March 1959

Bell Laboratories

RECORD

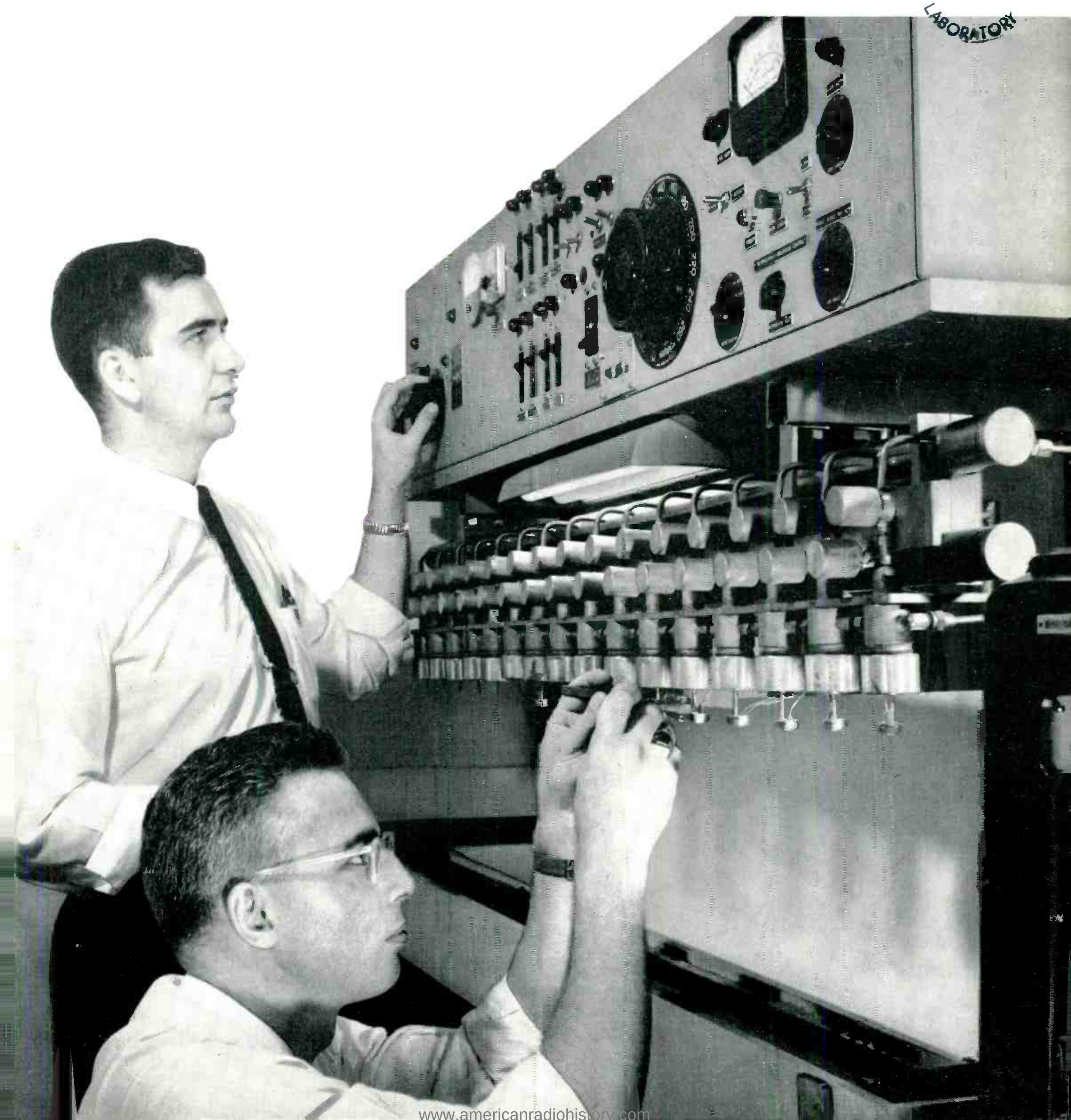
TASI: A Time-Assignment System

Transistors for Electronic Switching

Test Patterns for Printed Circuits

Canaveral: Timing-Signal Transmission

Message Billing in No. 5 CAMA



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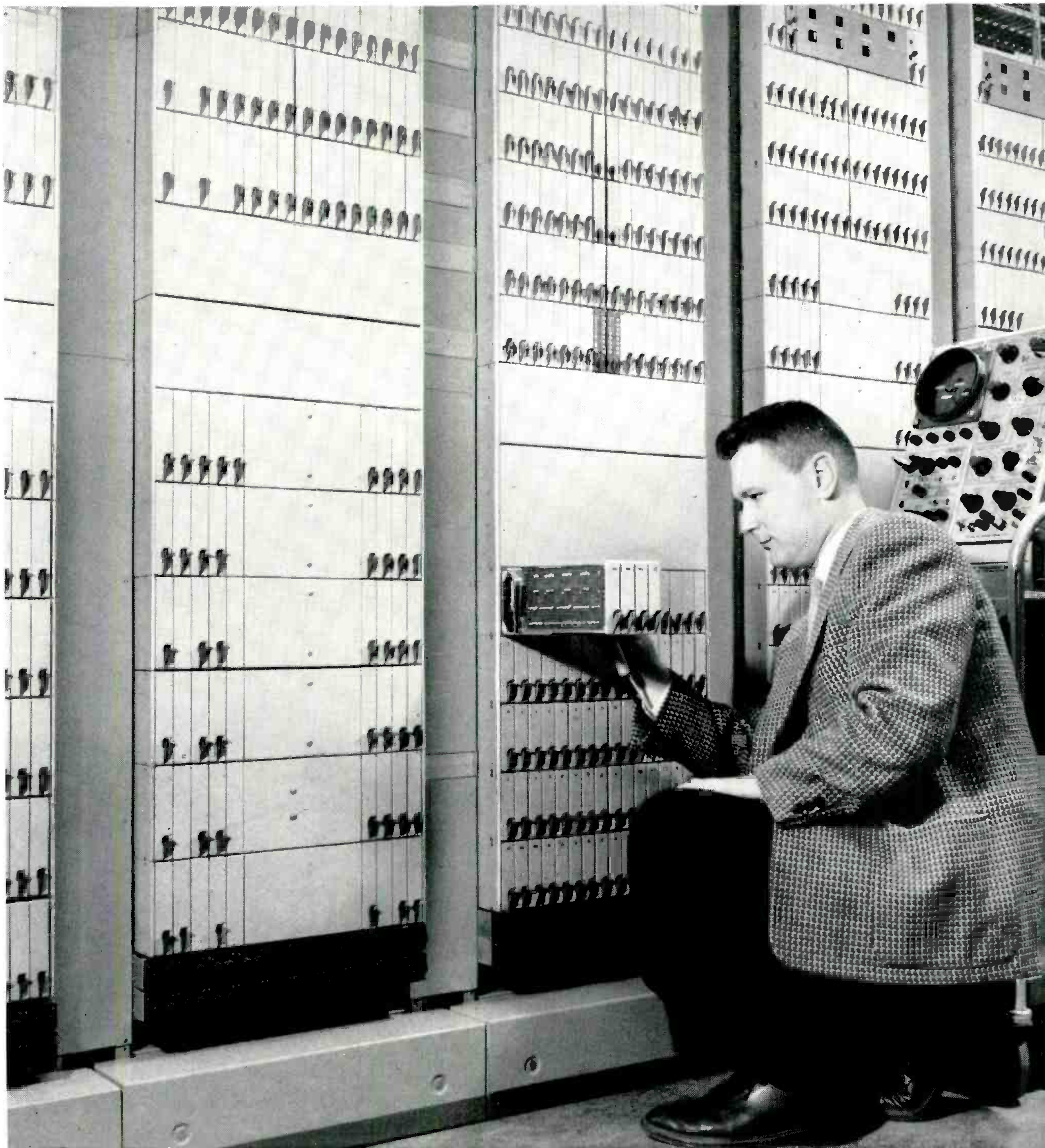
Contents

Cover *R. W. Westberg (foreground) and T. R. Robillard using pump equipment to evacuate and backfill development models of ESS transistors at the Allentown, Pa., Laboratory (see page 88).*



Final developmental model of a portion of the TASI system. R. L. Madsen is testing a group of printed wiring cards mounted in a special holder. Complete system will be made up of about 2,500 of these cards, mounted in such slide frames and inserted into slotted shelves of equipment bays.

To make available additional, much needed transatlantic telephone circuits, Bell Laboratories is harnessing the fourth dimension. The "time saver" is a system for using all the idle time in the conversation of talkers on a group of channels to provide paths for other talkers. This system, which may double the traffic capacity of the present cable, is called —

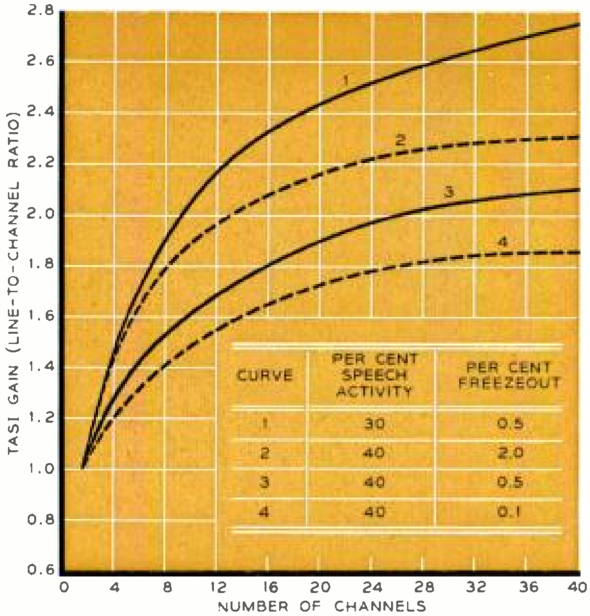
E. F. O'Neill

TASI

One of the most important contributions the telephone makes in today's busy world is helping us to make more efficient use of our time. For example, we call our physician or dentist and make an appointment to share with his other patients a definite portion of his valuable time. Also, on business trips, a busy engineer or salesman generally telephones ahead and arranges a full schedule of appointments, because on such trips, "time is money." For the telephone plant, time is money, too. And just as the engineer or salesman attempts to fill his schedule, transmission systems development engineers at Bell Laboratories are designing equipment to arrange a fuller schedule for the transmission facilities he uses — the long-distance circuits of the Bell System.

Because of the transmission factors involved, almost all of these long-distance circuits are of the "four-wire" type. This means that the opposite directions of transmission in a two-way connection are carried over two physically separate pairs of wires. Or, on the same line, the opposite directions might be transmitted over two separate channels that are carrier-derived. These four wires or two carrier channels, then, carry only the same amount of information as two wires do on the shorter local circuits. When our salesman is arranging an appointment with one of his customers, he spends half of his time listening, which means that his transmitting circuit is "inactive." And even while he is speaking, there will be pauses between his phrases and syllables or "talkspurts" that will reduce his conversational "activity" to less than half of the total time of the actual connection.

Proposals to improve the efficiency of toll circuits by taking advantage of the "talk-and-listen" nature of conversation date back at least 25 years, and considerable effort at Bell Laboratories has been devoted to the problem. The principle underlying most of these proposals is a form of "time sharing." In general the idea is to connect a talker to an available transmission channel for the duration of a talkspurt rather than for the duration



CURVE	PER CENT SPEECH ACTIVITY	PER CENT FREEZEOUT
1	30	0.5
2	40	2.0
3	40	0.5
4	40	0.1

This graph and table relate the four quantities important in line-concentration analysis: channels available, ratio of channels to lines, average activity of talkers and the "freeze-out" fraction.

of a whole telephone conversation or connection.

Schemes for implementing this kind of time sharing have for some years carried the more explicit title of "Time Assignment Speech Interpolation" — abbreviated TASI. As the name implies, TASI assigns a talker (and his listener) to a channel, and then as the need arises interpolates, or puts in between the bursts of his speech talkspurts from other talkers.

In all of these schemes, however, one thing was always obvious — the equipment for the ends of a transmission line would be complicated and expensive. And because of the rapid development of carrier techniques and multi-channel, high-frequency transmission systems such as coaxial cable and radio relay, it has been more economical to increase the number of transmission channels than to increase the time occupancy on existing channels.

With the advent of telephone service over transoceanic submarine cables, this situation has changed radically. Here, the difficulty and cost of providing additional channels make the application of time-sharing equipment much more attractive than it has ever been in the past. As a result, transmission engineers at Bell Laboratories began studying various schemes for increasing the efficiency of submarine circuits even before the completion of the first of these, the transatlantic cable, in 1956 (RECORD, *February, 1957*). These studies have recently culminated in a program for the development of a practicable TASI system.

The TASI arrangement under development is expected to double the traffic-handling capacity of the 36 two-way channels provided by the present design of submarine cables. By taking advantage of the "idle" periods in a normal conversation, the system can connect more talkers to channels than there are full-time channels available. When a talker starts to speak, TASI will connect him to one of the "idle" channels. If there are fewer talkers than channels, none of the talkers need be switched (interpolated) after his initial connection is established.

When there are more talkers than channels, the terminal equipment will very rapidly connect talkers who become active by disconnecting talkers who are silent at that moment. In turn, disconnected talkers will be quickly assigned to other momentarily inactive channels when they start to speak again. A talker will be disconnected only when he is silent.

With TASI, as with any line-concentration scheme, there is always a possibility that more people will be seeking access to the channels than there are channels available at that moment. When this happens, the speech of the overflow talkers will be clipped or "frozen-out." One can easily see that interpolation would not be practical with just two talkers for one channel, for they would frequently collide and the amount of freeze-out would be intolerable.

But this is not true for larger groups of talkers and channels. Under these conditions, the statistics become more favorable, and the possible gain in efficiency through interpolation increases with the size of the group. It is also evident that the gain in efficiency made possible by interpolation depends on the percentage of the total time the talkers are actually speaking—that is, the "average activity"—and on the "freeze-out fraction," or percentage of total speech lost, that can be tolerated.

The graph and table on this page relate gains in efficiency made possible by TASI (line-to-channel ratio) to group size, average activity and freeze-out fraction. Curve 3, for example, shows that for a group of 36 undersea channels and a speech activity of 40 per cent, a gain of slightly more than two to one (the ability to handle over 72 lines) will result in a freeze-out of 0.5 per cent of the speech. This slight clipping would be barely perceptible, even to a critical listener (*see photograph on page* 87).

Basically, the equipment for the TASI System consists of a transmitter and a receiver for each direction of transmission. The transmitters concentrate the talkspurts from the lines connected to them onto the channels of the cable. Receivers perform the inverse action — assigning the received talkspurts to the appropriate listeners' lines. The sketch on this page shows the TASI transmitters and receivers and the connections from the two-wire customer lines and the four-wire submarine cable.

TASI transmitters have four major parts: (1) a speech detector, (2) a high-speed switch, (3) a signaling circuit, and (4) a common control. A block schematic on the next page shows these major elements and their relationship to the undersea channels and the connected lines.

The speech detector serves the important purpose of deciding, and giving a discrete, "yes-or-no" indication of whether a subscriber is talking or not. While complicated in detail, the detector is, in effect, simply a high-gain amplifier with a "threshold" circuit that switches a voltage onto one of the two output leads. It switches to the "inactive" output if the customer is not talking, or to the "active" output when he is. The transfer from one output to the other occurs when the speech energy at the input exceeds a predetermined low level.

This level is difficult to establish because the detector must distinguish between low-energy speech sounds and the noise that is inevitably present. If the detector (amplifier) is made insensitive, the talker's speech will be mutilated because of the loss of low-level sounds. If it is made too sensitive, even a talker's breathing will cause an active output and make his channel appear busy. This, of course, would entirely defeat the operation of the system. In addition to sensitivity, the frequency response, operate time, and release time are carefully controlled to discriminate against noise yet give optimum operation from speech signals.

The second major part of the TASI transmitter — the high-speed switch — does the actual switching of talkspurts from one channel to another. Unlike most switches currently used in the telephone system, whose connections are completed through a space array of contacts, the TASI switch operates on the "time-division" principle.

In this time-division switch, the speech on each line is sampled 8000 times per second. Each sample, however, occupies only a very short interval — about two microseconds. Sampling for a very short interval makes it possible to sample all the connected talkers at the 8000-cycle rate with no overlapping of the sampling intervals. The pulses that result from this sampling are steered to the appropriate channel, during the sampling intervals, by the selective operation of transistor "gates" in each channel.

Each channel, therefore, receives a train of

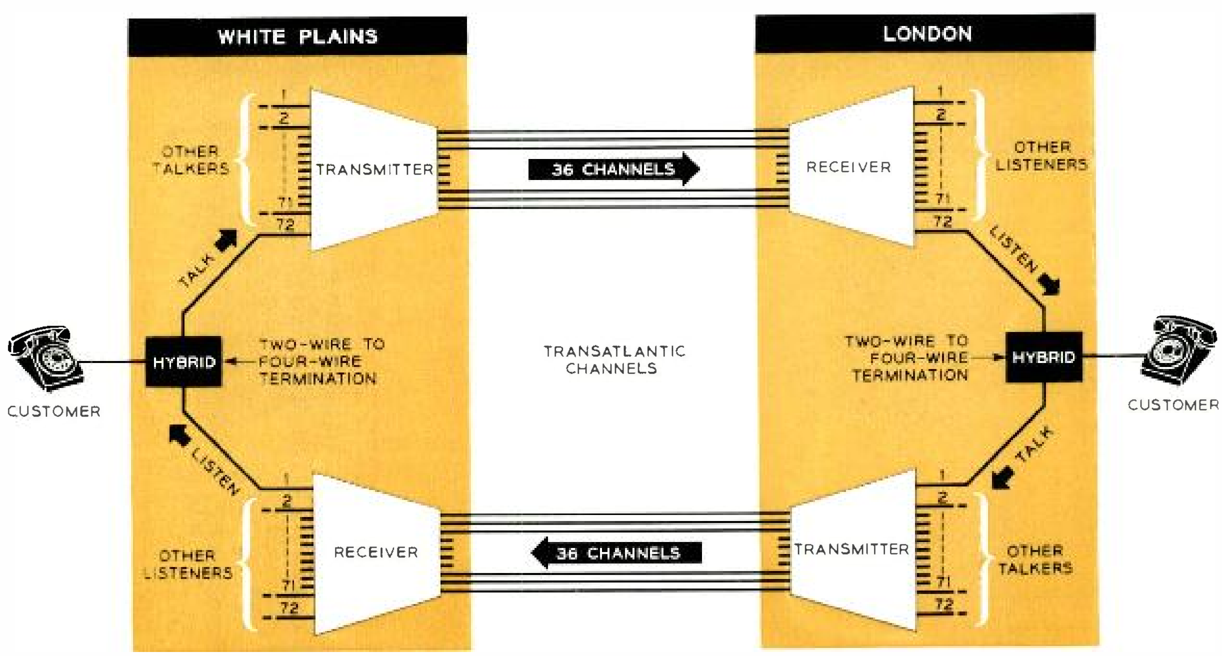


Diagram showing the basic TASI plan. Note that terminals are at White Plains, N. Y., and London, England, not at the ends of the deepsea portion at Clarenville, N. S. and Oban, Scotland.

A careful program of development is usually necessary to advance a discovery to the point where it is useful in an actual system. Such is the case with the transistor: through a program of continual improvement to fit special needs, it has found many applications and is now being incorporated into telephone circuits to be used in a field trial of an electronic switching office.

T. R. Robillard and R. W. Westberg

Transistors for Electronic Switching

Some time during 1960, it is expected that a Bell System field-trial installation of an electronic telephone switching system (ESS) will be put in service, and will represent the first Bell System application designed to incorporate transistors as active switching elements. Basically, this system will consist of high-speed data storage and processing equipment, which in several units will use transistors as control elements (RECORD, *October*, 1958).

The data equipment will be of the common-control type — that is, an electronic machine that performs actions common to all calls in the office. The talking-path connections for telephone conversations will be made with gas-tube switches. Another system, as yet only in the planning stage, may use transistors in both talking and common-control circuits.

Transistors offer two distinct advantages over electron tubes, namely, increased reliability and low power consumption. Many engineers believe that electronic systems will inevitably take over a larger and larger part of the telephone job in future years.

A unique feature of the new electronic system will be the use of basic circuit packages which plug into equipment frames and which may be readily removed for servicing. Several types of transistors will be used *(see Table on next page)*, but the majority of applications will incorporate two types of germanium alloy-junction transistors (RECORD, *January*, 1956). These transistors, an n-p-n and a p-n-p, are to be used as amplifying devices in switching circuits. In terms of their circuit functions, they will be used as pulse generators, pulse amplifiers and memory or storage elements.

Both units have identical mechanical structures, and each will dissipate 400 milliwatts of power at room temperature in free air with no externally-attached heat sink. During initial development, improvements of the external structure culminated in the present design, which measurements now show is capable of dissipating about one watt of power under the same conditions of operation. To satisfy speed requirements, these transistors must have an alpha cut-off frequency greater than 4 megacycles. This means that as the signal frequency is increased, the current amplification of the device shall not fall to 0.707 of its low-frequency value until a frequency of at least 4 megacycles is reached. For these devices, alpha cut-off is measured by the large-signal pulse response method.

The structural design of a conventional medium-power transistor demands that the unit be clamped to a chassis to conduct the internally generated heat at a rate sufficient to limit the alloy junction temperature to some safe maximum, say 85°C. As shown in the photograph on page 90, the mounting board for the transistors and their associated circuit elements is a printed wiring card to which the transistors are secured with auxiliary spring clips. Since this is an insulated mounting and therefore does not conduct heat away from the transistor, a new structural design concept was devised in which the entire transistor enclosure now performs the same thermal functions as a supplemental chassis. The enclosure itself thus serves as a self-sufficient heat dissipator.

The photograph also shows how closely the plug-in cards may be packed without exceeding the allowable limit of heat dissipation; the base module here is only ¾ inch in its horizontal dimension and 2 inches in its vertical dimension. With this arrangement, the transistor can radiate only a very small amount of heat from the end of the transistor structure because other "hot" transistors may be mounted on adjacent cards. However, sufficient heat is dissipated by convection and by radiation from the cylindrical sides of the unit to keep the transistor junctions at a safe operating temperature.

The horizontal spacing of the circuit boards includes room for withdrawal of the board, and this requirement limits the over-all height of the transistor to 0.6 inch. The maximum diameter of the transistor (about 0.9 inch) was limited by the space available for mounting two transistors lengthwise in a two-inch space of the 1-¾ by 7 inch circuit board.

In the usual operation of a transistor, the collector junction is the primary source of heat. So that this heat may pass easily out of the structure, the design incorporates a direct connection of the collector junction to a post on an all-copper mount. The flange of this mount is joined to a drawn-copper can *(see drawing on page 91)*. The sealed area provides a good thermal connection between the mount and can, and the generated heat quickly travels to the cylindrical surface of the can where it may be effectively dissipated.

These transistors have a number of important electrical requirements which can be understood by considering the way an alloy transistor is fabricated. A given mass of molten doping material (usually indium or an indium-gallium alloy for the p-n-p transistor, and lead carrying a little arsenic dope for the n-p-n) is able, at a

TYPES OF ESS TRANSISTORS

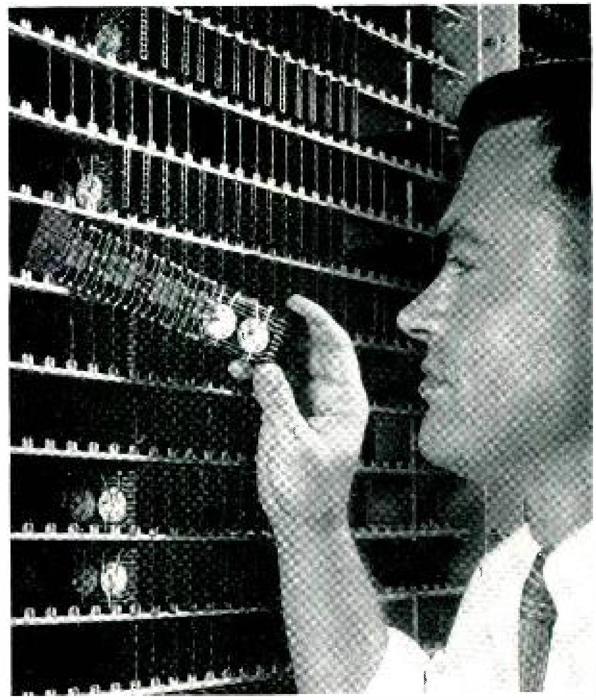
Western Electric Transistor Code	Bell Telephone Laboratories Development No.	Usage
F-51607	A-1778 (p-n-p)	Tone Ringer Telephone
F-51694	A-1778 (p-n-p)	Tone Ringer Telephone
F-51618	A-2037 (n-p-n)	Common Control & Network
F-51619	A-2038 (p-n-p)	Common Control & Network
F-53094	A-2074 (p-n-p)	Network & Power Equipment

given temperature, to dissolve a precise amount of germanium with which it is in contact. In practice, the alloying process consists of accurately placing doping materials on opposite sides of a germanium wafer, heating the parts to allow the "dope" (or carrier metal containing dope) to melt and dissolve part way into the wafer. The structure is then cooled to crystallize out doped germanium onto the undissolved layer of original germanium, which constitutes the "base" or central layer of the transistor. By restricting the alloyed area to a limited range, the depth of penetration can be controlled by adjusting the alloying temperature and the mass of the doping (or carrier) material. When the molten alloy cools, the dissolved germanium recrystallizes on the base layer, which acts as a single-crystal seed. The regrown germanium is now doped to a conductivity type opposite to that of the base layer. The resulting transistor element will be n-p-n or p-n-p, depending upon the type of original germanium and the nature of the doping materials.

When the crystallographic planes of the germanium are advantageously oriented, the doping materials will uniformly dissolve the germanium crystal. This results in the formation of flat, parallel junctions. Another alloying process is involved in making a low-resistance connection to the base layer; this is done by "bonding" a ring of gold alloy to the periphery of the wafer.

In essence, the basic fabrication is now complete; all that remains is to make electrical connections to the base ring and emitter electrode and to solder the collector electrode to the copper mount. The mounted element is then chemically etched to improve its electrical properties and is encased to preserve these properties.

In a transistor, there occur several phenomena which are at odds with one another insofar as the design of the device is concerned. The thickness of the base layer determines the speed at which the transistor will perform its switching function. Individual carriers of electrical charge differ in their velocities of travel through this base layer, and therefore in the times (transit time) taken to travel from emitter to collector. As the thickness of the base layer is reduced, the average transit time and also the *spread* of individual transit times are correspondingly reduced. It is this spread of transit times, in fact, which ultimately shapes the transistor's high-frequency response. Also, as the bias voltage on the collector is increased, the region immediately



R. E. Eberhardt, Illinois Bell, on loan to Bell Laboratories, holding a printed-circuit card (two transistors can be seen mounted close to hand). View also shows close spacing of cards in bay.

adjacent to the collector junction, which is free of mobile charges (depletion layer), widens into the base region. The front of this region advances toward the emitter junction until, at a certain "punch-through" or "reach-through" voltage, the collector is electrically linked to the emitter. Transistor action stops at this point. Thus, in developing a transistor, a compromise must be reached by choosing a base layer thin enough for high-speed operation but still thick enough to provide a high punch-through voltage.

In addition, for a given base-layer thickness, the punch-through voltage can be increased by decreasing the resistivity of the base layer. But the collector capacitance will then be adversely increased, and the voltage breakdown ratings of emitter and collector junctions will be decreased. The diameter of the collector junction could be reduced to bring down the capacitance, but there would then be less area available for conduction of heat out of the junction.

All of these effects require a design compromise and point up the need for rigid manufacturing controls on the variables which affect the base-layer thickness, junction area and germanium properties. The most important of these are:

- the crystallographic perfection (orientation and dislocation density) of the germanium wafer,
- thickness of the etched germanium wafer before alloying,
- mass of the doping material being alloyed into the wafer,
- alloying time-temperature cycle, and
- wetted area of the alloyed regions.

This class of high-speed power units poses special problems not encountered in the design and fabrication of lower-power devices. For example, the nominal p-n-p base-layer thickness must be about 6 ten-thousandths of an inch with a permitted variation of less than 2 ten-thousandths about the nominal. Very special techniques were devised, and precision tooling designed, by the W.E. Co. in order to obtain the required controls.

Improved crystal-growing techniques and x-ray orientation methods have produced well oriented wafers having sufficiently low dislocation density for the requirements of this device (RECORD, *March*, 1955). Control of wafer thickness has been achieved with a special etching solution which etches uniformly over the entire surface of the wafer. An optically amplified thickness gauge is used for the precise measurements required. This combination results in a practical production process for fabricating wafers whose thicknesses are within plus or minus 60 millionths of an inch of the control point.

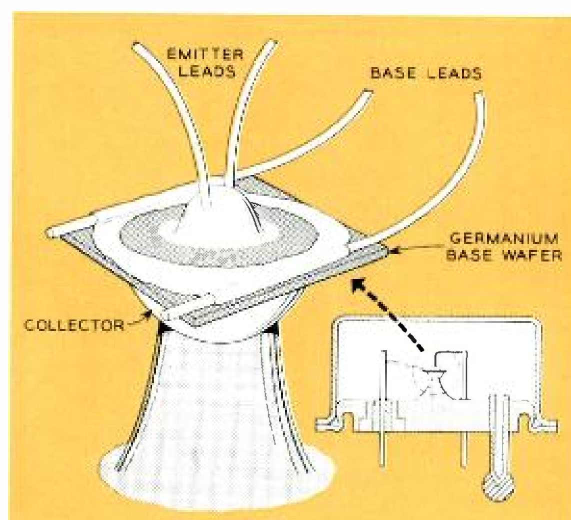
The mass of the alloying material, nominally in the shape of a sphere, is controlled by first sorting for sphericity on a tilted oscillating table. The lopsided "balls" are automatically rejected, leaving good-shaped spheres which have a known relation between diameter and volume — and therefore between diameter and mass. These more nearly perfect spheres are then sized with a roller micrometer, which consists essentially of two contra-rotating cylinders whose inclined axes are set at an angle with one another. This equipment drops the spheres into a series of buckets corresponding to gradations in size.

Assuming constant thickness of wafer and temperature of alloying, a 5 per cent variation in mass of both emitter and collector spheres would cause a 15-25 per cent change in the thickness of the base layer. For example, on a p-n-p, a 5 per cent increase of mass of both emitter and collector spheres would shift the frequency cut-off of the typical unit from 7 megacycles to 5 megacycles. It should be pointed out that for these transistors, the practical working limits of frequency cut-off are between 4 and 11 megacycles. The lower limit is a specification value and the upper is a virtual specification limit dictated by the punch-through voltage requirement. Typically, both units exhibit cut-off frequencies of 7 megacycles while maintaining reach-through in excess of 75 volts.

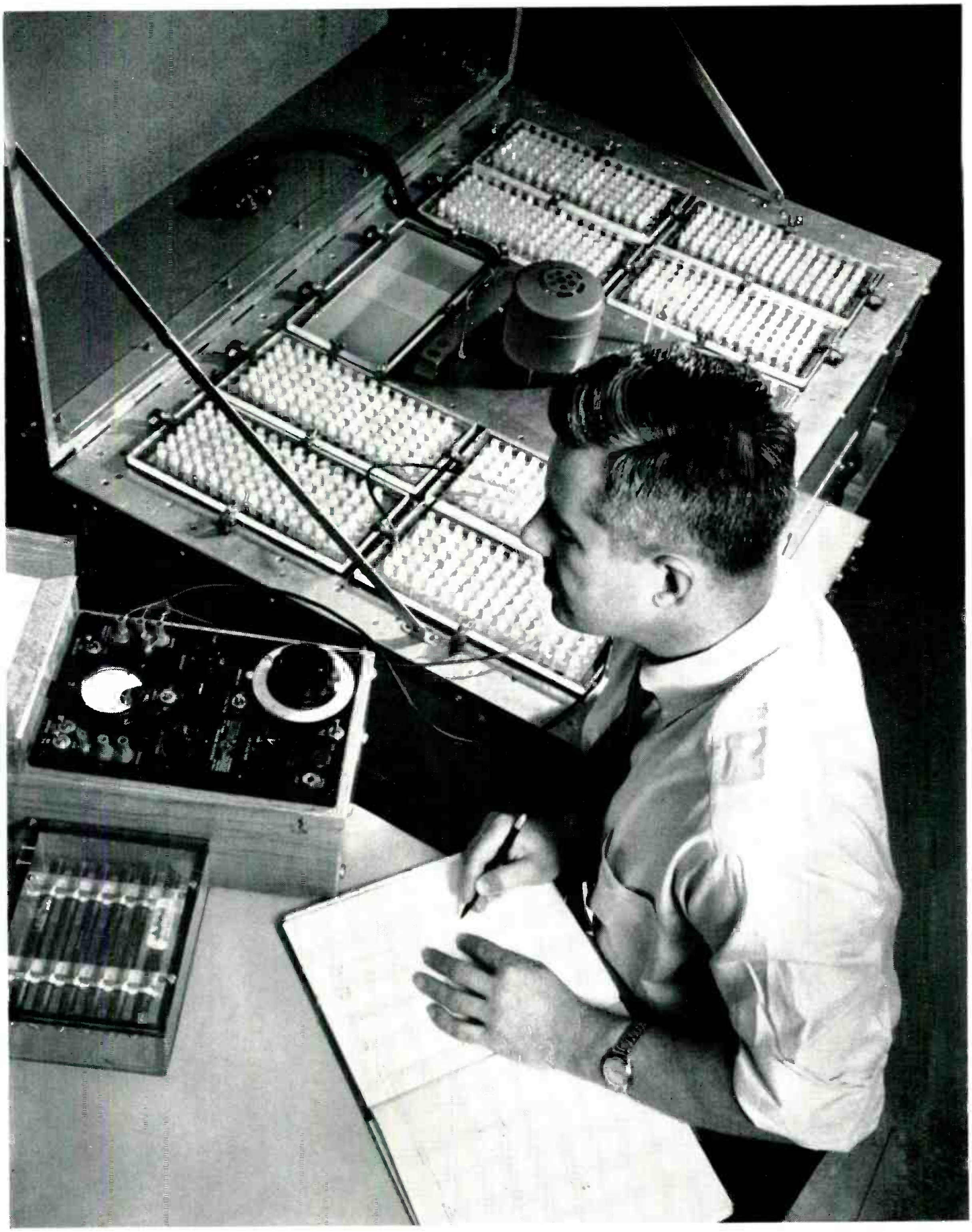
Reproducibility of alloying cycle and peak temperature is accomplished with a slightly modified commercial program-controller incorporating saturable reactors. This equipment is capable of reproducing the peak temperature within plus or minus 5°C. Under optimized conditions of alloying, a change in alloying peak temperature of more than 5°C is enough to reduce the alloying yields by 10 to 15 per cent.

Since the emitter and collector junctions on the two transistors are 0.025 and 0.035 inch in diameter respectively, and since junctions must be accurately located on opposite sides of the wafer, precision jigging fixtures were developed to locate and constrain the button-wetted areas during alloying. Extreme cleanliness is necessary to permit uniform wetting over the whole emitter and collector areas and to prevent localized deep alloying, which would cause low punch-through voltage or even a short circuit from emitter to collector.

This program for the development and manufacture of these transistors has added much to the fund of information and experience required to tailor transistors for various applications.



Details of transistor structure: mounting arrangement permits rapid dissipation of collector heat.



A. P. Broyer checks insulation resistance of samples of circuitry material undergoing temperature and humidity tests. Tests for water absorption use spaces 11 and 16 of the master test pattern.

The rapid increase in the use of printed circuits has created a need for tests to evaluate these items — a need that is fulfilled by standardized methods developed by Laboratories engineers. As a result, designers now enjoy a predictable reliability for an entire range of new printed-circuit materials.

T. D. Schlabach and E. E. Wright

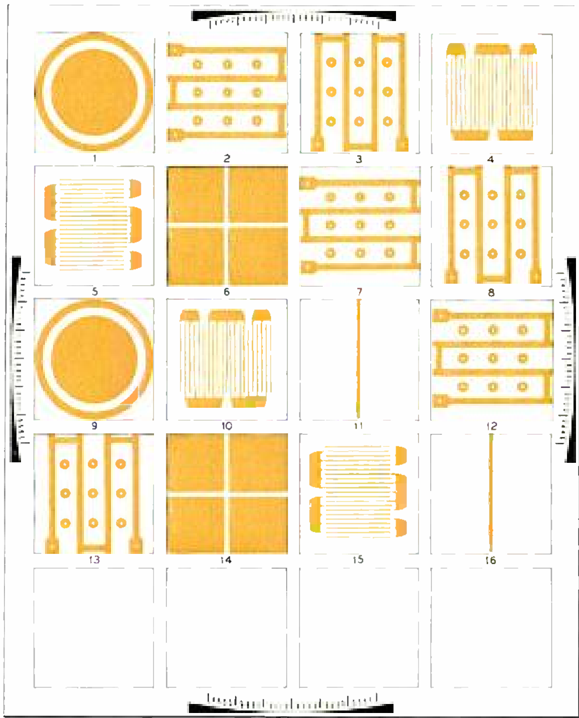
Test Patterns for Printed-Circuit Materials

During the last several years, the use of printed circuits has increased tremendously. Within Bell Laboratories alone, there are dozens of projects that make use of this technique — Nike, TRADIC, the electronic switching system, and P-carrier (to name only a few). As a result, this trend has caused a similar growth in the use of metal-clad laminates; conservative estimates are that twelve million square feet of such material will be used annually for printed circuits by 1960. This emphasizes both the importance of these materials and, to insure reliability in the final product, the need for suitable tests and requirements.

Metal-clad thermosetting laminates generally consist of layers of paper, synthetic fiber, or glass cloth impregnated with resin and covered with metal foil (usually copper, 0.0014 or 0.0027 inch thick) on one or both surfaces. These layers are bonded under heat and pressure to produce a strong, uniform sheet. By choosing suitable impregnating resins and fibrous reinforcement, we can vary the physical and electrical characteristics of the sheet over a wide range. It can then be used to make a printed-wiring board — the basic building block of a printed circuit.

Printed-wiring boards may be of different constructions and can be made by a variety of processes (RECORD, *April*, 1958). Let us look at the question of reliability, and at the tests and requirements needed to insure this in a printed-wiring board. Historically, insulating materials of this general type, such as phenol fiber, have been available for many years. Adequate test methods and requirements have been well worked out to cover the use of these materials in terminal strips, relays, transformers, motors, and the like. Application of these materials to printed circuitry, however, presented unique problems, due principally to the manner of use and to the presence of the metal cladding. These problems required the development of new tests and requirements.

This development was characterized in part by the development of test patterns — that is, actual arrangements of printed wiring on boards. And, for the results to have meaning, there must be common denominators. To achieve these



This master test pattern contains test patterns for complete evaluation of a metal-clad laminate, i.e., of its base material, bonding, and foil of its cladding. Bottom four empty spaces are for potential new patterns, and the quality etch wedge calibrations help determine thickness of the etch.

common denominators, patterns were developed. Among the tests are those for insulation resistance, peel strength, solderability, water absorption, volume and surface resistivity, and current-carrying capacity. The patterns, as finally adopted at the Laboratories, consist basically of 2-inch by 2-inch squares of the metal-clad laminate. The foil on each of these squares is of a pattern appropriate for the particular test.

As a final step in establishing suitable test patterns for foil-clad laminates, a composite pattern was developed *(see drawing on this page)*. This "Master Test Pattern" contains all of the test patterns in such numbers as to allow complete evaluation of a base material, its bonding, and the foil with which it is clad.

Preparing such a master test pattern has several advantages. All of the required patterns can be prepared simultaneously — thus minimizing variations in the preparative procedure. Also, the fixed spatial arrangement seen in the drawing provides standardized sampling within the master area, and the uniform 2-inch by 2-inch modules give flexibility for rearrangement if desired.

Double wedges on each side of the master pattern are used to determine the quality of etch during preparation. With increased severity or duration of etch, the thin central portion of the wedge pattern is etched away. The distance between the remaining wedges gives a direct measure of this effect.

Space has been left on the master for the inclusion of new patterns as the need arises. New materials, for example, may very likely require the development of new tests. To use the test patterns, the individual modules are cut apart.

Let us now consider some of the individual patterns and the tests performed with them. Much study and work went into their development. First, the requirements that must be met by printed-wiring boards had to be established; then, suitable tests had to be developed for each. Once a requirement and the test for it had been established, the test pattern was developed.

To insure satisfactory electrical performance, the first test developed was for insulation resistance. Here we have to consider that in a typical printed-wiring board, all conductors are closely spaced and have a common insulating base. In the fabrication process, the insulator may be electrically degraded by the etchant, by electroplating baths, or by flux residues. After several electrode configurations were tried, the pattern shown in modules 4, 5, 10, and 15 of the master test pattern was adopted. Insulation resistance is measured between various pairs of electrodes at elevated temperature and humidity for periods of up to thirty days.

By preparing various laminates with different methods, we obtain relative figures of merit for the various processes. Characteristically, the insulation resistance after thirty days at 90 per cent relative humidity and 95°F. may vary from 1,000 megohms for a copper-clad, phenol-fiber laminate to 1,000,000 megohms for a copper-clad, nylon-phenolic laminate. Contamination of the insulator surface by etchant residues or by fingerprints can easily lower these values by a factor of 1,000.

Another requirement that must be met by printed-wiring boards concerns the bond between the base and the metal. To obtain a satisfactory bond between the metal foil and the base laminate, an adhesive is generally used. The properties of this adhesive bond are very important. It must be strong enough to withstand normal processing without loosening because of thermal shock during dip soldering, mechanical peeling, or chemical attack by etchants, plating-bath salts, or organic solvents. It should also be able to withstand service at elevated temperatures —

possibly accompanied by shock or vibration.

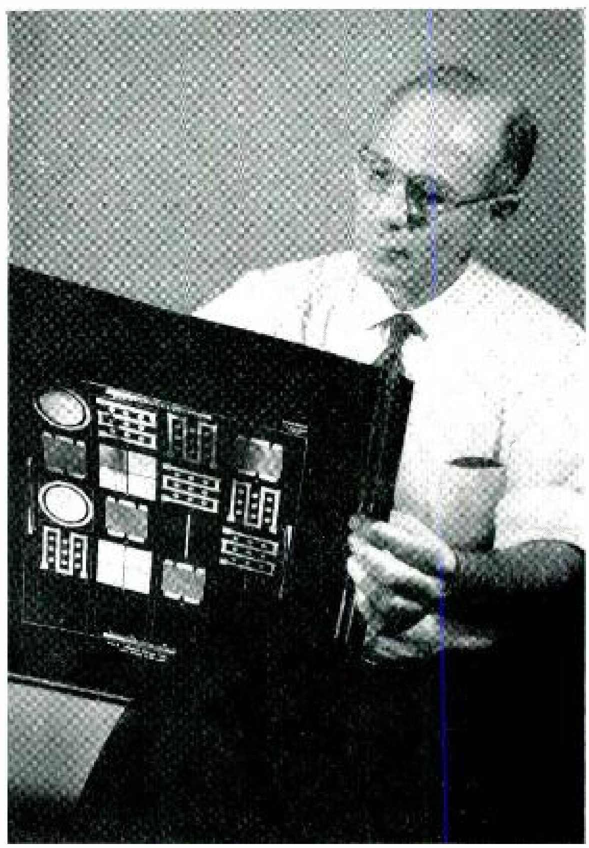
Peel-strength tests, which measure the force perpendicular to the surface that will separate the foil from the base, give an accurate measure of this bond strength. For these tests, the pattern consists of four parallel conductor strips (1/8-inch wide) separated by terminal pads, as seen in modules 2, 3, 7, 8, 12, and 13 of the master test pattern. Such narrow strips are deliberately used to conform closely to the widths usually encountered, to accentuate discontinuities in the bond, and to magnify the effect of bond attack by any of the chemical treatments. Normally, the peel strengths range from six to eight pounds per inch of width. Values as high as 75 pounds per inch of width have been obtained, however, in the case of brass-clad polyethylene. It should be noted that the electrical characteristics of the adhesive layer are also very important. The adhesive is continuous over the insulating base and is in direct contact with all conductors.

To insure successful mass solder dipping of the assembled printed circuit — an essential feature if automation is to be used — a solder-dip resistance test is required. For this, the test specimens are four conductor squares on 2-inch by 2-inch modules (see spaces 6 and 14 of the master test pattern). These are cleaned, fluxed, and dip-soldered at 450°F. — usually for ten seconds. The soldered specimens are then examined visually for blisters. With a poor bond, the foil may come completely off during this test because of the severe thermal shock. This test is only semi-quantitative at best, but necessary.

In addition to these tests, several others are routinely made — for example, tests for water absorption (using the modules in spaces 11 and 16 of the master test pattern) and tests of volume and surface resistivity (using the modules of spaces 1 and 9). Special tests have been developed for evaluating solderability, the current-carrying capacity of printed conductors, and boards with electroplated feedthrough connections.

Once the test procedures were determined, an extensive evaluation of metal-clad laminates was undertaken at the Laboratories. All of the commercially important laminates were screened, and from the statistically analyzed data, requirements were written for representative materials in each of four types. These are two grades of clad phenol-fiber (the "workhorse" of most printed-circuitry), clad nylon-phenolic (used when excellent electrical characteristics are needed at high humidity), and clad epoxy-glass laminate (used when high mechanical strength and dimensional stability are important). Fire-retardant grades of phenol-fiber and epoxy-glass laminates are also covered. At present, work is being done to include clad Teflon-glass laminates (for use at high temperatures and in certain microwave applications).

The Laboratories derive several important advantages from this early and thoughtful standardization of test procedures. First, this common standard of comparison for both printed-circuit materials and processes results in rapid accumulation of useful data, since these tests are made every day by many different groups in the Laboratories and at Western Electric. Second, this amassed testing background strengthens our voice in the establishment of industry-wide standards through such organizations as the A.S.T.M. and the E.I.A. (formally R.E.T.M.A.). Finally, and most importantly, it insures the design engineer a predictable measure of reliability, and it aids industry in the continuing growth of this new and vitally important field.



E. E. Wright examines a negative of the master test pattern before using it to prepare test samples. The fixed spatial arrangement seen here will provide a standardized laminate-foil sampling.

To furnish a time scale for the occurrence of events during the flight of test missiles, Bell Laboratories has designed a system to transmit timing pulses throughout the USAF missile test range at Cape Canaveral. A characteristic of the system is the way it performs task of altering pulses to a form suitable for transmission through narrow-band transmitting and receiving equipment.

R. P. Wells

CANAVERAL TEST RANGE: TIMING-SIGNAL TRANSMISSION

The nerve column of the Air Force missile test range in the West Indies is the submarine-cable communication system designed by the Laboratories to link missile observation stations from Cape Canaveral, Florida, to Puerto Rico (RECORD, *September*, 1956). Many of the transmission features of this cable system have been described in an earlier article (RECORD, *September*, 1957). An additional important feature is that of the range-timing signals sent over a single channel of the system. This article is devoted to a description of the methods by which this is accomplished.

To properly evaluate all electronic and optical data obtained during the flight of a missile, these data must be referred to a common time-base at all observation stations in the test range. For this reason, a "master clock" is located at Cape Canaveral to indicate "zero" at some reference instant. All prelaunching and subsequent flight occurrences are measured with respect to this zero.

The procedure consists of transmitting a series of pulses, synchronized with Cape Canaveral clock time, to all observation stations over one of the channels of the submarine-cable system. At each station the arrival of a synchronized pulse triggers a "local clock." To coordinate the zeros of all the clocks, the transmission time from Cape Canaveral to each observation station must be very accurately known.

In their initial state, the synchronizing pulses are too "narrow" to be transmitted through the available channel width of three kilocycles. Therefore, it is necessary to provide special pulse-shaping equipment at Cape Canaveral to modify the pulses into an acceptable form for transmission. This must be done without destroying their value as accurate time-reference signals. Also, each observation station needs pulse-reconversion equipment to accept the specially shaped synchronizing pulses from the cable system and to reconvert them to the short pulses which actuate local timing equipment. The principal problems to be solved were: how to convert a short pulse to reduce its bandwidth, how to reconvert it without loss of timing accuracy and how to measure accurately its delay in transit through the cable system.

The pulse-shaping equipment at Cape Canaveral alters the very short, rectangular timing pulse to "Gaussian" form. This shape was chosen because it allows the major portion of the pulse spectrum to be contained within the available three-kc transmission bandwidth.

The shaping technique is illustrated in the top part of the illustration below. The steep leading edge of a reference pulse triggers a generator which, in turn, delivers two Gaussian-shaped pulses of alternate polarity. Rectification eliminates the negative pulse, while the positive signal is transmitted. A double modulation process then centers the spectrum of the shaped pulse within the assigned transmission channel, and the result is "flat" transmission and minimum delay-distortion of the pulse envelope.

At observation stations, receiving equipment demodulates the carrier signal and delivers a Gaussian output pulse which resembles the original. The point in time corresponding to maximum amplitude is then identified by differentiating the Gaussian envelope. The point of greatest amplitude, or zero slope, corresponds to the instant at which the differentiated waveform crosses the zero axis. At this instant a comparator circuit generates a narrow pulse of moderate amplitude. This pulse triggers a blocking oscillator, to produce a sharp signal of high amplitude to synchronize local timing circuits.

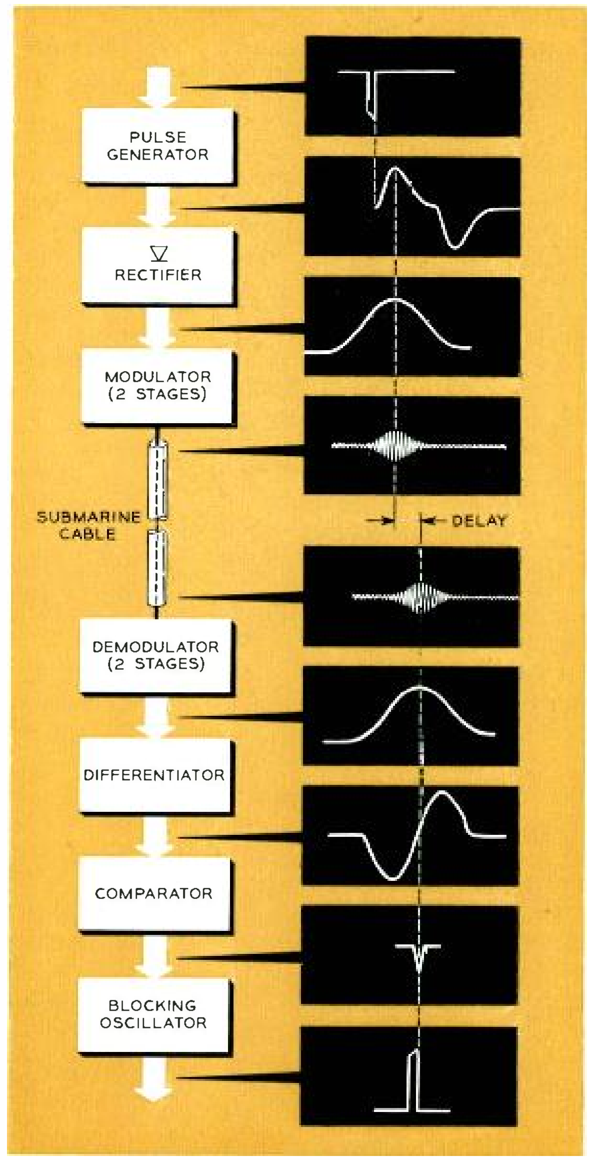
In the receiving equipment, "threshold" circuits are located ahead of the differentiator to prevent the comparator from responding to noise disturbances. These circuits allow no output unless the input exceeds a certain amplitude.

The application of these principles in the missile-test system is illustrated in detail in the block diagram overleaf. This figure shows how a timing pulse is dropped off at an observation station with the aid of pulse-detection apparatus bridged across the signal path. Channel 8 (one of the 12 allocated telephone channels) is used as the transmission path for timing signals; it shares its allocation with normal telephone service. At the sending end of this transmission path, the Gaussian pulse is modulated with a 6.2-kc carrier in a suppressed-carrier type of modulator. The Channel 8 modulator then transposes the pulse spectrum to the center of the modulator band filter of the channel.

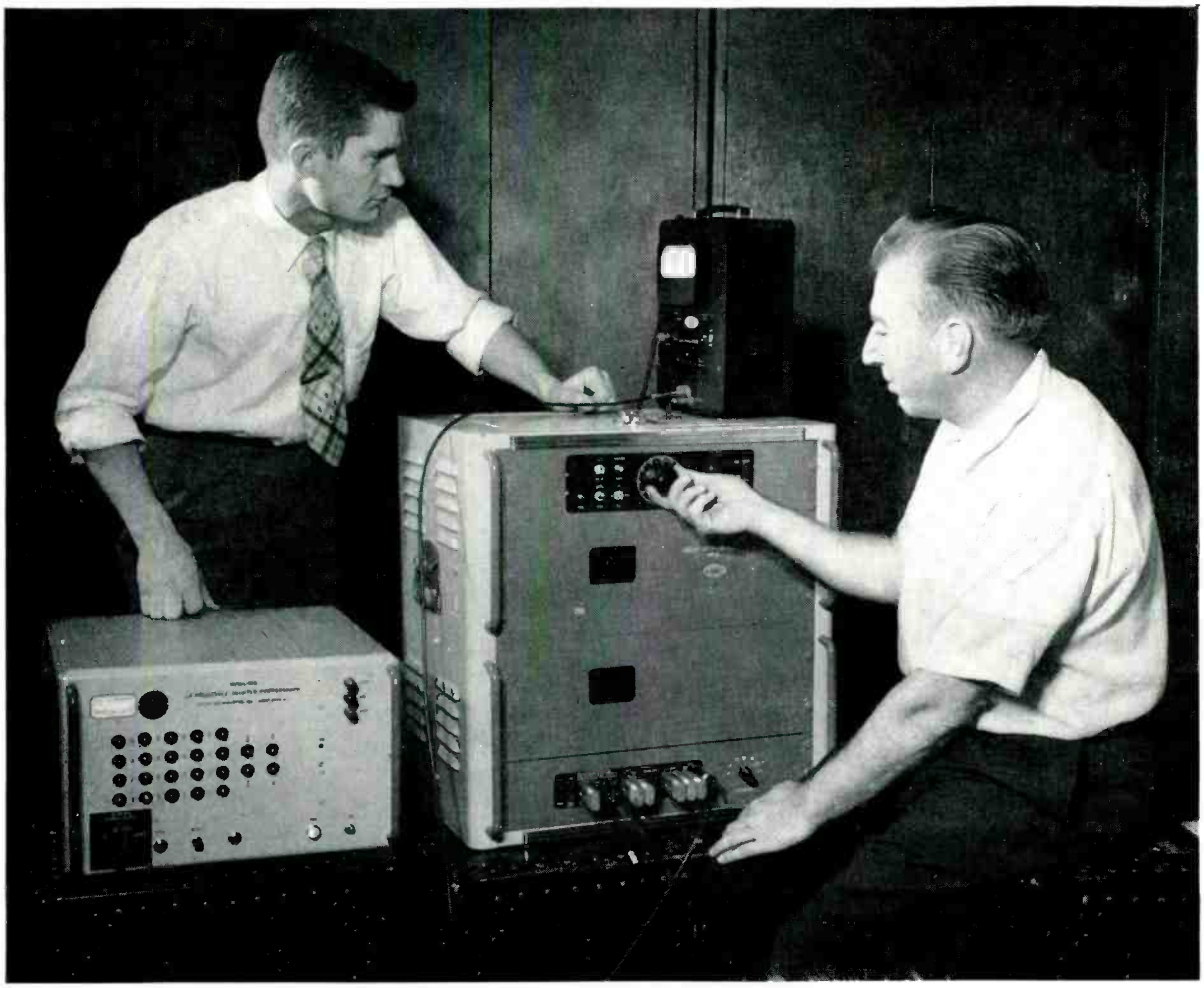
At the receiving point, the signal from the line is reduced to a 6.2-kc carrier which is modulated by the Gaussian envelope. A detector then recovers the Gaussian pulse by rectification.

The cause of delay in a timing signal transmitted from Cape Canaveral is the finite velocity of signal propagation. A finite velocity is encountered because of the many cable sections and circuits that comprise the submarine-cable system. The design objective demanded that these delays from the launching site to each observation station be known to within plus or minus 50 microseconds.

Transmission delay can be easily measured when the input and output terminals of a circuit are close to one another. For single lengths of submarine cable where the ends are miles apart, however, a more involved measuring technique is necessary to enable tests to be made from one



Narrow synchronizing pulses trigger circuits to produce a shape that can be transmitted without distortion over a narrow bandwidth. At observation stations, the pulse is re-formed to furnish a duplicate of the original synchronizing signal.



The author, left, and T. C. Barlow adjust the signal levels with a delay-measuring set. The set has an electronic counter to measure the time intervals and a terminal to transform pulses.

end only. In the technique which was used, a pulse is superimposed on a carrier frequency and is transmitted down the test section. At the far end, the circuit is looped, and the pulse is returned to the point of origin via one of the carrier frequencies used in the opposite direction. The total round-trip delay is then measured. Measurements of the round-trip delay for three combinations of three different carrier frequencies furnishes the data necessary to compute the one-way delay at each frequency.

The Laboratories designed a special test set to measure the delay of various elements of the system. This test set consists of two principal parts: an electronic counter which measures the time interval between consecutive pulses, and a transmitting and receiving terminal which uses the principles outlined above to convert and reconvert the pulses. The counter, when triggered by a pulse, indicates precision increments of time cumulatively until a second trigger pulse is applied to stop it. The time interval between the two pulses may be read to the nearest increment.

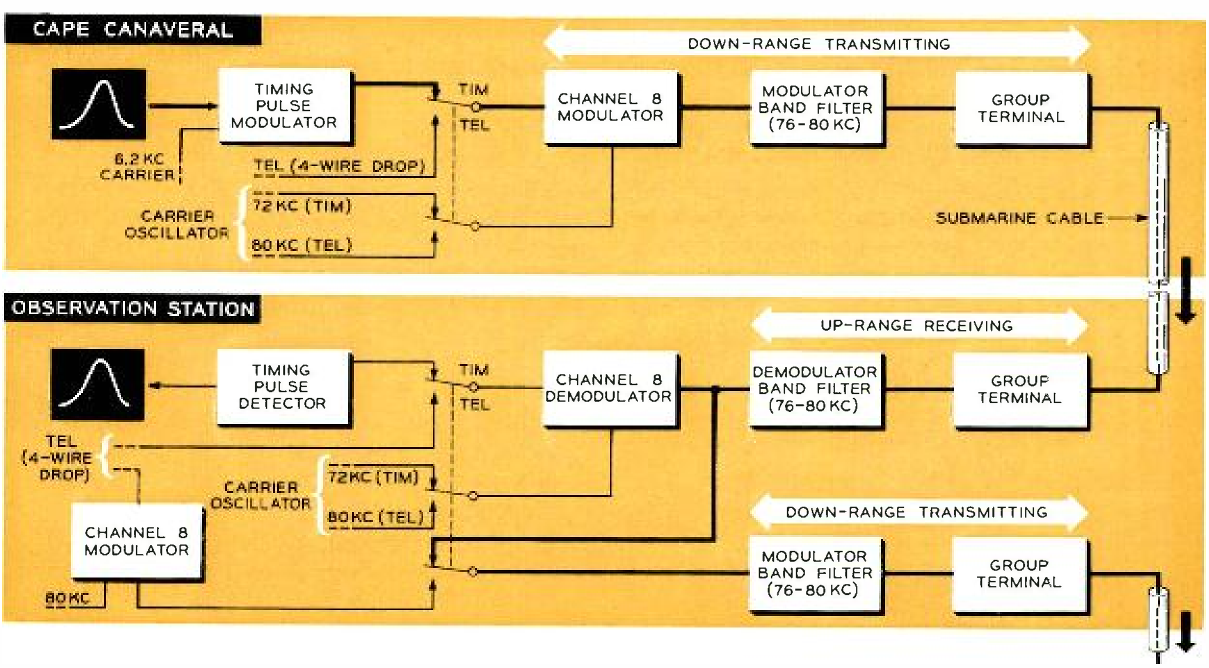
Measurement of the delay of individual components throughout the system was followed by a tabulation from which the one-way delay to any point in the system, in either direction of transmission, could be calculated. Delay measurements through repeater equipment in the field, however, would have made necessary the interruption of power fed to the repeater over the submarine cable. To avoid this, a second delay test set was used to measure delay during manufacture of the repeaters.

During the over-all system lineup, loop measurements were made from Cape Canaveral to each observation station. These results were compared to the computed loop delay obtained from the addition of the delays of the component parts. The resulting discrepancy, for the longest delay, was less than 22 microseconds out of approximately 46,000 microseconds. It can therefore be assumed that the probable error in the one-way delay to the farthest observation station is approximately one-half this discrepancy, or 11 microseconds. This is well within the plus or minus 50 microseconds objective.

A change in the one-way delay to any station will be reflected in the loop measurement to that station, and the delay test set can thus be used to locate the cause of the change. The transmission equipment contained in a loop to the furthermost station includes nearly 2800 nautical miles of cable and much terminal and repeater apparatus. Loop delay measurements to this station reveal the spread of successive measurements to be within plus or minus 3 microseconds. This indicates the stability both of the timing circuits and the system.

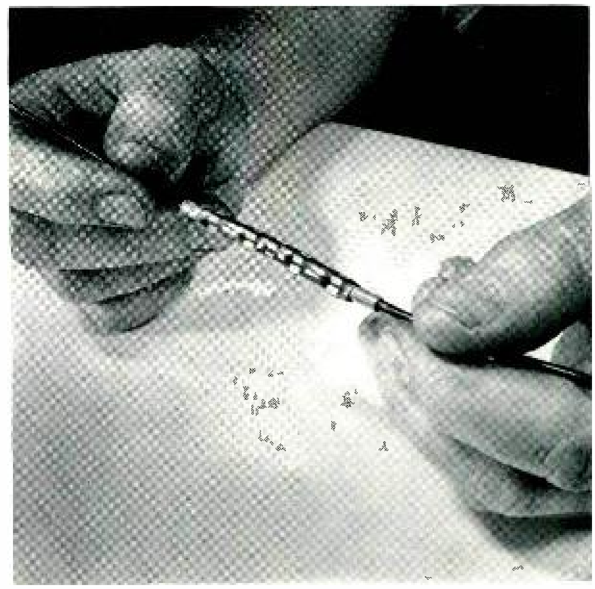
The submarine cable system also provides frequency space for a number of broad-band FM telemetering channels used to transmit information from observation stations to Cape Canaveral. Delay distortion across the spectrum reserved for telemetering may be measured with the aid of the pulse-delay set. The technique consists of measuring the round-trip pulse delay between Canaveral and any one of the observation stations. The carrier frequency in one direction of transmission is held constant, and the pulse delay is measured as the carrier in the other direction is varied across the telemetering band. Accuracies of better than one microsecond are obtained by automatically averaging delays of 100 successive pulses on an electronic counter.

The transmitting and receiving circuits for the range-timing system are assembled on separate panels. To guard against long time interruptions on the timing channel, standby panels are furnished for the direction in which timing pulses are transmitted during range operations. Cape Canaveral has a spare transmitter panel, and all other stations have spare receiver panels. The receiver at Canaveral and the transmitter at each observation station are used only for checking the system loop delay, and therefore are not duplicated. Control keys at each station permit service on Channel 8 to be converted readily from telephone use to timing-pulse transmission or to set up the circuits for timing-loop tests.



Each observation station contains terminal equipment which picks off the timing pulse delivered from Cape Canaveral. Each terminal has a detector to recover the Gaussian waveform, and also has pulse circuitry that abstracts a sharp timing pulse for synchronizing the station's "Local Clock."

New Method for Splicing Rural and Urban Wires

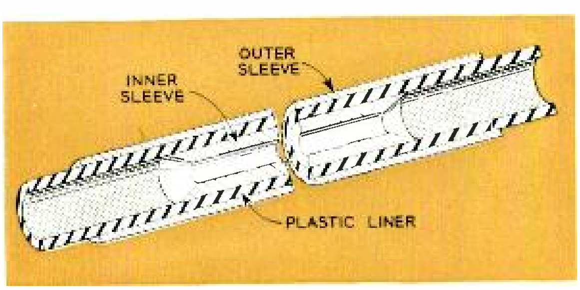


Completed splice; presses grip conductors, forming a waterproof seal with plastic insulation.

Two new types of wire for outside aerial telephone lines have been introduced into the Bell System during the last few years. Both consist of twisted pairs of plastic-insulated copper conductors stranded around an insulated steel support wire (RECORD, *May*, 1954). The conductors are not enclosed in a sheath — thus permitting ready access both for terminating and for splicing (RECORD, *October*, 1956). Rural Wire and Urban Wire serve well in specialized applications where only a few pairs are needed and have the added advantage of easy, quick installation.

This use of plastic insulation has resulted in the development of a new and more efficient method for joining the conductors at a splice. A splice between the ends of two plastic-insulated conductors must not only produce a good electrical and mechanical connection, but must also provide a waterproof encasement for the metallic joint. In the past, the workman used a pressed metal sleeve to complete the metallic connection and then wrapped the joint with an organic tape to waterproof and insulate it.

This joining method, although somewhat time-consuming, has been generally satisfactory for the relatively strong 19-gauge conductors of Rural Wire, but the smaller 24-gauge conductors of Urban Wire sometimes broke during the taping operation. For this reason, a new and faster method for joining these conductors has been developed at the Laboratories. In this method, a composite sleeve simultaneously joins the conductors and insulates and seals the joint against moisture.



Composite sleeve assembly showing copper inner sleeve, plastic liner, and the copper outer shell.

The composite sleeve consists of an inner metal tube for joining the conductors, a plastic tube liner for insulating and sealing the joint, and an outer copper shell. A factory-made indentation midway in the length of the outer shell holds the assembled parts together. For purposes of identification, the Rural-Wire sleeve has a gray plastic liner and the Urban-Wire sleeve has a black plastic liner.

To make a splice, the workman inserts the stripped ends of the two conductors into opposite ends of the sleeve until each is stopped by the center indentation of the inner sleeve. He then makes four "presses" along the length of the outer copper shell.

The innermost presses constrict the inner sleeve of the assembly sufficiently to hold the conductors, and the outer presses constrict the plastic liner enough to form a moistureproof seal with the plastic insulation of the conductors. This method of joining the conductors develops a holding power equal to the breaking strength of the conductors — with no appreciable impairment of the insulation resistance of the wire. The dielectric strength of the splice is from 13,000 to 18,000 volts, rms.

C. C. KINGSLEY
Outside Plant Development Department

The continued expansion of extended area dialing has been made possible by improved automatic accounting procedures. Among the newest devices in this field is a versatile billing indexer which permits a CAMA center to extend its accounting function to as many as 48 originating offices.

R. C. Avery

MESSAGE BILLING IN No. 5 CROSSBAR CAMA

In many areas served by the Bell System, telephone customers can dial calls beyond the range of their local central office. Such calls are routed by automatic switching equipment, and are billed by automatic message accounting (AMA) equipment. Obviously then, as extended-area dialing — and its counterpart direct distance dialing — continues to grow, so must the facilities for AMA.

To parallel the growth of AMA with that of switching, Bell Laboratories engineers have recently developed a new "billing indexer." This device enables No. 5 crossbar tandem centers to handle charging for calls from as many as 48 local offices. Handling information from so many sources is, of course a complex process. Therefore, let us examine the basic steps in AMA that have led to development of this circuit.

LAMA (Local Automatic Message Accounting) serves No. 5 crossbar switching offices that have a volume of extra-charge traffic sufficient to justify the cost of the common-control circuits required (RECORD, *September*, 1951). CAMA (Centralized Automatic Message Accounting) is furnished in suitably located No. 5 offices which serve as switching centers for other No. 5 offices with a smaller volume of this traffic, and also for step-by-step offices which are not equipped to record extra charges (RECORD, *August*, 1957). The extra-charge calls from a number of these tributaries make use of common recording and routing equipment at the switching center.

The No. 5 crossbar system is readily adaptable as a CAMA facility at such central points, because it is arranged for tandem switching (RECORD, *April*, 1956) as well as for completing calls that are trunked directly from office to office. In effect, CAMA has been designed as an integral part of this system.

The common-control circuits that route calls through a No. 5 LAMA office can handle a maximum of 6 central-office names, or directory codes. The marker determines the charging rate on calls from these 6 offices by comparing the originating class of service with the code of the terminating office, at the same time that it selects the route the call will take. However, a CAMA center may serve as many as 48 originating offices. The billing function in this case is therefore more complicated and has been incorporated in a separate circuit called a billing indexer. The major CAMA circuits involved in billing calls are as follows.

A call originating in a nearby step-by-step or No. 5 crossbar office enters the CAMA equipment through an incoming trunk and an incoming register. This register receives the dialed digits and transfers them to a marker. The marker recognizes this as a CAMA call and passes information to a CAMA sender, after which the

Originating		Terminating Offices (Theoretical Maximum 1920)							Originating Rate Treatments (Max. 20)
Office (Max. 48)	Rate Class	A	B	C	D	E	F	G†	
A	0	0*	1	0	0	2	3	9	00
	1	0*	1	0	0	3	4	9	01
	2	0*	9	0	0	9	9	9	02
B	0	1	0*	1	1	2	4	9	03
C	0	0	1	0*	1	1	3	9	04
Terminating Rate Treatments (Max. 60)		00	01	00	02	03	04	05	

* In these cases the originating and terminating offices are the same.

† Offices beyond bulk billing range are assigned message billing index 9.

marker and incoming register are then released.

Upon receipt of all necessary information, the CAMA sender transfers the calling and called customer's numbers to a transverter. The transverter then passes to the billing indexer all information required to determine the message-billing index. Through the assigned recorder, the transverter controls perforation of the tape for the initial entry. The associated call-identity indexer identifies the incoming trunk for the tape record. After release of the transverter and recorder, the CAMA sender connects to a marker a second time — the latter completes the call.

For multi-party lines in the same marker group, the operation differs only in that an originating register and a CAMA junctor are used instead of an incoming register and trunk. Calls from another marker group in the same building may be completed through CAMA by "inter-marker-group" trunk and sender circuits.

Two types of message billing are used in AMA systems. With the first type, bulk billing, a customer is charged at the rate of one or more message units per call — depending upon the distance involved and how long he talks. In the second type, detail billing, the charges for each call are computed at the accounting center and are itemized on a toll statement.

In general, bulk billing is used for comparatively short-haul calls; the charging rates are identified by one of eight message-billing indices. One of the indices 1 through 8, as required, is perforated on the AMA tape for each such call. Calls that receive toll-statement treatment are identified on the tape by message billing index 9. These index numbers are code numbers, not to be confused with message-unit numbers.

The originating offices which operate through a CAMA center may be located in a maximum of three numbering plan areas. Bulk billing may be used, within the limit of its range, only for calls completed to offices in these areas. Operating companies, however, may use detail billing for any part or all of the destinations for which bulk billing is available.

To determine charges, the information identifying originating and terminating offices must be compared in some manner. If this were done directly, a considerable amount of equipment would be required because of the large number of offices involved. Furthermore, each of the 48 originating offices may have three rate classes which permit different charges for the various classes of service.

To simplify this problem, the CAMA centers use "rate treatments." These are patterns, representing charging rates to or from other central offices. Where bulk billing is used, each originating office and rate-class combination is assigned to one of 20 originating-rate treatments. Also, each office at which calls are terminated (theoretical maximum 640 offices per area) is assigned to one of 60 terminating rate treatments. These quantities are sufficient because several offices have corresponding charging rates to or from other offices. Thus a relatively few originating and terminating rate treatments may be compared to determine all the necessary information.

Rate-treatment assignments are shown in the table (*opposite*). These offices are arbitrarily designated A, B, and so forth. Originating-office and rate-class combinations are shown at the left of the table, and terminating offices across the top. The message-billing index numbers are coded representations of the charging rates on calls between associated offices. Originating-rate treatments consist of horizontal rows of message-billing index numbers; terminating-rate treatments appear as vertical rows.

Index 0, shown in the table, does not represent a charging rate — but rather informs the transverter that the call is a non-charge or free one, with respect to the CAMA equipment. Such calls are either within the flat-rate dialing range or are charged for by local message-register operation at the originating office. Free calls should be routed directly over local trunks, but may reach the CAMA point by incorrect dialing at step-by-step offices. These calls are not perforated on the AMA tape, but are intercepted by an operator to discourage such attempts — avoiding unnecessary use of the more expensive CAMA routes.

Rate treatments are also used for areas arranged only for toll-statement treatment if it is desired to divert free calls. Here the rate-treatment tables include message-billing indices 9 and 0 only.

The billing indexer determines the message-billing index by making three successive translations (see diagram). These translations are carried out by a coil field through which "jumpers" are threaded. The coils are inductors activated by voltage surges in the jumpers, causing associated electron tubes to fire. Connected to the tubes are relays that then operate and lock. The coils and tubes are used successively for the three translations — connected in turn to the respective input information and output registers.

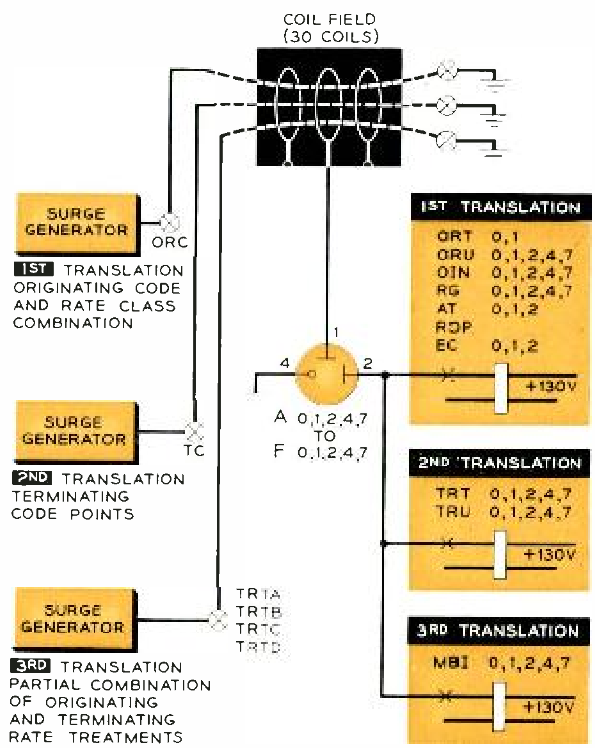
In the first translation, several items of information are derived from the originating-code and rate-class combination of the calling station. These include the originating-rate treatment tens and units digits and the office-index digit. The latter identifies the calling office on AMA tape.

In the second translation, the terminating-rate treatment tens and units digits are determined from the terminating code and the area to which the call has been placed. The three possible geographical areas involved are represented by coil groups A and B, C and D, and E and F respectively. The pair, corresponding to the required geographical area only, is connected to the output.

The third translation combines the rate treatments to obtain the message-billing index. Here, the terminating-rate treatment terminals represent (in the diagram) 60 terminating-rate treatments in combination with four groups of five each of originating rate treatments. One of coil groups B to F, as required, is cut in to select the message-billing index for one of the five originating-rate treatments represented by a jumper.

Calls to areas arranged for toll-statement treatment without diversion of free calls do not require translations for the rate-treatments and message-billing index because in these cases the index is always 9. Therefore, only one translation is made to derive the office index, plus minor items.

The circuit arrangements for the billing indexer are highly efficient. The same coils are used over again in succeeding cycles for different functions. Because they use a two-out-of-five code, only half as many are required as would be with decimal operation. Furthermore, this device permits the derivation of a number of items of information from a single index, and this greatly reduces the amount of relay equipment.



The translating arrangements of the billing indexer circuit. The coil field is used for three successive translations, to determine the message billing index and other items of information.

A New Gauge for Testing Pressurized Cable

Throughout the Bell System, many important telephone cables are filled with dry nitrogen or dry air and maintained under constant pressure. These dry gases protect the insulation on the cable conductors from the physical and dielectric deterioration that might be caused by water or moist air entering the cable through a fault in the sheath.

Sheath faults may occur from any of a multitude of causes, and the positive pressure in the cable is also used as a means of locating these faults. This is done by observing the pressure gradient which exists along a leaky line. Pressure readings are made along a stretch of cable at valves provided for this purpose, and then plotted against distance to determine the location of the leak or fault in the cable sheath.

The pressure gradients present in some leaky cables are not very great, so the instrument used for measuring pressures must be quite accurate. Gauges of various types and sensitivities have been used in the past, and in general have performed reasonably well. In many cases, however, these gauges are used every day, and under such circumstances even minor deficiencies in test equipment can increase significantly the time and money spent on maintenance. In the currently available gauges, operation, handling and initial cost precluded complete acceptance of a single, standard instrument by those responsible for the field maintenance of pressurized cables.

To provide a single, general-purpose gauge capable of replacing these various gauges, a new pressure-measuring instrument has recently been standardized by the Outside Plant Development Department at Bell Laboratories. This instrument, shown in the accompanying photograph, has been designated the "C Pressure Gauge." The new gauge was standardized to replace the portable pressure gauge, a device of the Bourdon-tube type, capable of measuring from 0 to 30 psi, with scale divisions of 0.2 psi. This latter instrument is inherently insensitive to small pressure differentials.

The new C pressure gauge may also eliminate the need for the mercury manometer. This mercury gauge has a range of 0 to 11 psi, with scale divisions of 0.02 psi. It is accurate and dependable, but it is large and somewhat cumbersome; it also requires constant maintenance because it must be kept very clean to work properly.

The new C pressure gauge was designed principally to eliminate the shortcomings of the portable pressure gauge and the mercury manometer. It is a diaphragm-type gauge of sturdy construction, and is inherently more sensitive than a gauge of the Bourdon-tube type. The range is 0 to 12 psi, and the scale — calibrated at 0.05-psi intervals — can be quickly and easily read. The initial calibration of the new gauge is not affected when it is subjected to pressure twice the normal

The author demonstrates, in the laboratory, the use of the new C pressure gauge. Small fitting on the top of gauge is for storing hose valve.

cable pressure, and the instrument can stand a cable pressure of five times the normal without damage. Adjusting equipment is furnished with the gauge for resetting the indicator should the initial calibration be disturbed.

In essence, this new gauge has adequate range and greater accuracy than the portable pressure gauge which has been in use for many years. After experience has been gained in its use, the accuracy of the new instrument should be comparable to that of the mercury manometer. The design and construction of the C pressure gauge provide, at moderate cost, a dependable and accurate tool for general pressure-gradient work.

E. T. Lundgren
Outside Plant Development

A number of advantages result from placing telephone lines below ground. Thus, there is a growing trend toward more buried plant — made possible by new cable-laying equipment and by new developments at Bell Laboratories in the fields of wire and cable design.

W. J. Lally and C. C. Lawson

Buried Telephone Plant In Residential Areas

In the early days of telephony, outside plant consisted almost entirely of wires strung on the crossarms of telephone poles. As the demand for telephone circuits grew, however, these "open wires" on a line of poles became so numerous that they began to exceed available pole space — even with the tallest poles obtainable. Consequently, it became necessary to devise a more compact type of plant.

One result of such a requirement was the "cable" art. Insulated wires, "cabled" together, had been in limited usage as early as 1882 for special installations where open-wire construction was not possible. These included circuits carried in tunnels, on bridges and under rivers. Cables offered the desired compactness of plant, and their use increased rapidly in the early part of this century.

Essentially the same design of cable has since been installed aerially on pole lines and in underground ducts for congested urban areas. In 1882, an experimental cable was buried directly in the ground along railroad tracks between Attleboro and West Mansfield, Massachusetts — a locomotive furnished the power to dig the trench. As the years went by, direct burial became commonplace for intercity cables, but until recently, it has not been economical for customer plant in exchange areas. A few years ago, however, outside-plant engineers began to extend the use of buried cable and associated service wires to the "exchange" plant. This recent trend is a result of new developments, both in methods of designing conductor insulation having high resistance to moisture and in methods of laying cable.

In reference to telephone cables, the term "underground" describes a cable placed in an underground conduit. The conduit provides a path for the cable through the maze of pipes and ducts that usually exists under the busy streets of cities. Furthermore, it protects the cable from damage by heavy traffic and, to some degree, from the digging activities of other utilities. Here, the provision of additional ducts at the time of construction is an important feature for later expansion.

The term "buried" refers to cables and wires placed directly in the ground without supplementary protection. This article is devoted to buried construction as it applies to rural and urban distribution systems where the low concentration of cables does not justify the placing of conduit.

There are many reasons for locating more telephone plant below ground where this is economically feasible. One reason is the severe damage to aerial wires and cables caused by ice storms, hurricanes and tornadoes in areas of dense telephone concentration. Another reason is the change in building construction in suburban areas where ranch-type homes and other low-contour modern houses accentuate the conspicuousness of pole lines. Furthermore, with underground plant, telephone workmen are exposed to less hazardous working conditions.

Until recently, the only cable available for buried use was a type insulated with paper, sheathed with lead, coated with jute and often covered with a steel-tape armor. While this was a satisfactory product, its installed cost was too great for wide use in buried distribution plant. Wherever a sheath opening was made in this type of cable, as at distribution terminals and other splice points, the cable had to be hermetically resealed to prevent moisture from entering the paper-insulated core. This moisture would lower the insulation resistance, leading to noisy circuits and, consequently, to reports of trouble. Similarly, trouble would result if a crack in the sheath allowed moisture to enter.

Plowing of rural distribution wire in the Illinois countryside. A special plow, used here, has modified industrial tractor and special reel equipment.

Recent developments in the wire and cable field have been a significant factor in making possible the large increase in buried distribution. These developments, coupled with improved methods of placing and terminating, have made this type of construction economically feasible. At present, polyethylene-insulated cables with combination aluminum and extruded-plastic sheaths are being used successfully in both rural and urban buried distribution. These are the so-called "PIC" cables — a name coined from the words "polyethylene insulated conductor."

These cables use polyethylene, color coded for identification, as the conductor insulation. The cable cores are wrapped with a special tape that furnishes good dielectric strength under both dry and damp conditions. The wrapped core is then enclosed in an aluminum tape applied longitudinally with an overlapped seam. The outer jacket consists of extruded polyethylene, compounded for maximum life when exposed to the elements. This is the familiar "alpeth" sheath (RECORD, *November*, 1948). In the event of a break in the sheath, water entering the cable might cause transmission losses. But because of the water-resistant properties of the conductor insulation, the circuit can fail only at discontinuities in the insulation.

Greater protection against the entrance of water, and also from lightning, is available in the form of another sheath similar in construction to the alpeth. The additional protection comes from an extruded layer of polyethylene between the wrapped core and the aluminum. This sheath is called PAP (polyethylene-aluminum-polyethylene).

A new type of wire has also been developed to provide the service connection between cable and house. This wire facility has two pairs, since there is an increasing demand for two telephone lines in many customers' homes — particularly in urban areas. The conductors are made of annealed copper-steel for strength and flexibility and are insulated with color-coded polyethylene. The pairs, arranged with all four wires twisted together, are formed from diagonally opposite wires. A thin PVC (polyvinylchloride) jacket is extruded over the "quad" to hold the wires in place. This forms a cylindrical core, over which is placed a helically wrapped covering of aluminum tape and an extruded outer jacket of black PVC. These outer coverings provide protection from damage by termites and other insects. The aluminum tape also serves as an electrical shield to be grounded both at the point of connection to the cable and at the customer's house. This is particularly important in locations where there may be severe lightning exposure or where power-distribution cables and service wires are also buried.

The common practice in constructing rural buried plant is to place the cable by plowing it into the ground — usually along the shoulder of a road. Rural cables can be plowed-in for fairly long distances without interruption, since these areas are sparsely settled.

At customer locations, plowing is interrupted while a length of cable is drawn out of the ground for "looping" through a distribution terminal. The terminals are mounted on pedestals at one side of the road, frequently at a fence line. The most recent type of terminal is furnished factory-mounted on interlocked sections of galvanized-steel post.

A trench carries the loop of cable from the plow "slot" in the road shoulder to the terminal location. Within the terminal, a section of cable sheath is removed to expose the core, and one or more pairs of wires are then connected to terminal binding posts. On each post, a plastic terminal strip is mounted near the top, where it is easy to work on. A service wire is then extended from the terminal to the customer's house by plowing or other means. Since it is not necessary to seal the terminal hermetically, due to the moisture-resistant properties of the cable insulation, the cost for terminations is relatively low. An incidental advantage of the above-ground terminal is that it provides a convenient access point for testing. Also where loading is required on long lengths of cable, the terminal may serve to house the loading coils.

To minimize field splicing, the cable is furnished in lengths as long as the capacity of the shipping reels will permit. At reel ends, the cables are usually joined at a pedestal where the conductors may be joined on the binding posts of the terminal.

In urban residential areas, the greatest application of buried distribution has been in large units of individual or row-type houses. This type of development is characterized by large-scale efforts of many sorts being carried on at the same time. Streets and sidewalks are being laid while sewers and water and gas mains are being constructed. Usually, the utility companies wish to place their facilities while all of the other construction is under way. It is important, therefore, for the telephone forces to coordinate their activities with the builder and with the various other utilities.

C. C. Lawson, left, and W. J. Lally examining a post-mounted pedestal terminal. At these points service wires are connected to selected cable pairs.

Typically, the installation of buried distribution plant in an urban housing development involves trenching a slot along the desired cable path — commonly in a public-utility easement along the rear-lot line. The cable is first laid along the ground beside the slot, and then dropped into the trench. The trench is refilled by pushing dirt back into the slot; then the trencher or a truck is run over the filled slot to compact the loose earth. At points where distribution terminals are to be installed, a loop of cable is left above ground — as in the case of rural plant.

Service wires are trenched or plowed from cable line to house and are connected to the binding posts of the terminal. At the house end, the service wire goes through the building wall — either above or below the ground level.

One of the big problems in buried distribution is the design of the equipment that buries the cables and wires by plowing and trenching. For burying cables in rural areas, plowing is particularly well adapted because the runs are generally long and straight, and because there are few service-wire connections. On the other hand, trenching is better adapted to urban distribution where spaces are confined, and runs are short between customer-connection points.

Construction crews use types of plows and

A crawler-mounted trencher being demonstrated by the manufacturer. Different types of trenching machines are continuously studied as part of the program designed to discover the best-performing equipment for burying cables.

trenchers especially designed for cable laying. In a cable-laying plow, the plow share, which cuts a deep narrow slot in the earth, is equipped with a tube to permit the cable to be fed in at the top, pass down through and emerge at the bottom of the share at the desired depth below the surface of the ground. A wide variety of available shapes and designs of plows meet this general description.

Plows and trenching machines are continuously studied as part of the program designed to discover the best-performing equipment. In the case of plows, for example, the Laboratories is conducting studies to determine the tractive effort required to pull plows of different depths, widths and shapes through various types of soil. It is essential that the design chosen be one which makes possible attachment of the plow to any adequate-sized tractor such as is used by farmers or by utility contractors.

Buried cable may be placed at depths of as little as a few inches or as much as 3½ feet. The desirable depth, of course, is that which is most economical both in cost of placing and cost of maintaining the cable. This depth varies with the environment. For example, on private right-of-way in the country it should be below the depth reached by subsoilers. Also, on public right-of-way, in road beds or along road shoulders, it should be deep enough to avoid damage from road-maintenance equipment. In urban areas, sufficient depth must be maintained to avoid damage by "do-it-yourself" gardeners.

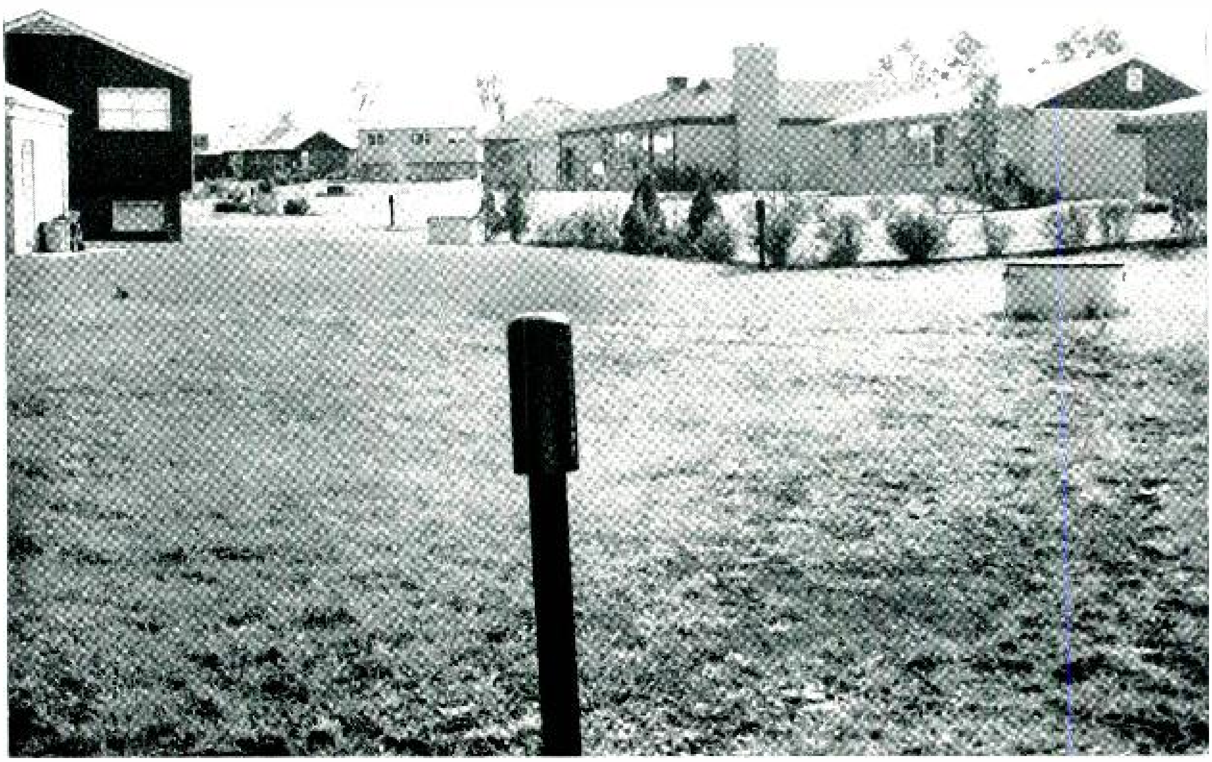
The Laboratories is continuously studying the subject of attack on cables and wires by animals, insects, and even bacteria and fungi. The materials used in design of the wire and cable, and those materials which will be used at splices, must last a long time. Thus it is important to determine the effects of subterranean environments on the wires, cables and other components. Some of these samples are being placed in areas of high biological activity, others in arid soils; still others are buried where they are exposed to insect and rodent attack. Close observation of these samples should uncover, early, any unanticipated source of degradation so that corrective action may be taken.

Installations of buried urban distribution plant have been made in most Operating-Company areas. These installations have furnished opportunities for engineers to make studies of work operations; to observe, at first hand, field performance of trenching machines under different soil conditions; and to study problems associated with coordinating the work of burying telephone plant with construction activities of other utilities and contractors working in the area. With average soil conditions, the combination of proper planning and adequate tools and equipment will produce buried urban distribution plant that compares favorably in capital cost with comparable aerial plant. Furthermore, maintenance costs are expected to be less than those for aerial plant. There still remain, however, problems to be solved and improvements to be made in tools and materials, and in construction and maintenance techniques.

The increasing volume of construction of buried plant has prompted a review of the safety considerations concerning people and plant where telephone and power distribution plant are in close proximity underground. In the aerial plant, clearances between telephone and power lines have been well established and have proven practical in many years of usage. While agreements exist regarding separation of facilities below ground, and safety regulations have been adopted on the basis of these agreements, the regulations are now being reviewed by a committee comprising interested engineers of the Edison Electric Institute and the Bell System. These studies have the general objectives of determining: (1) minimum depth for placing both types of plant, (2) horizontal and vertical separation between the two, (3) protection required at cross-over points, and (4) the development of methods of coordinating construction and of locating and identifying each service. The results of this study will probably become the basis for any modifications in the National Electric Safety Code that may be required.

Favorable results have tended to accelerate the burying of telephone wires and cables. It is estimated that 8500 new homes were so served during 1957, 14,500 during 1958, and 32,500 will be served during 1959.

An outstanding example of progress along these lines is the new Levitt development near Burlington, N. J., which will have all of its telephone distribution system buried. This development of 17,000 homes will become the largest community to enjoy the advantages of this improved type of telephone construction. When completed, the city will require its own central office and thus will be the first central-office area served completely by buried distribution plant.



In this Western Springs housing development, near Chicago, telephone pedestals and power distribution housings set along rear property lines. Ultimately, landscaping will hide these structures.

M. J. Kelly Retires From Bell Telephone Laboratories

A forty-one-year career devoted to science and technology in the Bell System came to a close last month when Dr. Mervin J. Kelly retired from Bell Telephone Laboratories. Starting as a research physicist with the Western Electric Company in 1918, Dr. Kelly participated in the inception (1925) and growth of the Laboratories. He has led the organization as its President since 1951, and in January of this year was elected Chairman of the Board of Directors.

Dr. Kelly graduated from the Missouri School of Mines and Metallurgy in 1914 with a Bachelor of Science degree. In 1915, he received his M.S. degree from the University of Kentucky, and earned his Ph.D. in Physics in 1919 from the University of Chicago. At Chicago he served as assistant to Professor R. A. Millikan — participating in the famous oil drop experiments for measuring the charge of the electron.

Transatlantic Telephone

Among Dr. Kelly's first projects in the Bell System was the problem of making commercially practicable the then new art of vacuum tubes. An achievement of the research group under Dr. Kelly was a great increase in the life span of telephone repeater tubes. In building transoceanic radio telephony tubes, which require very high frequencies and great power, Dr. Kelly and his associates also developed the first reliable water-cooled tubes.

Dr. Kelly recalls this work. "I can remember as vividly as if it were today," he has said, "the thrill that came when a group of us Bell engineers were working on the first transatlantic radio telephone.

"The problem was a tough one. The biggest vacuum tube available could produce only 250 watts. We had to develop a tube capable of twenty to twenty-five times that output . . .

"We built an experimental station out on Long Island and started transmission tests to England. Deliberately, we picked the most difficult sentences in the language for transmission to see if they could be heard and understood there.

"Finally, the word came back. Our messages were getting through. Transatlantic telephone service was assured. . . . "

Dr. Kelly subsequently was concerned with applications of acoustics in telephony, and later with work on photoelectric cells, vacuum thermocouples, ballast lamps and similar devices for communications. In 1934 he became Development Director of Transmission Instruments and Electronics, and in 1936 was appointed Director of Research. At the beginning of World War II he took charge of the war research and development effort. Almost a total activity for the Laboratories during the war, this work centered on radar, gunfire control and bombsights.

The many important contributions of America's engineers to our war effort was described by Dr. Kelly in an article in "The Bridge of ETA Kappa Nu" for September, 1943. In this article he wrote that, "After the incidence of war in Europe in the fall of 1939, we engineers were among the first to turn away from peaceful activities and to give attention to the problems of warfare in the modern style.

"Beginning with Pearl Harbor . . . our effort expanded at an unprecedented rate. . . . New laboratories and factories were constructed and placed in operation in time intervals measured in months. . . . Progress has been made in some fields of technology in a four-year interval that, under the normal conditions of peace, would have required from ten to twenty years."

Near the close of the war, in 1944, Dr. Kelly became Executive Vice President of the Laboratories, and in 1951 was elected President.

Science Education

Under Dr. Kelly's direction, the Laboratories made an outstanding contribution to scientific education with the founding, in 1948, of the Communications Development Training Program. C.D.T. was started as a three-year course to provide additional training for young engineers who had recently received their bachelor's and master's degrees. Dr. Kelly has said of this program, in a talk before the A.S.M.E. in 1955, that it has successfully emphasized "increasing depth in the physics, chemistry and mathematics essential to modern technology, with advanced courses in communications and electronic technology." Later, in 1957, the opportunity afforded C.D.T. students was expanded when New York University opened a graduate center at the Laboratories. In this program the students are earning graduate credits through courses offered by N.Y.U's College of Engineering.

Dr. Kelly has frequently pointed out the need for the nation to look to the training of its scientists and engineers for scientific and technical strength. Speaking at Cooper Union in 1956, he emphasized that "Strength in science and technology is essential to our protection and the preservation of our free society.

"Our strength," he said, "resides primarily in the production efforts of our scientists and engineers. To raise its level, there must be a larger number in each year who complete their academic preparation. The period of academic training must be increased beyond that of a large fraction of those now engaged in the effort. Not only is added time for training essential, but also our academic educational program in engineering must be revised for those who are entering creative technology.

"We must educate more young people in science and engineering and raise the quality of that education. . . . The period of academic training for these engineers must be lengthened and science and analytical engineering be made a large fraction of their present program."

Dr. Kelly is a Life Member of the Massachusetts Institute of Technology Corporation and a member of its Executive Committee. He is also a Trustee of Stevens Institute of Technology, and serves on advisory committees at M.I.T., Princeton, N.Y.U., Case Institute of Technology, Columbia University and the New York City Board of Education.

Dr. Kelly has held many public service assignments in Washington, including positions with the Atomic Energy Commission, the Department of Commerce and the Department of Defense. He is a member at large of the Defense Science Board. Among his many honors are the 1953 Trophy of the Air Force Association, awarded "for distinguished service to air power in the field of science." He also holds the Air Force Exceptional Service Award, presented in 1957. In addition, Dr. Kelly has been a member of the Naval Research Advisory Committee since 1954, and he served as vice chairman in 1956.

Dr. Kelly discussed the contributions of industrial research to the national security in 1954 when he spoke before the American Association for the Advancement of Science. "The continued security of our nation," he said, "is vital to this leadership and contribution. The research of the nation is essential to the maintenance of this security. Industrial research is carrying out some two-thirds of the nation's research program. Looking to the future, its responsibilities are increasingly great. The nation's industrial research is strong and virile. I am confident that it will measure up to its responsibilities."

Research Committees

In 1953, Dr. Kelly was chairman of a Defense Department committee that studied the problems of continental defense against atomic attack and had the responsibility of making recommendations on organization and programs. Early in 1954, he was named a member of the Hoover Commission Committee on Business Organization of the Department of Defense and was chairman of its Subcommittee on Research Activities in the Department of Defense and defense-related agencies.

Dr. Kelly is a member of the National Academy of Sciences and has been chairman of two committees of that organization which have served in advisory capacities to the Secretary of Commerce. In 1953 he headed a committee to study the effectiveness of the Bureau of Standards and to make recommendations concerning its organization and programs.

Dr. Kelly is a Fellow of the American Physical Society, the Acoustical Society of America, the Institute of Radio Engineers, and the American Institute of Electrical Engineers. He is a member of the American Philosophical Society, a Foreign Member of the Swedish Royal Academy of Sciences, and a member of the honor scientific and engineering societies Sigma Xi, Tau Beta Pi and Eta Kappa Nu. Dr. Kelly was awarded the 1954 medal of the Industrial Research Institute, and in 1955 received the Christopher Columbus International Communication Prize. He has been awarded eight honorary doctorates in recognition of his distinguished contribution to the fields of science and defense.

Dr. Kelly has served on the Board of Directors of Bell Laboratories since 1944. In addition, he is a Director of the Prudential Insurance Company of America, the Bausch and Lomb Optical Company, and the Tung-Sol Electric Company. He also serves as a Director of the Economic Club of New York.

Recent Honors Accorded Dr. Kelly

Just prior to his retirement, Dr. M. J. Kelly received two major awards — the 1958 James Forrestal Memorial Award of the National Security Industrial Association and the 1959 John Fritz Medal. On both occasions Dr. Kelly made major addresses.

Bell Laboratories and the American Institute of Electrical Engineers have also announced the establishment of the Mervin J. Kelly Award for achievement in the field of telecommunications.

Forrestal and John Fritz Awards

In receiving the Forrestal Award, Dr. Kelly joins President Eisenhower, David Sarnoff, General Alfred M. Gruenther and Admiral Arthur W. Radford, similarly honored in past years for their accomplishments in furthering national security. Dr. Kelly received a gold medal and citation at the N.S.I.A. Forrestal Dinner, January 29, in Washington, D. C. In tribute to James Forrestal's activities for, and his dedicated interest in our nation's strength, Dr. Kelly based his address on "Some Essentials for National Strength."

At the dinner, the following message from President Dwight D. Eisenhower was read:

"Please give my greetings to members and guests of the National Security Industrial Association gathered in honor of Dr. Mervin J. Kelly.

"In the presentation of the 1958 James Forrestal Memorial Award, Dr. Kelly's contribution to the defense of the nation is given special recognition. The career of this gifted and dedicated scientist is an inspiration to all to put their talents to fullest use.

"It is a pleasure to add my congratulations and best wishes."

Dr. Kelly received the 1959 John Fritz Medal on February 4 at the Winter General Meeting of the American Institute of Electrical Engineers in New York. In response he delivered an address on "The Development of the Nation's Scientific and Technical Potential."

Dr. Kelly was awarded this coveted honor for "his achievements in electronics, leadership of a great industrial research laboratory, and contributions to the defense of the country through science and technology." The Fritz Medal is sponsored jointly by the A.I.E.E., the American Society of Civil Engineers, the American Society of Mechanical Engineers and the American Institute of Mining, Metallurgical and Petroleum Engineers.

Presented not more than once in any year for "scientific or industrial achievement" in any field of pure or applied science, the Medal was established in 1902 as a memorial to the engineer and steelmaker whose name it bears. The roster of medalists includes another former President of the Laboratories, Frank B. Jewett, and Alexander Graham Bell, John J. Carty, Thomas A. Edison, Guglielmo Marconi, George Westinghouse, Orville Wright, Charles Kettering, Michael Pupin, Elmer A. Sperry, Gen. George W. Goethals, Herbert Hoover and others of the world's outstanding engineers and scientists.

Mervin J. Kelly Award Established

On January 20, the Laboratories and the A.I.E.E. announced the establishment of the Mervin J. Kelly Award. The Kelly Award will be made annually by the American Institute of Electrical Engineers to an individual who has made an outstanding contribution to the advancement of the art of telecommunications. The prize will consist of a bronze medal, a cash stipend and a certificate. The first award will be made by the A.I.E.E. in 1960. The award is being sponsored by Bell Laboratories but will be administered solely by the Institute.

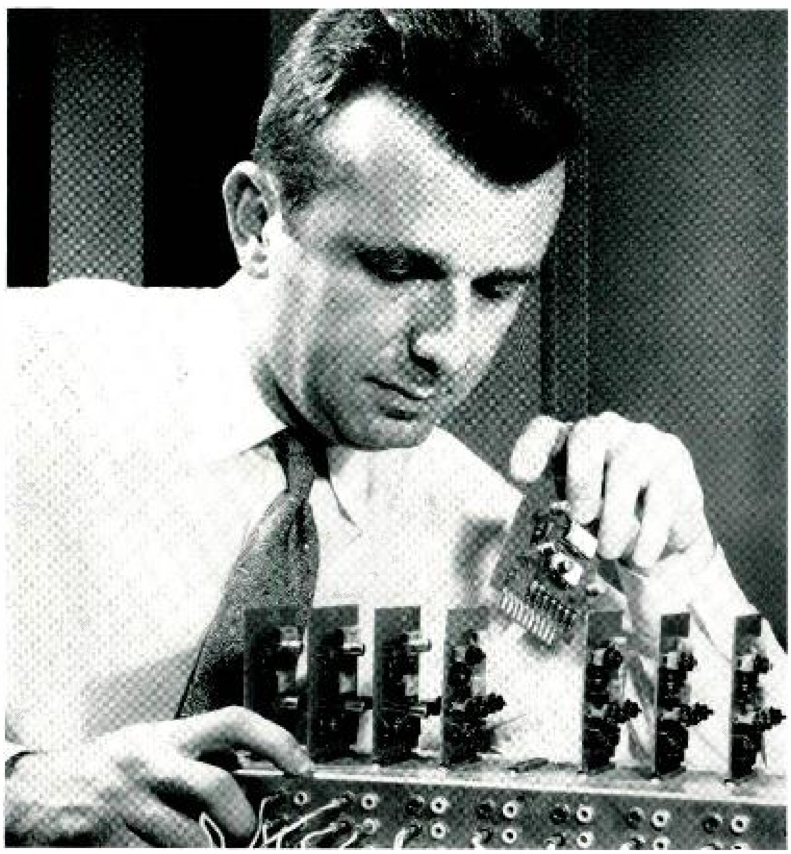
news notes

Electronic Circuit Simulates Living Nerve Cell

Bell Laboratories scientists have recently developed a simple electronic circuit that simulates some of the functions of nerve cells. Like an actual nerve cell or neuron, the circuit is sensitive to stimuli and responds by transmitting electrical pulses. Researchers have also combined numbers of new "artificial neurons" into experimental networks that are roughly analogous to the nerve systems of the eye and ear.

Currently there is considerable interest in the function of visual and auditory nerves and how signals from these nerves may be interpreted by the brain. Such basic research may lead, as it has in the past, to better and more economical communication.

L. D. Harmon, of the Visual and Acoustics Research Department, initiated the project. He has combined cells into groups that simulate simple functions of the eye, and W. A. Van Berjeijk, of the same department, has started similar experiments with models of the ear.



L. D. Harmon assembling a network of electronic "nerve" cells. Such transistorized circuits simulate some functions of actual nerves.

In living nerve systems, cells that receive stimuli are termed "receptors"; these emit pulses which in turn stimulate neurons in the nerve system to emit other pulses. The pulses usually have a constant amplitude and duration, but vary in rate of repetition. The artificial neuron circuit, designed by R. M. Wolfe of the Communications Techniques Research Department, behaves very much like its natural counterpart.

An increase in the intensity of excitation can increase the frequency of pulsing in the artificial as well as the natural neuron. Also, the artificial cell can be arranged to "accommodate" itself to a continuous excitation — the frequency of pulsing can be made to decrease with time. This is analogous to similar behavior in a living nerve.

To "fire" a biological cell, a stimulus must surpass a certain threshold value; however, two or more pulses, each below threshold value, can be "summed" by the cell to produce firing. Furthermore, certain stimulus conditions, while exciting one nerve, may prevent a neighboring one from firing. And in all cases, a cell must rest momentarily before it can respond to another signal.

The artificial neuron circuit behaves in a similar manner. It has a certain threshold value but can integrate pulses below that value for successful firing. Also, a particular input connection can, when energized, inhibit firing of the neuron by other inputs. And finally, following a stimulus the electronic neuron's threshold rises to infinity, and for a few milliseconds *no* input signal can fire the neuron again.

The circuit includes four transistors, thirteen resistors and two capacitors, mounted on a three-by-four inch printed-circuit card. Most of the time constants of the artificial cells approximate those of biological neurons, and because the electronic inputs and outputs are compatible, the circuits can be assembled into chains and networks.

As an example of an application, electronic neurons can be combined with photo-resistive cells, acting as receptors, to simulate simple functions of nerves in the retina of the eye. Some receptors, known as "on" receptors, fire only when the light intensity they receive is increasing; "off" receptors fire only when the light is decreasing; and "during" receptors fire while they receive a steady light.

Engineers have also artificially simulated "flicker-fusion." In the human eye, this phenomenon causes a sequence of flashes, of suitable intensity and repetition rate, to be seen as continuous illumination — a property of vision that makes possible the practicability of motion pictures and television.

Engineers have also demonstrated experimentally the mutual inhibition of cells in an array. Some animals have been observed to possess this arrangement by which a cell in the eye receiving a greater light intensity inhibits the firing of nearby cells that receive less light. This can result in sharpening the boundary detail of the image on which the eye is focused.

Flanagan Named Fellow Of Acoustical Society

J. L. Flanagan of the Acoustics Research Department was elected a Fellow of the Acoustical Society of America at its 56th biannual meeting, held recently in Chicago.

Acting on a recommendation of the Society's membership committee, its executive committee named Mr. Flanagan for his contributions to the field of speech processing.

Dr. Kelly Speaks on Basic Research

Dr. M. J. Kelly recently spoke before two organizations on the subject of the Nation's need for basic research.

On January 14, he spoke before the American Management Association Conference on research about "The Expanding Dimensions of Research and Engineering."

At a luncheon of the University Club in New York City on January 31, Dr. Kelly talked on "The Nation's Need for More Basic Research."

R. K. Honaman and W. K. Lowry Named To Information Group

The Board of Directors of the Engineers Joint Council has announced the appointment of R. K. Honaman, Director of Publication at Bell Laboratories, and W. K. Lowry, Manager of the Technical Information Libraries, to the Council's recently formed Committee on Engineering Information Services. In naming the members, the Directors acted upon the recommendations of leaders in the field of engineering information.

The Committee was founded as a result of the Council's recognition that "the adequacy of systems for abstracting, indexing and disseminating technical information to meet national needs has become a public as well as an inter-professional problem." As organized, the Committee is to "review existing engineering abstracting, indexing, and related services, and prepare and maintain an appraisal of their adequacy to meet the needs of the profession during this era of rapid technical growth, increasing national responsibility and higher integration of physical sciences. In addition, under the general supervision of the EJC Board, the Committee is responsible for the presentation of the results of this work where necessary in the national and professional interest."

Miss M. N. Torrey Named Fellow of American Statistical Association

The American Statistical Association has announced that Miss M. N. Torrey, of the Quality Assurance Department at Bell Laboratories, has been named a Fellow of the Association. The award was made at the Annual Meeting in Chicago.

During the award ceremonies, Miss Torrey was cited for "her contribution to the theory of sampling inspection; for her able analyses of engineering data; and for her clear and concise presentation" of quality control in electronics. An article on this subject, "Quality Control in Electronics," was published by Miss Torrey in the November, 1956, issue of the *Proceedings* of the Institute of Radio Engineers.

J. R. Townsend Heads Standards Association

John R. Townsend, Materials Consultant at Bell Laboratories and Special Assistant in the Office of the Assistant Secretary of Defense for Research and Engineering, has recently been elected president of the American Standards Association.

Mr. Townsend was Director of Materials Applications Engineering at the Laboratories in 1952 when he was granted a leave of absence to take a similar position at the Sandia Corporation in Albuquerque, N. M. He was named to the Washington post in 1957.

TALKS

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

AMERICAN CHEMICAL SOCIETY, NORTH JERSEY SECTION, Meeting in Miniature.

Becker, E. J., and Cleveland, H. M., *Ultramicro Gas Analysis. Mass Spectrometer Instrumentation and Applications in the Electron Device Industry.*

Cleveland, H. M., see Becker, E. J.

Craft, W. H., see Koontz, D. E.

Craft, W. H., see Thomas, C. O.

Hawkins, W. L., Worthington, M. A., and Winslow, F. H., *Loss of Antioxidants from Polyethylene by Evaporation.*

Huyett, Miss M. J., see Lundberg, J. L.

Kohman, G. T., *Experimenetal Investigation of Diffusion Separation of Gases in Barriers.*

Koontz, D. E., Craft, W. H., and Thomas, C. O., *A Chemical Etching Technique for the Preparation of Ultraclean Surfaces,* (Presented by Craft, W. H.).

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

Laudise, R. A., and Harker, I. (Johns-Manville Research Center), *Chemistry under Hydrothermal Conditions.*

Lundberg, J. L., Wilk, M. B., and Huyett, Miss M. J., *The Diffusivities and Solubilities of Gases in Polyethylene.*

McAfee, K. B., Jr., *Experimental Investigation of Diffusion Separation of Gases in Silica Glass Barriers.*

Nelson, L. S., and Kuebler, N. A., *Heterogeneous Flash Pyrolysis of Hydrocarbons.*

Sullivan, M. V., see Thomas, C. O.

Thomas, C. O., see Koontz, D. E.

Thomas, C. O., Craft, W. H., and Sullivan, M. V., *The Design of Apparatus for the Preparation of Ultra Pure Water.*

Thomas, C. O., *Ultramicro Gas Analysis with a Gas Dilatometer.*

Wilk, M. B., see Lundberg, J. L.

Winslow, F. H., see Hawkins, W. L.

Worthington, M. A., see Hawkins, W. L.

AMERICAN PHYSICAL SOCIETY, New York City.

Anderson, P. W., *Time Reversal and Superconductivity in Imperfect Crystals.*

Bond, W. L., see Kaiser, W.

Frisch, H. L., see Reiss, H.

Hrostowski, H. J., and Kaiser, W.,. *Infrared Absorption of Oxygen in Silicon.*

Kaiser, W., see Hrostowski, H. J.

Kaiser, W., Bond, W. L., and Tanenbaum, M., *Nitrogen Content and Lattice Constant of Common Type I Diamonds.*

Moore, G. E., *Direct Observation of Surface Catalyzed Production of Hydrocarbons from Elements.*

Reiss, H., and Frisch, H. L., *Equation of State of Hard Sphere Fluids.*

Wertheim, G. K., *Recombination in Germanium with Nickel Impurity.*

Tanenbaum, M., see Kaiser, W.

OTHER TALKS

Anderson, O. L., *Adhesion of Metals in Air at Room Temperature,* Baltimore Section, Amer. Soc. of Mech. Eng., Baltimore, Md.

Barney, H. L., *Visible Speech and the Sound Spectrograph,* Madison Association of Science Students, Madison, N. J.

Barrett, W. A., *A New Solid-State Memory Device — The Twistor,* Engineers Club, Burlington, N. C.

Beck, A. C., *How Radio Astronomy Began,* Amateur Astronomers, Inc., Plainfield, N. J.

Berger, U. S., *What Is New in the Bell System,* Chapter of Am. Institute of Plant Engineers, Lowell, Mass.

Bömmel, H. E., *Some Applications of Ultrasonics to Solid-State Physics,* Physics Colloquium, University of Massachusetts, Amherst, Mass.

Chapin, D. M., *The Role of Minerals in the Solar Battery,* Paterson Public Library, North Jersey Mineralogical Soc., Paterson, N. J.

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

Harmon, L. D., *"Intelligent" Processes in Machines,* A.I.E.E., Cleveland, Ohio.

Harmon, L. D., *Pattern Recognition in Machines and Animals,* Spring Hill College, Mobile, Ala.

Harmon, L. D., *Brains and Computers,* A.A.A.S., Mobile, Ala., and Tulane University, New Orleans, La.

Honaman, R. K., *Communications —A Forward Look,* Seattle-Tacoma Section, A.I.E.E., Seattle, Wash. and Joint Meetings

TALKS (CONTINUED)

of the Portland, Oregon, Sections, A.I.E.E.-I.R.E., Portland, Oregon.

Honaman, R. K., *Bell Laboratories Developments in Communications*, Pacific Telephone and Telegraph Company, Portland, Oregon.

Hoover, C. W., Jr., *Methods for Measurement and Control in the Photographic Video Recording Process*, Cathode Ray Tube Recording Symposium, Dayton, Ohio.

Howard, J. B., *A Review of Stress-Cracking in Ethylene Plastics*, Soc. of Plastics Engineers, 15th Annual Technical Conference, New York City.

Jenkins, H., *Development of Concepts with Uncorrelated Informational Feedback*, University of Chicago, Ill.

Kaiser, W., *Mechanism of Donor Formation in Heat-Treated Silicon*, American Physical Society, Los Angeles, Calif.

Kelly, M. J., *The Expanding Dimensions of Research and Engineering*, American Management Association, New York City.

Kelly, M. J., *The Nation's Need for More Basic Research*, University Club, New York City.

Kimme, E. G., *Decomposition of Nonlinear Operators and Some Methods of Analytic Programming*, Convair Scientific Research Laboratory, Convair, San Diego.

Kostkos, H. J., *New Developments at Bell Telephone Laboratories*, Pacific Telephone and Telegraph Company, Seattle, Wash.

Liehr, A. D., *Colors of Ni(II) and V(III) Complexes*, Chemistry Dept. Seminar, Brown University, Providence, R. I., and New York University, New York City.

Lloyd, S. P., *Stochastic Processes with Analytic Covariance*, Am. Math. Soc., Philadelphia, Pa.

Mason, W. P., *Use of Internal Friction Measurements in Determining Dislocation Motions, Fatigue and Fracture in Solids*, Mechanics Colloquium, Cornell University, Ithaca, N. Y.

Mumford, W. W., and Engelbrecht, R. S., *Some Data on the Performance of MAVARS*, San Francisco Chapter, I.R.E. Professional Group on Microwave Theory and Techniques, Stanford University, Stanford, Calif.

Niedner, J. B., *Navigation by Inertial Instruments*, Chatham High School, Naval Reserve Composite Company 3-6, New Jersey.

Perkins, E. H., *Type P Carrier*, A.I.E.E. Subsection, New England Telephone Company, Portland, Me.

Schwenker, J. E., *Research Applied to Basic Communication Problems*, New York Section, A.I.E.E., New York City.

Sheppard, H. A., *Here Today, Gone Tomorrow! A Problem in Military Communications*, 2nd National Symposium on Global Communications, St. Petersburg, Fla.

Slichter, W. P., *Diffusion and Polymer Chain Mobility*, Institute for the Study of Metals, University of Chicago, Ill.

PATENTS

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

Allison, S. W. — *Toll Telephone Circuits* — 2,868,886.

Ashkin, A., and Walker, L. R. — *Modulated Backward Wave Oscillator* — 2,871,451.

Babcock, W. C. — *Antenna Array* — 2,869,122.

Bacon, D. D., Scaff, J. H., and Theuerer, H. C. — *Treatment of Semiconductive Material* — patent number 2,871,111.

Bacon, W. M., Branson, D. E., Knandel, G. J., and Locke, G. A. — *Message Transmission System* — 2,871,286.

Bell, N. W. — *Gain Regulator for Carrier Systems* — 2,867,774.

Branson, D. E., see Bacon, W. M.

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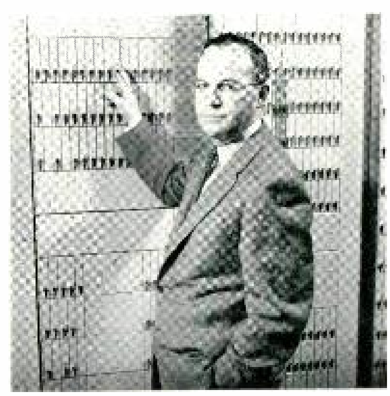

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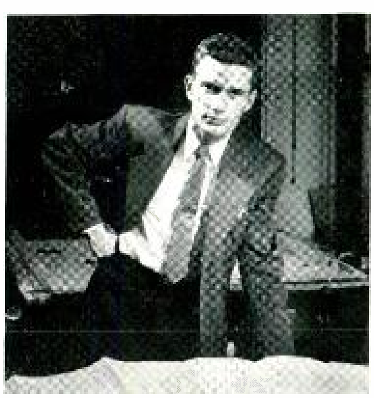

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