March 1960

Bell Laboratories RECORD

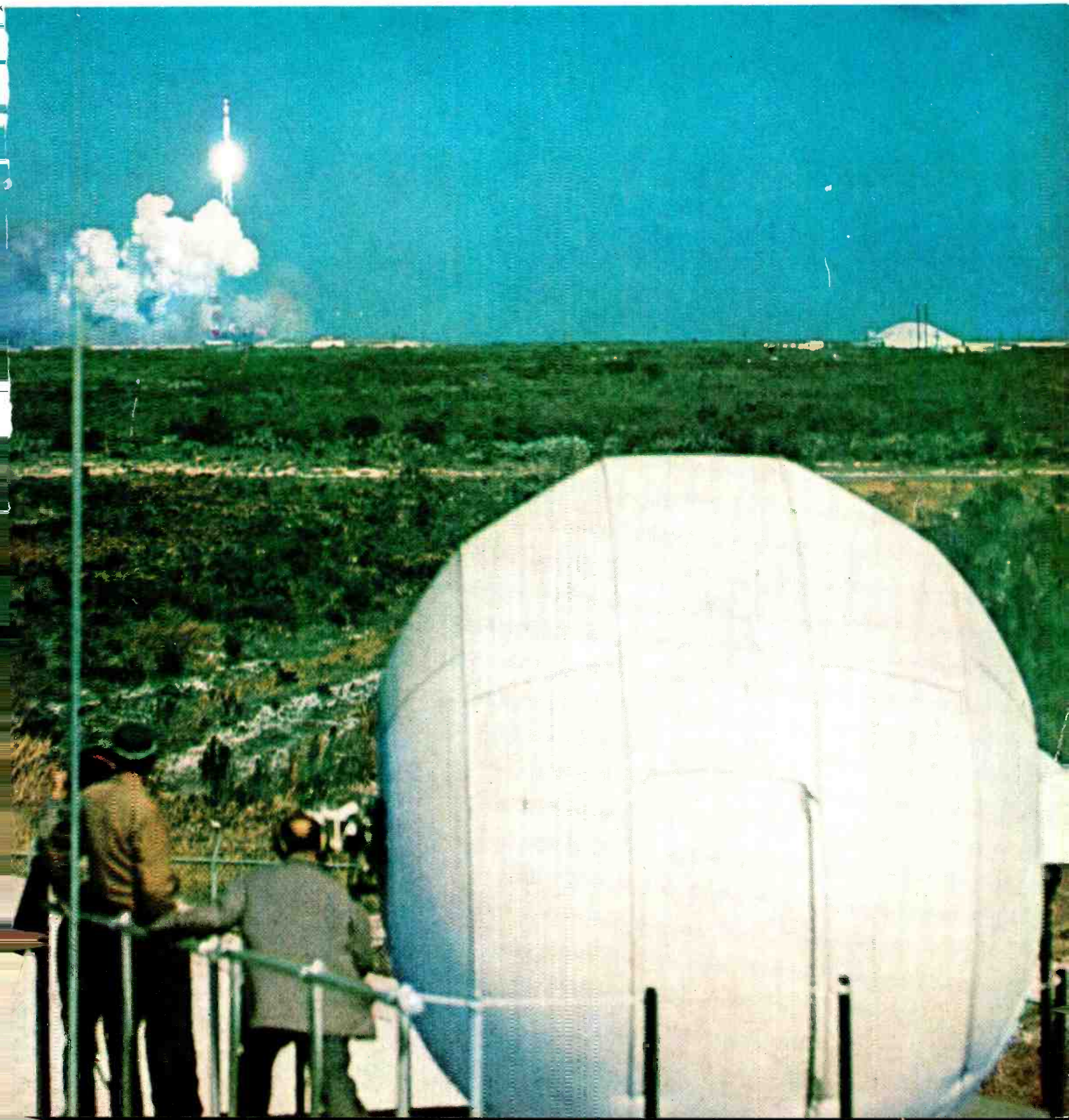
Push-Button "Dialing"

Semiconductor Reliability Studies

Magnetic Amplifiers

Measuring Line Level on Telephoto Systems

Audio Facilities for Recorded Announcements



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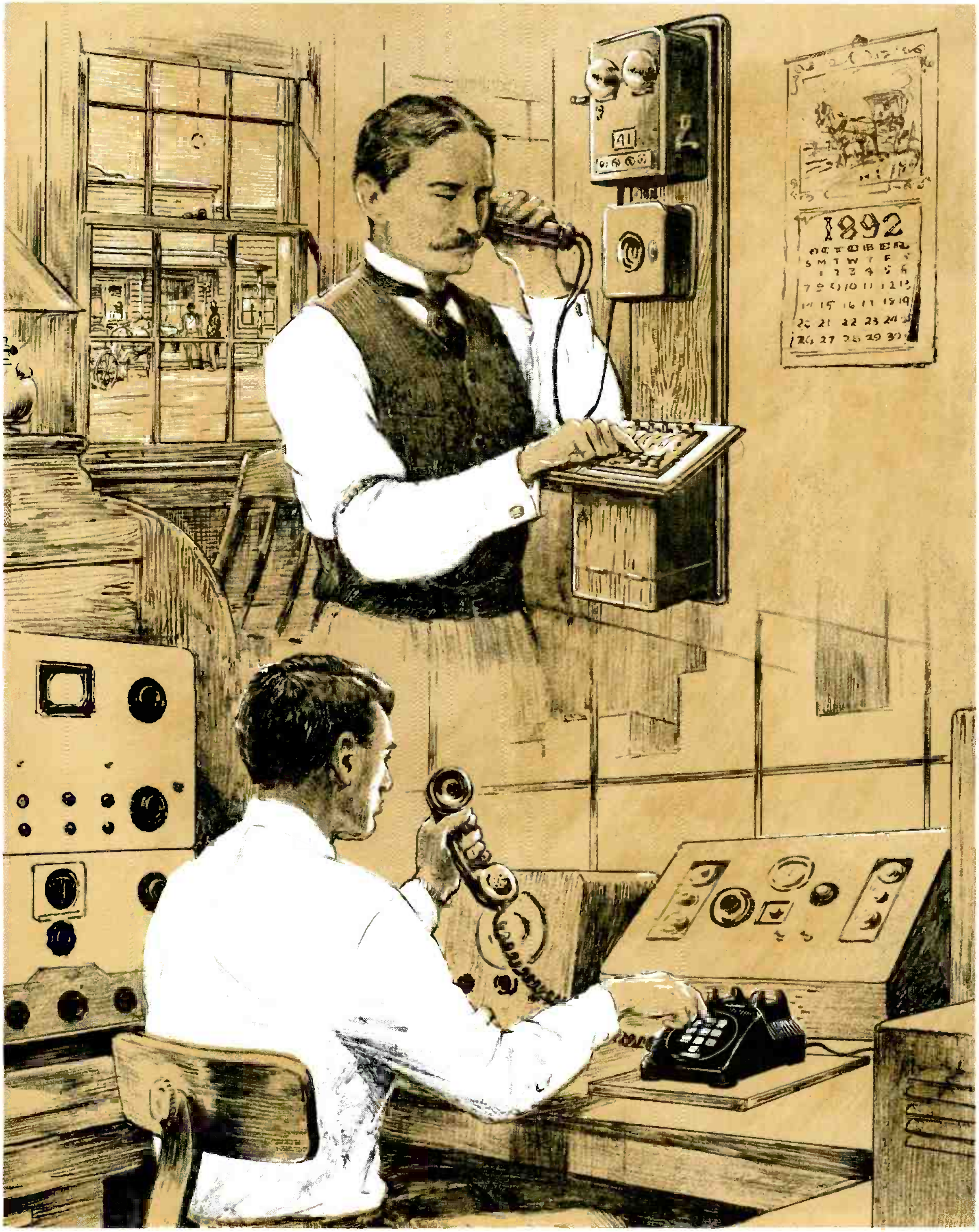
Contents

PAGE

Cover *The antenna of the Laboratories-developed command guidance system tracks the Titan missile from its launching pad in the first successful guided test flight of the huge Air Force ICBM. (See p. 109.)*



Push-button telephone in top sketch was the forerunner of the rotary dial. In 1892, customers used this key arrangement to send individually generated pulses to the first automatic exchange.

Today's version of the push-button telephone, now being developed at Bell Laboratories, sends a pair of distinct tones for each digit, and promises to make customer signaling easier and faster.

Push-button "dialing"—one of the most important concepts in future telephone service — has recently demonstrated its customer appeal in two field trials. Interestingly, many of the firm bases for this very modern method of customer signaling go back to early telephony.

H. F. Hopkins

PUSH-BUTTON "DIALING"

For four months last year, 200 customers in Hamden, Connecticut, and a similar number in Elgin, Illinois, used telephones equipped with push buttons instead of dials. This field trial was, at least, a partial implementation of an objective that has been sought over 60 years of telephone development. For even in the very early days of telephony, pioneer engineers recognized the need for automatic switching systems and, more importantly, for ways of easily and economically directing such systems from the calling station. Inventions aimed at the replacement of the well-known telephone dial have cropped up fairly regularly since before the turn of the century. Now, with the development of newer solid-state devices, a promising solution to simplified customer control of switching machinery appears within reach.

The results of this important trial of push-button signaling from the customer's telephone indicate that the development of push-button station apparatus may become increasingly important. With this fact as its basis, this article introduces some of the important concepts that underlie push-button signaling.

Very early in its history, the tremendous potential for growth of the Bell System became evident to those who were guiding its development. In his book, *History of the Telephone*, published in 1910, Herbert N. Casson wrote: "Already the Bell System has gone far in this direction by organizing what might fairly be called a 'Foresight Department' . . . Even in the city of New York, one half of the cable ducts are empty, in expectation of the greater city of eight million population which is scheduled to arrive in 1928." Telephone planners soon recognized that if the number of telephones increased at the expected rate, the problem of hiring and training enough operators to handle traffic manually would be just about impossible.

There were many who opposed the proposed solution to this problem—automatic switching systems with "customer calling". They predicted that such systems would be too complicated, and therefore unreliable and uneconomical; too expensive; and too inflexible, and therefore unadaptable to special services. Further, oppositionists felt that automatic switching was wrong from the customer's viewpoint. "The public will not tolerate doing its own operating," they said.

In spite of these pessimistic predictions, the first "step-by-step" system of automatic switching was put in service in La Porte, Indiana, in

1892. The stepping switches in this system were actuated directly by pulses generated by the customer at his station (progressive control). By 1908, step-by-step exchanges were in use in about 70 cities and towns in the United States.

Prior to 1896, customers on these automatic systems called the desired number by pressing push buttons. These buttons or more precisely, keys, can be seen on the early instrument in the sketch on page 82. On some versions of this early telephone there were three buttons on the "calling device," as it was commonly called. The button on the left was labeled HUNDREDS, the middle one TENS, and the one on the right UNITS. To call 143, for example, the customer would push the left-hand button once, the middle one four times, and the right-hand one three times. Customers using this system made many calling errors. Consequently, in 1896, a "contact-making machine," now commonly called a dial, was substituted for the push buttons. These governor-controlled dials were similar in principle to those in use today.

Another important advance, in both automatic switching and push-button signaling, came in 1910. This was the year the Western Electric Company developed the panel system of automatic switching. A semi-automatic system of 450 lines, the first switching system to use "common control," was set up for trial at what is now the New York location of Bell Laboratories. In 1914, a complete panel system of this type was installed in Newark, New Jersey.

With the semi-automatic versions of panel, the customer told the operator the number he wanted, and she completed the call with push buttons. Each operator's position had five vertical rows, each with ten push buttons, or "keys." This arrangement permitted the keying of decimal numbers up to five digits long.

In 1921, the first fully automatic panel system was installed in Omaha, Nebraska. Here, the customers were provided with dials. An "automatic caller," with five preset levers and an actuating arm, was also used at this time.

Early Rotary Dials

The governor-controlled rotary dials developed for the early progressive-control systems were well suited to the pulse-handling speed of the stepping switches. Also, a rotary dial with finger holes of adequate size requires only reasonable and easily applied wind-up forces to generate the mechanical energy needed for controlled-speed pulsing contacts.

On the contrary, it is difficult to generate this energy mechanically with push buttons, because the shorter stroke available requires rather high mechanical forces. Suggestions for reducing the mechanical loss due to the governor, or for using escapement mechanisms and schemes other than friction governors, have not borne fruit.

Dials were further suited to early switching systems because the time required by the customer to search for a following digit, plus the time required to wind-up the dial preparatory

Mrs. Carole Rustako of the Laboratories demonstrates the first step in dialing SH-1, one of the office codes used in the Elgin trial. She is using an exploratory model similar to those used in the actual trials.

to pulsing, add up to a satisfactory interdigital interval for activating stepping-type switches. Although many improvements have been made in dial mechanisms over the years, the basic design adopted in 1896 has withstood the test of time as the soundest method of manually applying the energy to generate selected, timed pulses.

Things are changing in the Bell System, however, and the time has come to look seriously for more effective methods for customer signaling. There are now nearly 60,000,000 telephones in the System and about 55,000,000 of these use dials. Instead of restricting dialing to local calls, the Bell System is rapidly extending the convenience of dialing by instituting customer dialing of toll calls in many areas. The number of digits to be dialed for some of these toll calls may be as high as 14. Furthermore, the calling rate, particularly on toll calls, has increased materially.

New types of switching systems have also been developed. Systems like No. 5 crossbar are capable of establishing telephone connections at speeds far greater than those of older systems. The experimental electronic switching system (ESS) (RECORD, *October*, 1958), now called the electronic central office (ECO), opens up even greater potentials for high-speed calling devices. These factors, along with the current flood of push-button devices in other fields, conspire to make this an appropriate time to consider the introduction of push-button calling to Bell System customers.

Actually, Bell System toll operators have used push-button calling, or key pulsing, for some time. This system, using voice-frequency pulses, was introduced in toll service in about 1940. The arrangement uses a two-out-of-six frequency code. But because they are all in the voice-frequency band, the signaling frequencies can inadvertently be imitated by speech or other sounds transmitted over the trunk. Therefore, special operating procedures have been adopted to prevent interference with the signaling process. These special procedures cannot practically be imposed on the customer, however, and a more sophisticated system for protection against voice-frequency interference had to be invented before practical voice-frequency signaling could be introduced to customers.

Efforts in this direction, using various signaling schemes, have been tested and in some cases commercially used, both in this country and abroad. In Europe, push-button calling systems have been developed, using dc signals obtained from combinations of polarity checks from the two sides of a telephone line to ground. This method involves the use of diodes to maintain proper signal direction. A trial installation, employing a modification of this principle was made at the Laboratories in 1943. Because of the possible inductive effects from extraneous sources, however, a grounded system of this kind is generally considered undesirable for the Bell System.

Telephones used in the 1948 trials of push-button calling. Pencil shows transducer that picks up tones from plucked reeds (fixed to the base behind the key levers). Note arrangement of buttons.

There have also been tests of a push-button pulsing scheme based on the dc voltage drop in the customer's loop. This system creates a problem in voltage regulation, and does not appear well suited for use in a large and complex telephone network. More recently, a pulse-position code with six positions was suggested and evaluated by the Switching Research Department in the early 1950's (BSTJ, *May*, 1952).

Station devices for generating dial pulses in a decimal code, similar to those produced by existing rotary dials, have also been investigated. Some of these devices were mechanical and some were electronic. Such schemes require waiting periods for both the transmission of the pulse train and the inter-digital spacing, and thus require self-discipline by the user. For high-speed systems, this self-discipline might be tolerable, but for the slower speeds demanded in current step-by-step switches, waiting would undoubtedly become a source of irritation to the customer.

The two-out-of-six frequency signaling system currently used by operators for toll keying is satisfactory from the standpoint of operating speed, but it requires improved pulse-receiving circuitry to guard against voice interference. Such circuitry has been developed, but the present analysis indicates that a new multifrequency signaling system has many advantages.

This new system — a four-by-four frequency scheme proposed by L. A. Meacham of the Station Development Department — seems to attain most of the objectives desirable in a push-button calling system for customers (BSTJ, *January, 1960*). A complete explanation of this system would itself take several articles. But briefly the proposed system uses one frequency from each of two bands (high and low) for each digit it transmits. The frequencies that are used minimize interference from harmonics. This permits instantaneous limiting in both frequency bands, and satisfactorily guards against possible voice interference.

To this point, we have been primarily concerned with the historical basis for push-button signaling and with some of the experimental and developmental efforts devoted to it. Because it has been broad and brief, this background has barely mentioned the most important parameter in any telephone system — the customer. This important consideration poses such questions as: Will customers like push-button calling? Can they learn to use it readily and accurately? Will "push buttoning" improve their service?

The Media Trial in 1948

To make a start on getting answers to such questions, Bell Laboratories in 1948 arranged a small-scale trial of push-button calling, limited to 35 employees of the Pennsylvania Bell Telephone Company. The trial was held in Media, Pennsylvania, the town in which the No. 5 Crossbar switching system was first introduced. This switching system had, in its registers, receivers that used the two-out-of-six multifrequency code. Registers are the units that store and then spill out the dialed digits as they are required by the switching mechanisms. These receivers thus made the No. 5 system very well suited to a trial of customer signaling with push buttons.

For the trial, the customers were given a special, mechanical push-button station mechanism. The unit had mechanical linkages that plucked two of six metal reeds, each tuned to resonate at a desired frequency. When the customer pushed any one of the ten buttons, two reeds would be plucked and transmit the code for the desired digit. A view of this mechanical arrangement and the external appearance of this experimental push-button telephone are shown on page 85. The frequency pulses were generated in coils by magnetic induction from the reeds. Although this mechanism was not handy by present-day standards for push buttons, the customers were enthusiastic. Their performance was reasonably adequate, according to both field and laboratory studies. This trial established the desirability of push-button signaling, from the customers' viewpoint. But the technical approach did not appear attractive, so further work on this form of signaling was deferred.

Recently, however, advances in technology, particularly in the fields of transistors, ferrites, and other solid-state electronic devices, have provided new tools for implementing the required signaling circuitry at both the station and at the central office. Furthermore, the conception of the four-by-four frequency system has made possible a relatively simple mechanical structure at the telephone set.

Concurrent with these electrical and mechanical developments, human-factors engineers at the Laboratories have made careful psycho-physical studies of customer preference and performance to determine the optimum arrangement, size, spacing, stroke and operating force for push buttons. These studies indicated that push buttons could facilitate and speed up customer calling without seriously increasing dialing irregularities. Encouraged by the results of work in both of these areas — solid-state technology and psycho-physical studies — the A.T.&T. Company and the Laboratories decided to go ahead with a moderate-sized field trial of push-button calling.

The main objective of the trial was to evaluate the customers' performance in using a modern push-button mechanism. A central-office receiver and converter were available in the form of a "black box" device developed for another purpose. Although not the ultimate in sophistication, this device would perform all of the necessary central-office functions. The black boxes were capable of repeating standard dial pulses, receiving multi-frequency (MF) signals, and converting MF signals to dial pulses for use by the switching equipment.

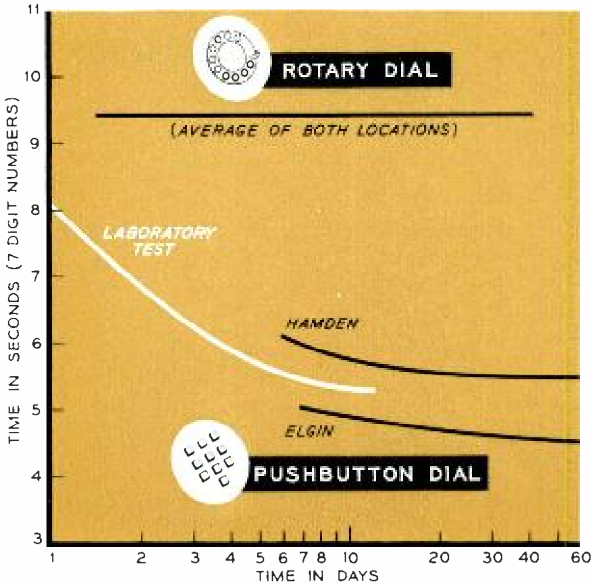
In the step-by-step trial arrangement at Hamden, Connecticut, the receiver-converters were installed between the first two elements in the switching network — the line finder and the first selector — in a segregated group of line finders. In the No. 5 crossbar office at Elgin, Illinois, they were put in between the trunk-link and register circuits. About 170 individual and two-party stations in each central-office area were equipped with push-button sets. In addition at each location about 30 key sets (telephones with several lines selected by buttons) and an attendant's position on a PBX were so equipped.

Even though trouble rates were relatively high due to the lack of refinement in apparatus design, customers in both areas were enthusiastic about the service. Speed and ease of use were the most frequently mentioned advantages. In a relatively short period, the customers with push-button sets were approaching the dialing accuracy they had achieved with regular dial telephones. Laboratories' engineers knew beforehand that irregularities with push buttons tend to be greater than those with the rotary dial — probably because of the ability of push buttons to operate at higher speed. There is every indication that this small increase in errors will be overcome with "learning," as is the case when a manual office is changed to dial.

The adjustment of an individual to the operational procedures of any new mechanical device requires a period of learning. The graph opposite compares learning curves, for speed of operation, for the Elgin and Hamden trials. These curves are also compared to an average rotary-dialing-speed curve for both locations. One might suppose, from a cursory look at the curves, that people in Elgin are faster dialers, or button pushers, than those in Hamden. It was found, however, that a large proportion of the calls in Elgin are to the local offices SH 1 and SH 2. In the push-button configuration used on the trial telephones *(see photograph on page 84)*, the buttons for dialing SH 1 are in bottom-to-top sequence in a vertical row, an arrangement well suited to fast operation. Dialing SH 2 is almost as readily managed. The rate of learning, however, is about the same in both areas.

Learning Rates

The curves show that several weeks were required for the customers to develop operating skill approaching their potential end-point performance. This is because most people make only a few telephone calls a day, and therefore get no concentrated practice. For a further comparison, a laboratory-measured learning curve is also included. These data were obtained at the Laboratories by testing twelve people who were asked to dial ten, seven-digit numbers each day for twelve days with the push-button set used in the trial. The numbers used in these tests are comparable with those encountered in Hamden, and no easily manipulated numbers such as those found in Elgin are involved. The facility of operation these subjects attained in a few days equals that attained by the Field-trial customers at Hamden in several weeks. Thus it is possible to get approximate evaluations of customer performance in a relatively short time in the laboratory. However, a full-scale trial of customer and equipment performance in the field is required to evaluate a new design fully.



Graph comparing speed of learning to dial with push buttons with average rotary-dialing speed. A laboratory-measured learning curve for ten calls a day shows how fast skill in push-button dialing can progress with more frequent practice.

From the customers' point of view, push-button calling is easier and faster than rotary dialing. At the present state of the art, however, the push-button station set is expected to cost more. Also, rather costly additional central-office equipment will be required in existing offices.

Why, then, is the Bell System interested in the possibility of providing push-button calling? One reason, of course, is that it is always interested in anything that provides better service to the customer. Another reason is confidence its ability to solve the technical and economic problems involved in this possible future service. Finally, a push-button device for voice-frequency signaling provides the customer with a potential (slow-speed) data transmitter.

The trials at Elgin and Hamden indicate that customer approval of push-button dialing is appreciable. The next step, which is already under way, is to progress from the exploratory equipment and apparatus designs used in these trials to more sophisticated prototype models. These models will then be used for additional larger trials to evaluate the potential marketability of push-button dialing and to explore in more detail the technical and maintenance problems. Trials of this type are scheduled for later this year.

The ubiquitous semiconductor is enjoying an ever-increasing popularity in electronics. One reason designers are always ready to use these solid-state devices is that they know they can trust them. This faith is attributable, in part, to the reliability studies carried out by Bell Laboratories for Bell System projects.

M. C. Waltz

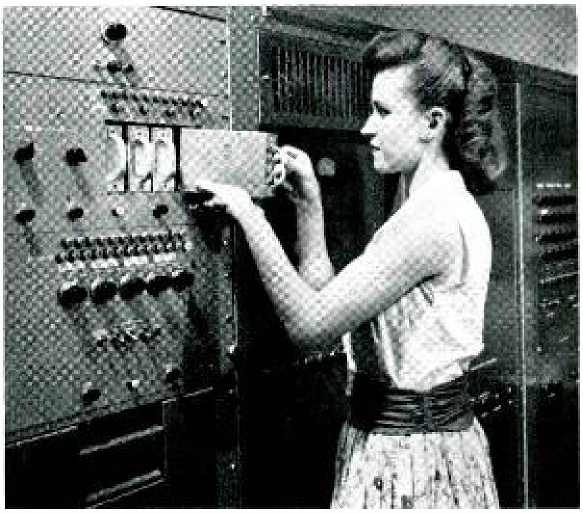
Semiconductor Reliability Studies

Designers of electronic equipment can gain many important advantages from using semiconductor devices such as transistors and diodes. These small, lightweight components furnish low-voltage operation, low power consumption, and a mechanical ruggedness that surpasses that of most other constituents of electronic equipment. The design engineer, however, must first assure himself of the feasibility of these devices by making an important test. This is the test of reliability — key to the successful use of semiconductors.

The concept of reliability has been increasingly emphasized as engineering systems have become more complex. Consider, for example, a table radio with five tubes. If the radio is used ten per cent of the time, and its tubes have a failure rate of 4½ per cent per 1000 hours, only one will fail in five years. Compare this record with a large computer containing 300,000 transistors. If the computer is to operate one week between breakdowns, these transistors must have an average failure rate of less than 0.002 per cent per 1000 hours. In other words, the transistors must be over 2000 times more reliable than the tubes.

The more complex systems require a larger number of devices which must have an increased life expectancy roughly proportional to their increased number. Furthermore, automatic assembly of systems leads to constructing their parts in packages, and the failure of any one device makes the entire package unusable. This, of course, increases the cost of a failure of the individual device, and thus requires the newer devices to have a reliability much greater than was expected a few years ago. The rapid development of new types of devices, and the rapid incorporation of these devices into what we hope will be reliable systems, means that we must find ways to demonstrate their reliability in a much shorter interval of time.

As the mean lifetimes of semiconductor devices improve, it becomes either a larger or a longer job to determine this life with the same confidence. To illustrate, let us use the five-tube radio set and the 300,000-transistor computer as before. Fifty representative tubes life-tested for 1000 hours with no failures will verify with reasonable confidence (90 per cent) that the radio will be reliable. To verify with the same confidence that the transistors will be satisfactory for use in the computer, we must life test 110,000 of them for 1000 hours (or 12,000 for one year), again with



Semiconductor reliability testing equipment used at the Allentown location. Pauline Holschwander removes tray of devices from program panel.

no failures. This requirement, coupled with the shorter development schedules for devices, makes such evaluation a large-scale operation.

There are two methods of gathering information about the life expectancy of devices required to have long life. One source of information is the field; the other source is the laboratory. The field observation has the advantage of using more devices than would be watched in the laboratory, as well as the advantage of exposure to actual operating environments. On the other hand, the laboratory trial has the advantages of closer control of the environment and better observations of the device behavior. Also, the cost of a failure in the laboratory is much less than a corresponding failure in operating field equipment. A well-balanced reliability program, of course, obtains data from both sources.

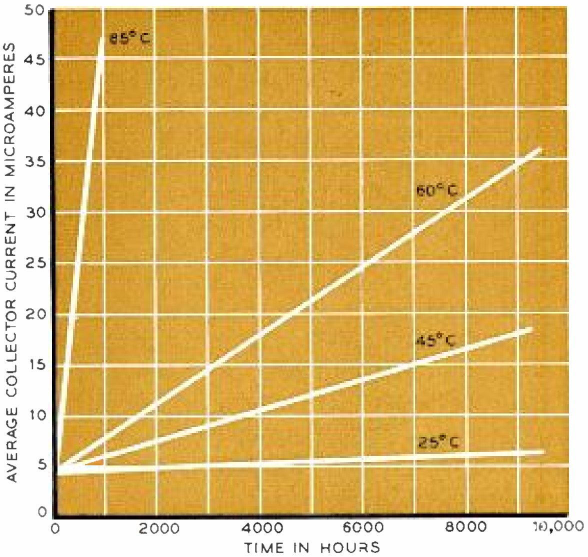
Device designers generally gather data from the field through cooperative effort with the system designers. They acquire the information by methods that vary widely from one field trial to the next. The data from the laboratory experience, however, can be obtained by well-designed statistical, experimental plans. And most of these plans require observations to be made at certain times on the aging of devices.

Various tests can be set up in the laboratory to check the reliability of transistors and diodes. For example, if an engineer needs to know the reliability of a device at the same time he is making feasibility studies on it, he would use a type of reliability test very different from one he would use on devices in pilot production.

First of all, he would life test only a few devices under a few conditions for a short time. In a typical situation, forty diodes were fabricated. One half of them were assembled by thermo-compression bonding (RECORD, *April,* 1958) and the other half by soldering. All of the devices were life-tested at full power for about two months. After that time both groups appeared to be similar, so the engineer concluded that the new technique of thermo-compression bonding was as satisfactory as the old technique of soldering.

Since the reliabilities did not differ appreciably between the two techniques, we chose thereafter to use thermo-compression bonding because it was less expensive. An experiment of this type gathers preliminary information on the life expectancy of the device and uncovers its inherent weaknesses. It may also indicate undesirable steps in fabrication.

When the device is in pilot production, however, the reliability experiment would be made on a much larger sample under a wider variety of aging conditions. Also, we would need much longer periods of time to gather information about device behavior under conditions that might be duplicated in the field. The knowledge gained on this test would determine realistic ratings for the device and guide the user of the device in its reliable application. Various pertinent device parameters would be measured during both of these types of tests with little regard for what might be defined as a success or failure.



Results of shelf-aging experiments of an experimental n-p-n alloy germanium transistor. Note effect of temperature on the collector current.

An experiment of the second type was performed on a new type of click reducer. Formerly a copper-oxide varistor, this "eardrum protecting" device in the telephone handset was to be made experimentally of diffused silicon. In the experiment, 240 silicon varistors were divided into ten groups, and each group was exposed to a different set of conditions. One group was stored at room temperature as a control while the other nine were exposed to combinations of three elevated temperatures (50, 80, and 110 degrees C) and three powers (0.7, 7, and 70 milliwatts). The test ran over eighteen months with measurements at periodic intervals to determine the aging behavior. The silicon varistor showed markedly less aging than did the copper-oxide varistor it was expected to replace and thus is considered to be extremely reliable for telephone use.

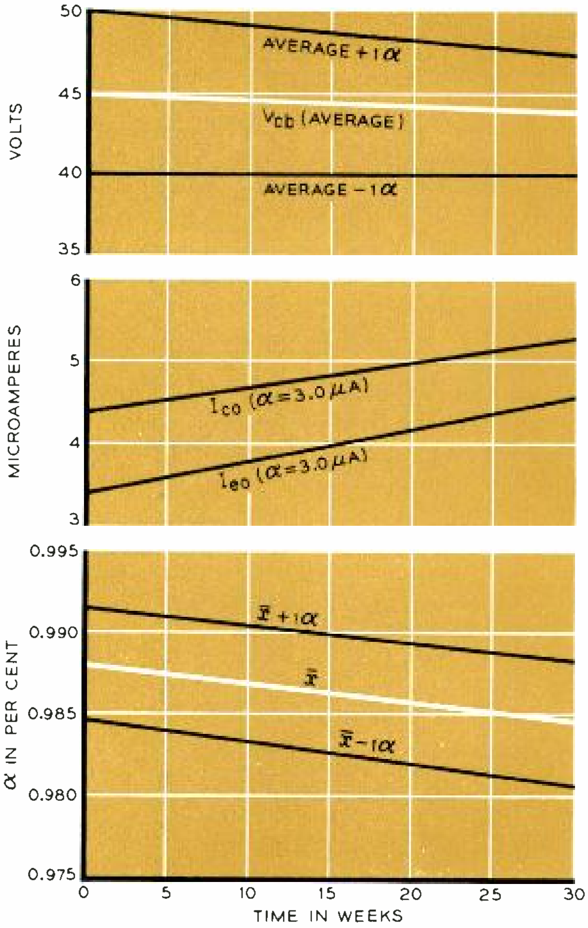
The failure of a device is generally understood to be its failure to perform satisfactorily in a particular circuit in a particular system. Thus the failure of a device is inexorably tied to the circuit in which it is used. The device designer would employ a third type of experiment in a laboratory to gather this type of information. This experiment requires devices to be put into actual circuits and allowed to operate while the circuits are exposed to simulated changes in the surroundings similar to those expected to be encountered in the field. In general, parameters of the device would not be measured during the experiment. But the experimenter would observe the time between each failure of the circuit and correlate these failures with the devices.

In the proposed line concentrator for the No. 5 crossbar switching system, engineers assembled in the laboratory a skeletonized system containing 127 germanium alloy transistors. They placed this system in simulated operation while cycling the temperature from room temperature to 60 degrees C. Alarm circuits were arranged to indicate a failure of the system. In about a year they had observed no failures due to transistors. The experiment showed both the devices and their associated circuits to have a reasonable reliability.

If the extreme values of the parameter of a device that cause failure in the circuit are known or can be found, the experiment with the pilot models can be used to compute the results to be expected of the "in-circuit" experiment. In general, however, the results of an in-circuit experiment cannot be applied to other uses of the devices in other circuits and thus it is less useful than the previous types.

When engineers suspect a weakness in the design of a device or actually detect one by the foregoing tests, they can perform a "mechanism" test to verify the weakness and uncover its source. A large variety of independent variables may be introduced into this type of test. The device can be exposed to mechanical, thermal, or electrical conditions in an attempt to understand why the device behaves or misbehaves the way it does. For instance, if engineers suspect that leaky seals are causing abnormal aging, they can age groups both in a deleterious, or wet, atmosphere and in an inert atmosphere to verify leaks as a cause of the unreliability.

The device designer performs another type of test — the "accelerated" test — to gain insight into the long-time behavior of a device by a short-time test. This is applicable *only* after similar behavior data have been obtained by both a normal-use life test and the system test. When the de-



These sketches show general trend of various parameters of a group of 613 n-p-n germanium alloy transistors given life tests. Information from the thirty-week test indicates that currents change in percentage more than voltage and transfer characteristic over an extended period of time.

Margaret Perez, left, plugs device tray into furnace while author adjusts power controls on life rack. Reliability tests are made at the Allentown location of the Laboratories.

signer has determined the acceleration factors, he then has a particularly useful test as a quality control check on a manufacturer's product.

Since a reliability program has life testing of the devices as one of its purposes, one of the types of equipment needed is a life rack. For this reason, the Laboratories has designed a general-purpose life rack for semiconductors. This piece of equipment can impose bias and temperature aging conditions on eight hundred devices at one time. The diodes or transistors are placed in small trays which are plugged into the life rack. The trays are removed when measurements are required on the transistors. The measurements are made by plugging the trays into an appropriate measuring set.

Many of the measurements can be made automatically and the results directly recorded as punched holes in business-machine cards. Computing machinery can then analyze the data. It is the automatic measuring equipment and machine computation equipment that make it possible to perform the relatively large-scale experiments necessary to describe device behavior.

The results of aging experiments can be plotted in many ways. One way is shown in the curves on page 90. In these curves, the average value of a parameter, as well as its standard deviation, is shown as a function of time. From this type of presentation we can obtain an estimate of reliability. In particular, we can detect unsatisfactory behavior quite soon.

Shown in the figure are four parameters — I_{co} (collector current), I_{eo} (emitter current), V_{cb} (collector voltage), and alpha (a current transfer, or gain, characteristic) — for a group of 613 germanium n-p-n alloy transistors made in 1956. These transistors were life-tested at a temperature of 20 degrees C and dissipated 24 milliwatts of power during the period of the test. The curves indicate that the collector and emitter currents were increased by about 40 per cent per year, while the transfer characteristics and breakdown voltage were changing by much smaller amounts. Even smaller changes are observed on transistors as presently constructed.

Changes are correspondingly small for groups of germanium n-p-n grown-junction transistors and germanium p-n-p alloy transistors. Extremely small changes of the parameters are also observed for most diodes, such as the diffused and alloy-silicon types.

The real usefulness of some of these tests becomes apparent when a group of experimental devices, on life testing, indicates abnormal behavior such as is shown in the curves of the second figure. In this case, the leakage current increased rather rapidly when the devices were aged at 60 degrees C, and increased very rapidly at 85 degrees C. A subsequent change in the manufacturing process led to improved aging behavior.

Laboratory techniques can evaluate the aging behavior of a device — the first step in determining its reliability. The usefulness of these techniques lies in their ability to gain information about aging behavior before the devices get into large-scale use. Thus remedial action can be instituted early to clear the difficulty. The proper use and interpretation of these tests will result in more reliable transistors in the field.

Magnetic amplifiers are finding increased popularity with designers of modern communications equipment. Taking advantage of this art, Bell Laboratories engineers have applied the analog aspects of these devices to many recent Bell System projects.

T. G. Blanchard

MAGNETIC AMPLIFIERS

Analog Operation and Applications

An operator rotates a pointer to an arbitrary position and simultaneously, a short distance away, a small statue of The Huntress Diana turns to aim an arrow in the same direction. This is a typical scene at the Traveling Magnetic Amplifier Display exhibited at several Bell Laboratories locations. This particular demonstration is a simple illustration of remote positioning control—a typical analog application of magnetic amplifiers.

Magnetic amplifiers obtain their amplifying qualities from the non-linear characteristics of saturable ferromagnetic cores. By virtue of their construction and principle of operation, magnetic amplifiers have many desirable characteristics. Among these are: ruggedness, reliability, long life, low maintenance, simplicity, small size, high efficiency, no warm-up time, and great versatility.

In a large measure, the versatility of magnetic amplifiers may be attributed to several features not found in other amplifiers. These features include: (1) many possible types of operation, (2) the availability of magnetic feedback in addition to electrical feedback circuitry, and (3) the possibility of using, on the same core, several signal input windings, and these of arbitrarily chosen numbers of turns.

On the other hand, since magnetic amplifier operation depends on the saturation characteristics of ferromagnetic cores, the output voltage of the amplifier may be greatly affected by properties of the magnetic core, voltage level, frequency and wave shape of the power supply, and configurations and parameters of the circuit. Therefore, and this is also true of other types of amplifiers, the relationship between amplifier output and input is generally less precise than that required in a closely engineered system.

To achieve more precision, magnetic amplifiers use the technique of negative feedback. In analog applications, negative feedback circuitry minimizes deviations from ideal performance. Such circuitry has the fundamental advantage that proper "external" circuit behavior does not depend upon precise "internal" performance. To get this characteristic, the output of the amplifier, transformed if necessary by a suitable feedback network, is compared to the circuit input. The difference, or error, is the signal to the amplifier. This error signal causes the amplifier output to vary so as to reduce the error, maintaining precisely the desired input-output relationship.

For example, in the display mentioned above, the adjustable pointer is fastened to the shaft of a potentiometer that provides the electrical input to the circuit. The output, the position of the statue, is transformed to an electrical signal by a second potentiometer, serving as the feedback network. The difference between the two potentiometer voltages becomes the input to a magnetic amplifier whose output signal drives the motor that turns the statue. When the potentiometer voltages are equal, at any value, the motor receives no power from the amplifier and remains at rest. When the potentiometer voltages are unequal, the amplifier drives the motor in the proper direction to restore equality. Thus, the circuit output is related to the input almost entirely through the characteristics of the feedback network, and is nearly independent of the characteristics of the amplifier.

Forms of Input or Output

Where required, the input and output quantities might relate to many different forms of information. For example, the position of Diana might be the position of a radar antenna, a control surface of an aircraft, or an instrument pointer. Moreover, the output quantity may relate to some mathematical function or to a resistor value, rather than to the control of a mechanical quantity. The input, too, may have different forms. It may be a voltage or current obtained from a thermocouple, a pressure transducer or a standard reference source.

Thus, magnetic amplifiers employ non-linear ferromagnetic cores with rather loosely controlled characteristics. They can be used to advantage to produce widely divergent, yet precisely controlled, analog relationships. This can be demonstrated by a few typical applications.

Consider as a quantitative illustration, the problem of electrically positioning a rotary shaft relative to a second shaft. Requirements may include angular accuracies of ±5 minutes for rotational speeds up to 10 degrees per second, and of ±10 minutes for rotational accelerations up to 100 degrees per second per second. This is roughly the performance required of an automobile driver who lines up the hood ornament with the white center line of a road immediately in front of the car and drives steadily at 100 miles an hour. Following the road, including its curves, he must not allow the ornament ever to go outside the limits of the line. Practically, this positioning problem arises in aircraft navigation when a compass bearing must be inserted as a shaft position into a navigational computer or autopilot without disturbing operation of the compass.

A typical rectifier, regulated magnetically, used in the "floating" storage battery. Here, the author is adjusting the degree of line compounding.

A typical application of magnetic amplifiers to this problem was made in the TRADIC bombing-navigational computer (RECORD, *April,* 1955). Here, the final circuit combines several magnetic amplifiers and transistors to take advantage of each type of device. In a small package, the main ac transistor amplifier furnishes high gain and responds rapidly — attributes typical of transistor circuits. An input magnetic amplifier operates stably and reliably at input-signal levels of power below the capabilities of a transistor amplifier. An output magnetic amplifier supplies the power required to drive the shaft-positioning motor at full speed.

In TRADIC, the input magnetic amplifier that couples the input-signal network to the transistor amplifier is of a type known as a "magnettor" or second-harmonic modulator. This magnettor produces an ac output signal with a frequency twice that of the power supply. Magnitude and polarity of a net dc signal of extremely low power determine amplitude and phase, respectively, of the magnettor output.

The device used here produces full output with an input signal of one microampere at a power level of 10^{-9} watt. In addition, this amplifier combines three input signals furnished to its three input windings without the loss encountered in conventional passive networks. The result is an output specifically matched to the input requirements of the ac transistor amplifier.

The output magnetic amplifier is of the "self-saturating" type. It furnishes up to 2 watts of 400-cycle power to the reversible ac motor in response to signals from the transistor amplifier.

The complete servo amplifier, from input shaft to output shaft, has a bandwidth of approximately 14 cycles per second. This means that the output shaft will assume its new position within approximately 0.02 second after the input shaft has completed its move. The principal limitation of this speed of response is the motor itself. This application illustrates how magnetic amplifiers may be used in conjunction with other conventional elements — in this case transistors — to produce a unified system. It exploits the complementary properties of both types of devices to yield their best performance.

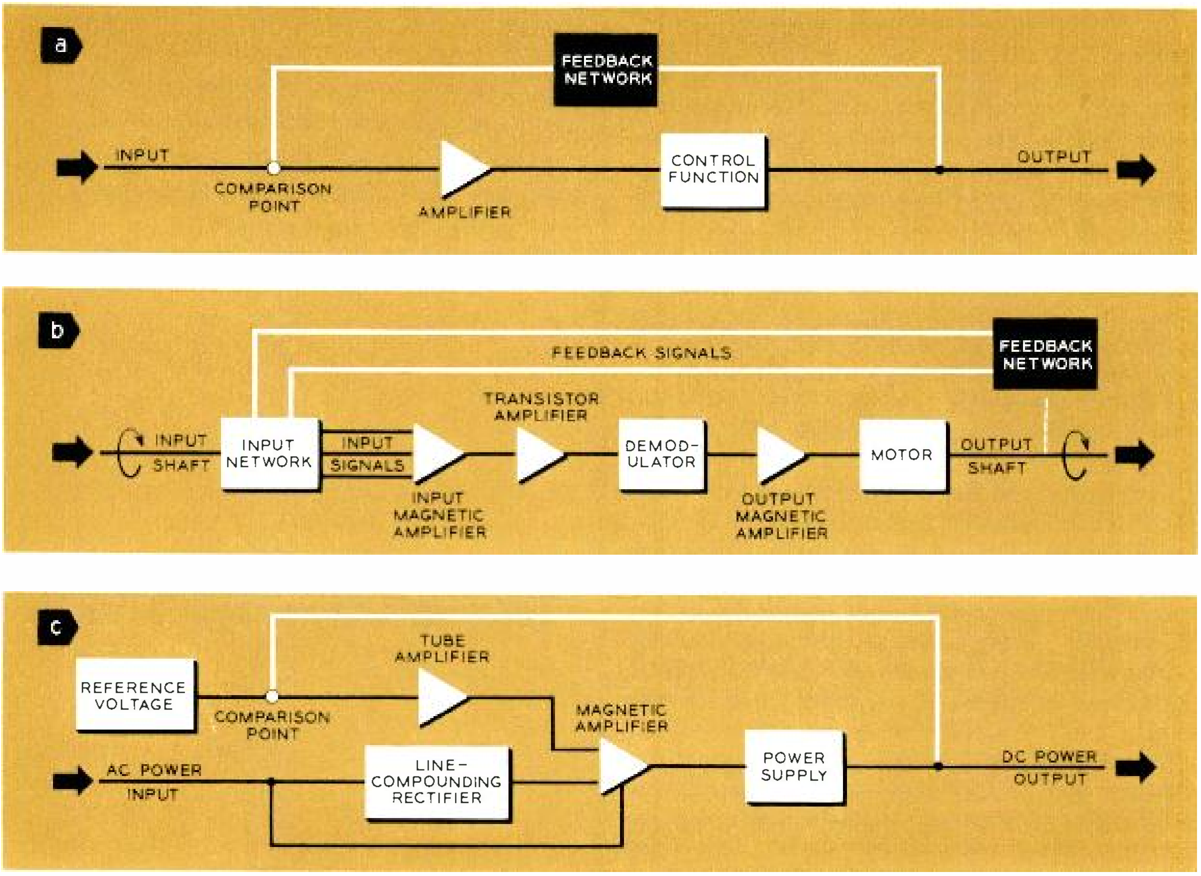
Another application of magnetic amplifiers is in voltage stabilization of power supplies. The objective is to maintain constant voltage out of the power supply regardless of changes in the line voltage, load, ambient temperature and characteristics of the circuit. Because of the differing nature of their loads, various supplies may require devices that will control the peak, the root-mean-square, or the average rectified value of an ac line voltage. By fairly simple changes in circuitry, magnetic elements may be made to control any one of the above characteristics.

A computing amplifier before it is enclosed. Within this space, besides the magnetic cores and windings, are various precision resistors, adjusting potentiometers, and semi-conductor diodes.

In a power-supply arrangement developed at the laboratories, for example, the dc output voltage from the power supply was to be held constant to within a few hundredths of a per cent. Such a performance is obtained with a combination of magnetic and electron-tube amplifiers. The magnetic amplifier provides the power-handling capability to control the ac input to the power supply. The electron-tube amplifier provides sufficient gain to furnish negative feedback signals to the magnetic amplifier in response to error voltage signals in the output. Since the output of this power supply varies with changes in the average rectified value of the ac input voltage, the magnetic amplifier reduces variations in this value caused by changes in the line voltage independently of the action of the feedback amplifier. This action is controlled by signals derived directly from the ac line voltage — a technique known as "line-voltage compounding." Compounding reduces the effects of ten per cent line-voltage changes to one per cent at the power supply. Such circuitry lightens the burden on the feedback amplifier and thus permit it to be smaller and less critical in design. It also improves over-all circuit performance.

Another special field where the Bell System uses magnetic amplifiers to advantage is in the application of "battery-float" rectifiers. Here, storage batteries are connected across a rectifier output. They supply high load-current peaks in excess of the rectifier rating and carry the full load in case of an ac power failure. The rectifier voltage, however, must be regulated so that the batteries suffer neither overcharge nor net discharge during normal operation. A regulated rectifier does this with a magnetic amplifier which controls the current into the rectifier in response to negative feedback signals from another magnetic amplifier in the feedback loop.

In addition to the normal error-voltage signal, the feedback amplifier supplies what is called "load compounding." Here low resistance in series with the dc load yields a signal which varies the input voltage of the rectifier to offset fluctuations in the output voltage caused by changes in the load current. However, the rectifier



Simple diagram of negative feedback system, part a. Part b applies to servo amplifier used in TRADIC, and shows interconnection of components. Diagram c shows a voltage-stabilized rectifier. The line-compounding signal and error signal cooperate to control amplifier output.

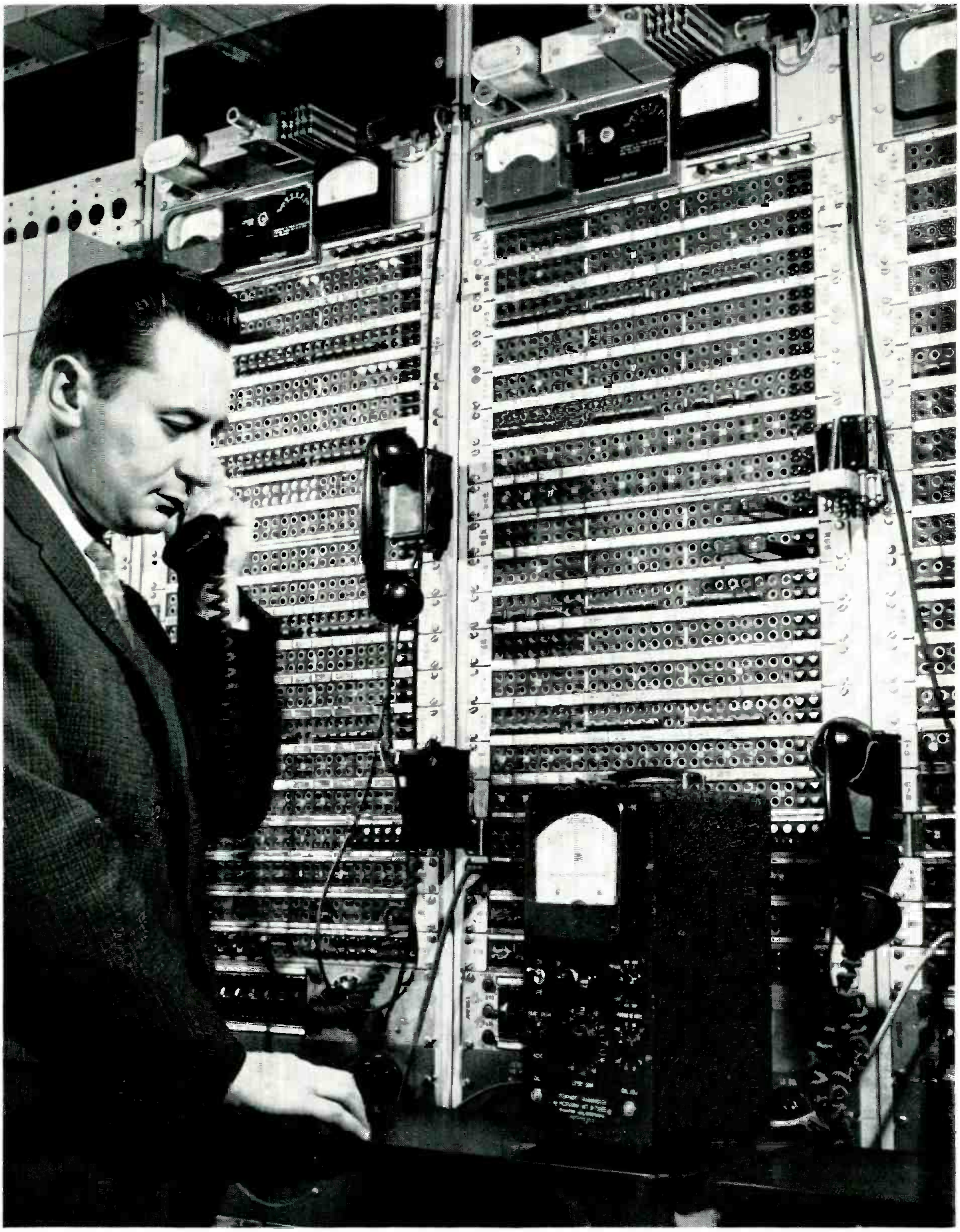
current must be limited to a safe value upon application of ac power after the batteries have been discharged to any degree. This is done by designing the feedback amplifier to "saturate" at approximately a 25-ampere load. Under these conditions, despite increasing error-voltage and load-compounding signals, output voltage drops off to limit the short-circuit current to 45 amperes.

Use in Analog Computations

Magnetic amplifiers have also proven attractive in applications involving analog computations. Here, the magnetic amplifier itself is the principal circuit element, and its output versus input characteristic must be held to very close limits. This is done by using the technique of connecting a negative feedback loop around the magnetic amplifier from output to input.

Operation of an analog computing circuit may be best understood by considering a dc voltage amplifier of high linearity. Amplification is determined by the feedback network over a dynamic voltage range from a few millivolts to several hundred volts. The output error is determined principally by the accuracy of components in the feedback network, and may be as little as ±0.05 per cent.

Using the various possible types of feedback connections, design engineers can make the input and output resistances of the magnetic amplifier high or low and can choose the input and output polarities. The introduction of non-linear elements — such as diode-resistor networks — into the feedback loop can be used to shape the characteristic to produce almost any arbitrary function. Such functions might be an output signal independent of input polarity, or related by an exponential or trigonometric characteristic. Thus, by converting input voltages to logarithmically related currents and adding these currents algebraically, the output of an exponential amplifier will be proportional to either the product or the quotient of the input voltages.



The author using a prototype model of the new measuring set at the telephoto test center in the Long Lines building in New York City. Line level appears as a steady indication on the db meter on the test set. Mr. Benewicz reports reading to maintenance people along the network.

quality of the received picture, therefore, depends very much on the stability of the transmission facilities over which it is sent.

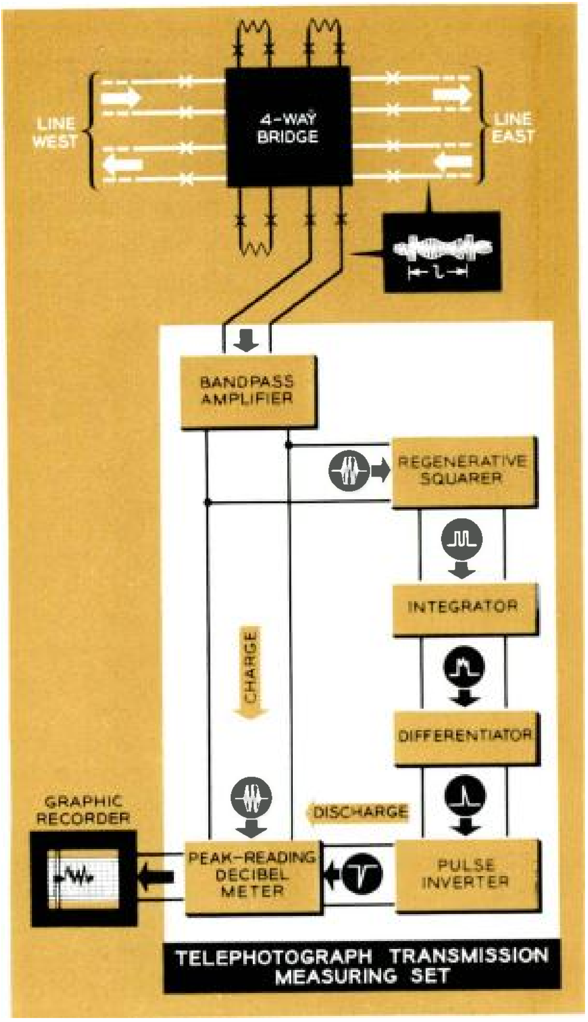
More specifically, present high-definition telephotographic systems are capable of detecting sudden changes in amplitude level as small as 0.25 db. The resulting light or dark areas in the picture copy depend on whether the change was in a positive (increased gain) or negative (increased loss) direction. Changes of 0.4 db or greater will in most cases evoke a complaint from the customer.

Bell System statistics indicate that over one-half of the reported troubles associated with the operation of long-distance press networks are due to intermittent changes in the net loss of the transmission circuits. Since many of these networks are built up of tandem circuits, it is a difficult and time-consuming procedure to locate the particular link that is causing the intermittent changes in the over-all level of the network.

Heretofore, testing these leased networks for variations in level has been conducted largely by the "out-of-service" method. In this method, maintenance people — sometimes with the cooperation of customer stations — approximate the trouble location. Often this is a section of the tandem facilities. A "patch" is established to bypass the suspected section, and the out-of-service circuits are then investigated with static testing methods. For these level-variation investigations, maintenance people use graphic recorders to monitor a steady test tone applied to the circuit. When a customer is receiving telephotographs, however, the detection of trouble conditions is delayed from five minutes to an hour. And this situation often results in additional impaired transmissions.

These, then, are some of the fundamental problems involved in detecting and locating sudden changes in transmission level. In a few words, the problem is one of making direct determinations of the trouble locations in a minimum time; preferably as they occur.

To help solve this problem, Bell Laboratories has developed a Telephoto Transmission Measuring Set (TPTMS) which automatically and continuously indicates the amplitude level of the telephoto circuits between a sending and receiving station. The new set does this by taking advantage of a hitherto unimportant part of picture transmission — the "clamp-bar interval."



Block diagram of the Telephoto Transmission Measuring Set. Line signal enters the set at the top and arrows indicate how signal is processed.

Unlike video signals, which synchronize once during each line, telephotograph systems generally remain in synchronism for the duration of the entire picture transmission interval — approximately eight minutes. After an initial phasing, where the receiver scanning mechanism is positioned to correspond with the transmitting mechanism, only picture modulation signals are transmitted. There is, however, a certain amount of "dead-time" available during each scanning line. This dead-time corresponds to the scanning of the clamp-bar, a device which holds the picture copy securely on the transmitting drum. Though no clamp-bar is required in flat-bed systems, an equivalent clamp-bar period is transmitted.

Since the clamp-bar interval represents repeatable dead-time, this time can be used for "in-service" measurements of the transmission level of the system. This is done by inserting a special signal at the transmitter during the dead period and then detecting it at the receiving station. In the new system, the inserted signal is a burst of tone, with a frequency outside the band occupied by the modulated telephoto signals. This pulse is separated from the telephoto signal by a filter arrangement at the receiver, and then is used to indicate line level.

One of the first steps in the development of the measuring system was the design of a pulse generator capable of inserting a burst of tone during the clamp-bar interval. The diagram below shows the general arrangement of this generator. A small permanent magnet on the drum of the telephoto transmitter passes the pole-piece of a pickup coil at the same time the optical system scans the clamp-bar. Thus, each revolution of the drum induces a pulse in the coil. This pulse is amplified, shaped, and made to drive a modulator which gates a 1000-cycle oscillator. The resultant output signal is a 25-millisecond burst of 1000-cycle tone during each clamp-bar interval. This signal is combined with the normal, amplitude-modulated telephoto transmitter output, and yields a composite line signal like the one shown on the opposite page.

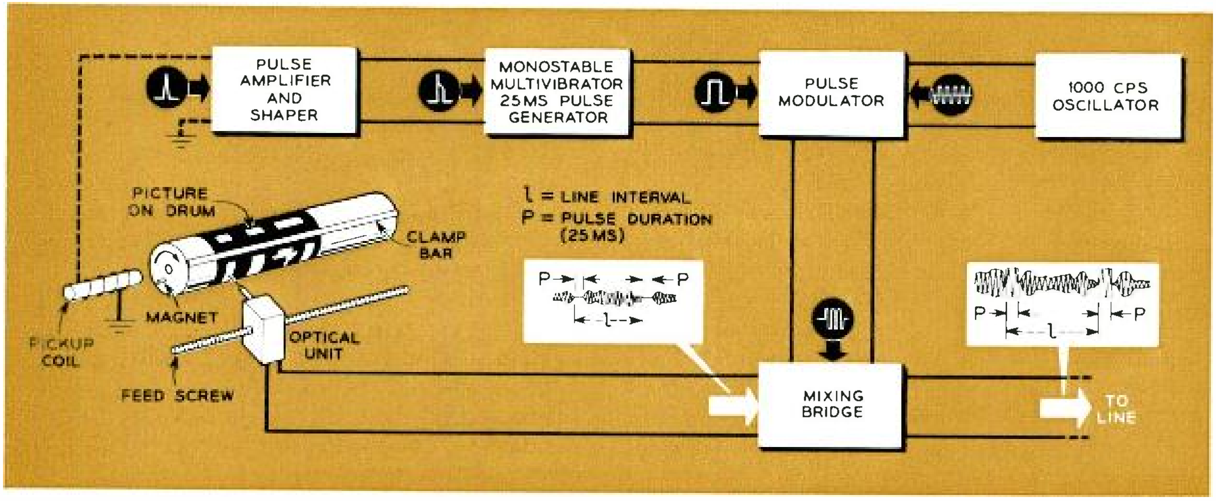
The clamp-bar pulse is transmitted once per revolution of the transmitting drum — a pulse rate of from one to three per second, depending on the telephoto system. Because these pulses are so widely spaced in time, measuring them in a way that would give a continuous display of the network level posed a problem.

To meet this requirement, the designers of the set developed a unique peak-discharge circuit. This arrangement makes it possible to measure the level of an individual clamp-bar pulse and retain this reading until the next pulse is received and its level recorded. The meter, therefore, displays a steady reading on transmission facilities which do not exhibit level changes.

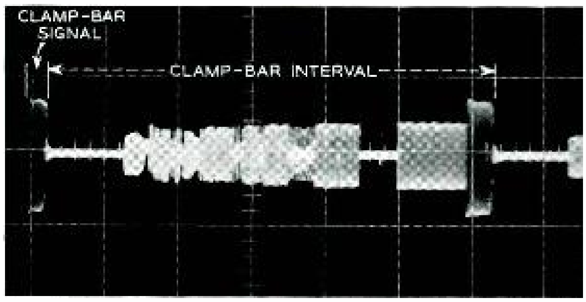
The actual flow of a line signal through the measuring set and the major circuits of the unit are shown in block-diagram form on page 99. A composite signal (picture signal and tone burst) is taken off the line at the measuring-set location by a four-way bridge. In the band-pass amplifier, the clamp-bar signal is separated from the composite line signal and amplified. A voltage measurement that corresponds to the level of the clamp-bar signal is then displayed on a peak-reading meter calibrated in decibels. The discharge time-constant of this measuring circuit is longer than the time between clamp-bar pulses, so the meter retains an indication that does not change perceptibly during the picture interval between pulses.

For a new measurement of network level to be made during each clamp-bar interval, however, it is necessary to discharge the peak-reading circuitry. To do this, a second output from the band-pass amplifier feeds a series of pulse-forming elements which derive a spiked pulse corresponding in time to the beginning of the clamp-bar signal. This pulse discharges the meter circuitry, but immediately following discharge it is recharged by the remainder of the clamp-bar signal. This discharge-charge process occurs in an interval of time so short that the mechanical inertia of the meter prevents a noticeable deflection, provided the level of the clamp-bar signal is the same as the preceding signal.

In addition to visual monitoring of the meter, the measuring set may also be connected to an



A diagram showing the clamp-bar pulse generator. The pulses and line signals shown are idealized.



Typical line signal illustrating clamp-bar pulse. Levels of picture signal are 4 db below maximum.

external graphic recorder to permit unattended operation. The response of the measuring set is such that it can indicate changes in level of from ±0.25 db to ±10 db from pulse to pulse.

One point that has not been covered so far is the exact method of inserting the clamp-bar pulse signal. It appears advantageous that this be done by the customer. Starting the pulse at his station allows for an over-all measurement of all of the facilities involved, including the transmitting loop, the terminating key equipment, and the telephoto transmitter. This also simplifies the circuitry, since the regulated voltages necessary to power the clamp-bar pulse generator are in most cases available from the customer's transmitter. The frequency of the clamp-bar signal can be simply derived by dividing the carrier frequency by two.

A trial of the Telephotograph Transmission Measuring Set has been conducted with six models, placed in service on one leg of a large telephoto network. Thirty additional production models will be completed and in service soon. A prototype of these portable units is shown in use in the photograph on page 98. Transmission levels were monitored continuously through the use of strip-chart recorders. Even with only one sending station equipped with a pulse transmitter, many irregularities were detected. Though a majority of the level irregularities were of small amplitude, a number of serious level changes were also recorded. The set has also proven useful in detecting excessive-noise conditions, and some thought has been given to using the clamp-bar signal for automatic gain control of telephoto systems.

Universal application of the new level-measuring system, through the cooperation of the Bell System's telephoto customers, will result in a reduction of outage time on telephoto networks. The new technique should likewise lead to considerable economies in the operation of large telephoto networks.

Nike-Zeus Successful In Test Firing At White Sands

On February 3rd, the Army successfully test fired a Nike-Zeus anti-missile missile at the White Sands Missile Range, New Mexico. On the basis of the initial data, the launch, boost, separation and sustainer operations all were successful, the Army said. All objectives of the test were achieved.

The test was one of a series of preliminary firings to evalute the aerodynamic characteristics of the anti-intercontinental ballistic missile weapon now under development by the Army Ordance Corps. Prime contractor for the system is the Western Electric Company. System development is the responsibility of Bell Laboratories, and the missile and its handling equipment is in the hands of Douglas Aircraft. The rocket motors were produced by Grand Central Rocket Company and Thiokol Chemical Corporation.

The firing was successful in all characteristics. The Zeus traveled an unguided ballistic course. To accomplish this the guidance fins were locked in zero-degree position. Both the booster and the sustainer motor were fired successfully. Developing 450,000 pounds of thrust, this booster is the largest solid-propellant motor, using single-grain fuel, ever fired.

Nike-Zeus will be an anti-missile missile capable of intercepting enemy intercontinental ballistic missiles before they can reach their targets.

An early test model of the Nike Zeus anti-missile missile awaits take-off at White Sands, N. M.

Two new systems are expected to help meet the increased demand for recorded-announcement services. For these systems, audio facilities have been designed to include many improvements—among them "variable cycle" operation that gives greater freedom in choosing the length of the recorded announcement.

C. M. Taris

NEW AUDIO FACILITIES FOR RECORDED ANNOUNCEMENTS

Recorded announcements have been serving Bell System customers for many years. Since 1939, for example, residents of the New York metropolitan area have been able to call a telephone number and hear the current weather forecast. More recently, Operating Telephone Companies have added other recorded announcement services. Sports news, highway traffic reports and department-store sales bulletins are a few of the announcements that are being made available to the public through their regular telephone facilities.

The success of these services prompted the development of two new standard announcement systems. One of these is designated the 8A Announcement System and is intended for services where the calling rate is relatively light, as in announcing theater programs. The other is the 9A System (RECORD, *February*, 1959) for heavy-traffic services — for example, the previously mentioned weather-forecast announcements in large cities.

Both systems were developed in two more or less independent parts: the central-office "switching facilities" and the "audio facilities," of which only the latter will be discussed in detail in this article. The switching facilities include incoming trunk circuits, alarm circuits and arrangements for distributing the recorded announcement. Basically, the audio facilities consist of:

- a mechanism for recording the announcement and playing it back; this is known as the "recorder-reproducer" or "announcement machine";
- relay switching units for controlling this mechanism;
- an amplifier used in both the recording and the playback operations; and
- "remote control" apparatus that permits a person at a distance from the announcement machine to control the machine and to record announcements.

The objectives of the work on these new audio facilities were to incorporate improved recording techniques, to simplify operating procedures, and to provide a more integrated and therefore more versatile recording-reproducing system.

To appreciate the nature of this new equipment, it will be helpful to look at the announcement service from the point of view of the "sponsor" — which may be the Telephone Company itself or another organization.

The sponsor uses the "remote control" apparatus to control the machine and to record the announcements. This apparatus, shown on the left in the diagram on the next page, consists of a special handset, a small control unit, and a small wall-mounted box. When the Telephone Company is the sponsor, this apparatus will usually be at a quiet location in the same building with the announcement machine; otherwise, it can be miles away on the premises of the sponsoring customer.

The New Equipment

To dictate (record) an announcement, the sponsor uses the handset and the various switches and keys on the control unit. The handset, although it appears to be of conventional design, has a dynamic (moving-coil) microphone in place of the carbon-grain transmitter. This unit improves both the speech quality and the intelligibility of the announcement. The receiver, used to check and monitor the recorded announcement, is the U1 unit used in 500-type telephone sets.

All the manual controls required for operating the announcement machine from the sponsor's premises are on the front panel of the control unit. A speech-level indicator, with a two-color band for a scale, is also mounted on the front panel. It serves as a simple talking-level guide for the user.

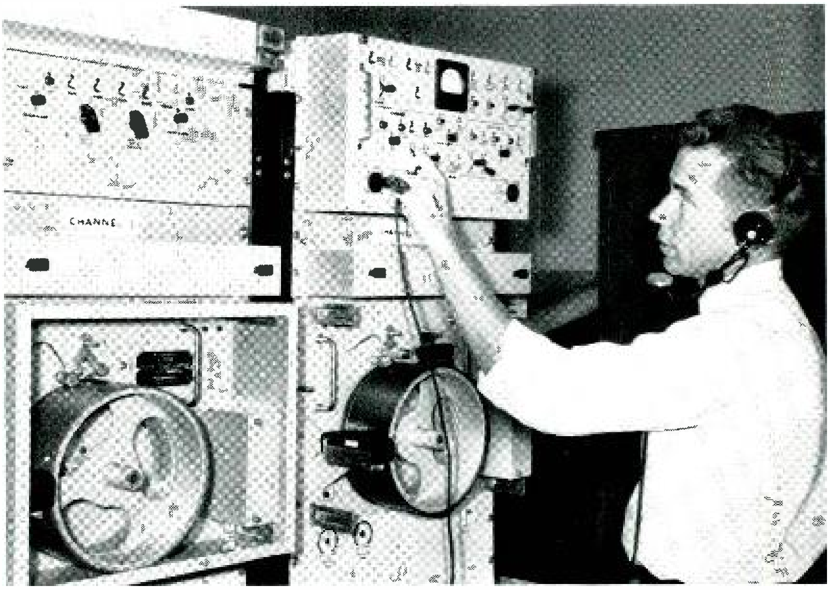
A circuit in the wall-mounted box amplifies the output of the handset. Gain is adequate for the lowest talking level likely to be encountered, and in addition, the circuit has an automatic loudness-control action to equalize the recording level of loud talkers with that of weaker talkers. This "constant-loudness" feature, along with the indicator in the control unit, aids the user considerably in making a satisfactory recording on the first try. Thus, the possible annoyance of repeated recording is greatly reduced.

From the remote-control apparatus, the speech signals are sent to the announcement equipment (*see photograph below*). This equipment, consisting of the announcement machine, record-reproduce amplifier, coupling and distribution units, will usually be located in a central office.

The speech signals go from the coupling unit to the record-reproduce amplifier, where they are amplified and combined with a high-frequency "bias" signal. Bias current is needed so that when the combined signal is applied to the recording head, an undistorted pattern of residual magnetization is produced in the recording medium.

The recording medium here is "magnetic rubber," made by combining an elastic, rubber-like material (currently the commercial product Hypalon, a polyethylene derivative) with magnetic iron oxide. The mixture is molded in the form of a circular band and is then stretched over a nonmagnetic, metal drum.

Only one announcement at a time can be placed on the recording drum, but its duration may range from a few seconds to 4 minutes. Furthermore, the machine automatically establishes a



W. Buckalew checking a dual-channel set up; variable length announcement—up to four minutes long—is recorded on the large magnetic drums.

playback cycle whose length corresponds closely to the length of each new recording.

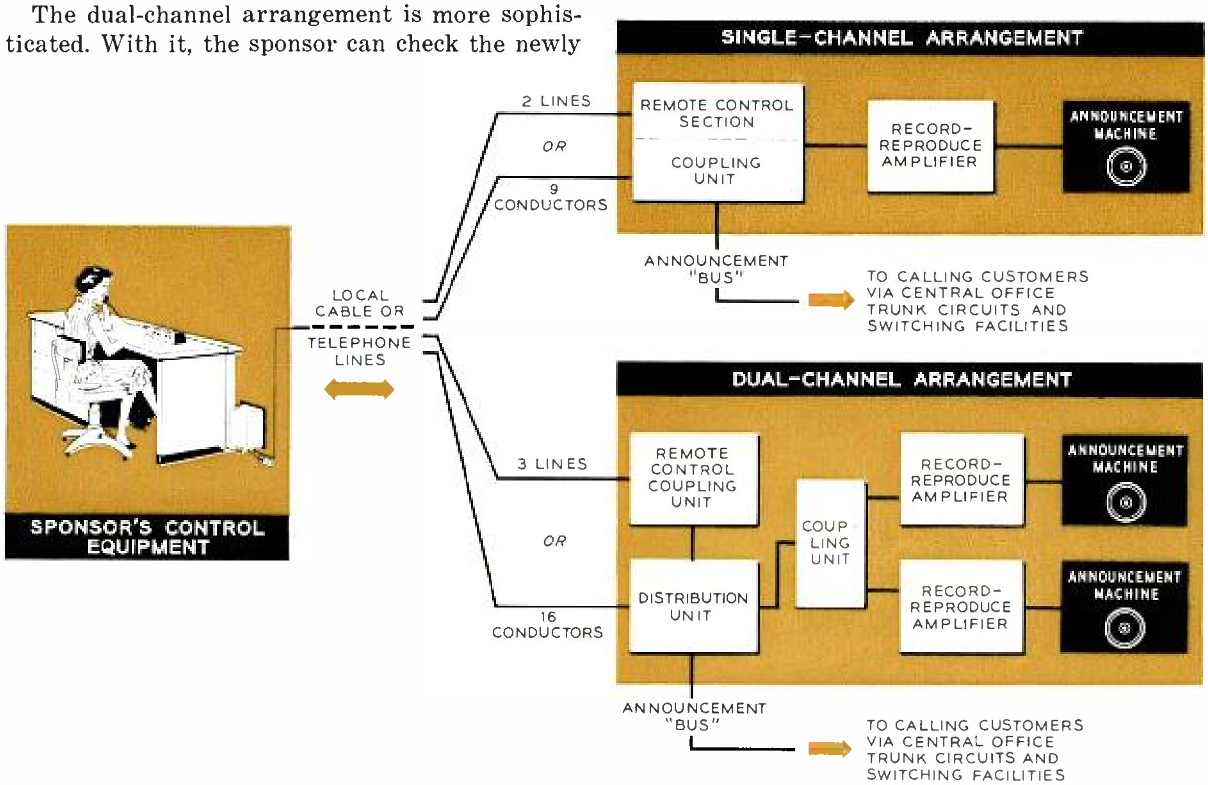
This feature, called "variable cycle," is an important part of the new development. With "fixed cycle" machines now in use, it is necessary to "tailor" the lengths of announcements carefully to make a satisfactory recording. If the length falls short of the allotted time, undesirable "dead time" results, during which the calling customers hear nothing. If the length is excessive, of course, the announcement will not be entirely recorded.

The block diagram below shows a single-channel and a dual-channel arrangement of the audio facilities. In both cases, the speech and control signals originate at the remote-control equipment (left), and are sent to the announcement equipment via telephone lines or, when the control equipment is nearby, via conductors in a local cable.

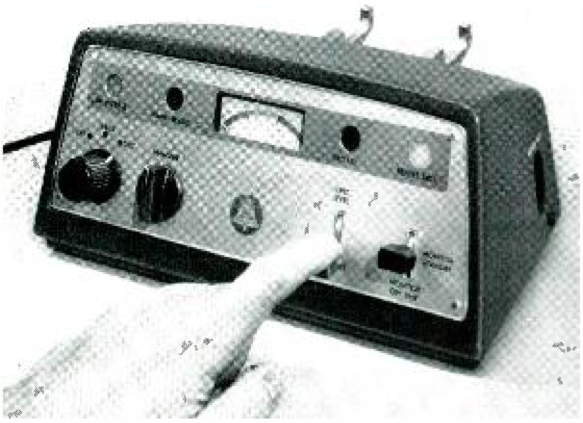
The single-channel arrangement is obviously the simpler of the two, and represents the minimum amount of equipment. To avoid service interruption during recording, the control circuitry is arranged for "live dictate." This means that calling customers, instead of getting a busy signal when a new announcement is being recorded, hear the actual voice "live" as it is recorded.

The dual-channel arrangement is more sophisticated. With it, the sponsor can check the newly recorded announcement before it is made accessible to callers. In addition, it ensures a higher degree of service reliability. Parts of the announcement equipment are duplicated so that there are two independent channels — one is connected to the circuit, or line, outgoing to the distribution and trunk circuits in the central office, and the other is connected to the sponsor's recording apparatus. The latter is in a standby status, ready for recording a new announcement or for transferring to the line, in the event of "on-line" channel failure.

As noted on the block diagram, the single-channel arrangement requires two telephone lines from the remote-control equipment, and the two-channel version requires three lines. When the remote-control position is nearby, nine and sixteen conductors, respectively, in a local cable may be used instead for the two arrangements. For these cases, the remote-control portions of the announcement equipment shown in the diagram are not required. The "coupling unit" and "distribution unit," also shown on the diagram, connect the remote-control equipment and announcement equipment to the central-office cir-



Both the single-channel and the dual-channel arrangements for recorded announcements are represented in this drawing. Sponsor's attendant dictates announcement into handset of control unit, left, and signal is carried over telephone lines or local cable to announcement equipment.



Close-up of control unit showing various control knobs. Here, attendant is depressing DICTATE *key.* DICTATE *light (above) lights when drum is "clean."*

cuits. In addition, the coupling units permit local control of the announcement machines, so that Operating Company personnel can record and check announcements for maintenance and tests. A switch on the coupling unit disconnects the sponsor's apparatus local operation.

A brief description of the recording procedure for the dual-channel arrangement will illustrate several of its advantages: The sponsor's attendant at the remote-control equipment can change the announcement at will. To do this, she sets the control unit to DICTATE (*see photograph on this page*) and depresses a "dictate" key. This action erases the old recording in the standby channel. Erasure of the entire recording drum takes about six seconds, after which the "dictate" lamp lights on the control unit. The attendant then begins talking (dictating) into the handset. The words are recorded on the "clean" magnetic rubber of the standby channel.

At the end of dictation, the attendant releases the dictate key and sets the control unit to CHECK to listen to a playback. If she detects a verbal error or is dissatisfied with the announcement for other reasons, she merely repeats the procedure as many times as necessary. This does not interfere with service, since she is recording on the standby channel.

When she is satisfied with the announcement, she operates a TRANSFER switch on the control unit. As the on-line announcement in progress ends, the newly recorded channel is automatically transferred to the line. The channel with the old announcement still recorded on it thus becomes the standby.

We now have the new announcement in service with the old announcement still on the second channel. At this point, however, the announcement equipment automatically performs an additional important step. It causes the old announcement to be erased from the standby channel and the new one to be recorded in its place. Thus, as a result of this "automatic dubbing" process, identical announcements are on both channels with no further action required of the attendant. Then, if an electrical or mechanical failure should occur in the on-line channel, the standby is automatically transferred to on-line operation. Interruption in service is thus very brief.

Other operational features are also designed into both the single-channel and dual-channel systems. For example, a "repeat dictate" lamp on the control unit lights if the announcement being recorded or the one just recorded is technically unacceptable (because of low speech level or excessive length). The attendant then knows that she must repeat the dictating procedure in a satisfactory way.

In the dual-channel arrangement, another lamp, the "transfer ready," tells the attendant whether her newly recorded announcement is technically adequate and reminds her to transfer this announcement to the line. She can also cancel the "transfer" and "automatic dubbing" functions if she finds it necessary to change the new announcement at this time.

Other Features

For longer-life service, the announcement machines will normally operate only on demand — that is, the on-line machine will run only when one or more calling customers are connected to the system. The standby channel machine will remain idle unless recording or checking is in progress. As an optional feature. continuous operation of either or both channels is available.

Although these and other features of the audio facilities add to the complexity of the circuitry, they simplify operating procedures. The tasks of the user are reduced to a minimum consistent with flexible and dependable operation of the systems, and moreover, the user does not have to develop special skills.

Since these audio facilities provide completely integrated and independent recording and reproducing, they are expected to find many applications in addition to the 8A and 9A Announcement Systems. But what is also important, the 8A and 9A Systems, because of their improved performance and reliability, versatility and simplicity of operation, are expected to promote the widespread use of recorded announcements of many varieties.

A recent addition to the art of telephone switching permits customers to enjoy the advantages of extended-range dialing from telephone booths. Originally designed for panel and No. 1 crossbar offices, "coin zone dialing" is now available in those areas served by No. 5 crossbar.

M. C. Goddard

Coin Zone Dialing In No. 5 Crossbar

Of the approximately 50 million telephones in the Bell System served by dial central-office equipment, about one million are of the pre-payment coin type. Over the past few years, the Bell System has substantially improved non-coin customer service by developing new switching and charging features. Charging arrangements, such as multiple registration and Automatic Message Accounting, have greatly extended the areas reached by direct dialing. However, these developments are not applicable for coin stations since they make no provision for collecting the charges at the time of the call.

Calls originated at dial coin stations and destined for other stations within the minimum charge local zone can be dialed directly and do not require the assistance of an operator. In some metropolitan areas, however, dial coin stations originate a substantial amount of multi-unit (zone) traffic for points beyond the minimum local zone. In New York City, for example, an initial deposit of ten cents is required for minimum-charge local calls. But there is a substantial amount of multi-unit traffic to offices in other zones where the charge for the initial period is 15, 20, 25 and 30 cents. A system of operation permitting the customer to dial such calls is known as coin zone dialing.

Originally, Laboratories engineers developed coin zone dialing to permit completion of calls from panel and No. 1 crossbar offices by way of a panel-sender tandem office only. Later, they developed a way to permit completion by way of a crossbar tandem office also. And recently, they designed coin zone dialing for use with No. 5 crossbar. In this system, however, completion of calls is not limited to a route through tandem offices, but may go over direct trunks to the terminating office.

On a coin zone call, the customer makes an initial deposit, just as he would for a local call. Then he dials the call directly as though it were originating at a non-coin phone. However, since the call is to a point beyond the local zone, the common-control switching equipment signals an operator and indicates to her, by a distinctive lamp, the amount of the charge for the initial period. When she receives this lamp indication, she plugs a cord into a corresponding jack in the switchboard multiple and requests the customer to make his deposit. When he deposits the money, she withdraws the plug from the jack, permitting the call to proceed. She need do no more unless the call involves overtime.

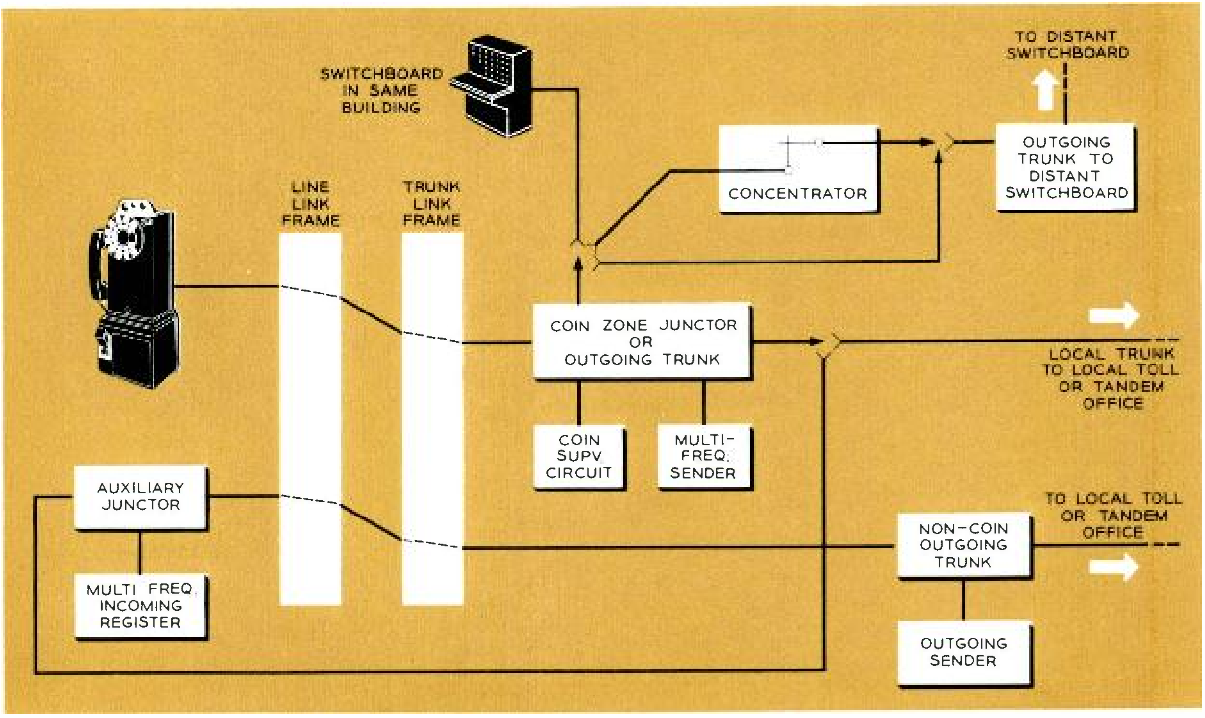
Overtime Charging

If overtime is involved, and this occurs only on a minority of the calls, a timing mechanism in the trunk circuit again signals the operator, this time by flashing the same lamp. She can then time the overtime conversation, determine the overtime charge, and supervise the deposit for the overtime charge for that particular call.

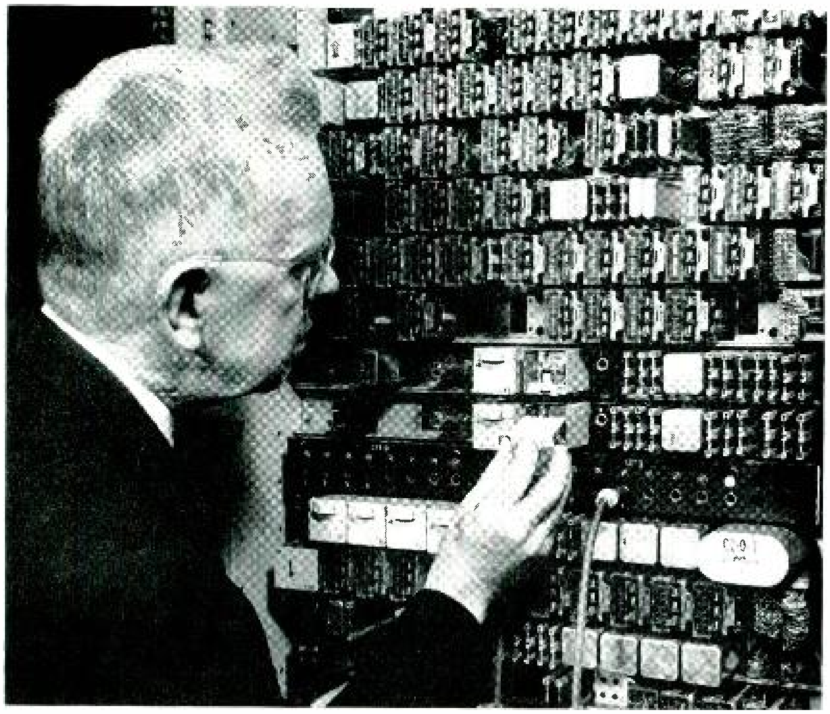
Coins are collected in several ways. For example, if the conversation extends to within one-half minute of the end of the initial timing interval, the coins deposited for that interval are collected at this time. However, if an answered call terminates before this time, the charge is collected when the calling customer hangs up. On the other hand, charges for the initial period are returned automatically if the calling customer hangs up before the call is answered. Also refunded automatically is any additional deposit made *during* the last one-half minute interval and up to the time an operator connects to the circuit as a result of her receiving an overtime signal.

As indicated in the block diagram (*below*) the operators who supervise the initial deposit and overtime on coin zone calls may be located in the same building with the No. 5 crossbar equipment or in a distant building. When they are located in a distant building, the system might make use of a concentrator — a device that "funnels" the traffic of a relatively large group of trunks to a group of fewer trunks to the switchboard in the central office.

A maximum of eight "zones" can be indicated for each trunk on lamps at the operator's switchboard. These lamps are controlled by polar duplex signals applied to each of the two conductors of the speech path. Nine combinations of signaling are available in each direction, each independent of the other direction. Signals from the switch-



In junctor operation, traffic from coin stations is concentrated into one group of circuits and directed through the switching equipment for delivery over non-coin routes, alleviating traffic problems.



M. C. Goddard with the laboratory model of the trunk frame for switching arrangements for coin telephone dialing.

board indicate operator's actions — for example, whether she has answered, or whether she has operated a coin return, a coin collect, or a ringing key.

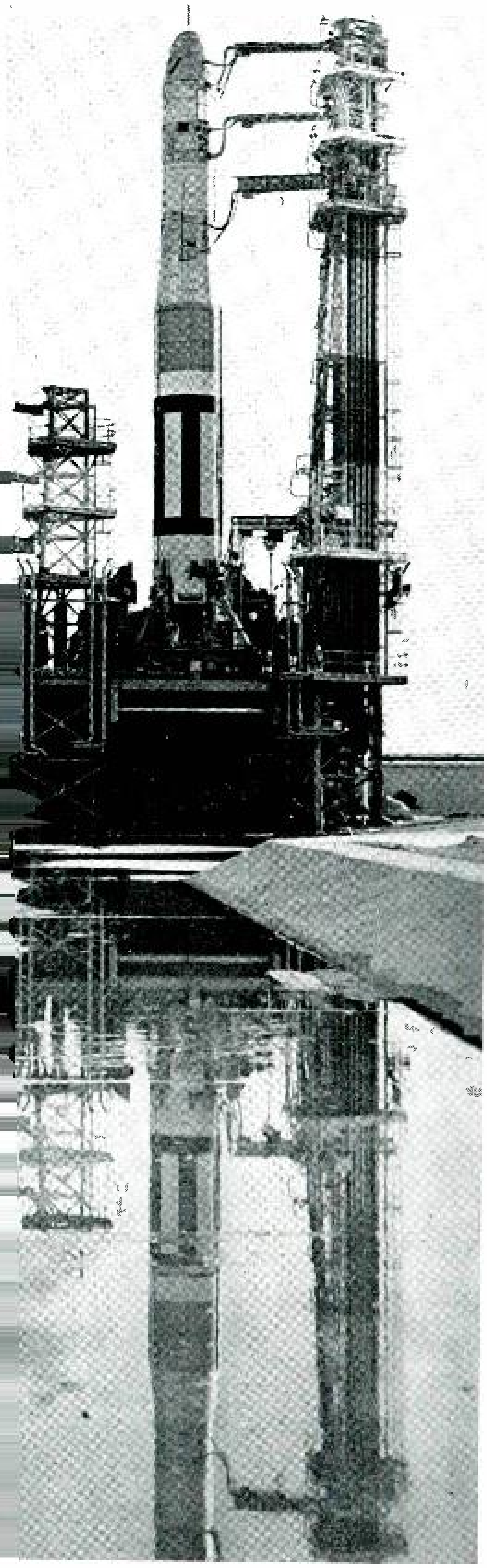
Coin zone calls in No. 5 crossbar will ordinarily be handled by junctor operation. This is a method of concentrating the traffic for many destinations into one group of coin zone circuits and then directing the call through the line-link and trunk-link frames to a non-coin route to the desired destination. Since the periods of heavy coin traffic during an average day are different from those of heavy non-coin traffic, the same trunks can be used in common for both services. There may be cases, however, that justify direct coin-zone trunks rather than junctor operation. In such cases, direct trunks would avoid the need for extra channels through the No. 5 crossbar office and for the common-control equipment inherent in junctor operation.

Only multifrequency pulsing senders have been arranged for coin zone operation. Their advantage lies in their rapid outpulsing, or "delivery" of the dialed digits. The operation of the sender is affected in two ways in coin zone dialing: (1) the connection toward the called party is delayed until the operator has verified a proper coin deposit for the initial period, and (2) timing of the call is cancelled while the operator is connected to the circuit.

System in Use

Long Beach, New York, on the south shore of Long Island, was an early candidate for coin zone dialing. Primarily a summer resort area, it has a high proportion of transient visitors and short term residents — a population situation resulting in a large volume of coin telephone traffic. Moreover, Long Beach is fairly close to New York City and, as a result, much of the traffic is zone traffic.

At Long Beach, the New York Telephone Company has set up 80 coin zone circuits — 40 coin zone junctors and 40 direct trunks to a crossbar tandem office in Manhattan. Coin zone dialing has been introduced in No. 5 crossbar offices in several additional places in the New York City area. Moreover, other metropolitan areas such as Los Angeles and San Francisco are planning to use this type of service.



Two Titan Missiles Successfully Guided by Laboratories-Developed Command Guidance System

In an important series of test firings of the Titan ICBM (intercontinental ballistic missile) from Cape Canaveral, Florida, last month, the command guidance system developed at Bell Laboratories twice successfully guided the huge missile. In the first of these successful firings, on February 2, the second stage of the Titan was steered on its predetermined trajectory over the Atlantic Ocean.

This was the first guided test flight of the over 90-foot, 110-ton Titan missile. In previous flight tests, only the first-stage rocket engines were fired. The dummy second stages were filled with water. In one previous test (May 4, 1959), following a successful launching and engine burnout of the first stage, the second stage was *separated* from the first, but as in previous flights, was not fired.

In the February 2 test, after separation of the two stages, the second-stage engine was fired and continued to accelerate the vehicle to the desired altitude and velocity under the control of the command guidance system. Then commands were sent to cut off the engine, and the missile followed a ballistic trajectory to its selected destination hundreds of miles away.

In the second successful test firing, on February 24, the missile's reentry vehicle (nose cone) was separated from the second stage and landed in a preselected target area in the Atlantic Missile Range. An instrumented data capsule was ejected from the nose cone and picked up by a waiting Air Force recovery vessel.

Signals were sent from a ground guidance station at the launching site to the missile *(see cover)* to steer it along a desired trajectory. After separation from the second stage, the reentry vehicle followed a ballistic trajectory to its selected destination, some 5,000 miles away.

In this type of guidance system, (RECORD, *June*, 1959) small light-weight guidance equipment is aboard the second stage of the missile. The missile is controlled by the ground guidance station which sends precise steering orders to guide the Titan to its selected target with what Laboratories engineers describe as "pinpoint accuracy."

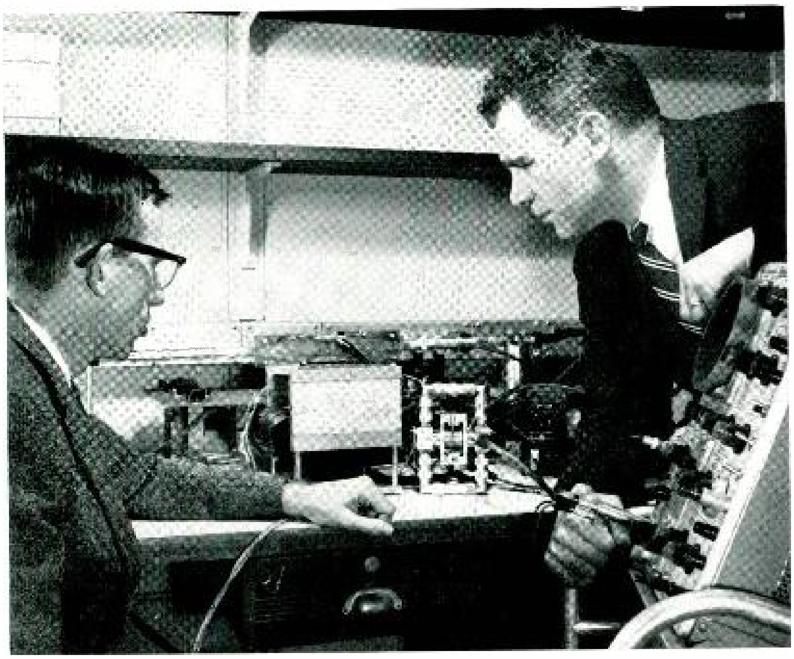
Developed for the Air Force Ballistic Missile Division, the command guidance system for the Titan was previously tried out in a series of Thor Able II test shots (RECORD, *May*, 1959). This highly accurate guidance system helped the Air Force make the first recovery of a nose cone fired over an ICBM range. Teamed with the Laboratories in the guidance-system project is Remington Rand-Univac, who developed and produced the computer used in the guidance system. The system itself is produced by the Western Electric Company.

The Titan missile, assembled by the Martin Company, is designed to fly at speeds of more than 17,000 miles per hour with a range of over 6,000 statute miles. Insuring that it reaches its desired target requires precise control. For example, at the time of cut-off of the second-stage engine, when the missile may be traveling about 25,000 feet per second, a difference of one foot per second in the desired speed can cause a miss of one mile at the target. Signals to control the exact moment of engine cut-off are a guidance-system function.

The Bell Laboratories command guidance system, its accuracy and reliability already tested, is also scheduled for use in forthcoming satellite launches and space probes in other programs.

NEWS

New Traveling-Wave Amplifier Uses Esaki Diodes



William W. Anderson, left, and Marion E. Hines inspect laboratory model of new traveling-wave solid-state amplifier. Device combines negative resistance of Esaki diodes and one-way attenuation of ferrite strip transmission line arrangement for improved amplification.

Bell Laboratories announced a new broadband microwave amplifier using all solid-state devices at the Solid-State Circuits Conference held February 10 in Philadelphia. The device was described in a paper by Marion E. Hines and William W. Anderson of the Solid-State Electronics Research Department. The new amplifier makes use of a property of the Esaki, or "tunnel," diode. This property is "negative resistance" — a decrease in current with an increase in voltage. The device also makes use of a ferrite property — the ability to provide attenuation for only one direction of wave propagation. These two properties help the amplifier achieve a high amplification ratio without self-oscillation.

The new amplifier can be used to increase the strength of radio signals over a broad band of frequencies in the microwave range above 1000 megacycles. Laboratories engineers expect it to have applications in radar, microwave radio relay, satellite communications, and waveguide transmission systems. They also expect the low-powered device will cost less and have greater reliability than other methods of achieving comparable amplification of signals.

The device is built on a traveling-wave concept with a row of Esaki diodes along the center of a strip transmission line waveguide. The negative resistance of the diodes causes the power in a signal wave to increase progressively as it travels along the waveguide. By including a magnet and a piece of ferrite material in the structure, the designers have made the device absorb waves traveling in the undesired reverse direction while it amplifies waves traveling in the desired direction. This feature allows a large total amplification to be obtained with complete stability by eliminating internal "feedback" — a phenomenon that had previously caused oscillations and other difficulties in amplifiers of this type.

The Esaki Diode

The active diode used in this amplifier was discovered by Leo Esaki of the Sony Corporation in Japan. It has aroused considerable interest in the electronics industry because it is a simple semiconductor device which can convert direct current into useful alternating-current signals in communications and computer circuits. The Esaki diode has only two terminals and thus is easier to construct than triode transistors or vacuum tubes. Yet it can do many of the same jobs.

Its most useful aspect is its negative-resistance. This lets it add to the power of signal waves instead of absorbing the power as a positive resistance does. Although negative-resistance devices have been known for many years, the Esaki diode is superior to previous types in its simplicity, in its low-power requirements, in the magnitude of its negative-resistance effect, and in its ability to operate at extremely high frequencies.

The new amplifier opens a new field of useful applications for the

Esaki diode by eliminating undesired feedback — one of the major difficulties in applying it as a signal amplifier. The model described has operated most efficiently between 1200 and 1600 mc. Engineers expect that the frequency of operation of future models can be extended to above 3000 mc, still using germanium diodes. Much higher frequencies, perhaps into the millimeter wavelength range, should be possible with diodes of indium antimonide which have been made by R. L. Batdorf, also of the Solid-State Electronics Research Department.

Esaki Diodes Improve Faster Than Ways To Measure Them

Scientists at Bell Laboratories are creating their own problems in characterizing Esaki diodes as they push the operating speeds of these devices up and up. However, Donald E. Thomas of the Solid-State Electronics Research Department described new techniques developed for stabilizing and evaluating the characteristics of the tiny new devices. These techniques have proven very successful for Esaki diodes whose time constants are as small as 10^{-10} seconds (100 milli-microseconds).

Speed of New Models

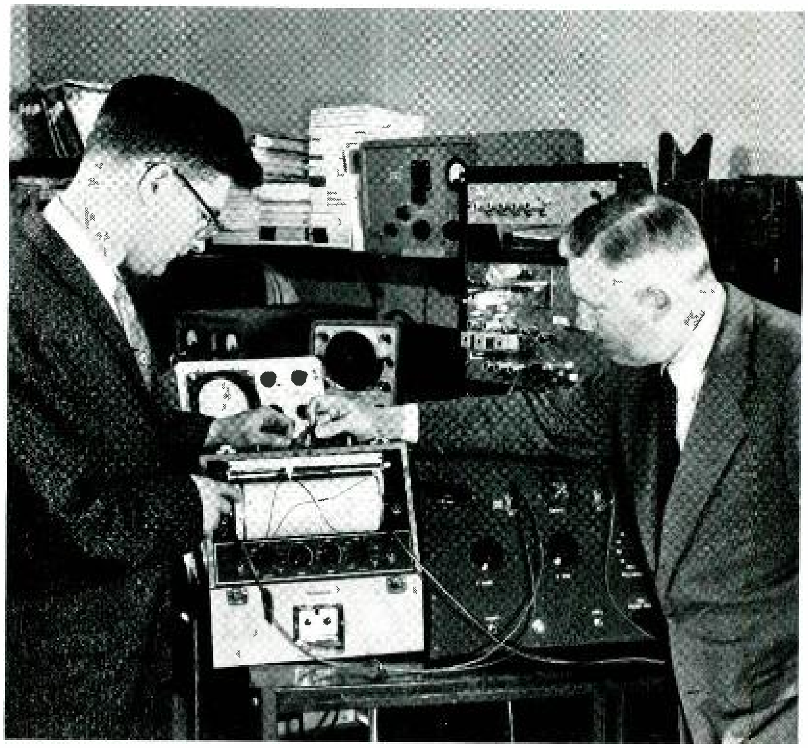
In fact, these methods have worked for indium-antimonide diodes having speeds several times faster. However, new models being devised by Robert L. Batdorf and other members of the Solid-State Electronics Research Department are so fast that they are beyond present stabilization techniques. For example, one such diode has switched a signal of a quarter volt in less time than it takes light, whose velocity is approximately 186,000 miles per second, to travel 2½ inches.

An Esaki diode (see item on opposite page) is a semiconductor device which exhibits a negative-resistance region in its voltage-current curve when biased in the forward direction. In other words, the current decreases as the voltage increases. This negative resistance, multiplied by the junction capacitance of the diode, gives a time constant indicating the relative merit of the device. In general, a smaller time constant corresponds to a faster operating device.

To make direct measurements of the negative resistance and junction capacitance, the engineer must first stabilize the diode in its negative-resistance region. He can do this by shunting the diode with a resistor made equal to or smaller than the negative resistance of the diode. Then if the series inductance in the circuit connecting the shunt to the diode is small enough, the combined diode and shunt will show a voltage-current curve which is stable and positive in slope over the entire voltage range of the diode and which, therefore, can be plotted. If the engineer plots the voltage-current characteristics of the shunt resistance alone and subtracts the shunt resistance current manually from the total current, he can obtain the current characteristics of the diode.

Mr. Thomas described an improvement of this technique at a meeting of the American Institute of Electrical Engineers held on February 4 in New York City. In the new method, the current through the shunt resistance is automatically subtracted from the total current during a characterization trial, thereby giving a direct plot of the voltage-current curve of the diode.

The stabilization methods used for negative-resistance curve tracing are also useful in measuring the junction capacitance of the diode. The characterization methods described have been extremely helpful in research and development efforts aimed at improved diodes for still faster operation.



Robert L. Batdorf, left, and Donald E. Thomas inspect voltage-current curve of an Esaki diode just traced on new instrument. Measuring instruments such as this one must be constantly improved to keep up with the development of devices they measure.

The Laboratories Role In Project Mercury

Details were made public recently of the major scientific and technological effort being mustered toward achieving the first satellite-tracking and ground instrumentation system to encircle the globe. This is a vital phase of the National Aeronautics and Space Administration's Project Mercury.

The joint announcement followed the signing of a contract for more than $30 million by the Western Electric Company, prime contractor on the project, and NASA. Several firms described the roles they will play in the Mercury Project communications network. Major participants with Western Electric are Bell Laboratories, Bendix Aviation Corp., and Burns and Roe, Inc.

Construction on the network has already begun. Eighteen sites make up the world-wide chain of ground stations. When completed in 1961 they will provide communications to America's first astronaut as he orbits the earth in space at 18,000 miles per hour.

Tracking Stations

The world-wide complex essential to the success of the project will have a computing and communications center at the Goddard Space Flight Center, Beltsville, Md., and a control center at Cape Canaveral, Florida. The 18 stations comprising the tracking and ground instrumentation system will include Cape Canaveral, Grand Bahama Island, Grand Turk Island, Bermuda, specially equipped ships in the Atlantic and Indian Oceans, the Canary Islands, two sites in Africa, West and South Australia, Canton Island, Hawaii, two on the west coast of North America, White Sands, N. M., South Texas, and Eglin Air Force Base, Fla.

For the project, Bell Laboratories will handle the basic systems engineering associated with communications and visual presentation and will provide consultation in radar and communications. The Laboratories also will study the compatibilities of various equipments, and develop operational plans to insure the adequacy of the requirements for the over-all system.

W.E. Co. Responsibility

Western Electric will be responsible for managing and directing the activities of other team members to see that the network is built on time and that it has the required capability and reliability to perform as specified in the contract. Western Electric is also responsible for the design and implementation of ground communications required at site locations, for the study of, and the lease arrangements for, suitable communications among the 18 sites. The Company will also train maintenance and operational personnel.

New Modulator For Millimeter Waves

A high-speed pulse modulator for millimeter waves was described at the International Solid-State Circuits Conference held in Philadelphia on February 11. The modulator, which uses gold-bonded germanium diodes, was developed by E. T. Harkless and R. Vincent of the Transmission Systems Development Department.

Pulse code modulation with millimeter waves requires very narrow pulses that can appear and retire very quickly. With this new modulator, the designers have achieved pulse "rise" and "decay" times of less than 2 millimicroseconds at a repetition rate of 10 megacycles. The operation is carried out at carrier frequencies of 35 to 52 kilomegacycles.

The device is essentially a "switch," that is, it effectively turns the incoming radio-frequency carrier signal on and off at a desired frequency. It takes advantage of the fact that the RF impedance of the germanium diodes used with suitable waveguide mounts and tuning elements can be varied from a nearly perfect absorber of radio waves to a practically complete reflector. This change can be made merely by switching the bias signal on the diode. Sending about 40 milliamps of current through the diode in the forward direction gives rise to the absorbing factor. A reverse bias of 5 to 10 volts will then cause the assembly to be a nearly perfect reflector of radio waves.

The modulator uses a pair of diodes mounted in sections of waveguide, combined with a hybrid junction. When the modulator is "on," the diodes reflect essentially all of the incident energy, and the microwave signal is transmitted with an attenuation of only 1 or 2 db. When the modulator is "off," however, practically all of the energy to the diodes is absorbed, and the transmitted signal is attenuated 30 to 40 db. Engineers have used up to one watt of power to successfully modulate at 35 kmc, and have used pulses as short as 5 millimicroseconds.

The diodes in this assembly are formed inside the waveguide structure, using techniques developed by A. E. Bakanowski, D. E. Inglesias, and Mrs. M. S. Boyle, all of the Transistor Development Department. In the method, a gold wire is attached to an n-type germanium wafer by electrical bonding. The bonding process is carried out by passing three short pulses of current through the contact, giving a small, but secure, bond area.

Laboratories Detection System Finds Missile Nose Cones

The point where a ballistic missile or re-entry vehicle hits the surface of the ocean can now be located by special underwater detection systems. They have been developed for the U. S. Navy by Bell Laboratories and are being installed by the Western Electric Company at both the Atlantic and Pacific ballistic missile ranges. Now in operation at the Atlantic Range, the underwater detection systems are aiding recovery teams to find and retrieve the nose cones of missiles that have completed their space flights *(see page 109)*.

Two types of missile-impact locating systems (MILS) are used in locating the missile-impact point. One is a surface-impact system and the other is a Sofar (Sound Fixing and Ranging) bomb method. Both rely on the principles of transmission of sound under water.

The surface-impact system detects and locates the sound of a missile actually striking the ocean's surface. This system uses six hydrophones, or underwater sound receivers, installed on the ocean floor and connected by a special cable to the shore station. Five of the receivers are located in the shape of a pentagon with the sixth in the center. Information from at least three of the six hydrophones is needed to obtain an acoustic "fix."

Sofar Detection

In the Sofar method a bomb is ejected from the missile and exploded under water in the vicinity of the impact point. The sound of the exploding bomb permits the range and bearing to be measured to determine the area of impact. With Sofar systems, detection is possible at distances of several thousand miles.

For the Sofar detection method, a series of hydrophones, generally located in pairs, are spaced about a large area and connected to shore stations by submarine cables. Electronic equipment at the shore stations records the signals from the hydrophones when they receive sound waves generated by the explosion of the Sofar bomb. Trained operators at the shore installations use the time differences of the sound arrivals at different hydrophones to obtain the acoustic fix that establishes the spot where the sound originated.

Distance Determination

The operator obtains the time of arrival of the signal at each hydrophone of the various pairs of hydrophones he has selected. Subtraction gives him a time difference between any two hydrophones. Since the location of the hydrophones and the velocity of sound in water at each location are known factors, the operator can convert time difference into distance difference by multiplying the time difference by the average velocity of sound for the combination of two hydrophones. Then he determines the acoustic fix by locating the intersection of two or more distance-difference lines on previously prepared charts.

To arrive at an acoustic fix, operators must know the speed with which sound travels through water at the location of each hydrophone. This velocity of sound at any given point in the ocean is a function of temperature, pressure and salinity. To check velocity and other factors in the Atlantic Ocean, last year personnel from the Laboratories, Western Electric Company and the U. S. Navy conducted a three-month calibration operation. Some 1,500 explosive charges were dropped in the ocean range areas to simulate the conditions of a missile-locating operation. By knowing the explosion time and position of these charges, the scientists checked the accuracy of the underwater detection systems and provided data for the operators' use in determining acoustic fixes.

The detection system also serves as a navigation aid to recovery vessels. Prior to a missile launching, a ship drops Sofar bombs. The time of arrival of the signal at the hydrophones determines its exact position in relation to the expected impact point of the missile.

Although an operator at the MILS station plots the acoustic fix on his charts, a more exact calculation is obtained by using a computer. Arrival time data from the Atlantic shore stations are sent to Patrick Air Force Base, Florida, and relayed to Winston-Salem, North Carolina, where the information is fed into a computer at the Western Electric plant there. This operation furnishes precise determination of the impact point.

Several MILS stations have been established, including one on the British island of Ascension. Similar stations have been set up or are being constructed on islands in the Pacific for the Pacific Missile Range.

The Underwater Systems Development Department of Bell Laboratories developed the detection systems. Equipment for the systems is furnished and installed by the Western Electric Co. plant in Winston-Salem, North Carolina.

New Indoor-Outdoor Phone Booth Designed At the Laboratories

"The Universal," latest addition to the Bell System's family of pay phone booths, is a versatile new indoor-outdoor model, designed by Bell Laboratories. It will be available to the Operating Companies early this year.

The Universal was developed in answer to Operating Company requests for a small, glass-walled booth that could be placed in either outdoor or indoor locations — like sidewalks or stores — where space is at a premium. It also provides transparent booths that can be arranged in neater-looking compact groups.

R. K. Honaman Retires; G. Griswold, Jr. Named New Director of Publication

R. Karl Honaman, Director of Publication at Bell Laboratories, retired on March 1 after more than 40 years of Bell System service. Since 1945 Mr. Honaman has directed all public relations activities of Bell Laboratories, including press relations, employee information, advertising, technical and personnel magazines, technical libraries, and community relations.

He began his telephone career in 1919 with the Development and Research Department of the American Telephone and Telegraph Co. in New York. For the next 20 years his work dealt principally with the protection of telephone circuits, and a number of patents were granted to him for inventions in this field. As Assistant Protection Development Engineer, he transferred with his group to Bell Laboratories in 1934.

At the beginning of World War II, Mr. Honaman organized the School for War Training to instruct military personnel in radar and related developments, and served as its director until 1945. After the war, he was appointed Director of Publication, with responsibility for all publication and public relations programs of Bell Laboratories.

From October 1954 to January 1956, Mr. Honaman was on leave from Bell Laboratories to serve with the Federal Government. During the first part of this period he was Consultant to the Secretary of Commerce, and organized and served as Director of the Office of Strategic Information. From April to December 1955, he was Deputy Assistant Secretary of Defense, with responsibility for the public affairs activities of the Defense Department.

Mr. Honaman is Chairman of the Committee for Engineering Information Services, an Engineers Joint Council committee for cooperation with the National Science Foundation.

He is a Fellow of the American Association for the Advancement of Science and of the American Institute of Electrical Engineers. He is a Senior Member of the Institute of Radio Engineers, and past president of the New York Electrical Society. He is also a member of the American Management Association, The Society for the Advancement of Management, Public Relations Society of America, Public Relations Society of New York, The Commerce and Industry Association of New York, The New Jersey State Chamber of Commerce, The American Ordnance Association and the Armed Forces Communications and Electronics Association.

He is a director of the Rand Development Corporation, Cleveland, Ohio, of Floating Floors, Inc., New York, and of the New Jersey Council on Economic Education.

Mr. Honaman was a member of a delegation which visited Moscow in 1958 to discuss trade relations with the Soviet Union. In 1959 he visited a number of countries in Western Europe, where he discussed industrial and technological problems.

A native of Lancaster, Pa., Mr. Honaman received the B.S. and M.S. degrees from Franklin and Marshall College in 1916 and 1917, respectively. He was awarded the 1956 Alumni Citation of Franklin and Marshall College for "outstanding contributions to the greater community." In 1958 he received the Centennial Medal of Seton Hall University.

Griswold New Director

George Griswold, Jr., Assistant Director of Publication of the Laboratories, has been named Director of Publication, effective March 1, to succeed Mr. Honaman.

Mr. Griswold joined the Laboratories in 1955. Previously he had been associated with the Long Lines Department of the American Telephone and Telegraph Company and with *Newsweek* magazine.

A native of New York City, he is a graduate of Yale University. He served in the U. S. Navy during World War II and holds the rank of Commander in the Naval Reserve.

Mr. Griswold is a member of the Overseas Press Club, The Public Relations Society of America, and the National Association of Science Writers.

Benjamin Lax Wins Buckley Prize

The 1960 Oliver E. Buckley Solid-State Physics Prize was awarded to Benjamin Lax, head of the solid-state division of the Massachusetts Institute of Technology's Lincoln Laboratory in Lexington, Mass. Dr. George B. Kistiakowsky, President Eisenhower's special assistant for science and technology, spoke at the presentation, which was sponsored by the American Physical Society and the American Association of Physics Teachers.

The Buckley Award, which carries a stipend of $1,000, was established by Bell Laboratories in honor of the retired chairman of the board of the Laboratories who died last year.

E. E. David Wins Civic Award

Edward E. David, Jr., Director of Visual and Acoustics Research, was presented the 1st annual Outstanding Young Man-of-the-Year Award by the Summit, New Jersey Area Junior Chamber of Commerce. The newly instituted award, an engraved plaque, was presented at the Jaycees' annual awards dinner on February 2.

E. I. Green, J. R. Pierce Named Fellows of Acoustical Society

Estill I. Green, Executive Vice President of the Laboratories, and John R. Pierce, Director of Research - Communications Principles, have been elected Fellows of the Acoustical Society of America.

Mr. Green was cited for "his patents, publications and executive direction of the acoustics of the telephone and transmission media associated with telephony."

Mr. Pierce was cited for "technical exploration for world-wide speech communication by man-produced satellites; for formulation and lucid exposition of new communication principles with depth of understanding of the roles of psychological, physiological, and technological factors in communication."

S.B.Cousins,J.E.Dingman Elected Directors of the Laboratories

Sanford B. Cousins, Vice President—Personnel Relations of the A.T.&T. Co., and James E. Dingman, Vice President and Chief Engineer of A.T.&T., were elected to the Board of Directors of Bell Telephone Laboratories on January 25. At the same time, H. Randolph Maddox, former A.T.&T. Vice President, retired as a Director.

Mr. Cousins was Vice President and General Manager of the Laboratories from 1950 to 1952 and Mr. Dingman held the same post from 1952 to 1956.

Mr. Maddox, who retired at his own request from the A.T.&T. Co. on December 31, was Vice President-Personnel Relations from 1954 until last October when he became Vice President with responsibilities in the field of Management Development and Personnel Research. He had been in the Bell System since 1921.

James W. McRae, 1911-1960

James W. McRae, a Vice President of A.T.&T. Co. and former member of the Laboratories, died suddenly on February 2. Mr. McRae was coordinator of defense activities for the Bell System.

His career began in 1937 when he joined Bell Laboratories where his work included research on transoceanic radio transmitters and microwave techniques, both for civilian and military applications.

In 1942, as a Major in the Signal Corps, he coordinated development programs for airborne radar equipment and radar countermeasure devices. He was awarded the Legion of Merit for his military service. He was later chief of the engineering staff of the Signal Corps Engineering Laboratories at Bradley Beach, N. J., and subsequently Deputy Director of the Engineering Division.

Mr. McRae returned to the Laboratories in 1946 as Director of Radio Projects and Television Research. Early in 1949, he was named Director of Apparatus Development, then Director of Transmission Development. He was appointed Vice President in charge of Systems Development in 1951. He was elected President of Sandia and Vice President of Western Electric in 1953.

Mr. McRae, a native of Vancouver, British Columbia, received his bachelor's degree in electrical engineering from the University of British Columbia and his master's degree from the California Institute of Technology. He earned his doctorate there in 1937.

He was a Fellow of the Institute of Radio Engineers and served as President of the National Society in 1953. He was also a member of the American Institute of Electrical Engineers and Sigma Xi.

In October, 1959, the Army awarded Mr. McRae the Distinguished Civilian Service Medal for contributions toward development of a series of small tactical nuclear weapons while he was president of the Sandia Corporation.

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PATENTS

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

Abbott, G. F., Jr. — *Line Circuit* — 2,921,140.

Alford, E. L. and Benning, A. D. — *Combination Step and Extension Ladder* — 2,919,762.

Benning, A. D., see Alford, E. L.

Beurrier, H. R. — *Electron Discharge Devices Using Grid Control Scanning* — 2,920,231.

Bobeck, A. H. — *Magnetic Core Switching Circuit* — 2,922,145.

Bozorth, R. M. and Nesbitt, E. A. — *Permanent Magnets*—2,920,381.

Chynoweth, A. G. — *Ferroelectric Memory Device* — 2,922,986.

Clark, M. A., Miller R. L. and Sears, R. W. — *Two-Way Television Over Telephone Lines* — 2,992,843.

Cutler, C. C. — *High Speed Counting and Switching Tubes* — 2,922,069.

Friis, H. T. and Warters, W. D. —*Circular Electric Wave Transmission* — 2,922,969.

Friis, H. T. and Robertson, S. D. — *Finline Coupler* — 2,921,272.

Graham, R. E. — *Method and Apparatus for Reducing Television Bandwidth* — 2,921,124.

Harkless, E. T. — *Wave-Guide Coupler* — 2,922,122.

Harrison, C. W.—*Aperture Equalizer and Phase Correction for Television* — 2,922,965.

Haugk, G. — *Information Storage System* — 2,922,987.

Kennedy, K. K. — *Electrical Testing Device* — 2,921,191.

Kennedy, W. J. and Pferd, W. — *Coin Collectors* — 2,922,571.

Ketchledge, R. W.—*Wave Energy Translating System* — 2,922,100.

Kompfner, R.—*Nonreciprocal Elements in Microwave Tubes* — 2,922,917.

Krom, M. E.—*Line Concentrator Signaling System* — 2,921,139.

Mallery, P.—*Code Translators*—2,920,317.

Miller, R. L., see Clark, M. A.

Nesbitt, E. A., see Bozorth, R. M.

Nielsen, R. J. — *Fabrication of Grid Structures for Electron Discharge Devices* — 2,921,363.

Panner, E. J. — *Computing Circuit* — 2,920,826.

Peek, R. L., Jr. — *Contact Making Device* — 2,922,857.

Pferd, W., see Kennedy, W. J.

Reiling, P. A. — *Translating Circuits* — 2,922,151.

Reise, H. A. — *Quick Recovery Circuit for Blocking Oscillators* — 2,922,037

Robertson, S. D., see Friis, H. T.

Robertson, S. D.—*Finline Coupler* — 2,922,961.

Rosenthal, C. W.—*Magnetic Core Memory Circuits* — 2,922,988.

Scovil, H. E. D. and Seidel, H. — *Power Saturable Wave Guide Components* — 2,920,292.

Sears, R. W., see Clark, M. A.

Seidel, H., see Scovil, H. E. D.

Suhl, H. — *Hall Effect Device for Electromagnetic Waves*—2,922,129.

Suhl, H. — *Nonreciprocal Single Crystal Ferrite Devices*—2,922,125.

Suhl, H. and Walker, L. R.—*Nonreciprocal Wave Guide Component* — 2,922,126.

Tien, P. K. — *Traveling Wave Tube Amplifier* — 2,921,224.

Tinus, W. C. — *Electrical Impulse Transmitter* — 2,921,142.

Turner, E. H. — *Nonreciprocal Wave Transmission*—2,922,964.

Walker, L. R., see Suhl, H.

Warters, W. D., see Friis, H. T.

Young, W. R., Jr.—*Translator*— 2,922,996.

TALKS

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

ANNUAL MEETING OF THE INSTITUTE OF MATHEMATICAL STATISTICS, Washington, D.C.

Benes, V. E., *A Renewal Limit Theorem for General Stochastic Processes.*

Gnanadesikan, R., *On Certain Alternative Hypotheses on Dispersion Matrices.*

Groll, P. A., *A Problem in Restrictive Group-Testing.*

Gupta, S. S., *On a Single Sample Decision Procedure for Selecting a Subset Containing the Population with the Largest Mean and Some Extensions.*

Gupta, S. S., *On a Single Sample Procedure for Selecting the Population with the Smallest Variance.*

Gupta, S. S., and Sobel, M., *On the Distribution of the Ratio of the Smallest of Several Chi-Squares to an Independent Chi-Square.*

Murphy, R. B., *Some Statistical Techniques for Industrial Tolerancing.*

Sobel, M., see Gupta, S. S.

OTHER TALKS

Barry, P. H., and Whitman, A. L., *An Error-Detection System for 5-Unit-Code Teletypewriter Transmission,* A.I.E.E. Fall General Meeting, Chicago, Ill.

Batdorf, R. L., *Esaki Diode,* Rensselaer Institute, Troy, N. Y.

TALKS (CONTINUED)

Batterman, B. W., *X-Ray Intensity Measurements and the Distribution of Electrons in Iron and Copper*. Pittsburgh Diffraction Society, Pittsburgh, Pa.

Bender, W. G., *Pulse Code Modulation*, Merrimack Valley Subsection, I.R.E., North Andover, Mass.

Blumberg, W. E., Eisinger, J., and Shulman, R. G., *Nuclear Magnetization Distribution of Two Mercury Isotopes from Their Knight Shifts*, A.P.S. Meeting, Pasadena, Calif.

Bozorth, R. M., *Magnetic Properties of Ferromagnetic Superconductors*, A.I.E.E. Conference on Magnetism and Magnetic Materials, Detroit, Mich.

Buchsbaum, S. J., *Ion Plasma Resonance*, A.P.S., Plasma Symposium, Monterey, Calif.

Bulloch, W. D., *New Developments and Things to Come in Telephony*, A.I.E.E., Jacksonville, Fla., Dec. 14; Miami, Fla., Dec. 15; Tampa, Fla., Dec. 17, 1959.

Cohen, B. G., *What Are These Things Called Compound Semiconductors?*, Johns Hopkins University, Baltimore, Md.

Cornell, W. A., and Schulte, H. J., *Multi-Area Mobile Telephone Systems*, I.R.E. Prof. Gp. on Vehicular Communications, St. Petersburg, Fla.

Courtney-Pratt, J. S., *Image Dissection Cameras*, Soc. of Photographic Instrumentation Engineers, Long Island, N. Y.

Cutler, C. C., *Engineering Background for Communication in Space*, Montclair Soc. of Engineers, Montclair, N. J.

David, E. E., Jr., *Digital Simulation in Perceptual Research*, I.R.E., Atlanta, Ga.

David, E. E., Jr., *Perception and Coding of Speech*, Philadelphia Section I.R.E., University of Pennsylvania, Philadelphia, Pa.

DeCoste, J. B., and Stiratelli, B. A., *Characterization of Poly (Vinyl Chloride) Resins by the Conductivity of the Water Extract*, Sixteenth Annual Tech. Conf. of A.P.S., Chicago, Ill.

Eisinger, J., see Blumberg, W. E.

Engelbrecht, R. S., and Mumford, W. W., *Parametric Amplifiers: Historical Background and Recent Results with UHF Traveling Wave Amplifiers Using Diodes*, Monmouth Subsection of I.R.E., Little Silver, N. J.

Ferrell, E. B., *Fundamental Concepts of Statistical Analysis*, Alumni Association RCA Institutes, N. Y. C.

Fitch, F. B., *A Computer Program for Basic Logic*, Columbia University, Symbolic Logic Meeting, N. Y. C.

Fu, C., and Jepson, J. W., *Criteria for Design of Foundations for Precision Tracking Radars Considering Dynamic Response*, A.S.M.E. Meeting, Atlantic City, N. J.

Geschwind, S., *Optical Detection of Paramagnetic Resonance in Metastable State of Ruby*, New York University, Jan. 12; Columbia University, Jan. 19, 1960.

Gordon, J. P., *The Maser*, University of Syracuse, Physics Dept., Syracuse, N. Y.

Hammer, J. M., *Low Noise C Band Traveling Wave Tube*, I.R.E. Prof. Gp. on Electron Devices, Washington, D.C.

Jaccarino, V., *Nuclear Magnetic Resonance and Nuclear Quadrupole Resonance in Antiferromagnets*, University of California, Berkeley, Calif.

Jaccarino, V., *Temperature Dependence of the NMR in Ferromagnetic Cobalt*, A.P.S. Meeting, Pasadena, Calif.

Jepson, J. W., see Fu, C.

King, J. C., *Dislocation and Impurity Induced Defects in Quartz*, Thirteenth Annual Symposium on Frequency Control, Asbury Park, N. J.

McMillan, B., *Statistics, Measurement, and Information Theory*, University of Pennsylvania, Philadelphia, Pa.

Montsma, J., *Some Problems Associated with the Determination of the Shock and Vibration Environment of a Guided Missile in Flight*, Institute of Environmental Sciences, N. Y. C.

Moore, E. F., *Machine Models of Self-Reproduction*, Summit Association of Scientists, Summit, N. J.

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

Murphy, R. B., *Quality Assurance and Reliability*, Alumni Association RCA Institutes, N. Y. C.

Reed, E. D., *The Variable-Capacitance Parametric Amplifier*, I.R.E./A.I.E.E. Meeting, Philadelphia, Pa.

Schimpf, L. G., *The Application of Semiconductors in an 860-MC Radio Receiver*, I.R.E. Prof. Gp. on Vehicular Communications, St. Petersburg, Fla.

Schulte, H. J., see Cornell, W. A.

Scott, J. W., *Designing for the Shock and Vibration Environment*, A.S.M.E., College of Engineering, Newark, N. J.

Schimmin, E. R., Vanderlippe, R. A., and Whitman, A. L., *A Small Automatic Teletypewriter Switching System*, A.I.E.E. General Meeting, Chicago, Ill.

Shulman, R. G., see Blumberg, W. E.

Slichter, W. P., *Some Developments in Polymer Morphology*, University of Wisconsin, Dept. of Chem., Madison, Wis.

Stiralelli, B. A., see DeCoste, J. B.

Sundquist, M. R., *Sampling Techniques for Automatic Waveform Analysis*, Elks Club, Winston-Salem, N. C.

Vanderlippe, R. A., see Shimmin, E. R.

Wasserman, E., *Thermochromism and Linear Radicals*, New York University, Solid-State Physics Group, N. Y. C.

Wasserman, E., *Thermochromism of Bianthrone*, Princeton University, Princeton, N. J.

Whitman, A. L., see Barry, P. H.

Whitman, A. L., see Shimmin, E. R.

THE AUTHORS


H. F. Hopkins

Harris F. Hopkins, author of "Push-Button 'Dialing'" in this issue, joined the Laboratories (then the Engineering Department of the Western Electric Company) in 1920. Until 1949 he was concerned with the development of special products, such as the electrical stethoscope, equipment for sound systems and acoustical instruments. Since 1949 his efforts have been devoted to the development of telephone station apparatus. His present assignment — Station Instrumentalities Engineer — involves exploratory development and field appraisal of station apparatus and systems. Mr. Hopkins holds the E.E. degree from the Polytechnic Institute of Brooklyn.


M. C. Waltz

Maynard C. Waltz is engaged in development of electronic apparatus at the Allentown location of Bell Laboratories. His particular work at present involves silicon rectifier diodes. A native of Damariscotta, Maine, Mr. Waltz graduated from Colby College in 1938 with a B.A. degree in physics, and from Wesleyan University in 1940 with a M.A. degree in physics. Prior to joining the Laboratories in 1946, he taught at Wesleyan, and also engaged in microwave research at the Radiation Laboratory at M.I.T. Mr. Waltz is a member of Phi Beta Kappa, Sigma Zi, and Sigma Pi Sigma, as well as a senior member of the I.R.E. In this issue, he is the author of "Semiconductor Reliability Studies."


T. G. Blanchard

T. G. Blanchard, who is a native of Paterson, New Jersey, received his M.E. and M.S. degrees from Stevens Institute of Technology. He joined the Laboratories in 1942 to work in the Transmission Apparatus Development Department on the design and development of power transformers, reactors, charging chokes and magnetic voltage stabilizers. From 1950 to 1952, he engaged in fundamental studies of the behavior of solid and liquid dielectrics for use in transformers and capacitors. In 1952, he was assigned to the then newly formed magnetic amplifier group. Mr. Blanchard is at present in the Military Power Apparatus Department, concerned with the theory and design of magnetic amplifiers and circuits incorporating magnetic amplifiers. He wrote the article, "Magnetic Amplifiers: Analog Operation and Applications," in this issue.


C. M. Taris

C. M. Taris, a native of New Jersey, received the B.S. degree in Physics from Yale University in 1948. After about three years with the audio-video engineering department of the National Broadcasting Company, he joined Bell Laboratories in 1951. At the Laboratories, Mr. Taris has been engaged in the development of telephone answering sets and related apparatus and recorded announcement equipment — the subject of his article, "New Audio Facilities for Recorded Announcements," in this issue. He is a member of the Audio Engineering Society, the American Association for the Advancement of Science, Sigma Xi and Phi Beta Kappa.

T. F. Benewicz, a native of Fort Lee, N. J., joined the American Telephone & Telegraph Company in 1947. He was temporarily assigned to the Systems Engineering Department at Bell Laboratories in 1957, for the purpose of

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T. F. Benewicz

studying and developing improved telephoto testing and measuring techniques. He formally transferred to the Laboratories in 1958, as an Associate Member of Technical Staff. In 1959, he transferred to the Long Lines Department of the AT&T Co., where he is presently a Transmission Supervisor in the telephoto section. Mr. Benewicz is a member of the I.R.E., where he is secretary of the Committee on Facsimile. In this issue, he is the author of "Measuring Line Level on Telephoto Systems."

M. C. Goddard, a native of Sidney, Maine, graduated from Worcester Polytechnic Institute in 1921 with the B.S. degree in Electrical Engineering. He joined the Engineering Department of the Western Electric Company in June of that year, and has since been continuously with that organization and with Bell Laboratories. During his first nine years in the Bell System, Mr. Goddard was successively concerned with maintenance and descriptive circuit information, with laboratory testing of circuits, and with adaptation of standard circuitry to special field conditions. From 1930 to 1942 he designed circuits for the step-by-step system, and during World War II he was a member of the teaching staff on the Laboratories School for War Training, where he specialized in airborne radar. Since World War II he has been concerned with the development of the No. 5 crossbar system. He is a member of A.I.E.E. and is also a New York Licensed Professional Engineer.

M. C. Goddard