives for the system). In addition, simply watching for bipolar violations in the pulse train is a convenient method of detecting transmission errors.

Plug-In Units Used

The transmission circuits for all the signal processing operations that have been described are mounted on eight plug-in units. The timing circuits are mounted on another 12 units, eight of which are channel counters that are paired with the eight multiplexing gate units.

One further important function in any multichannel system is the system alarm. An alarm
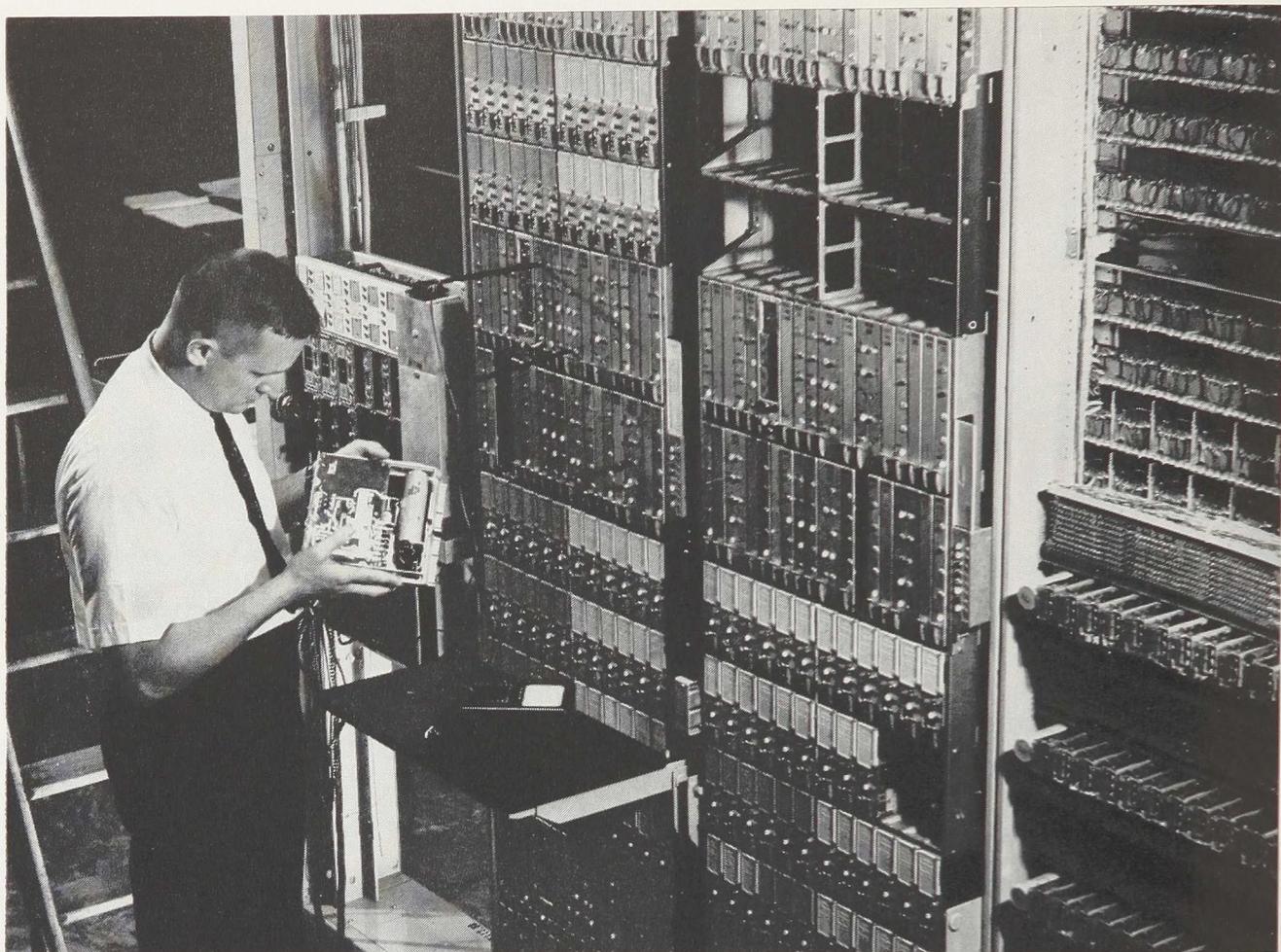
P. J. Greene studies a T1 Carrier System compressor. The T1 System equipment is mounted in four bays: The bay on the left contains repeaters;
the two bays in the middle contain terminal equip-for six T1 Carrier Systems; the bay on the far right contains carrier group alarm circuits.

unit interconnects with all vital parts of the terminal. It has one indication for loss of the incoming signal, synchronization, or battery supply; a second indication for an alarm at the far end of the system; and a third indication that operates in conjunction with a manually operated key to check local terminal operation. Alarm signals are also transmitted to the regular office alarm system, and to special carrier group alarm circuits which disable connecting trunks to prevent a general seizure of switching equipment if trouble occurs.

All the operating power for a T1 System terminal comes from the -48 volt battery that is generally part of any switching center. Because of the special T1 System requirements, i.e., voltages of both polarities and high stability, regulators and a multi-output converter are part of the equipment in each bay. The +24V, -24V, +48V, and -42V voltages that are required are supplied for a maximum of three terminals on a bay.

Like the transmission circuits, the power converter and regulators are fully transistorized.

All active circuits are located on easily demountable units which can be attached to a passive mounting panel that is permanently wired into the bay. The mounting arrangements and the connectors for the transmission circuits are also pre-wired in position on the bay, thus greatly simplifying installation. Plug-in units, the most expensive part of the equipment, can be bought and inserted when they are needed.

The economics of the T1 Carrier System which has been featured prominently in this article, was stressed in the design of the system. The low cost and simplicity of the individual channel circuits, and the common use by many channels of the more expensive and complex circuits, were essential parts of the design philosophy. The economic success of the system depends on its being lower in cost than loaded voice-frequency cable pairs. The highly efficient terminal make-up, more than anything else, allows the system to prove-in economically for use in the metropolitan areas for which it was designed.

Nike Zeus Intercepts Re-Entry Target

The U.S. Army's NIKE ZEUS anti-missile missile system successfully intercepted another re-entry target vehicle launched by a Titan I ICBM in another of a series of continuing development tests, the Department of Defense announced recently.

The NIKE ZEUS missile was fired and controlled from the Army test installation at the Pacific Missile Range Facility, Kwajalein Island in the southwest Pacific. The Army said that ground tracking equipment indicated the target vehicle was well within the lethal radius of the ZEUS missile's operational war head. Neither the intercepting missile nor the target vehicle carried a nuclear war head.

The target vehicle was boosted to an ICBM velocity on a 5,000 mile trajectory from Vandenberg Air Force Base, California, using a Titan I ICBM booster fired as a training exercise by the Strategic Air Command.

A number of NIKE ZEUS missiles have been fired to date as a part of the NIKE ZEUS development program. In addition to its firings against test targets and simulated targets (fed into the ZEUS system's target intercept computer from tapes) other firings have been conducted to verify missile structure and to test operation of the system's ground complex.

These tests have been conducted over the past four years from firing sites at White Sands Missile Range, N.M., at Point Mugu, Cal., and at Kwajalein Island in the Pacific. Of the tests conducted thus far, over one-half have been completely successful and an additional 25 per cent were partially successful in meeting test objectives. The capability of intercepting single ICBM's under research and development conditions is a valuable contribution to our understanding of the basic factors involved in problems in this field. The tests do not represent an offense-defense contest, but from the performance of components of the NIKE ZEUS system and the behavior of re-entry bodies, a better estimate of the capabilities of the NIKE ZEUS system will be possible following the test series.

The broad, general purpose of this test program is to gather data by the testing of various components. Information from test results can be used immediately to predict over-all system performance under various attack conditions. Knowledge gained in the continuing series of NIKE ZEUS intercept tests at Kwajalein will be of benefit to the Army in the development of the NIKE X anti-missile missile system, an advanced version of NIKE ZEUS.

Testing of the NIKE ZEUS system using ICBM-launched target vehicles will continue on the Pacific Missile Range.

I. O. Drewry, NIKE ZEUS Project Manager and his staff direct both the NIKE ZEUS and NIKE X program for the Army Materiel Command from Headquarters at Redstone Arsenal, Ala.

The Western Electric Company is prime contractor. Bell Laboratories has responsibility for system design and development. Douglas Aircraft Company builds the NIKE ZEUS missile.

An "X" in the sky above the Pacific marks the successful intercept by the U. S. Army's NIKE ZEUS of a special target vehicle boosted by a Titan ICBM. In this time exposure, the first ever released showing an actual intercept of an ICBM-boosted target vehicle, the target appears as the uppermost bright streak running from upper left to lower right. Intersecting the path of the target is a shorter streak traced by the burning third stage rocket motor of the NIKE ZEUS missile. The bright spot where the two lines intersect is caused by the detonation of the "spotting charge" carried in the NIKE ZEUS missile to simulate warhead burst. The lowest, brightest streak is the ICBM booster breaking up as it re-enters the atmosphere. Other dull streaks are star traces.
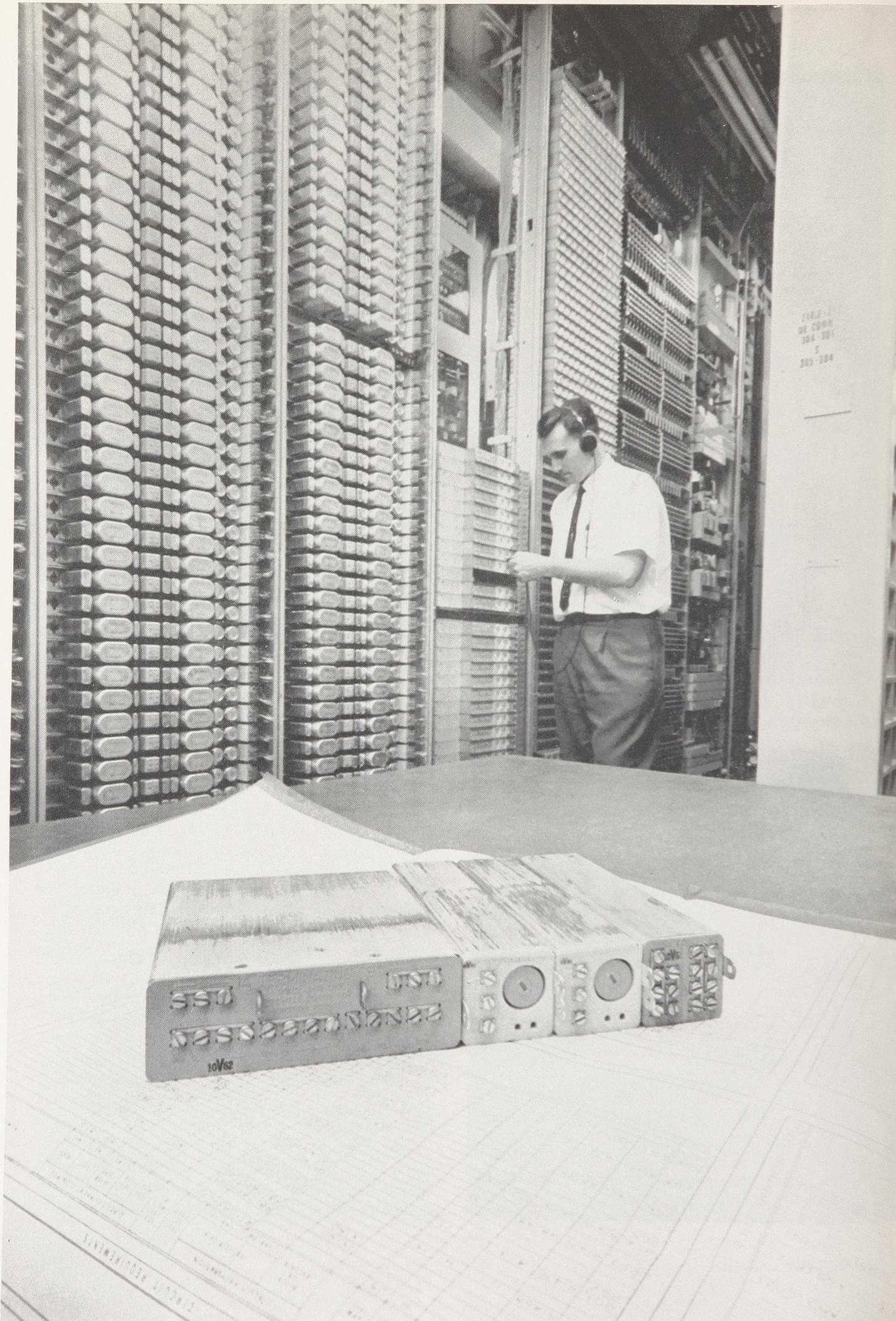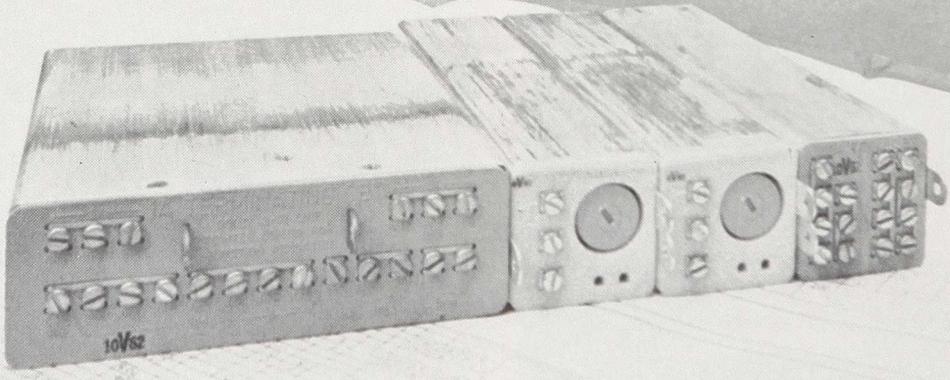
Laboratories engineers have boosted the efficiency, simplified installation and maintenance, and reduced the size and heat-dissipation requirements of the telephone repeater. Result:

The V4 Repeater

J. O. Smethurst

THERE ARE MILLIONS of telephone trunks throughout the Bell System—between local central offices, between central offices and toll offices and between toll offices themselves. On long-haul telephone circuits—15 to 3000 miles in length—carrier systems on wire, cable, and microwave radio systems are most economical for providing many hundreds of thousands of four-wire trunks to interconnect toll offices. For short distances, 5 to 15 miles, voice-frequency circuits, with either two-wire or four-wire connections, are cheaper to install and maintain, and large numbers of such trunks are used to join central and toll offices.

More than two million local and toll-connecting

The V4 repeater—used to insert gain and equalization at terminal points for four-wire trunks. In background, Gerard Hahn of the New York Telephone Company tests V4 repeaters in bay.

trunks in the Bell System today use the E-type negative impedance repeaters to furnish the low-net-loss two-wire circuits (RECORD, *October, 1961*). In spite of the widespread use of two-wire repeatered trunks, limitations within the E-type repeaters restrict their usefulness to uniformly loaded cable facilities. As a result, hundreds of thousands of trunks, consisting of various mixtures of wire gauge, in non-loaded and loaded cable sections, must be engineered as four-wire circuits to secure the wide-band and low-net-loss requirements for voice and data transmission.

Until recently, all amplifying devices used electron tubes requiring 24- or 48-volt battery for the heaters and a 130-volt plate-battery supply. The 130-volt batteries are not available in all central offices and are quite expensive to install and maintain. In many places, such as unattended community dial offices and customer private branch exchanges, lack of space for the battery equipment makes it impossible to install repeat-
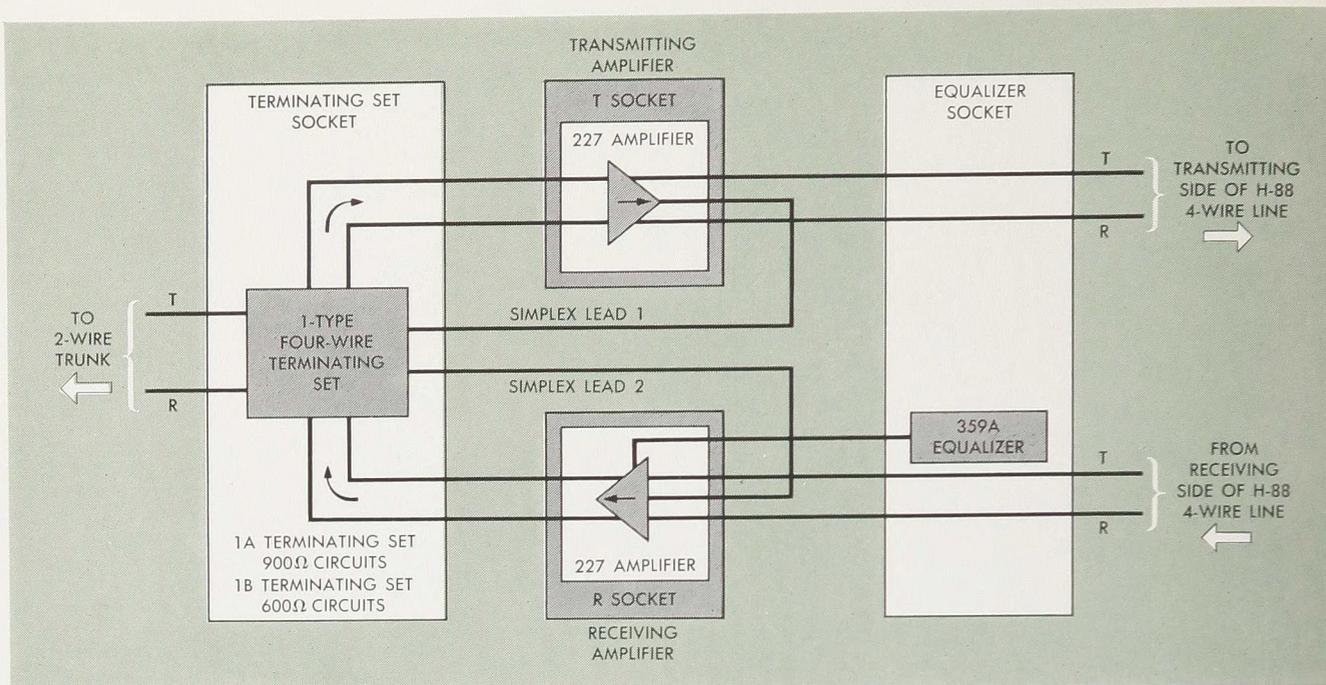
Block diagram of the 24V4 repeater showing how the repeater can be used to connect four-wire H88 cable to a two-wire trunk which terminates at central office or extends to a customer's PBX.

ers. In large offices where there are many bays of repeater equipment, the heat dissipated by the electron tubes can produce detrimental effects on apparatus and personnel. Since it is expected that a large number of four-wire voice-frequency trunks will be put into service over the next 5 to 10 years, the telephone operating companies want equipment which is more compact, more economical and easier for telephone craftsmen to install, adjust and maintain.

New Repeater Developed

To meet this need, Bell Laboratories engineers designed and developed a new voice-frequency repeater which went into full production last year at Western Electric's Merrimack Valley Works in Massachusetts. This new unit is the V4 telephone repeater. The use of transistors reduced the power requirements and heat dissipation, and the use of miniature components reduced the size of the repeater. New packaging and equipment designs, incorporating plug-in units, simplify engineering, installation and maintenance procedures. Printed wiring, Amplas (*Apparatus Mounted in Plastic*) molding and new assembling techniques have cut manufacturing costs. Western Electric now produces thousands of V4 repeaters per week.

The V4 repeater was designed as a completely wired unit assembled on a single mounting shelf and arranged to accept a variety of plug-in components. By grouping the apparatus together in as a compact unit, installation and maintenance costs are reduced, and office wiring and cross connections are held to a minimum. In addition, greater flexibility is achieved since single units can be installed one at a time as needed in small offices. Full bays — containing 66 mounting shelves (66 terminal repeaters or 132 intermediate repeaters)—are available for the larger applications.

The V4 repeater achieves extraordinary flexibility by standardizing two basic units: the 24V4 repeater which furnishes gain, equalization, and a two-wire to four-wire transition and the 44V4 repeater which inserts at an intermediate point the gain and equalization needed in the longer four-wire trunks. Two types of mounting shelves, one for each type of repeater, contain socket connectors to accommodate a large assortment of plug-in units which are available for engineering different types of voice-frequency circuits. Many combinations of plug-in units consisting of four-wire terminating sets, transistor amplifiers, equalizers and networks may be inserted into the mounting-shelf connectors to meet the telephone company requirements for high grade trunks.
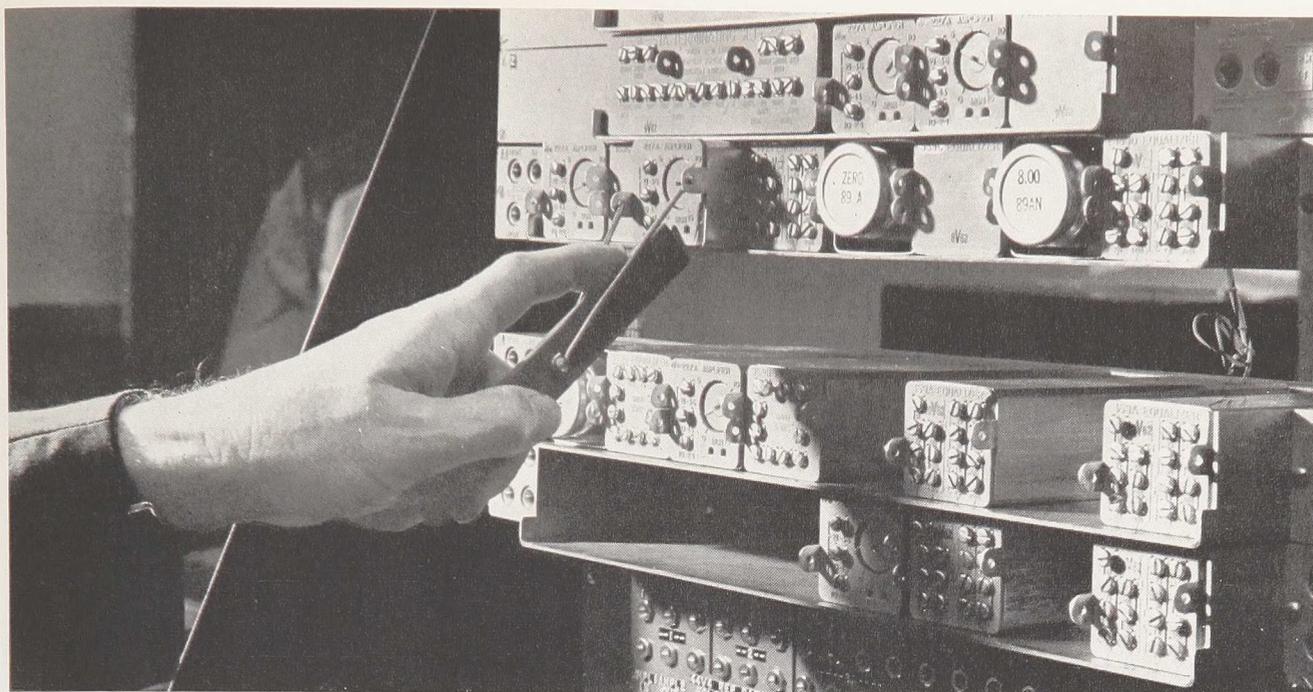
At Bell Laboratories, a 44V4 repeater undergoes tests. The 44V4 repeater is used over long circuits where the transmission loss exceeds 10 db and added gain and equalization are needed.

Repeater Provides Transition

The 24V4 repeater provides the transition between a four-wire circuit and a two-wire switching point or between four-wire and two-wire portions of the same circuit. In many applications, the four-wire lines, between two switching offices, are set up on voice-frequency cable pairs and two 24V4 repeaters are used—one at each end of the trunk. Numerous other voice channels, distributed by carrier systems, must be extended over cable, on a four-wire basis, and only one 24V4 repeater is required at the terminating office. Considering these two applications and allowing for the tremendous growth rate in special service lines and in PBX trunks and tie lines, some 75,000 24V4 repeaters will be required each year to meet the proposed objectives of upgrading the transmission characteristics of voice-frequency trunks on existing or new cable facilities.

A typical application of a large number of 24V4 repeaters is shown in the block diagram opposite. Here, the low-loss four-wire H88 loaded cable facility, using either 19-, 22-, 24-, or 26-gauge conductors, is connected into a two-wire trunk circuit for termination at the switches of a two-wire central office or into a two-wire facility to extend it to a customer's PBX as a private tie-line.

For this service the 24V4 repeater will include:

(1) a hybrid-coil terminating set for transforming the four-wire circuit into a two-wire line

(2) a transmitting amplifier with variable gain, for adjusting outgoing transmission levels

(3) a receiving equalizer with variable low- and high-frequency compensation, for flattening the frequency-attenuation characteristics of the incoming cable pair, and

(4) a receiving amplifier with variable gain for adjusting incoming transmission levels.

The configuration shown in the drawing on page 232 is only one of many arrangements which can be obtained for the 24V4 repeater. To secure maximum flexibility for the telephone companies, all of the individual pieces making up a repeater are designed as plug-in units. For example, two different codes of terminating sets have been standardized: the 1A set for 900-ohm offices and the 1B set for 600-ohm offices. In addition, two 227-type transistorized amplifiers, nine types of 359 equalizers and eight 849-type networks have been made available for engineering message and data trunks. All of the apparatus which requires adjustments to optimize transmission,
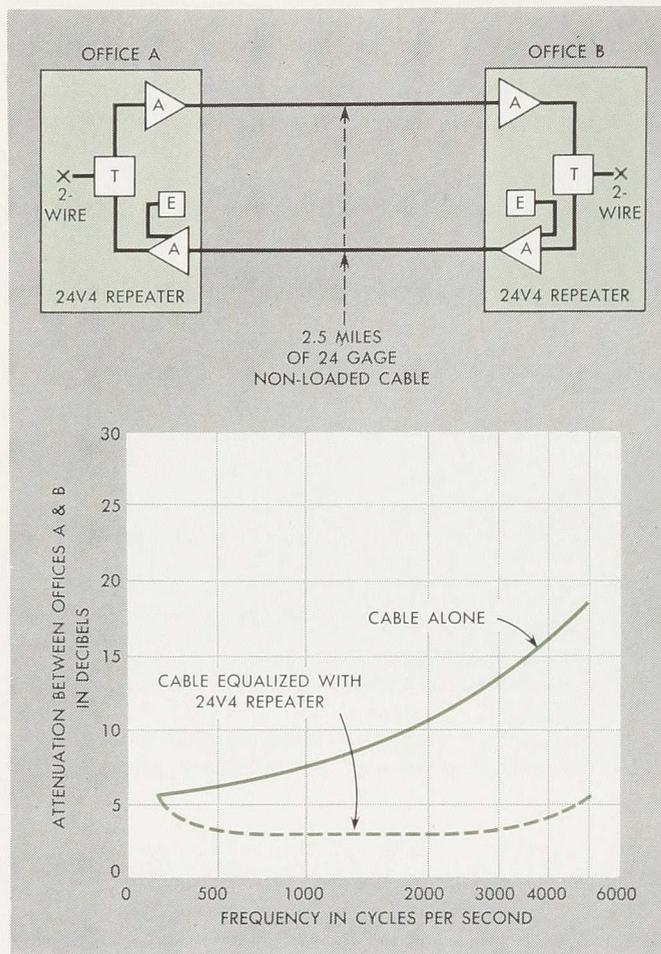
At left—diagram of field-trial arrangement in Chicago, Ill. At right—setup in Brooklyn, N. Y. uses loaded cable and requires intermediate repeaters. Transmission curves for trials are shown.
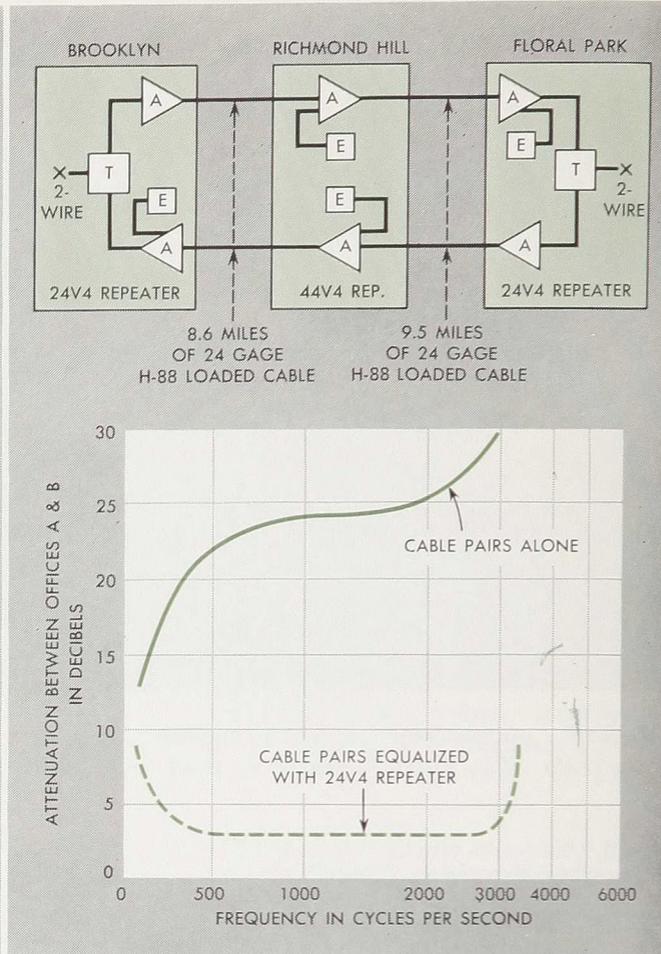
return loss, gain and equalization have screw-type switches on the face plate of the unit to simplify adjustments.

Repeater Can Be Modified

Many long-haul trunks derived by carrier or microwave radio systems terminate in a toll office and must be extended over non-loaded cable pairs to a serving central office. A large number of these circuits cover short distances—two to three miles between offices—and, since the levels from the carrier system are adequate to overcome the cable attenuation, a simplified 24V4 repeater is preferred to reduce capital investment and maintenance costs. In such cases, a modified repeater can be obtained quickly and easily by changing the plug-in units. While only two typical arrangements of the 24V4 repeater have been discussed, many other combinations of the plug-in units can provide low-loss high-grade trunks on either non-loaded cable or D88,

H44 and H88 loaded cable facilities using 19-, 22-, 24- or 26-gauge conductors.

When the voice-frequency trunk exceeds 10 db of transmission loss additional gain and equalization are usually required at an intermediate point to increase the signal amplitudes above crosstalk levels in the cable and to insure uniform response over the desired band of frequencies. For these long circuits, the 44V4 (four-wire to four-wire) repeater has been standardized as a completely packaged unit to meet a host of applications in the telephone plant. While its main function is to act as an intermediate repeater, the 44V4 unit will find many uses as a repeater for extending four-wire trunks through central offices to PBX switchboards and for providing the pre-equalization and post-equalization for carrier systems transmitting multi-channel data signals.

Each 44V4 repeater is made up of four pre-wired socket connectors and a test jack field. Plug-in equalizers, amplifiers and networks are provided to engineer low-loss trunks using the

non-loaded cable pairs or the loaded H44, D88 and H88 facilities most usually found between telephone offices.

Models Field Tested

Pre-production models of the 24V4 and 44V4 repeaters were field tested in Brooklyn, and Long Island, N. Y., Chicago, Ill. and Los Angeles, Cal. Trials on actual circuits permit design engineers to see whether the repeaters work as well in the field as in the laboratory. Such trials also give the operating company personnel a chance to make helpful suggestions before the units go into final production.

The field trial in Chicago is an example of the application of the 24V4 repeaters on non-loaded cable pairs between two central offices. In this case, the 24V4 repeaters not only improved transmission, but also provided the telephone company engineers with a compact package that simplifies installation and maintenance. A block diagram of the circuit layout, and the improvement in transmission obtained with repeaters, are shown at the left.

At another test location, long four-wire circuits were set up, using 24-guage H88 loaded cable, between the Brooklyn tandem office and Floral Park, Long Island. In this case, 24V4 repeaters were used at the end offices and a 44V4 repeater was inserted at an intermediate office in Richmond Hill, Long Island. A block diagram of the circuit layout and the improved transmission achieved with the V4 repeaters are shown at the left. Note the better quality of trunk obtained by using the V4 repeaters where the high-loss trunk between the two offices was reduced to a low-loss circuit with uniform response across the voice band.

The widespread use of direct distance dialing with the possibility of as many as 10 transmission links in tandem and the increasing use of voice-frequency facilities for data transmission have put tighter requirements on the variations permitted in the exchange and toll area plant. In addition, frequent changing of customer requirements for new types of service in the PBX area has established the need for a variety of voice-frequency circuit arrangements that can be engineered and provided quickly and cheaply on a plug-in basis, without making extensive installation wiring changes with a soldering iron. The V4 telephone repeater provides the operating telephone companies with a new tool for meeting these new objectives.

Telephone Circuits Used To Transmit Drawings and Documents

Data-Phone data sets that make it possible for customer-owned facsimile machines to send drawings, maps, charts and other documents over regular telephone lines are scheduled to be made available for use to Bell System customers starting in mid-summer.

Transmitting at the rate of one 8½ by 11-inch page every six minutes, the new service is expected to be a boon for weather services, engineering companies, contractors and others who need to speedily transmit drawings, charts and diagrams.

Customers with proper facsimile equipment and *Data-Phone* data sets will be able to send drawings over regular telephone lines by simply dialing the connection through the regular switching network.

After dialing the distant number and establishing a circuit, the customer feeds the page he wishes to transmit into his facsimile machine. The machine scans the page a line at a time— moving back and forth across the page much like the carriage on a typewriter. Usually there are from 85 to 100 scanning lines per inch.

As the machine scans the page, line by line, it generates signals that indicate whether the points being scanned are black or white. Marks on the page, of course, register as black, and blank spaces register as white.

These signals are fed into the data set. It converts them into frequencies that indicate degree of blackness or whiteness. For example, a 1500-cycle frequency indicates white, a 2500-cycle frequency indicates black. Frequencies in between designate shades between black and white.

These frequencies are transmitted over telephone lines to the *Data-Phone* data set on the other end, and are there reconverted into signals the receiving facsimile machine can understand.

The facsimile machine used to reproduce the drawings uses chemically-treated papers sensitive to electrical impulses, converting these impulses into marks on the paper. The reproductive processes differ slightly by make of facsimile machine.

The process faithfully reproduces within prescribed limits a duplicate of the original document in black and white. In tests now in progress, various types of documents are being sent over different distances to determine how well the original is reproduced.

A

B

C

D

E

F

G
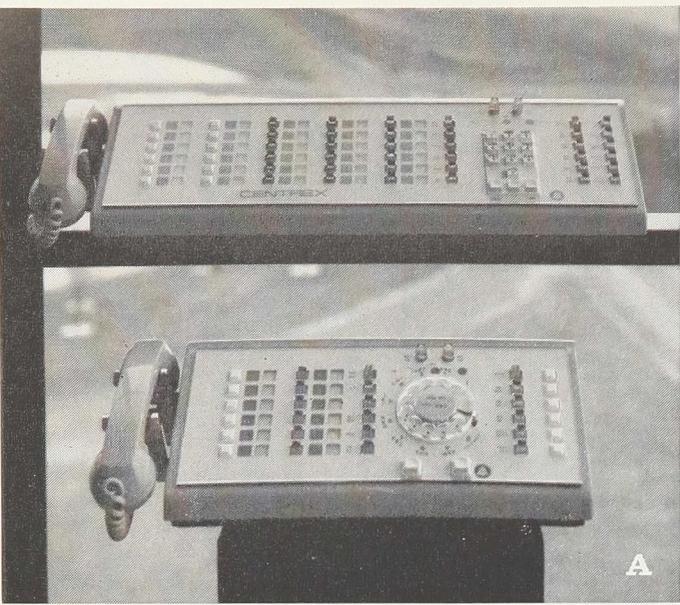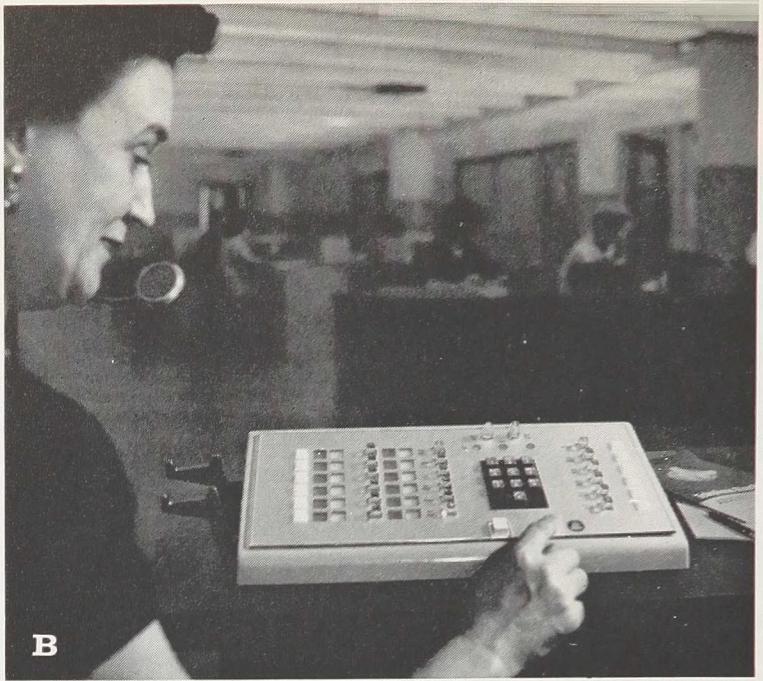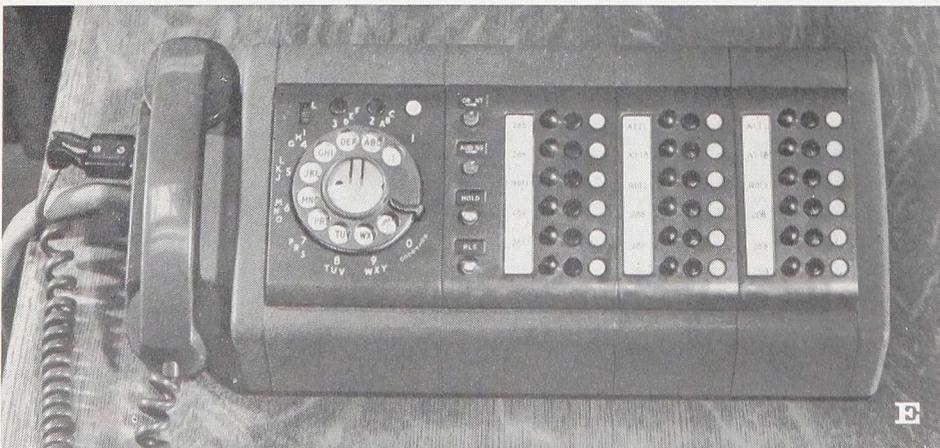
Miss J. H. Coyne
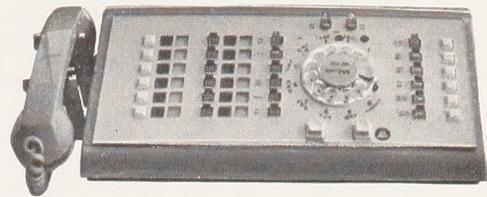
PBX *Consoles*

TELEPHONE SWITCHBOARDS have long been a familiar sight in business establishments. In Private Branch Exchange (PBX) service, operators initially used the cords, plugs and jacks on these switchboards to perform all switching for internal communication as well as to make connec-

PBX Consoles, old and new—The new Universal Console, available in two sizes (A), provides pushbutton control for attendants associated with most modern types of dial PBX systems. Typical of recent installations is that at the Advance Division of Carlisle Chemical Works in New Brunswick, N. J., where Mrs. Mary Schreiner operates the small Universal Console in connection with the 101 Electronic Switching System (B). Long before pushbutton design, however, cordless consoles with lever-type keys were associated with small step-by-step 740A (C) and 740C and (D) PBX systems. An early console (E) for the small crossbar 756A PBX was replaced by the still more modern 3A Telephone Console (F). A prototype (G) for the development of the Universal Console appeared with some of the early Direct Inward Dialing installations.
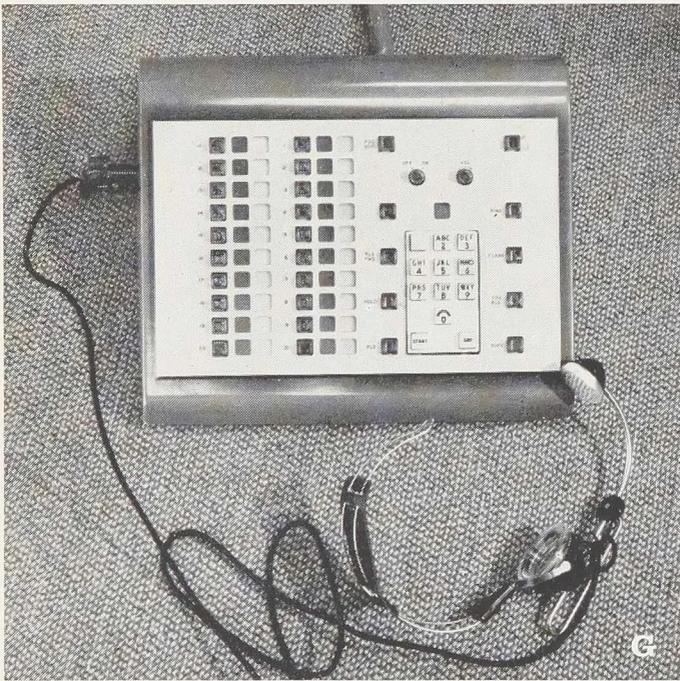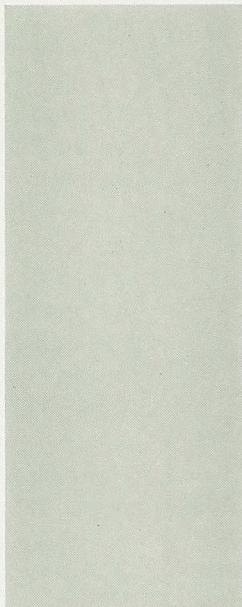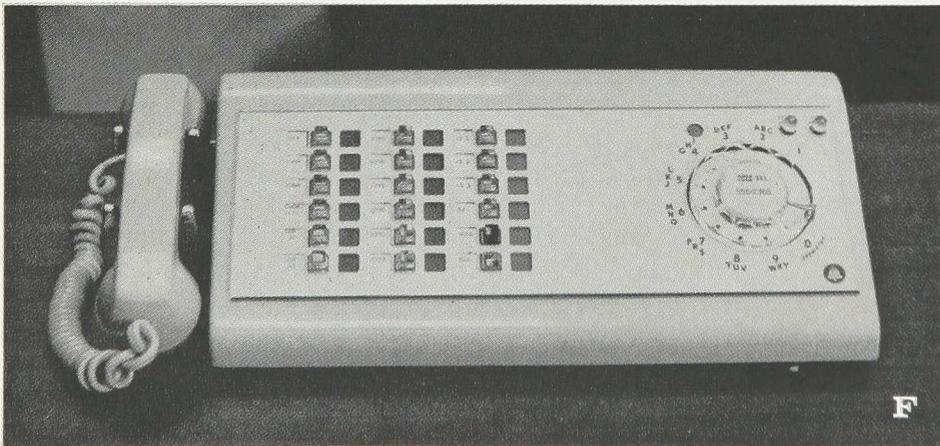
tions between the customer's stations and the exchange network. Even with dial PBX systems, cord type switchboards continued to be used for incoming and assistance calls. This tradition now has been challenged by the introduction of PBX attendant consoles which operate without cords, plugs and jacks.

The modern console is a small, attractive, key operated "switchboard" which may be placed on the surface of a desk or table. The attendant uses pushbuttons and a dial to answer and complete calls; actual switching occurs in associated dial switching equipment. Tones and illuminated panels and buttons give all the signaling and supervisory information needed to handle the calls.

Cordless consoles increase operating efficiency and speed call completion as well as improve the attendant's working environment. Operating efficiencies are achieved by saving the attendant's time and effort through such features as dial completion and automatic disconnection. The usual switchboard jack field is eliminated and all attendant operating equipment is confined to a small area. Reduced attendant work, motion, and time result in faster call completion. Operating efficiency and speed of call completion are increased still further

by the addition of auxiliary features such as automatic call distribution and call "Camp-on." Camp-on holds a call to a busy line and automatically connects to, and rings, the called line as soon as it becomes free.

Decorative Console Design

The current trend toward more attractive offices and office equipment has created a customer demand for PBX attendant positions of modern design. This demand is particularly evident in the case of small businesses where the PBX attendant frequently serves also as the company's receptionist. When using the new compact consoles, the attendant sits at a desk as do other office personnel. Removing the old shoulder-to-shoulder assembly line type of switchboard arrangements in multiposition installations has vastly improved the attendant's working conditions.

The pushbutton operation afforded by consoles fits in well with other trends in telephone service for business customers. One such trend is the increase of dial PBX service. In 1954, dial PBX extension lines represented about 38 per cent of all PBX lines in Bell System service; by 1962 this figure had grown to 67 per cent. The proportion of dial lines is expected to continue to rise with added emphasis through the recent introduction of CENTREX service. This new business telephone offering provides dial PBX service to the customer, but permits most of the calls to and from the exchange network to bypass the attendant. However, even with Direct Inward Dialing provided by CENTREX service, the attendant plays an essential role by handling incoming calls to the customer's "listed" number and other special calls.

Certain special features to be offered to business customers in the near future will allow even more calls to bypass the attendant. With one such feature, a station user will be able to transfer his incoming calls to other stations without attendant assistance. Another feature will permit him to dial a conference connection involving as many as six parties. These features afford customers faster and more convenient service. At the same time, they relieve the PBX attendant of much routine work, freeing her to handle those calls requiring more personalized service.

Consoles are not really new to the Bell System. Table top cordless attendant positions were used with small step-by-step PBX's as early as 1928. However, these early consoles were limited to use with certain relatively small switching systems of low or medium traffic handling capacity.

During the intervening years, various attendant consoles were designed for use with specific dial PBX switching systems. An objective of each design was to improve upon its forerunners with regard to appearance, space, capacity, ease of operation, and flexibility for performing miscellaneous functions. Some of the highlights in this succession of consoles are interesting to note.

Small cordless positions featuring locking type pushbuttons were made available for use with the small crossbar 756A PBX. Bell Laboratories also designed an attendant telephone console for use with 701B PBX's which were specially modified to provide direct inward dialing. This console featured nonlocking pushbutton pickup keys and a pushbutton dial for call completion and served as a prototype for the development of a universal console.

Of course, a single standard operating method as well as a universal apparatus design is highly desirable in place of individual development of consoles for each system. Recognizing this, as a first step, Bell Laboratories systems engineers studied the basic service objectives of PBX attendant facilities. These studies showed that good PBX service means that the attendant should answer calls promptly and informatively with different responses on different types of calls. Each call should be dispatched promptly, but when delays do occur, the calling party should be kept informed with progress reports at regular intervals. The attendant is expected to complete outward calls for restricted stations, assign priority for use of certain tie lines and conference circuits, and handle certain toll calls. The attendant should also be able to transfer calls when requested. She may also be expected to perform miscellaneous functions such as giving out number information and taking messages as well as other part time duties.

Improved Operating Procedure

The Laboratories next undertook studies of PBX attendant operating procedures which would meet these service objectives and be compatible with general design objectives of small size, attractive appearance, ease of operation, reasonable cost, and universality for application to various systems. Several alternative schemes were conceived and evaluated in cooperation with AT&T engineers. The operating procedure finally standardized contained elements from each of several of these alternative plans.

The studies leading up to this standardization brought out some very intresting problems. One such problem was the determination of the relative merits of automatically switching the call to and from the console versus having the call always associated with the console. Another was the use

INCOMING SIGNALS	KEY	SOURCE	DESTINATION
LISTED NUMBER CALL	dark	flashes once per second	dark
DIAL "O" CALL	dark	flashes twice per second	dark
RECALL	dark	flashes twice per second	dark
SUPERVISORY SIGNALS			
ATTENDANT ANSWER	lighted	lighted	dark
CALLED STATION BUSY	lighted	lighted	flashes once per second
CALLED STATION BEING RUNG	lighted	lighted	winks once per 2 seconds
ATTENDANT RELEASE DURING RINGING	dark	lighted	winks once per 2 seconds
ATTENDANT RELEASE DURING CAMP-ON	dark	lighted	flashes once per second
STATION ANSWER WITH ATTENDANT CONNECTED	lighted	lighted	lighted
STATION ANSWER WITH ATTENDANT RELEASED (DIRECT TRUNK)	dark	lighted	lighted
STATION ANSWER WITH ATTENDANT RELEASED (SWITCHED LOOP)	dark	dark	lighted
STATION ANSWER WITH LOOP HELD	winks once per 2 seconds	lighted	lighted

LEGEND

☐ LAMP LIGHTED STEADILY   ▨1 LAMP FLASHES ONCE PER SECOND   ▨ LAMP WINKS ONCE PER 2 SECONDS

▨ LAMP DARK   ▨2 LAMP FLASHES TWICE PER SECOND

CONSOLE OPERATION

SOURCE LAMP FLASHES TO INDICATE INCOMING CALL;
↓
ATTENDANT OPERATES PUSHBUTTON KEY TO ANSWER;
↓
ATTENDANT COMPLETES CALL BY DIALING

757A PBX 701B PBX NO. 101 ESS OR NO. 5 CROSSBAR SWITCHING EQUIPMENT — PUSH BUTTON KEY, KEY, SOURCE, DESIGNATION, DIAL AND CONTROL KEYS — CONSOLE

DIRECT TRUNK OPERATION

PBX SWITCHING EQUIPMENT — ATTENDANT TRUNKS, CENTRAL OFFICE TRUNKS — TO CENTRAL OFFICE — CONSOLE

SWITCHED LOOP OPERATION

PBX SWITCHING EQUIPMENT — TRUNKS — CALL DISTRIBUTION — LOOPS — TO CENTRAL OFFICE — CONSOLE

This table summarizes the lamp signals for the new Universal Console. At right, general call handling procedures and a comparison of the two basic means of connecting calls to the consoles.

of various apparatus elements, such as locking versus nonlocking keys. A third involved the choice of a signaling medium for displaying supervisory information to the attendant.

Solving Standardization Problems

The basic operating features as devised appeared to be reasonable and achievable for PBX attendant consoles associated with the various systems under consideration. However, before proceeding with actual development, Bell Laboratories engineers devised a means of simulating various operations. Consequently, a model console was constructed and connected to a device designed to simulate the PBX switching system. This equipment enabled systems engineers to show the operating characteristics of a working console for study and demonstration purposes.

Two new switching systems (the 757 PBX and the 101 Electronic Switching System) have been designed and the Bell System's old faithful 701 PBX and No. 5 crossbar central office (RECORD, October, 1962) have been modified to provide CENTREX and other new service features. The attendant facilities of each of these systems op-

erate according to the standard PBX attendant operating procedures. Minor deviations from the standards have occurred in a few cases where complete uniformity would have placed an undue economic burden on a particular system. For the most part, however, the objective has been achieved of keeping the attendant operation the same, regardless of which dial PBX is used.

The actual operation of the console is of interest. When a call requires attendant assistance, a lamp flashes on the console and the attendant answers by operating the associated nonlocking pickup key (pushbutton). To complete the call the attendant dials or keys the number of the desired called party. Tones and lamp signals keep the attendant informed of the progress of the call so that she can judge when further assistance is needed.

Each pickup key is illuminated and has two additional supervisory lamp panels — a green source lamp and a white destination lamp. The key lamp provides supervisory information relating to the attendant's association with the particular call; the source and destination lamps provide supervisory signals relating to the calling and called parties, respectively. Three different

Miss Coyne and R. J. Braund discuss key arrangements for an experimental PBX console.

operation (see diagram on page 239.), each trunk coming in from the exchange network is terminated in an illuminated pushbutton and associated source and destination lamps on an attendant console. A number of attendant trunks, also individually terminated in pushbuttons and associated supervisory lamps, are provided for dial "O" and other assistance calls.

In the case of switched-loop operation fewer attendant's pushbuttons are required. These pushbuttons are associated with common control circuits called loops instead of with individual trunks. These loops are brought into the connection somewhat like senders or other common control dial switching equipment in that they are associated with each call only long enough to do their job; then they become available for another call. Calls are switched to pushbutton-terminated attendant loop circuits only when attendant handling is needed and can be automatically released when the called party answers. Calls stay on loop circuits only so long as the attendant's help is needed, while directly-terminated trunk calls remain associated with the console for the entire conversation time.

Economical Production Features

In the design of the universal console, a number of factors led us to follow the general styling of the CALL DIRECTOR set. For one thing, this design has been found to be an attractive complement to modern business office decor. Its unitized construction with plug-in components facilitate variations in capacities and operating features. Its molded plastic cover could readily be made available in a variety of colors to suit the particular customer's tastes. Futhermore, by using this basic design for the universal console, some of the CALL DIRECTOR set's component parts could also be employed. Since these components are manufactured in large quantities, this tended to reduce the cost of the console.

The universal console has been made available in two sizes and four colors (grey, green, white and beige). The capacity of the smaller 1-type telephone console is 12 pickup buttons, while the larger 2-type can accommodate up to 30. The keys, lamps, dials and other components are arranged in uniform size plug-in units so that each of the two basic console models can accommodate some variation in capacity and features. Either a matching plug-in handset or standard operator's head telephone set may be used.

It is expected that within a few years the universal console will be as familiar a sight in business establishments as the cord switchboard is today.

flashing rates are used to indicate the type of call involved and the status of each of the connected parties. (See chart on page 239.)

For example, if someone were to call the listed telephone number of a business firm served by the universal console, a green source lamp would flash once per second. When the attendant has depressed the associated pickup key, the key lamp and source lamp would both light steadily and the attendant could talk to the calling party. If the caller desires to speak to one of the PBX extension telephones, the attendant would operate a common start key and dial or key the desired extension number. When the called station is being rung, the attendant would receive the usual audible ringing tone as well as a distinctive ringing signal on the destination lamp.

By using various common control pushbuttons on the console, the attendant may perform such functions as releasing a connection to a busy or "don't answer" station, flashing a toll operator, or splitting the transmission connection to announce calls privately. With some dial switching systems, a TOUCH-TONE dial or other pushbutton type dial may be used in place of the familiar rotary dial.

The universal console is arranged for either of two basic methods of operation called "direct trunk" and "switched loop." With direct trunk

C. Schneider

Actual Size

A Miniature Latch-In Relay
For the Telstar Satellite

THE TELSTAR SATELLITE circuits required nine two-transfer relays of small size and high reliability to perform the desired switching functions. Little power was available to operate these relays and no power could be dissipated to hold them operated. Thus the design had to be sensitive, and capable of being latched in either of two operated positions.

A bistable magnetic latch-in relay is ideally suited to this application. In a relay of this type, the armature, after being switched to either of two operated positions depending upon polarity of the applied voltage, is held operated by a permanent magnet when power is removed. When the winding is energized at reverse polarity, the armature moves to its other operated position and again is latched magnetically.

Since reverse polarity was not available in the Telstar satellite, the relay had to be equipped with a center-tapped winding for operation in either direction. Thus, only ½ of the available winding space could be utilized to meet the sensitivity requirements. The circuit requirement was that the relay should operate within the duration of a capacitor charging pulse at 10-16 volts dc.

The relay also had to be rugged to withstand the vibration, shock and acceleration of missile launching.

When the need arose for this relay; the Switching Apparatus Department was engaged in developing a high reliability, microminiature, bistable, magnetic, latch-in relay.

This design employed the same basic structure as a neutral sensitive relay, which the Western
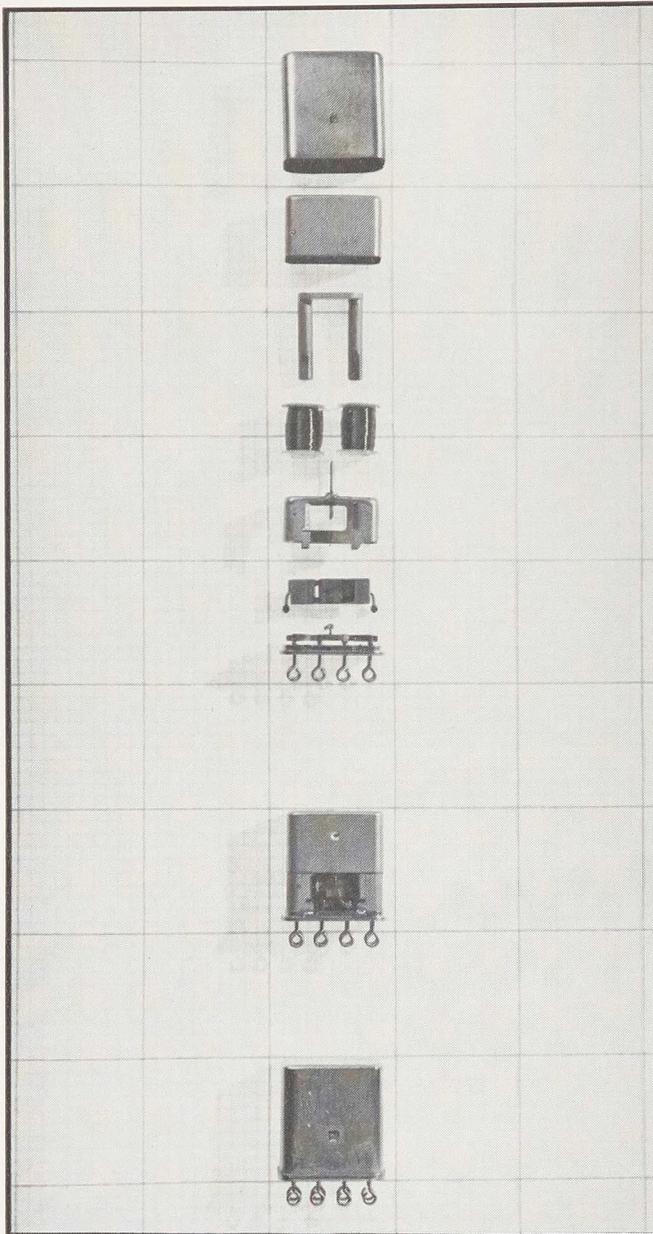
Component parts of the miniature latch-in relay are shown at left in various stages of assembly. Within the armature chamber (upper right), a permanent magnet provides latching and carefully
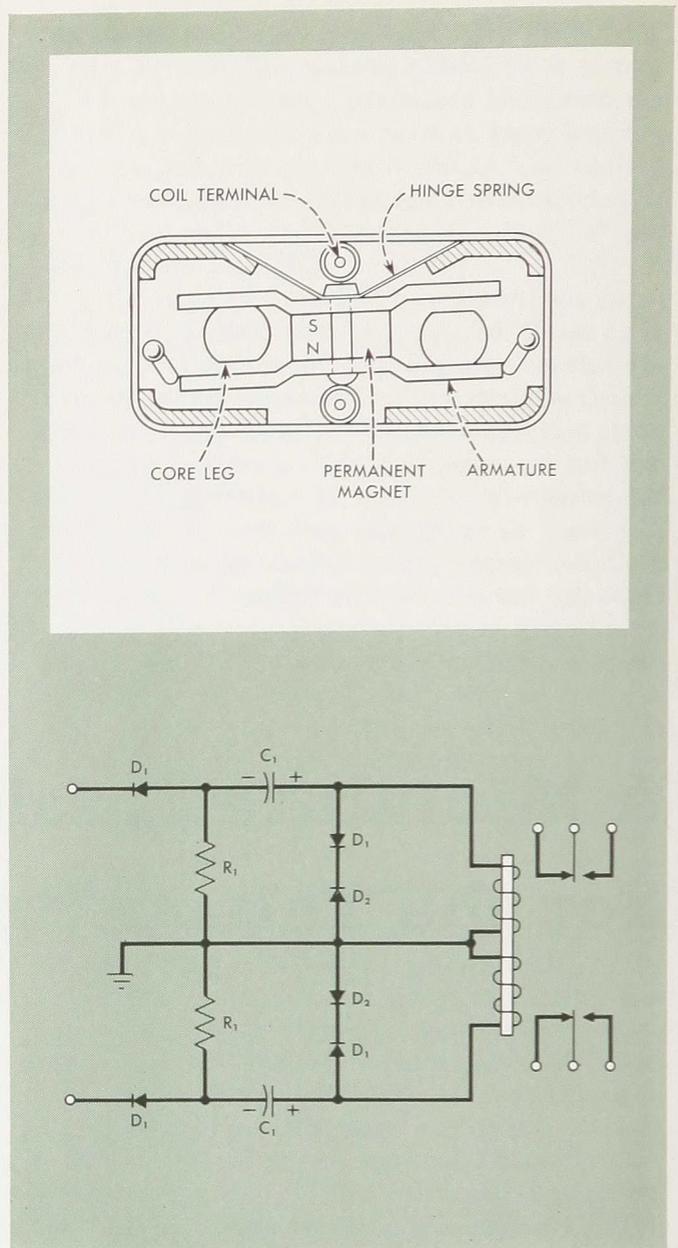
balanced construction prevents false action in a dynamic environment. The simulated Telstar circuit below illustrates how relay action is triggered. Center tapped winding and relay contacts are at right.

Electric Company had been producing at Winston-Salem for use in military missiles. Experience with thousands of these relays manufactured and installed in military systems over a period of several years had established that the design was extremely reliable under environments similar to those to be encountered in the satellite.

The bistable design of the adapted relay utilized most of the standard parts of the neutral relay production design. New parts were required only for the armature system. The design also was readily adaptable to the Western Electric

Company's procedures for assembly, cleaning, baking, evacuating, and hermetic sealing in a nitrogen-helium atmosphere. These circumstances made it possible to provide relays of proven reliability with a minimum amount of new development effort.

Each relay is equipped with a rotary armature which is dynamically balanced about its axis of rotation, thereby offering maximum resistance to motion that might be induced by the external forces of vibration, shock and acceleration. A "V" shaped hinge spring supports the armature, main-

taining the balance feature and avoiding the frictional effects inherent in conventional sleeve and trunnion bearings. A permanent magnet which provides the latch-in feature is mounted centrally between the armature legs. Sensitivity may be adjusted by magnetically varying the strength of this magnet in the completely assembled relay.

The contacts, sealed in a separate chamber, are isolated from any organic materials and vapors which could accelerate contact erosion or promote the formation of insulating films on contact surfaces. Bifurcated contact springs and gold alloy contacts provide additional assurance of contact reliability.

The winding, consisting of two coils, one on each leg of a one-piece, "U"-shaped core, is encapsulated in a separately sealed chamber. The one-piece core formed from round stock eliminates reluctances caused by joints, thereby offering high sensitivity and maximum efficiency of the magnetic circuit.

The latch-in relay used in the satellite weighed 21 grams and measured 0.82 by 0.45 by 1.2 inches exclusive of mountings. Each was required to pass the following environmental screening tests:

1. Temperature extremes ranging from —55 degrees C to +85 degrees C.
2. Vibration over a range of 5 - 17.8 cps at 0.25 inch amplitude and 17.8 - 2000 cps at 10 G.
3. Shocks of 60 G severity and 11 millisecond duration.
4. Acceleration up to 60 G.

Throughout the environmental tests the relays were measured for stability of electrical characteristics; i.e. operate current, contact resistance, insulation resistance and voltage breakdown. During vibration, shock and acceleration the contacts were monitored to determine that there was no false opening or closure in excess of 10 microseconds duration.

The relay provided for the Telstar satellite represents the application of a basic design to a particular set of requirements. The design can be adapted to a variety of circuit and environmental conditions. Sensitivity will depend, however, upon the severity of the application and whether operation with a single or double coil is desired. Where dynamic conditions are not too severe, and the full winding space is utilized, sensitivity will be approximately 10 - 15 milliwatts at 25 degrees C.

Although only nine relays are used in each Telstar satellite, approximately 150 relays were manufactured and tested. The feasibility of manufacturing this type of relay on a production basis has thus been demonstrated.

Two New College Science Films Available

Bell Telephone Laboratories has announced the availability of two new college science films, one in the field of physics and the other in physical chemistry. The films, entitled, "Principles of the Optical Maser" and "Physical Chemistry of Polymers," were prepared at Bell Laboratories under the direction of scientists who are acknowledged authorities in their fields. Both films are available on free loan from local Bell Telephone business offices throughout the country.

"Principles of the Optical Maser" (16mm, sound, color, 30 minutes) presents the fundamental physical concepts of the optical maser (laser). Dr. C. G. B. Garrett of Bell Telephone Laboratories, with the aid of demonstrations and animation, describes the optical maser as a generator of electromagnetic energy in the optical frequency range, having many similar qualities to standard radio and microwave oscillators. Maser action is made clear by analogy to the already familiar concept of sound waves. The film concludes with laboratory demonstrations of the principal types of gas and solid-state optical masers.

"Physical Chemistry of Polymers" (16mm, sound, color, 21 minutes) is a lecture-demonstration by Dr. F. H. Winslow of the Polymer Research Department, concerning the effect of molecular size and shape, the way the molecules pack together, and the forces between molecules on the physical properties of polymers. Dr. Winslow uses numerous experiments and demonstrations, one of which visually simulates the effects of thermal agitation on rubber molecules.

Bell Laboratories has also produced a two-record album entitled "The Science of Sound," containing demonstrations of acoustic phenomena.

The films, like all educational aids from Bell Telephone Laboratories, are for classroom and instructional purposes and contain no advertising.

Errata:

Optical Properties
of Chromium Tribromide

The May issue of the RECORD carried a news item on page 210 describing a discovery by Laboratories scientists that light passing through a crystal of chromium tribromide is strongly affected by the magnetic properties of the crystal. Using these properties, they obtained extremely large magnetic rotations of polarized light. In so doing, they modulated light at higher frequencies than ever before.

Unfortunately, in our presentation of the item, the wrong drawing was used to illustrate the magnetic rotation of light caused by the crystal. The proper drawing, showing the microwave-optical experiments in which modulation was achieved, is reproduced at the right.

The drawing shown last month illustrated another effect imposed by chromium tribromide on light passing through it. During the course of their work on magnetic rotation, the investigators, J. F. Dillon, Jr., of the Solid-State Electronics Research Laboratory, H. Kamimura of the Semi-conductor Research Laboratory, and J. P. Remeika of the Physical Research Laboratory discovered that visible light passing through thin sections of unmagnetized chromium tribromide was diffracted by the domain structure of the crystal. In fact, the effect was so pronounced that it was impossible to make meaningful measurements of light transmission of demagnetized samples at temperatures below its Curie point.

This diffraction, according to the investigators, results from the fine-grained domain structure possessed by chromium tribromide in its demagnetized condition below the Curie point. These domain dimensions are comparable to the wavelength of visible light, and the optical modulation which results constitutes a grating, which gives rise to readily-observed diffraction rings—typically a red central spot and a green diffraction ring, as illustrated in the May issue. The domains can be removed by magnetic saturation.

Study of the rings provides a new technique for the investigation of domain structure.
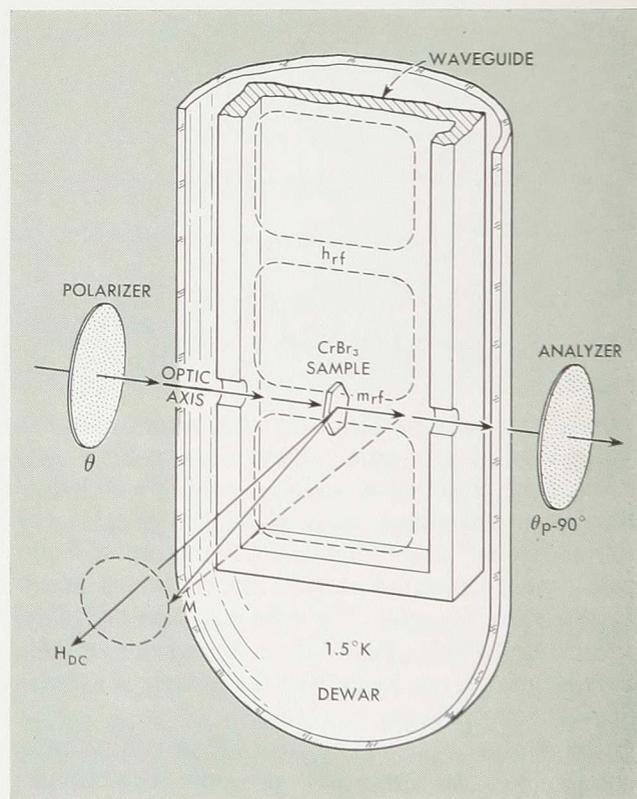
Chromium tribromide sample, mounted in a waveguide immersed in liquid helium. At ferromagnetic resonance, polarized light passing through the sample is rotated by an amount which is modulated at the microwave frequency.

news in brief

Honorary Degrees Conferred

James B. Fisk, President of Bell Laboratories, was recently awarded an honorary Doctor of Science degree from New York University. He was cited for having combined "a distinguished career in industrial research with outstanding service to our nation in the field of science."

Walter H. Brattain of the Surface Physics Research Department at Murray Hill, N. J., was awarded an honorary Doctor of Science degree from Gustavus Adolphus College. Mr. Brattain won a Nobel Prize in Physics in 1956.

Dr. William O. Baker received an honorary Doctor of Science degree from the University of Pittsburgh. Dr. Baker is Vice President for Research at the Laboratories and past member of the President's Scientific Advisory Committee.

The Polytechnic Institute of Brooklyn awarded an honorary Doctor of Science degree to Dr. John R. Pierce, one of the early leaders in developing the Telstar communications satellite. Dr. Pierce is Executive Director for Research of the Communications Systems Divisions at the Laboratories.

Robert H. Shennum, Head, Satellite Design Department, received an honorary Doctor of Philosophy degree from his alma mater, Montana State College. The college conferred the degree for Mr. Shennum's work on the Telstar project.

Mrs. Elizabeth Wood was awarded an honorary Doctor of Science degree from Wheaton College. Mrs. Wood has been a member of the Technical Staff on Crystal Research at the Laboratories in Murray Hill, N. J., since 1943.

Book Published By Labs Members

"Printed and Integrated Circuitry" by Tom D. Schlaback and Don K. Rider of the Chemical Research Laboratory has just been published by the McGraw-Hill Publishing Company.

The new book presents the fundamental aspects of printed and integrated circuitry from the viewpoint of the materials and processes involved. The authors provide a unified treatment of each of the diverse disciplines— mechanical and electrical engineering, graphic arts, chemistry, metallurgy, ceramics, — affecting the materials engineering, design, manufacture and evaluation of these types of circuitry.

Many recent advances, such as integrated circuitry, modern packaging and printed microwave applications are also included.

New Transatlantic Telephone Cable to Connect U.S. with England

Laying operations on the first transatlantic telephone cable to link the U. S. directly with England began in early June off the coast of New Jersey. The single cable system, that will stretch 3,500 nautical miles from Tuckerton, N. J. to Widemouth in Cornwall, England, is a joint undertaking of the Long Lines Department of AT&T and the British Post Office.

Two cable ships are taking part in placing this new system. *HMTS Alert*, a British Post Office ship, has placed the shore-ends and the first section. The *C.S. Long Lines*, world's newest and most modern cable ship, will put down about 3,000 miles of the deep-sea cable. This will be the first cable-laying assignment for *C. S. Long Lines*.

The crew of the *Alert* floated the cable-end ashore at Long Beach, N. J. The cable was spliced to the land section that crosses Long Beach and Barnegat Bay to the cable system's underground terminal in Tuckerton. The *Alert* then sailed east, playing out the 638 miles of the first section.

The $47,000,000 cable system is scheduled for service in the fall. It will be able to carry 128 simultaneous conversations—more than triple the capacity of the first transatlantic telephone cable when it was opened for service in 1956.

President Nominates Former Labs Man

President John F. Kennedy announced recently he will nominate Brockway McMillan, present Assistant Secretary of the Air Force for Research and Development, as Under Secretary of the Air Force to succeed Joseph V. Charyk, who has resigned.

Mr. McMillan has been assistant secretary since June, 1961 coming to this office from Bell Laboratories where he was Director of Military Research. Prior to that, he served as Assistant Director for Systems Engineering with the Laboratories.

The Under Secretary-designate has been a consultant to a number of offices in the Department of Defense during the past several years. Included in his service were positions with the Weapons System Evaluation Group, the Office of Defense Mobilization and the Office for Science and Technology.

Mr. McMillan is a graduate of Massachusetts Institute of Technology, with a Ph.D. in mathematics. He is past president of the Society for Industrial and Applied Mathematics, a fellow of the Institute of Radio Engineers and a member of the American Mathematical Society, Mathematical Association of America, Institute of Mathematical Statistics, Operations Research Society and the American Association for the Advancement of Science.

HIGHLY SENSITIVE QUARTZ CRYSTAL THERMOMETER

Temperature changes as small as 1/100,000 degree C can now be measured by a quartz thermometer that incorporates recent advances in transistor circuit and crystal plate design. The thermometer is capable of making the most sensitive measurements of any to date. It detects small temperature changes by corresponding frequency changes in a precision oscillator controlled by the quartz crystal thermometer.

Developed by W. L. Smith and W. J. Spencer of the Components and Solid-State Device Laboratory, the thermometer has measured small temperature changes in ovens used to improve the frequency stability of quartz crystal-controlled oscillators. The thermometer operates without damage from near liquid helium temperatures (-454 degrees F) up to 212 degrees F. Thus, the device can measure the exact temperature at which many materials change phase, for example, from a solid to a liquid state. The thermometer can also detect whether a material absorbs or gives off heat during a phase change. In addition, it can be used as a reference standard for the comparison of other types of precision thermometers.

NEW ENCODER USES THIN MAGNETIC FILM

A new type of analog-to-digital encoder consisting only of windings and a thin magnetic film has been designed. The new device is faster than transistor encoders and in principle more reliable than vacuum tube encoders. It is capable of fully encoding an analog current into a five-bit binary word every tenth of a microsecond.

The new encoder, designed by W. A. Barrett, of the Solid-State Device Laboratory, and T. R. Long and J. E. Schwenker, of the Communications Systems Research Laboratory, uses a thin magnetic film plated on a beryllium copper wire. The film has a preferred or "easy" direction of magnetization along the wire's axis. The encoder's high operating speed depends upon the rotational switching of the magnetic film. The direction of rotation is determined by the intensity of the analog current. The rotating magnetization induces voltages in a series of coils along the wire. The binary information is contained in the polarity of these voltages.

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

Abbott, H. H., Martin, C. R., Previte, R. A., Walsh, H. J., Walsh, J. G.—*Private Branch Exchange Telephone System*—3,087,025.

Ashkin, A.—*Parametric Amplifier*—3,085,207.

Buchsbaum, S. J.—*Plasma Heating*—3,085,058.

Becker, J. A.—*Radiant Energy Translating Device*—3,088,029.

Bobeck, A. H.—*Magnetic Memory Devices*—3,083,353.

Brooks, C. E., O'Neill, H. J., and Stover, W. M.—*Circuit for Detecting and Restoring Off-Normal Selectors*—3,086,084.

Burlin, J. N., Dreyfus, H., Seretny, S. E., and Smith, E. M.—*Data Telecommunication Subset*— 194,874.

Cath, P., and Hill, L. O.—*Telephone Pay Station*—3,086,081.

Chapin, D. M., and Newby, N. D.—*Remote Meter Reading System*—3,083,357.

Clemons, D. G.—*Magnetic Memory Construction and Circuits*—3,084,336.

Cook, J. S., and Louisell, W. H.—*Noise Elimination System for Parametric Amplifiers*—3,086,176.

Cook, J. S., Louisell, W. H., and Quate, C. F.—*Noise Reduction System for Parametric Amplifiers*—3,087,119.

Cook, R. S.—*Apparatus for Applying a Dispersion Coating to a Surface, Such as a Tape*—3,077,859.

Cutler, C. C.—*A High Efficiency Frequency Modulation System for Television and Speech Signals*—3,084,327.

Davey, J. R., Engel, J. S., and Flavin, M. A.—*Linear Automatic Volume Control System*—3,080,524.

DeLoach, B. C.—*Low Noise Amplifier Input Network*—3,079,569.

Devlin, G. E., and Schawlow, A. L.—*Optical Maser Elements*—3,087,374.

Dreyfuss, H., see Burlin, J. N.

Dreyfuss, H., Herrington, H. W., and Logan, T.—*Side Mounting Telephone Set*—195,129.

Embree, M. L., and Montone, L. J.—**Direct Reading Time-Interval Measuring Set*—3,080,522.

Engel, J. S., see Davey, J. R.

Feder, H. S.—*Switching Circuit* 3,086,083.

Fischer, W. A.—*Telephone System Including Coin Control Circuits*—3,086,082.

Flavin, M. A., see Davey, J. R.

Fuller, C. S.—*Treatment of Gallium Arsenide*—3,085,032.

Garrett, C. G. B., and Kaiser, W. K.—*Terbium and Cerium Activated Calcium Flouride Optical Maser Material*—3,079,347.

Gibbs, W. B., Wahl, C. V., and Wenny, D. H., Jr.—**Processing of Soft Magnetic Materials*—3,086,280.

Godfrey, J., and Thurber, E. A.—*Protective Element for Hermetically Enclosed Semiconductor Devices*—3,083,320.

Goetz, F. M.—*Electronic Binary Counter and Convertor*—3,076,601.

Goodall, W. M.—*Timing for Regenerative Repeaters*—3,085,200.

Hall, W. G.—*Unanimity Memory Circuit Utilizing Transistor Resistor Logic Means*—3,081,407.

Handelman, E. T.—*Fabrication of Semi-conductor Devices*—3,085,033.

Herrington, H. W., see Dreyfuss, H.

Hershey, H. J.—*Centrifugal Governor*—3,080,020.

Hewitt, W. H., Jr.—*Nonreciprocal Rectangular Wave Guide Device*—3,076,946.

Hill, L. O., see Cath, P. G.

Hutchison, P. T.—*Communication System Using Polarized Waves and Employing Concentric Waveguides to Control Transmitter - Receiver Interaction* — 3,086,203.

James, D. B.—*Analog-To-Digital Encoder*—3,087,150.

Kaiser, W. K., see Garrett, C. G. B.

Ketchledge, R. W.—*Coincident Flux Memory Device*—3,078,447.

Lee, C. A., and White, H. G.—*Fabrication of PN Junction Devices*—3,082,127.

Linden, S. L.—*Electroluminescent Storage Systems*—3,085,231.

Logan, B. F., Jr., and Schroeder, M. R.—*Compatible Single-Sideband Transmission*—3,085,203.

Logan, T., see Dreyfuss, H.

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

Mallery, P., and Pupprecht, E. G. *Control Circuit*—3,083,328.

Marcatili, E. A. J.—*Waveguide Elbow*—3,087,130.

Marcatili, E. A. J., and Ring, D. H.—*Crosstalk Reduction In Plural Carrier Multiplex Systems*—3,084,223.

Martin, C. R., see Abbott, H. H.

Mathews, M. V., and Miller, J. E.—*Vocoder Apparatus*—3,083,266.

Mattke, C. F.—*Desk Telephone*—D 195,086.

Mayo, J. S.—*Pulse Repeater Marginal Testing System*—3,083,270.

McConkey, J. F., Jr., and Van Slooten, D. J.—*Cushion Mounting for Electrical Apparatus*—3,087,095.

McLean, D. A.—*Film Forming Metal Capacitors*—3,079,536.

Meinken, R. H.—*Encoder*—3,081,452.

Meyers, S. T.—*Remote Testing Arrangement*—3,084,231.

Miller, J. E., see Mathews, M. V.

Miller, S. E.—*Spurious Mode Suppressing Wave Guide*—3,078,428.

Mills, J. K.—*Transistor Oscillator Employing Current and Voltage Feedback*—3,078,422.

Montone, L. J., see Embree, M. L.

Muller, J. F.—*Electromagnetic Drive Mechanism*—3,080,492.

Newby, N. D., see Chapin, D. M.

Niederer, O. C.—*Cable-Handling Equipment*—3,086,754.

O'Neill, H. J., see Brooks, C. E.

Pfann, W. G.—*Method of Con-

*Joint with Western Electric Company, Incorporated

trolling Liquid-Solid Interfaces by Peltier Heat—3,086,857.

Pferd, W.—*Ticket Operated Telephone Set*—3,087,018.

Pohl, K. H.—*Pressure Piercing Terminal Connector*—3,078,434.

Powers, R. E.—*Transmission Regulator Utilizing Passive Variable-Losser Which is Controlled via Circuit Having Expansion Network, by Signal Level*—3,086,179.

Previte, R. A., see Abbott, H. H.

Pupprecht, E. G., see Mallery, P.

Quate, C. F., see Cook, J. S.

Raisbeck, G.—*Self-Timed Regenerative Repeater for PCM*—3,086,080.

Remeika, J. P.—*Process of Grow-Single Crystals*—3,079,240.

Ring, D. H., see Marcatili, E. A. J.

Roberts, A. W.—*Logic Circuitry*—3,084,861.

Ross, I. M.—*Semiconductive Switch*—3,078,196.

Rowen, J. H.—*Electromagnetic Wave Generation Utilizing Electron Spins in Magnetic Materials*—3,087,122.

Sandberg, I. W.—*Multibranch Circuits for Translating Frequency Characteristics*—3,081,434.

Savadelis, I. C.—*Ohmic Contacts to Semiconductor Devices*—3,087,100.

Schawlow, A. L., see Devlin, G. E.

Schroeder, M. R., see Logen, B. F., Jr.

Schulte, H. J., Jr.—*Sequential Circuits Employing Magnetic Elements*—3,086,124.

Seretny, S. E., see Burlin, J. N.

Smith, E. M., see Burlin, J. N.

Stover, W. M., see Brooks, C. E.

Tanenbaum, M.—*Ferrimagnetic Crystals*—3,085,981.

Tanenbaum, M.—*Uniform N-Type Silicon*—3,076,732.

Tenten, R. C.—*Delay Apparatus Using Accoustic Line with Magnetostrictive Input and Magnetoresistive Output*—3,080,537.

Thurber, E. A., see Godfrey, J.

Van Slooten, D. J., see McConkey, J. F., Jr.

Vogt, I. M.—*Ferroelectric Counting Circuit*—3,082,409.

Wahl, C. V., see Gibbs, W. B.

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Walsh, J. G.—*Private Branch Exchange Telephone System*—3,087,024.

Walsh, J. G., see Abbott, H. H.

Weller, D. C.—*PCM Telephone Signalling*—3,083,267.

Wenny, D. H., Jr., see Gibbs, W. B.

White, E. W.—*Pulse Generator Circuit Employing Diode and Inductor to Reduce Cycle Time* 3,080,489.

White, H. G., see Lee, C. A.

Wintringham, W. T.—*Sum and Difference Stereophonic Transmission With Negative Feedback*—3,083,264.

Wittenberg, A. M.—*Electroluminescent Matrix and Access Device*—3,078,373.

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Yokelson, B. J.—*Ring Counter Employing NOR Stages with Parallel Inputs and Capacitive Interstage Triggering*—3,079,513.

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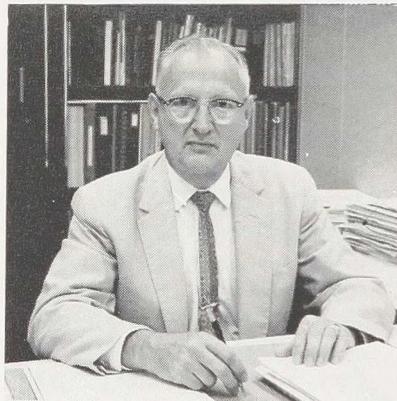
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