July 1961

Bell Laboratories RECORD

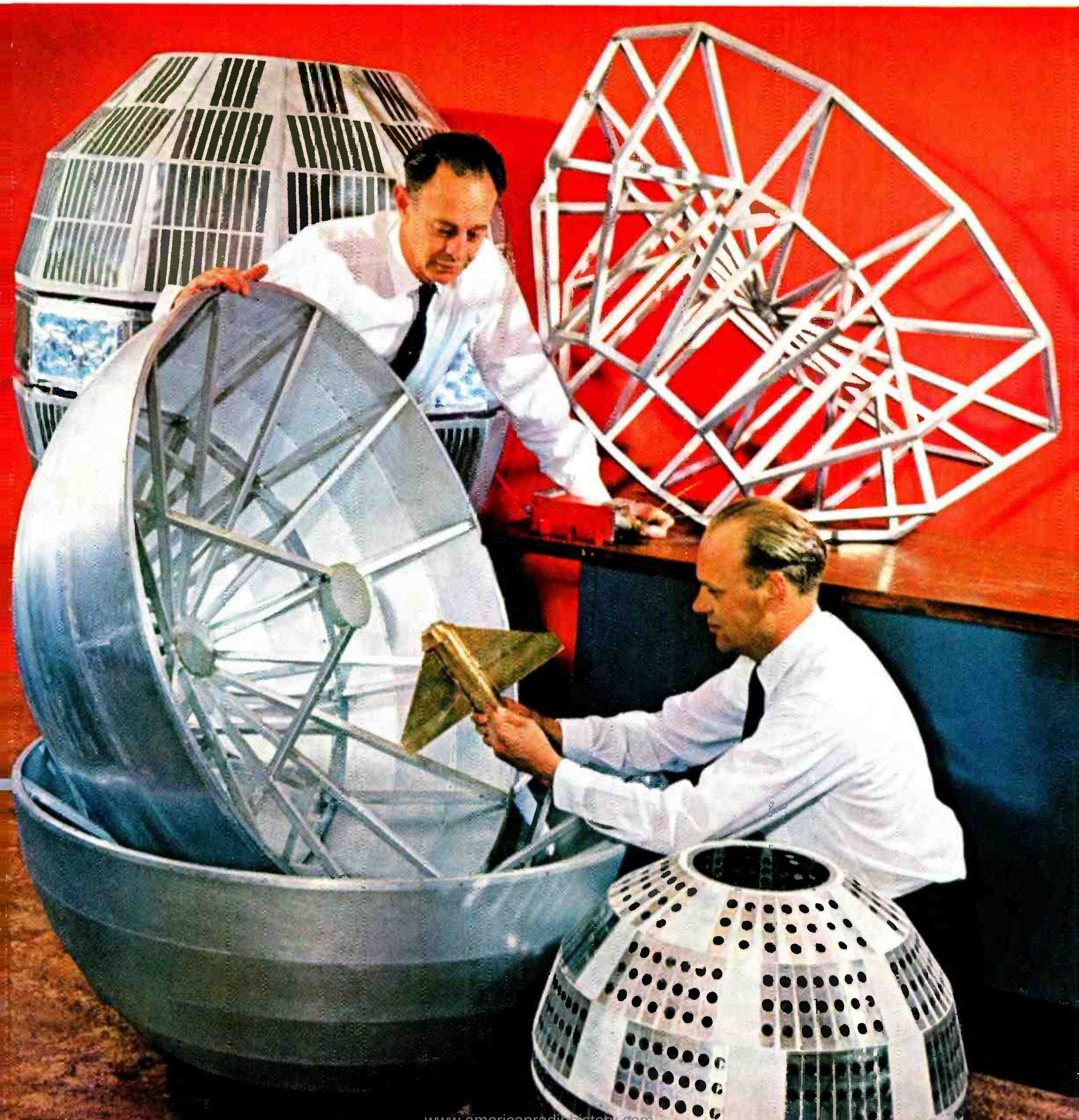
SAC's Primary Alerting System

Dialing Overseas Calls

Air-Drying for Microwave Systems

A Self-Protecting Transistor

Static Frequency-Generators



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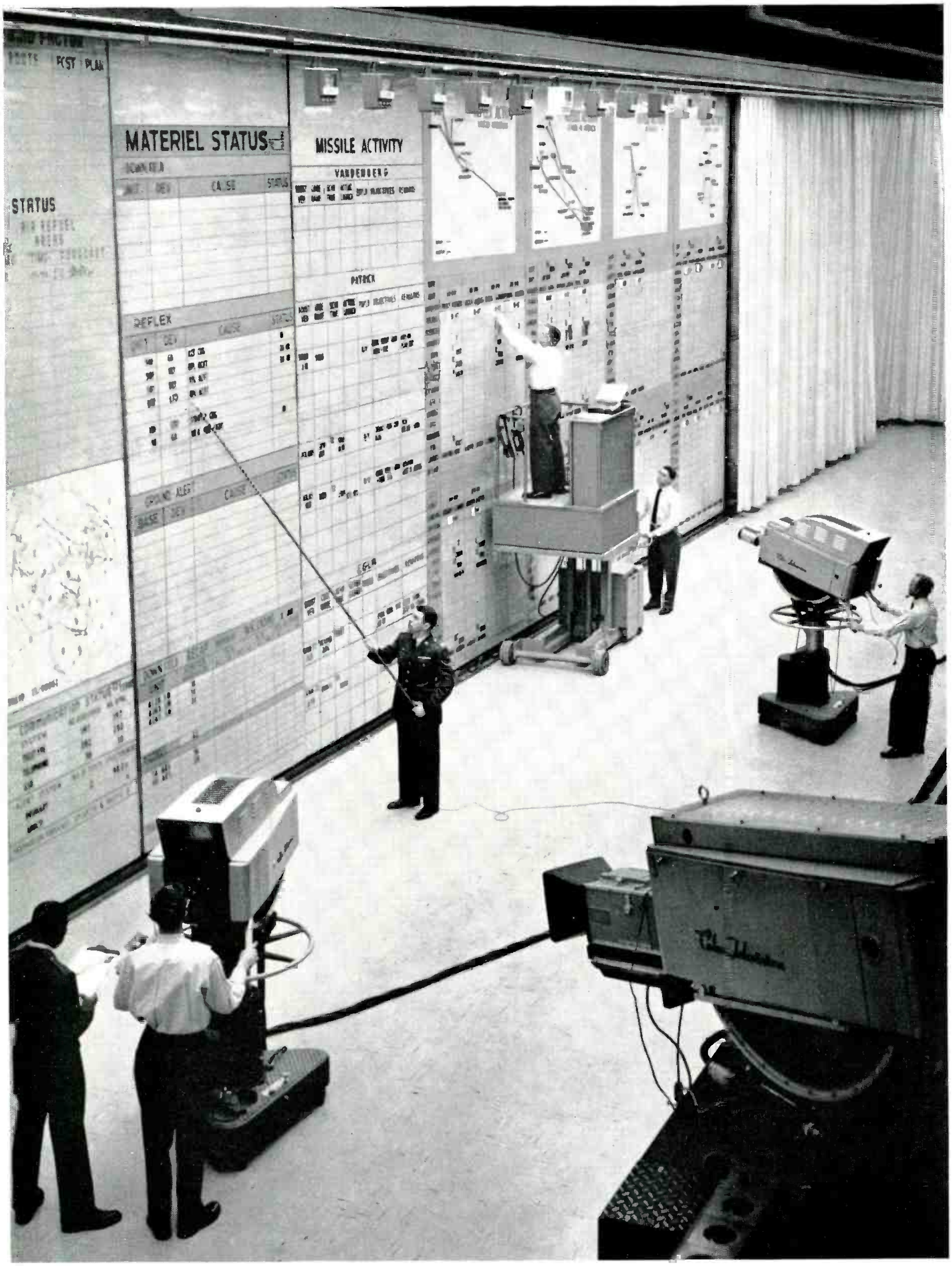
Cover

John W. West (left) and Leif Rongved, surrounded by developmental models of active satellites, discuss a brass frame for holding electronic equipment inside such a satellite (see page 258).



Closed circuit television cameras focus on briefing officer at SAC's underground command post. Information gathered at these sessions forms basis for "alerts" issued over Primary Alerting System.

SAC has a force of bombers and missiles capable of preventing war by deterrence. Bombers on the ground, however, represent a loss of strength in the event of attack. The Laboratories-developed Primary Alerting System gets them "upstairs" fast.

H. J. Michael and H. M. Pruden

SAC's Primary Alerting System

"Peace is our Profession" is the slogan of the Strategic Air Command, whose mighty retaliatory force is a major factor in insuring continued peace in the world. To fulfill its mission adequately, SAC must be ever alert—ready to go into action at a moment's notice.

Under recently established "airborne alert" training procedures, a certain proportion of SAC's bomber fleet is airborne at all times. In addition, a substantial portion of the bombers are on "ground alert" status. These are always ready to take off, to be airborne within minutes after receiving warning of an attack. In this business, time is precious. Every second cut from the time lapse between first awareness of attack to the command to "scramble" means more bombers in the air, ready to carry retaliatory devastation to the enemy, and fewer vulnerable bombers on the ground.

Playing a vital role in cutting this time lapse is communications—getting immediate word of imminent attack to all the far-flung SAC bases. To obtain the extra precious seconds needed to launch a maximum force, SAC now has in operation the Primary Alerting System (PAS). This system provides a ready-to-use communication network for broadcasting "alert" announcements to all SAC bases, with emphasis on voice communication. It is a permanently assembled network, furnished as a Bell System service. Specially designed signaling and alarm arrangements are incorporated to insure the reliability and continuity necessary in so important a service.

The Primary Alerting System was developed at the request of the Air Force. The A.T.&T. Co., Western Electric Co., and Bell Laboratories worked with customary teamwork, and the system was planned, designed, manufactured, and put into service in less than one year.

The Air Force has two prime requirements: (1) that the network always be immediately available to broadcast alerts; and (2) that it have maximum reliability. To provide the desired availability, the system uses a so-called "hot-line" arrangement. In this way, the voice path is always available directly from a controller to all bases with no intermediate switching required.

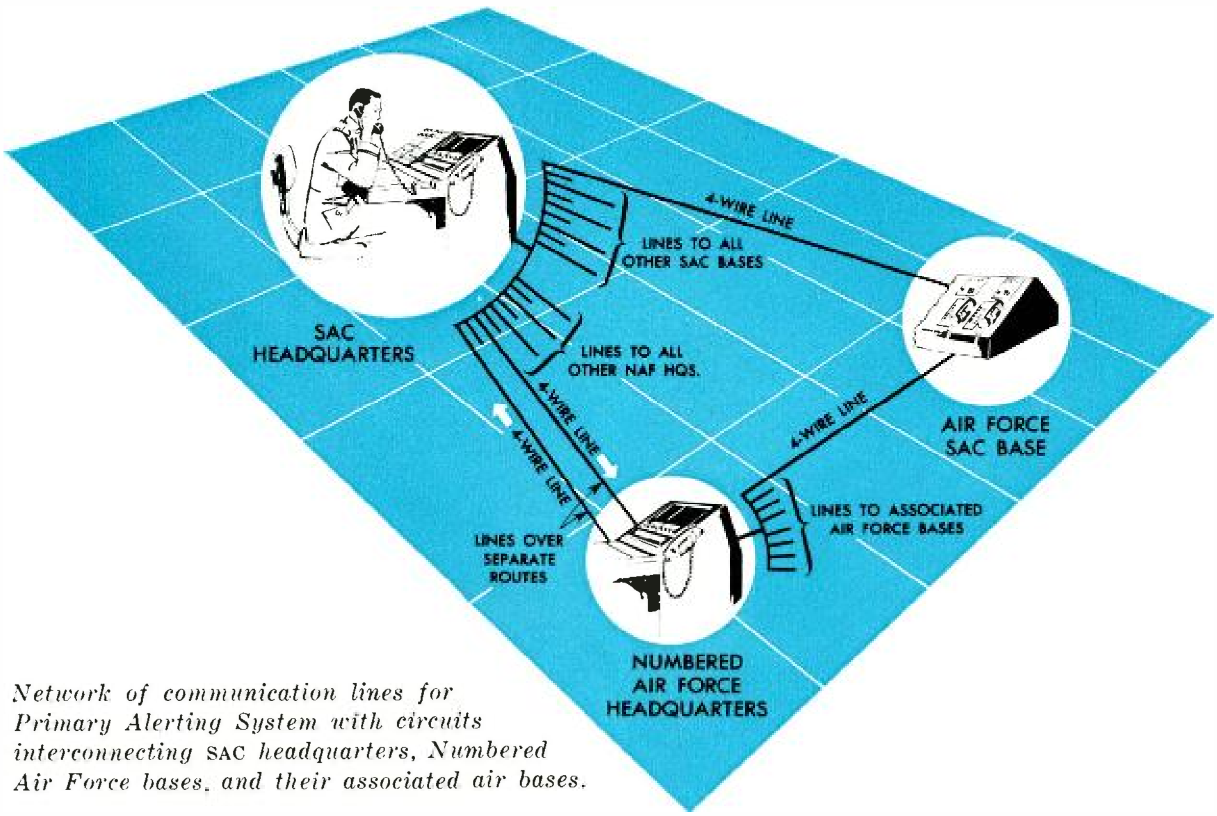
In order to visualize the function of the alerting system more easily, a brief description of SAC's geographical organization is in order. SAC headquarters, the nucleus of the command, is at Offutt Air Force Base, Omaha, Neb. Major subordinate commands within the continental United States consist of three numbered Air Forces and a missile division. These Numbered Air Force (NAF) bases exercise authority and control over all SAC units within three geographical areas covering the eastern, central, and western portions of the United States. More than sixty SAC bomber units are located within these three areas.

As a step in providing the required reliability, the system designers employed dual 4-wire lines throughout the network. This is illustrated in the simplified layout of the network shown below. All outgoing lines bridge at SAC headquarters and radiate outward to the Numbered Air Force headquarters and their associated Air Force bases. At each NAF headquarters, the incoming line from SAC is permanently connected to other lines going out to its associated bases. Thus, there are two separate lines to each Air Force base, laid over separate routes and using separate equipment; one line goes direct from SAC headquarters and one goes via the NAF headquarters. (For reasons of economy, overseas bases will not in all cases have direct circuits from SAC headquarters, although they will be reached via two alert circuits.) Each line also appears in a console at headquarters, and it is possible to hold conversation on a selected line without causing interference on any other line.

Continuous Supervision

As a further measure to insure reliability, all lines, including the circuits on each base, are under continuous electrical supervision and have suitable alarms at the originating-headquarters end of each circuit. This provides SAC with an "up-to-the-second" status check on each circuit.

Because the continuity of all circuits must be checked, even while they are in use, a frequency-sharing, or "slot," signaling technique is used. This technique requires that a band about 250 cycles wide be derived in the normal speech channel. All signals are transmitted in this 250-cycle



Network of communication lines for Primary Alerting System with circuits interconnecting SAC headquarters, Numbered Air Force bases, and their associated air bases.

Senior Controller at SAC *underground headquarters in Omaha places a test call over the* PAS *"Red Phone."*

slot. The basic talking and signaling path for all circuits is outlined in the diagram on page 238. As indicated, band-rejection filters isolate all telephones and loudspeakers connected to the voice circuits. These filters prevent listeners from hearing the signaling tones and keep voice currents from interfering with signaling.

All signals are transmitted over the voice circuits by carrier telegraph terminals, designated "43A1," which operate at voice frequencies. Different frequencies are used for signaling in opposite directions to prevent confusion in the signaling system if the two sides of a 4-wire circuit cross each other.

The signals passed through the 43A1 terminals are simple and highly redundant. These characteristics help to insure the reliability of the system, even under adverse conditions. The signals include those for: testing circuit continuity in both directions; sending alerts toward the bases and acknowledgment signals toward headquarters; and a call signal toward headquarters for non-alert calls. The arrangements for these signals and their purposes will be explained below.

Circuit continuity is checked by transmitting a short tone pulse every three seconds on the "send pair" of the four-wire circuit. Each Air Force base has an electronic pulse repeater that returns an answering pulse at a lower frequency to headquarters on the "receive pair" of the circuit. The originating end of each circuit is equipped with a receiving circuit synchronized with the pulse-generator circuit, so that only pulses received at the correct time are accepted as valid reply pulses. These receivers are arranged to send alarms to both Air Force and Operating Telephone Company personnel if the reply pulses fail to arrive after 20 seconds, or if too many false pulses are received.

Circuits on the base itself are also checked for continuity by a flow of direct current. If this current is interrupted, the tone pulses normally returned toward the headquarters are blocked. This causes the circuit to send an alarm.

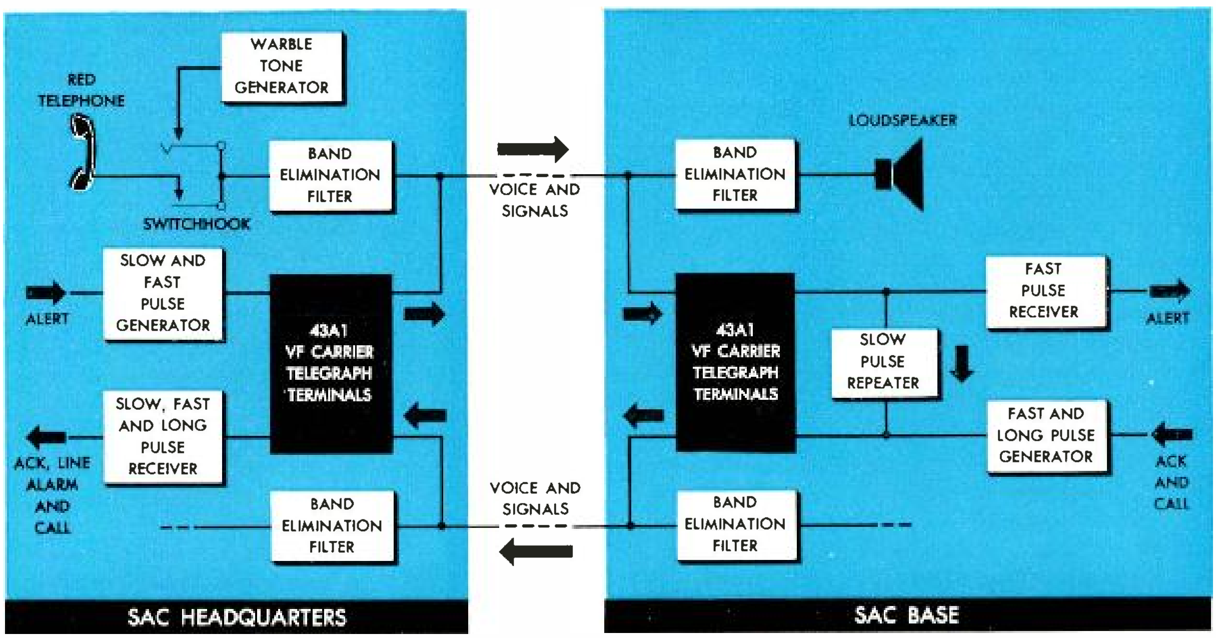
The alerting and acknowledgment signals, which are sent in opposite directions, are 100-millisecond pulses transmitted at the rate of five per second for three seconds. The electronic, slow-pulse repeaters at the bases prevent retransmission of these pulses.

A call signal of about one second is used for calling headquarters from the bases. This call signal and the acknowledgment signals are automatically timed, and are produced by momentarily operating the proper key.

All alerts are initiated and all circuit alarms and individual acknowledgments are indicated on specially designed consoles at SAC and NAF headquarters. The senior controller's console shown on page 237 is equipped with a red telephone for alerts and a gray telephone for point-to-point traffic. All other consoles, at both the headquarters and the associated bases, have only gray telephones. In addition to the common keys and lamps involved in alerting and testing, the consoles have individual "appearances" for each line. Each line appearance consists of two lamps and an illuminated, non-locking, push-button key. The red lamp, which is at the bottom of the line appearance, indicates the status of the particular circuit. If illuminated, it indicates that the circuit is in trouble. The push-button key above the red lamp is used to select individual lines for point-to-point traffic, which will be described later. The amber lamp above the push-button is the acknowledgment lamp. Since all of these may be illuminated at one time, neon lamps are used for both status (red) and acknowledgment (amber) lamps to minimize instantaneous current drain and reduce heat dissipation.

At the Air Force bases each line terminates in a loudspeaker that is always ready to receive alerts, and a telephone set for point-to-point traffic. There is also an "acknowledge" button used to return acknowledgment signals when requested, and a "call" button for ringing headquarters. The base units are suitably packaged and conveniently mounted in a special console, known as the Combat Wing Console, a Bell System service furnished at each base.

The Primary Alerting System is very simple to operate. To initiate an alert from the underground SAC Command Post at Offutt Air Force Base, the senior controller merely picks up the special red telephone and presses the "alert" button on the alerting console. This transmits both an alerting tone and an alerting signal simultaneously over both paths to each base. The former consists of alternate spurts of tones at 900 and 1400 cps, transmitted as long as the alert button is operated. This alerting tone is received on the loudspeakers at all Air Force bases and serves as a warning that an alert announcement is coming. The alerting signal lights the acknowledgment lamps in the consoles at all headquarters and disconnects any point-to-point traffic which may be on the lines at the time. After the voice alert message has been broadcast, all base controllers are asked to acknowledge receipt of the message by pressing the "acknowledge" button. This transmits acknowledgment signals simultaneously to SAC and NAF headquarters, and these signals extinguish the individual acknowledgment lamps. The system is arranged so that a controller at NAF headquarters may also broadcast alerts, including the tone, signal and acknowledgments,



Schematic diagram of equipment at SAC headquarters and associated Air Force bases.

SAC Control Center Air Policemen guard the main entrance corridor at Underground Command Post.

to his associated bases in the same manner.

Another feature of the system is that during times when an alert is not in progress, the individual lines may be used for point-to-point traffic between controllers. A headquarters controller, using the gray telephone handset associated with the console, may select any desired line merely by pressing a nonlocking pushbutton on his console and calling in the selected remote point by voice. Conversely, a base controller may call headquarters by operating a pushbutton that transmits a call signal toward headquarters. On receipt of this call signal at headquarters, the associated line lamp flashes at all console positions, which are in multiple, and an audible signal sounds. When the call is answered at one of the console positions by operating the "line" key, the lamp will flutter at this position, indicating that this is the connected line. At all other positions, the lamp for this line will be steady.

This connection may be released either by selecting another line or by momentarily operating the common "release" key. If this type of call is in progress at a time when an alert is to be transmitted, operation of the alert key will immediately disconnect it.

The designers of the Primary Alerting System have made special efforts to assure continuous service and to permit rapid and easy detection of troubles should they occur. They duplicated equipment in all critical parts of the system and provided adequate alarms. For example, a voice alert may be broadcast from either one of two completely separate originating red telephone sets, with their associated equipment. They provided duplicate sending circuits, including amplifiers and 43A1 sending units. The output is continuously monitored by feeding back one leg of the output bridge to a monitoring receiver. Should a single pulse of the alerting signals be missed, an alarm sounds, and the alternate sending circuit, which is also continuously monitored, automatically switches in to replace the regular circuit.

As previously mentioned, every circuit can be continuously checked, with visual and audible indications of its status. For example, should the circuit fail or its transmission be impaired by as much as 12 db for a period of more than 20 seconds, the red status lamp for that circuit will flash. In addition, at the console a common alarm lamp will flash and a common audible signal will sound. When the audible signal is silenced by operation of the alarm release key, the status lamp will light steadily. It remains lighted until the circuit is restored to normal, then goes out.

Arrangements have been incorporated in the circuit to permit a fairly complete test of this important feature directly from the console. The controller need merely hold the continuity check key operated for a period of 20 seconds. This key blocks the check pulses from going out on the line, for as long as it is operated. When no return pulses are received, the alarm circuit starts "timing." At the end of the 20-second interval, all status lamps will flash. This not only checks the lamps, but the alarm circuits as well.

System to Be Extended

All reports from the Air Force, as well as those from the Operating Telephone Companies who provide and maintain this system, indicate that the Primary Alerting System has been performing satisfactorily in all respects. The system is now being extended to all of SAC's overseas bases.

The Primary Alerting System is an excellent example of how the Bell System team, in this case spearheaded by the Systems Engineering experience of the Laboratories, is contributing every day to the defense of our country. This contribution to the deterrent might of the Strategic Air Command will hopefully lead to an even more important goal—world peace.

- There will be a new supervisory signaling plan that will be the same in both directions in respect to format and frequencies.
- Address information will be sent by multi-frequency pulsing at 10 digits per second.
- All cable circuits will handle two-way traffic (traffic originating at either end).
- Only machine access will be allowed to transatlantic channels.

In the proposed transatlantic network, the numbering plan used in Europe will meet CCITT recommendations; North America will use the standard North American plan. Each country will maintain the internal features it likes. For European international calls, the CCITT numbering plan uses a two-digit country code, a language digit, an area code which may be a single digit, an office code and a line number. On a call to London from any other country in Europe, for example, the dialing might proceed as shown in the table below.

DIGITS DIALED	SWITCHING INFORMATION
44	Country code, United Kingdom
2	Language digit
1	Area code, London
222	Office code
1234	Line number

The language digit, the second entry in the table, denotes the language of the calling country. This is to ensure that calls requiring operator assistance in the called country will be directed to an operator who speaks the language of the calling country. The office code will not necessarily contain three digits.

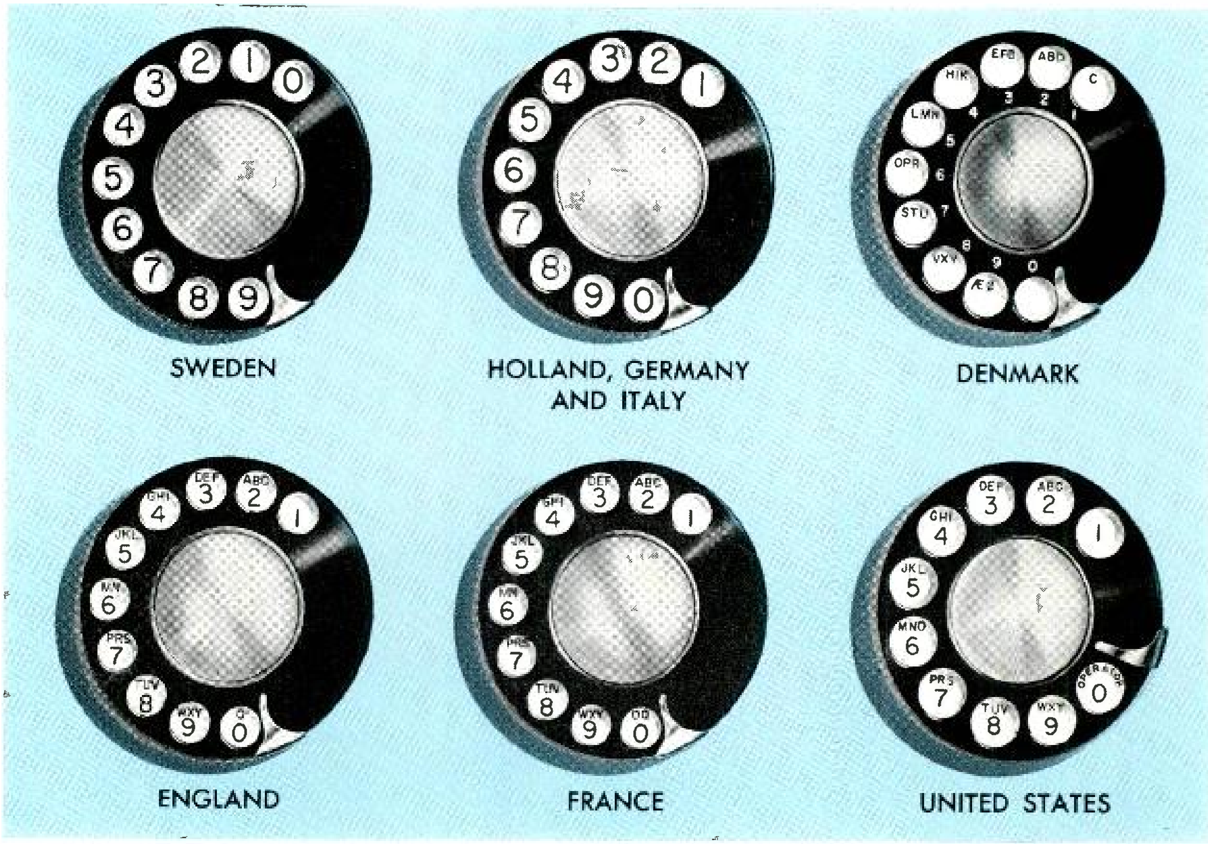
The arrangements will not be quite the same in both directions on the transatlantic circuits. Mainly because of differences in numbering and switching philosophy, some aspects of dialing from North America to Europe will vary from dialing in the other direction. The major difference is the "gateway city" concept of the United States and Canada. With this mode of operation, calls to Europe from any point of origin in either country will be routed through a gateway city—New York and Montreal are typical—and dialed from these points. This is a very manageable concept because special equipment for overseas dialing need be installed only in the gateway cities. Similarly, special operating requirements are limited to staffs in these cities.

The European plan, on the other hand, prefers two types of operation called "terminal" and "transit," depending on whether the call is routed directly to the terminating country or switched through another country. If the call is terminal, the complete national number is sent ahead. If the call is transit, only the country code is sent to the transit points. The terminal country, when it is reached, requests the language digit and national number. Although this type of operation has the gateway-city advantages of limiting the requisite special equipment and operating procedures, it has the present disadvantage that all calls using the same country code must be routed via a single city. Thus, even though a short, direct route may exist between two cities, a call between them may have to be directed over a longer route through that single city. The alternative to this plan is the use of extra codes or more complicated translation.

Ultimately, transit operation may be needed for international alternate routing. In preparation for this, the North American gateway city equipment will be designed to send both terminal and transit signals. On calls from Europe to North America, no distinction need be made, because on this continent the same mode of operation serves all calls. In every case the complete address information is sent and received and the same group of registers is used for "via" and "terminal" traffic. The CCITT recommends two kinds of registers at each switch point, a two-digit register for transit calls and (usually) a ten-digit register for terminal calls. The language digit is stored in the trunk circuit, not in the register.

The language digit represents a small problem, though a practical rather than a technical one. On calls from North America to Europe the language digit must be sent and it will be inserted by switching equipment. On calls in the other direction, however, it is not practical to have assistance operators in the United States who speak the languages of Europe. Therefore, by agreement, all calls to the United States will be handled by European operators who speak English.

There are other numbering problems besides those discussed. One becomes immediately apparent with a glance at the dials used around the world *(see photograph on page 243)*. On the Swedish dial, for example, the numeral "0" is in the position of the numeral "1" on the other dials. Mechanical translation may be necessary to reconcile this dial with others. The differences between



Telephone dials from several countries showing some of the variations in lettering and numbering.

the English dial and the American dial are slight and operators could be trained to make the necessary translations between England and North America. But for customer dialing, the problem may be somewhat greater. When customer dialing is eventually introduced, all-number calling will probably be adopted.

Difference In Numbering Plans

Another problem arising from the difference in numbering plans has the same general outline—a minor difficulty if operators dial, but more serious if customers dial. This problem stems from the idea of a "closed" or an "open" numbering plan and the methods of determining that full address information has been received.

In the North American (closed) numbering plan, senders and registers "count" the digits that are dialed and "know" when the last one has been received. This arrangement can be made because there are a fixed number of digits for each telephone number. In some European (open) plans the number of digits varies. Eight to ten digits not including the prefix "0" are used in England, for example. Timing or special translation is used to indicate that the last digit has been received. In London, the area code, "1," indicates that nine digits (prefix "0" followed by eight digits) will be dialed. In other areas the number is considered complete if, after a fixed time, no further digit is received. When operators dial, an end-of-keying signal will be transmitted to indicate that the number is complete.

Another problem is that differences must be reconciled in modes of assistance operator and address signaling. The CCITT proposes either an arythmic or a binary code. Each code has 16 possible signal combinations; ten represent decimal digits, the eleventh and twelfth signal "Code 11" and "Code 12" operators for assistance. These last combinations correspond, respectively, to the North American 3-digit inward operator code "121" and the 4-digit delayed call operator code "115X." Three of the remaining four combinations in the CCITT code are spares, the other indicates end of pulsing.

For supervisory signaling the problem is a bit more complex. The CCITT recommends "spurt-type" signaling in which there are tones on the line only when trunk control, status, or address information is transmitted. When the line is idle or during conversation no tones are present. The North American network, on the other hand, uses continuous supervisory signaling in which there is a low-level tone always present on the line when it is idle. Interruptions of this tone transmit the signaling sequences. When signaling is completed and conversation has started, the tone is removed.

Another point of comparison is that the various line sequences—connect, disconnect, on-hook, off-hook—are represented in the CCITT plan by spurt signals of fixed duration and a specified combination of frequencies. To assure a high degree of accuracy, acknowledgment signals are needed. They are not needed with continuous signaling.

The supervision problem is further complicated by TASI. Continuous tone cannot be used on this system because its central idea is that the absence of any tones or speech energy on a channel indicates that it can be switched instantly to another

COMPARISON OF TRUNK CONTROL AND STATUS SIGNALS

Signals	Standard Bell System SF Signaling for Intertoll Trunks (2-way Operation) Frequency = 2600 CPS ▭		Signaling for Transoceanic TASI Derived Trunks (2-way Operation) Frequencies { 2600 CPS ▭ / 2400 CPS ▬	
	Direction of Transmission		Direction of Transmission	
	Orig-Term	Term-Orig	Orig-Term	Term-Orig
Idle Condition	⇨ (2600 CPS, continuous)	⇨ (2600 CPS, continuous)	No Tone	No Tone
Seizure	No Tone	⇨ (2600 CPS, continuous)	➡ (2400 CPS, continuous)	No Tone
Delay Dial	No Tone	No Tone	—	—
Proceed To Send (Start Dial)	No Tone	⇨ (2600 CPS, continuous)	➡ (2400 CPS, continuous)	⇨ (2600 CPS, continuous)
Address Signals	MFKP	⇨ (2600 CPS, continuous)	MFKP	No Tone
Customer Answer	No Tone	No Tone	No Tone	▬ (2400 CPS) 850
Called Customer Hang-Up (On Hook, Clear Back)	No Tone	⇨ (2600 CPS, continuous)	No Tone	▭ (2600 CPS) 850
Disconnect-Forward (Clear-Forward)	⇨ (2600 CPS, continuous)	⇨ (2600 CPS, continuous)	{ ⇨ (2600 CPS) + ➡ (2400 CPS), continuous }	No Tone
Disconnect-Acknowledge (Release Guard)	—	—	{ ⇨ (2600 CPS) + ➡ (2400 CPS), continuous }	{ ⇨ (2600 CPS) + ➡ (2400 CPS), continuous }
Ring Forward (Forward Transfer)	▭ (2600 CPS) 70-130	No Tone	▭ (2600 CPS) 850	No Tone
Busy-Reorder-No Circuit (Busy Flash)	No Tone	Audible Tone (30, 60, 120 IPM)	No Tone	*Audible Tone (30, 60, 120 IPM)

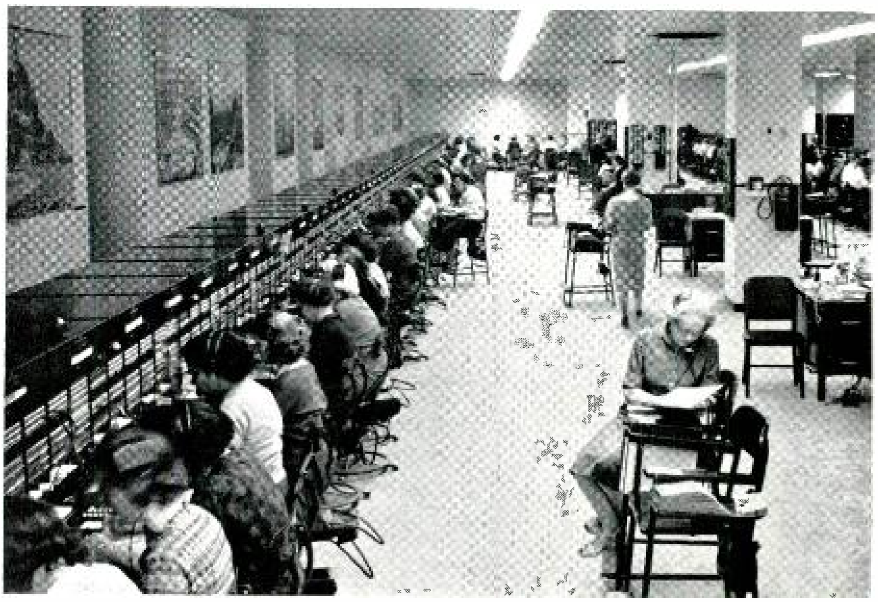
⇨ Continuous Tone

Duration of Pulses Indicated in Milliseconds

*For Calls to United Kingdom & Europe, a Busy Flash Signal ▭ (2600 CPS) 850 or an Audible Tone

Trunk control and status signals as they are used on present Bell System and on transoceanic trunks.

Over-all view of the Long Lines overseas switchboard room at the A.T.&T. Co. in New York City, one of the gateway cities.



talker. The signaling plan proposed for the transatlantic facilities is, therefore, a compromise between spurt and continuous signaling; each type is used where it is most advantageous. The chart on the opposite page compares the types of signals used for TASI derived trunks with those of standard North American plan.

It is important to remember that the transatlantic network will be compatible with both the European and the North American network, and that all countries will retain their internal features. Thus, in the matter of signaling, a converter will be used at each terminal to accept the type of signaling used on TASI and convert it to the type of signaling used either in North America or Europe. (See diagram on page 241.)

On the matter of trunks, CCITT operation in Europe is generally limited to one-way trunks. On the transatlantic circuits, trunks will be designed to handle calls originating at either end. The economies of two-way trunking are important, and for Europe, this type of operation will eventually become standard where it is economical.

Economy—at least in the narrow sense of the word—is, of course, not the only object of the decision to use two-way trunks. Nor, indeed, is it the aim of any other change or development described in this article. That aim is faster, more efficient handling of international traffic. Paradoxically, one result of improved methods of transmission is that they usually perpetuate and even increase an aspect of the traffic problem that they were intended to solve—its volume.

It is almost a truism that message circuits added to a crowded route will stimulate even greater volumes of traffic than had existed previously. Traffic doubled in the year following the cut-over of the first transatlantic cable to England. Conversation time per call also increased. An increase in traffic has occurred with each new cable and it can be predicted for planned cables. So the future of telephony is one of continued growth; its form is anybody's guess.

There are clear indications, however, that temper the guess with fact. It is quite likely that in the future, satellites will be used for intercontinental calls. Cables will, of course, be used for diversity and for protection against interference. In fact, some cable operating and signaling methods may be adapted to satellite operation. Worldwide calling with satellites will require a complete reappraisal of existing numbering, trunking, signaling, transmission and switching plans. Indeed, so great is the promise of satellites that work has already been started on worldwide numbering. Transmission, signaling, and trunking will be studied too. Intercontinental centers will probably perform the functions on a worldwide basis that regional centers now perform on a national basis. The horizons of technology broaden with new possibilities, and the physical horizons seem to grow closer as this technology brings nations to only seconds apart.

We are often told that the only real barrier between nations is their inability to understand one another. Understanding waits on a transfer of intelligence one to the other and the basis of this is a transfer of information. In a very real sense, the ultimate refinement in communications is not merely of the future, but will help to shape it.

When moisture accumulates in waveguides and antennas it may damage microwave signals. Therefore, Laboratories engineers have designed special apparatus to supply dry air under pressure to those vulnerable components of microwave systems.

J. M. Jackson

Air-Drying Apparatus For Microwave Systems

Daily, over five million cubic feet of dry air are supplied to the waveguides and antennas of the Bell System microwave network. Delivered by dehydrators designed at Bell Laboratories, this volume of dry air is a continuous guard against the accumulation of moisture within these critical components of microwave systems.

Moisture in the antenna and waveguide networks of microwave systems is a serious deterrent to good transmission characteristics. A layer of condensed water within the waveguides or on reflective surfaces of certain types of antennas may result in intolerable signal attenuation and sometimes may completely interrupt transmission. To prevent or minimize the effects of moisture, the waveguide networks are filled with dry air under low pressure.

The story of improving design of air-drying apparatus follows closely the story of new developments in microwave systems. In general, the problems involved in the design of air-drying apparatus were problems of volume and pressure. The basic design principle adopted by the Laboratories for all dehydrators—from those used with early systems, which required a relatively small volume of dry air, to those presently used, which require a substantially greater volume—was dynamic adsorption. Simply, this means that ambient air is passed through a desiccant bed; the desiccant adsorbs moisture and dried air is delivered to the system. When the desiccant bed in the large apparatus nears saturation it is reactivated; in the smaller apparatus it is replaced.

The first transcontinental TD-2 microwave route, established in 1951, operated in the 3700- to 4200-mc common carrier frequency band. Initially, this system used the delay-lens antenna (Record, *February*, 1952). In this system, only the waveguides were pressurized. To prevent dried air from entering the antenna, the waveguide run is equipped with two "windows"; one placed near the repeater equipment, another near the antenna. The windows are electrically transparent, but act as gas dams to confine the dry air to the section of the waveguide run between them.

With the volume to be maintained under dry-air pressure thus limited to that of the waveguide between the antenna and the repeater bay, only a few cubic feet of dry air are needed each day. For these low flow rates very large air-drying apparatus would be impractical. Therefore, Laboratories engineers designed small wall-mounted dehydrators to furnish several weeks of drying service with one desiccant bed. A visual indicator on these units warns local maintenance personnel when the relative humidity of the delivered air exceeds a critical value. The desiccant bed is then reactivated or replaced.

In recent years, the rapid growth in long-distance telephone and television transmission pointed up a need for a microwave system capable of operating simultaneously in several common-carrier frequency bands. To fill this need, the Laboratories developed the horn-reflector antenna and its associated circular waveguide (RECORD, *November*, 1955).

Air Pressure Problems of Horn Reflector

The incorporation of the horn-reflector antenna in both new and existing microwave routes, necessarily posed new problems of air pressure maintenance. These problems can be presented more clearly if we first consider the structure of the horn-reflector antenna.

This antenna is approximately 22-feet long, 11-feet wide and 10-feet deep; its internal volume is slightly over 300 cubic feet. A thin plastic cover —also called a "window"—covers the face of the antenna. This cover, which has an area of approximately 70 square feet, protects the inside of the antenna from adverse weather conditions.

The antenna is assembled from several sections bolted together at flanged, gasketed joints. The bolted construction and the temperature and weather conditions to which the antenna is exposed make it almost impossible to ensure a completely airtight assembly of the sections. This leads, as we will shortly explain, to air-drying problems of a somewhat different nature.

With this new antenna, Laboratories engineers decided to pressurize the horn as well as its associated circular waveguide to prevent moisture condensation within the antenna. One important factor in this decision was a problem arising from the plastic window.

It is obvious that with the horns mounted on towers rising to heights of 400 feet, the thin window would "flutter" during windy periods. This action is detrimental to transmission. A low pressure of dry air within the antenna offsets the wind load, the window tends to "bow-out," and flutter is reduced.

In this connection, it is interesting to note that should the window rupture in dry weather, service could continue with little ill effect. Actually, a two-fold benefit is derived from the pressure of dry air. Not only does it combat the entrance of moisture into the antenna, but its action in keeping the window bowed out assures a constant distance between the window and the reflecting surfaces of the antenna. This distance is critical because the continual change which occurs if the window is allowed to flutter can degrade transmission quality.

Antenna tower at Buckhorn Mountain, Colorado, microwave relay station. The 50-foot tower stands on a ground elevation of 8,306 feet. Mounted on it are both delay-lens and horn-reflector antennas.

With the horn antenna, dry-air pressure must be maintained at only a few tenths of a pound per square inch. Greater pressure may rupture the window, and the antenna and waveguide network could then fill with rainwater and service would be disrupted.

Another reason for pressurizing the horn is the extreme difficulty, previously pointed out, of achieving an air-tight assembly of antenna sections. By careful design of gaskets and judicious choice of gasket material, air leakage can be held to a few cubic feet per hour (RECORD, *April*, 1956). But even this relatively small leakage is many hundred times that normally experienced in earlier systems where only the fairly air-tight waveguide networks are pressurized. Thus the unique air-drying problem presented by microwave systems using the horn-reflector antenna was one of furnishing a constant large volume of dry air under very low pressure.

To solve this problem the Laboratories developed new dehydrating apparatus which can furnish up to 400 cubic feet of dry air per hour at a delivery pressure of only a few tenths of a pound per square inch.

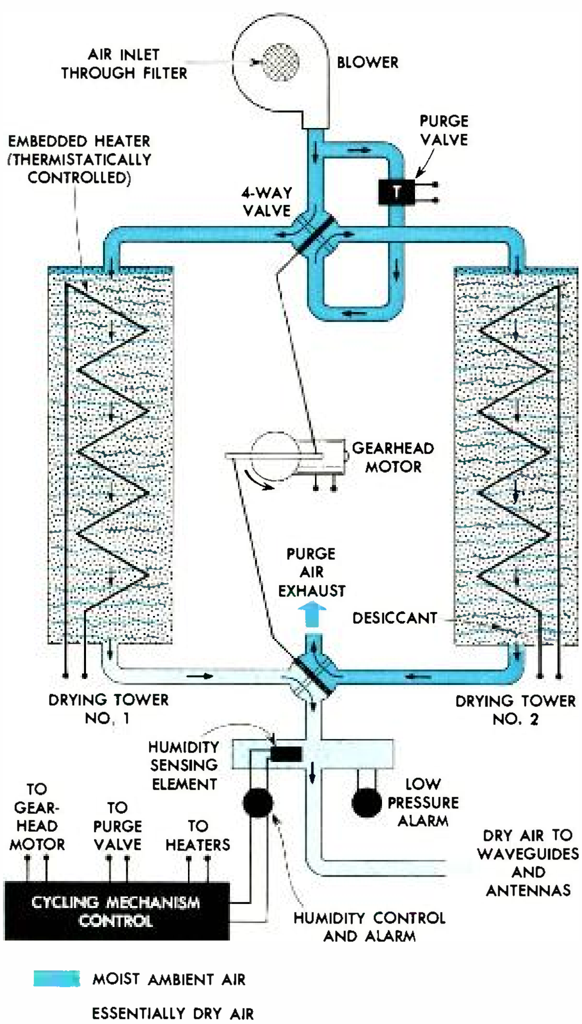


Diagram showing the flow of air through the drying tower of dehydrator to waveguides and antennas. The apparatus constantly uses one tower to supply dry air while the other is reactivated.

The new equipment comprises a centrifugal air blower, two desiccant-filled drying towers, and a humidity-operated cycling mechanism. In a continuous cycle, one tower supplies dry air to the waveguides and antennas while the other is reactivated. The operating scheme of this dehydrator is shown in the diagram on this page. In the diagram the light color represents dry air which is delivered to the antennas and waveguides, the dark color represents ambient air cycled through the tower being reactivated.

The blower delivers ambient air to one of the drying towers where the moisture vapor is adsorbed by the desiccant bed. Dry air is then piped to the waveguides and antennas. The quality of the air delivered to the waveguides is continuously monitored by a humidity sensing element. When the relative humidity of delivered air reaches a predetermined low value, the system is automatically cycled; the spent bed is purged with ambient air and the air to be dried for the waveguides is routed through the second tower. Thermostatically controlled heaters which are embedded in the drying agent then reactivate the spent bed.

Cycling the towers on a humidity basis—rather than on the basis of a preset elapsed time, which was employed in earlier models of dehydrating equipment—results in efficient use of the full drying capacity of the desiccant and has the added advantage of a decrease in power consumption. A tower may be used for drying for a minimum of 12 hours under the most severe conditions of flow rate, temperature and humidity. It may be used for periods of several days under more temperate conditions; for example where ambient operating conditions are milder and the leakage rate from the antenna system is lower.

Reactivation Cycle

The cycle of reactivation comprises periods of heating, purging and cooling. The heated desiccant releases moisture, which is purged from the tower by a small flow of ambient air. When all moisture is purged from the tower, the thermostat turns off the heaters and the solenoid control valve stops the flow of ambient air. The reactivated tower is cooled by radiation until the apparatus recycles.

Two sizes of dehydrators have been developed at the Laboratories. The larger apparatus, used

Author J. M. Jackson inspects control mechanism of air-drying apparatus. A simple schematic of the mechanism is shown in the preceding diagram.

primarily at main and terminal radio-relay stations with as many as twelve horn-reflector systems, furnishes up to 400 cubic feet per hour. A smaller unit, which is similar in design, is used at intermediate stations with a maximum of four antenna systems and has an output of 100 cubic feet per hour.

Several hundred dehydrators of this general design are in service throughout the Bell System microwave network. They are designed to operate in the most severe temperature and humidity conditions experienced in the continental United States. Dehydrators of this type have been modified slightly to meet other specific temperature and humidity ranges. For example, with appropriate modifications they are used with the White Alice communications network in the far north (RECORD, *August*, 1958).

The story does not end here. The excellent service records obtained over the last several years with the air-drying apparatus described in this article have not merely reaffirmed the efficacy of pressure maintenance in suppressing the effects of moisture. Rather, they have been a stimulus to engineering research on new techniques and new methods of drying air. Continuing studies at the Laboratories have resulted in a simpler, more compact, and less expensive air dryer (RECORD, *January*, 1960) designed around other principles of moisture removal—compression, refrigeration and expansion.

F. R. Kappel Stresses Defense Communications

The communications industry must do everything possible to satisfy military requirements for defense communications, Frederick R. Kappel, President of A.T.&T., said recently. Speaking before the annual convention of the Armed Forces Communications and Electronics Association in Washington, Mr. Kappel said industry must use initiative and creativeness to search for answers on its own "to help build our national strength."

In defining the Bell System's responsibilities for defense communications, Mr. Kappel mentioned several evidences of "our deep concern." He noted, "Work started more than seven years ago to build extensive long distance communications routes to avoid critical target areas."

Also, construction started last year on a new hardened cross-continent coaxial cable, entirely buried from end to end. On this cable, repeater and switching stations will be installed in heavily reinforced underground vaults, and certain key stations will be manned around the clock.

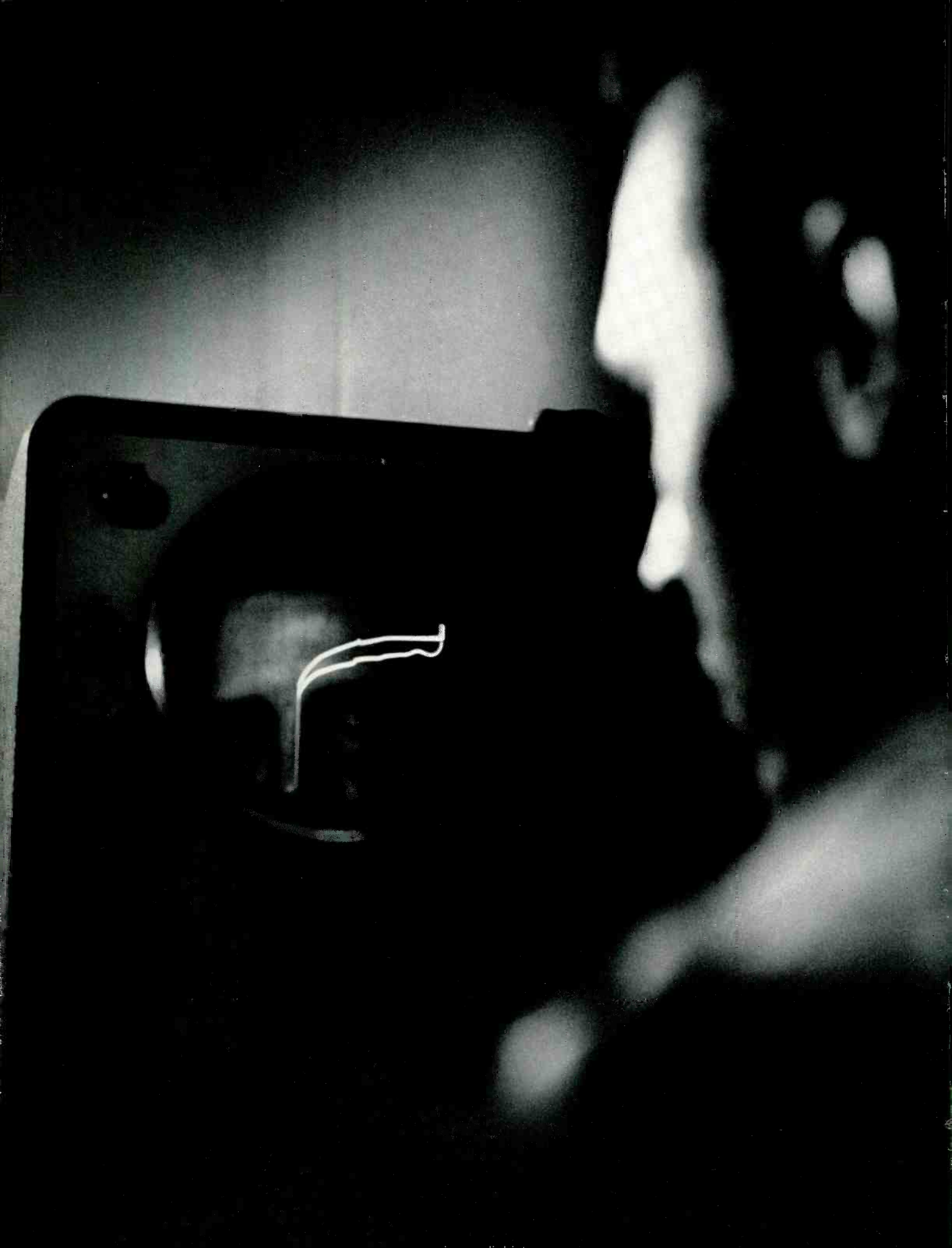
Mobility as a protection for defense communications is receiving serious attention. One of its many aspects, Mr. Kappel said, is the possibility of an airborne microwave system linking key areas by radio relay stations on circling aircraft. Studies show this idea deserves "full consideration," he added.

As to satellite communications, Mr. Kappel said "We have stated many times that both technically and financially we are ready to move on the double as soon as launching and other arrangements can be made with the Government.

Every feasible technical step to insure survivability (in military communications) must be employed, Mr. Kappel said. But at the same time, he added, let us remember human experience and competence.

"Thousands of telephone people all over this country are trained and conditioned to deal with the unexpected," he said. "They have a vast amount of knowledge and down-to-earth operating skill, along with a natural instinct to fix whatever may go wrong."

"All of us, associates and competitors alike, are united in devotion to the great task of building the nation's defenses as strong as they ever need be," Mr. Kappel concluded. Serving the Armed Forces as efficiently as possible is a clear obligation and "we intend to meet it."



A new transistor has been developed at the Laboratories that resists large residual surges of lightning and does not need the secondary protection of diodes. This device makes a big contribution to the success of another new development, the E-6 repeater.

W. M. Fox

A Self-Protecting Transistor For the E-6 Repeater

Thousands of times every year foreign potentials emanating from lightning attack the vast outside plant of the Bell System. Central office and station equipment would suffer severe damage if the full voltage of these potentials was impressed on telephone circuits. In fact, lightning damage to this equipment is negligible; protectors installed near customer's lines and at terminal equipment locations have proved highly effective in warding off excessive voltages. In the past, carbon-block protectors have been used, but as transistors and semiconductors find greater application in communication circuits, new protection techniques become necessary.

At an early point in the development of transistors for telephone circuits, Bell Laboratories engineers recognized a unique problem. Transistors, which operate on very low values of current, may be seriously damaged by a surge of voltage above their operating range. Such voltages may be impressed on telephone equipment when carbon block protectors "spark over." The problem was solved by employing diodes as secondary protection in conjunction with the primary protector, the carbon block. (RECORD, *July*, 1958). This was a successful device and it represented a new departure in protection for telephone systems. However, it was fairly costly.

The importance of the economic factor was pointed up when Laboratories' engineers estimated that substantial savings to the Bell System, and thus to its customers, would result if vacuum tubes could be replaced by transistors in repeater circuits. Repeaters are electronic devices which compensate for signal losses on transmission lines between offices. They are used so widely in the modern telephone plant that estimates showed a potential savings of two to three-and-one-half million dollars in a year's production. The longer life and lower power consumption of transistors would effect the savings.

However, these figures assumed in part the development of a low-cost transistor which could withstand residual lightning surges without secondary protection. Such a transistor has been developed for the E-6 repeater which is now being manufactured by the Western Electric Company.

The E-6 repeater is a transistorized version of the present E-23, which is a combination of the E-2 and the E-3. Comparing the E-6 and the E-23 on a component-for-component basis, we find that each of the two vacuum tubes in the old repeater is replaced in the new by four p-n-p low-power alloy-junction germanium transistors. The transistors of each pair are connected to each other in what is called a "pig-a-back" arrangement.

On first thought it may seem that using four

◀ *E. J. Seng studies the hysteresis loop of a transistor he is surge-testing for the new E-6 repeater.*

times the number of transistors as the number of tubes is incompatible with the goal of economy. This is not the case. In fact, early exploratory work had shown that gain in electrical current requirements in these transistors could be relaxed with the pig-a-back arrangement.

Precisely, designers computed the compound gain (mathematically represented as alpha) for the pig-a-back arrangement. This gain depends on the individual gain (alpha requirement) for each transistor. The computations showed clearly that a decrease of ten per cent in the alpha requirement of each transistor resulted in a decrease of only one per cent in the value of alpha for the circuit. A further benefit derived from using transistors is that all parameters of alpha change—time, temperature, variations in manufacture, for example—become less significant.

Different Transistor Characteristics Resolved

Another problem resolved during early development concerned the fact that early models of the E-6 repeater used three types of transistors, divided according to marked differences in characteristics. But as the E-6 developed, changes in circuit design led to changes in transistor requirements, until all transistors were the same type. The Western Electric Company was then manufacturing the Type 12 transistor which was electrically and mechanically compatible with the requirements for the E-6 repeater. However, little was known about the susceptibility of the Type 12 to lightning surges.

With this background, studies began that led to the development of a self-protecting transistor. The project was, incidentally, an excellent illustration of how different areas of development at Bell Laboratories often support each other. For while basic studies on transistors exposed to lightning were conducted at the Allentown Laboratories, engineers at the Murray Hill and Merrimack Valley Laboratories who designed the repeater circuit made changes in the circuit configuration that eased the requirements for any single transistor and therefore made the general development problem easier.

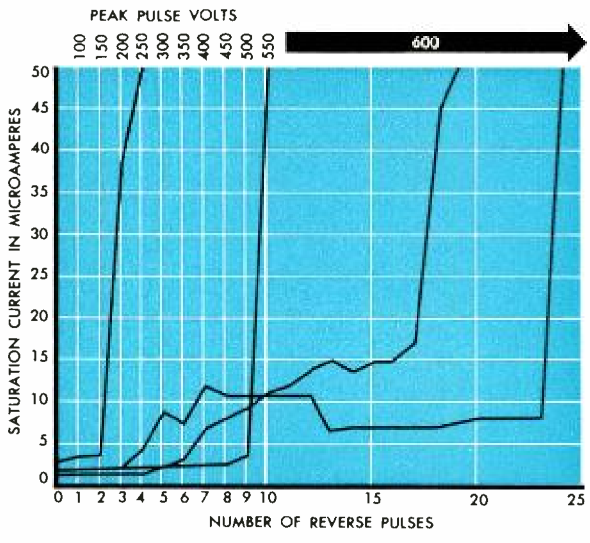
The primary development problem was twofold: first, to investigate the susceptibility of p-n-p alloy junction transistors to residual surges of lightning, and second, to ascertain the design factors that give a transistor resistance to these surges. The first practical step was to analyze the environment of the transistors during lightning exposure.

To do this, Laboratories engineers studied the circuit of the experimental repeater during exposure and measured surge voltages. On the basis of the experimental data they devised a surge test circuit which simulated the worst conditions of lightning exposure. With this test circuit engineers could study in the laboratory the reaction of a particular transistor junction to a residual lightning surge.

Testing was begun on a number of transistors having different mechanical, chemical and electrical properties. The extent of damage to any unit was determined by comparing its electrical characteristics after testing to its original characteristics. The change in these characteristics was the measure of the transistor's susceptibility to lightning surges. Of the group originally tested none was completely unaffected by surges, although some transistors were less susceptible than others. However, the degradation and ultimate electrical collapse of many of the transistors was so catastrophic that engineers assumed severe mechanical damage to the transistor had occurred.

Examination of these transistors under a microscope proved this. Nearly all units that failed revealed a filament-like growth of indium which formed radially outward across the junction from the indium electrode. If a transistor was subjected to further pulsation after it had failed, the filament grew until it was visible to the naked eye.

The mechanism behind the formation of this filament is a peculiar and interesting phenomenon and may be worthy of investigation in itself. Indeed, as we will show later, speculation on its causes had tangible results in design technology



Curves show the alteration of saturation current, an important measure of an alloy transistor's electrical stability, in four surge-tested transistors.

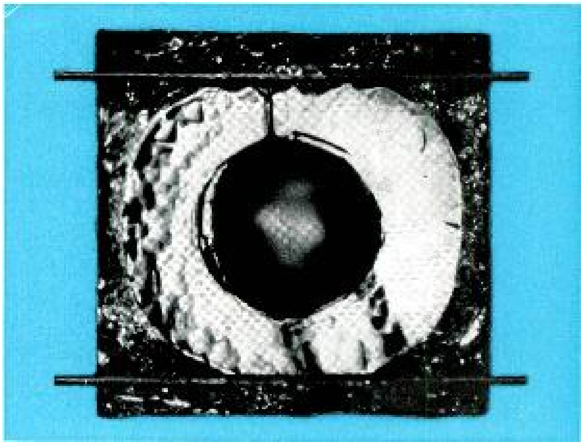
for the transistor. However, the main line of investigation was necessarily directed toward the discovery of methods to control the phenomenon rather than toward research on its causes. A promising step toward this control was taken through a redesign of the repeater circuit.

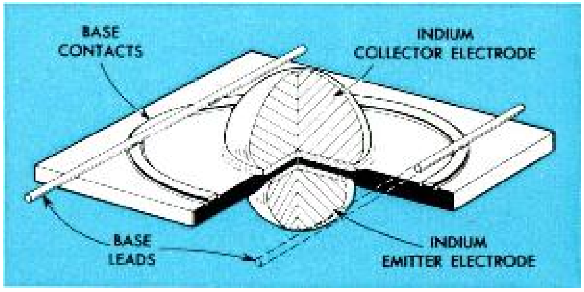
Engineers at Merrimack Valley had studied closely the environment of the repeater circuit when subjected to lightning surges. They found that the greatest energy component of a particular surge was invariably directed to one transistor in the circuit. On this basis circuit requirements were changed to redistribute foreign potentials. This, in effect, reduced the energy content of a typical surge under the worst conditions.

Transistors were then tested under the new surge conditions. As before, they failed; but with one significant difference. Units that failed under the new test conditions did not exhibit a visible filament. It is believed, however, that the cause was the same, the difference being that transistors tested under less intense surges developed filaments too small to be detected. Again, the mechanics of the formation of this filament was not, nor is it yet, clearly understood, but considerable evidence supports the hypothesis that it may be the same mechanism governing the phenomenon of surface breakdown.

The electrical characteristics of a semiconductor device are to some extent influenced by the condition of its surface as well as by its body properties (RECORD, *November,* 1957). For example, one important design parameter is the collector breakdown voltage—the voltage at which the collector current suddenly increases when a negative potential is applied to the collector. It was noticed that the breakdown characteristics of a transistor were more sensitive to change as a result of surge testing than were its other characteristics. Moreover, of all design factors which affect breakdown characteristics of a surge-tested transistor, surface treatment shows the most influence. Apparently a transistor's susceptibility to surges varies with its surface conditions. Optimum surface conditions are vital if a transistor is to withstand surge voltages from lightning.

Normally, the surfaces of semiconductor devices are composed of oxide layers of various degrees and purity. To realize optimum surface conditions these layers must be stabilized. This requires the application of a chemical oxide to the surface under carefully controlled conditions. However, because oxide surfaces are very sensitive to moisture, the stability of the "built-in" surface can be assured over a long period of time only if the device is encapsulated in a very dry ambient.





The semiconductor element of a typical alloy-junction transistor. The photograph is magnified approximately 30 times to show the filament (dark line, at the top) resulting from lightning surges.

To preclude any changes in the surface condition of the transistors for the E-6 repeater, a moisture "getter" (a glass sponge) was included in the capsule. Reliability studies conducted at the Laboratories on devices encapsulated in this manner indicated excellent prospects for a long service life for these transistors.

To confirm this, six final preproduction models of the E-6 repeater were installed and used for a year at both terminal and intermediate locations. Lightning surge recorders were installed with the repeaters. At the end of the year the repeaters were taken to the Laboratories and given gain and load tests. The surge data that were recorded indicated a high exposure to lightning, but no repeater tested showed any appreciable transistor aging.

In brief, the transistor developed for the E-6 repeater combined the ability to meet the electrical requirements of the repeater with resistance to lightning surges, stability during long-term service and the capability of low-cost manufacture.

Training Simulator For Flight Controllers

Author F. W. Monsees points out various types of keys on the simulator for the No. 300 System.

To meet the communication demands resulting from the tremendous increase in air traffic and faster aircraft, Bell Laboratories designed and developed the No. 300 Switching System for air route traffic control centers. This system provides voice-communication facilities within a control center as well as fast access to lines to participating agencies concerned with flying operations (see RECORD, *May*, 1961).

To train a controller to operate the equipment for this new system, A.T.&T. requested Laboratories' engineers to design a training simulator. This unit simulates the basic operating features of the console for the No. 300 Switching System, with provision for control by an instructor. The simulator consists of three basic parts: an instructor's console, a student's console and a cabinet containing the required relay equipment.

With his console, an instructor transmits signals to a student and monitors his responses. For signaling, there are three-position lever-type keys, both locking and nonlocking. A lamp associated with each key at the instructor's console is connected in parallel with a similar lamp in the student's console. In this way, the instructor sees all the signals he transmits to the student as well as all the signals the student originates. A voice circuit between the two consoles permits the instructor to tell the student what to do under certain circumstances and enables him to test the student's operating techniques. The instructor can simulate and control virtually all traffic conditions that confront a flight controller.

The keys, lamps, and pushbutton key set at the student's console are identical to those on the regular console for the 300 system. Multicolored designation strips indicate the various types of telephone services available to a controller. The student uses an "indirect-access" key to make a connection by pulsing a two- or three-digit code on his pushbutton key set. A "direct-access" key is used to place a call. To indicate the status of various types of calls, there are flashing, fluttering, winking, and steady lamp signals on the simulator.

As soon as the student receives an incoming call, a lamp flashes. When he answers the call, the lamp signal changes to flutter. The instructor transmits signals to the student in any combination. For example, he may cause several flashing lamp signals to appear simultaneously. By pressing the appropriate key, the student is connected to the instructor. When the student answers a second call, the first call is released unless it was placed on "hold." A call-storage feature indicates waiting calls by a "supervisory" lamp which continues to flash even when a call is answered.

By operating pushbutton keys, an instructor can transmit various tone signals to the student controller. These include the conventional dial tone, busy tone, and audible ringing. There is also a beep tone to indicate recording of a conversation, and a tone that indicates previous seizure of pulsing path by another controller.

The switching apparatus is housed in a standard cabinet with a removable front. Inside the cabinet, the relay switching and power equipment is mounted on a gate. The power is fed into a rectifier that provides the 48 volts needed for the relay equipment. To avoid damage to any equipment, the entire apparatus (including the consoles) is arranged to be inoperative until the instructor plugs his headset into the proper jack.

The portability of the equipment, the talking circuit between the instructor and student, the key system, and the duplication of lamp signals at the student's console provide all that is required for rapid, effective training of controllers.

The simulator was designed, built, and tested in 40 days. The satisfactory completion of this job is the result of close cooperation between the Federal Aviation Agency, Bell Laboratories, the American Telephone and Telegraph Company, and the Western Electric Company.

F. W. Monsees
SPECIAL SYSTEMS ENGINEERING

One important factor underlying the recent success of key-telephone systems has been the development of new, compact generators for converting local 60-cycle power at the customers' premises to 20-cycle ringing power.

W. F. Kannenberg

Static Frequency-Generators For Ringing Power

From the earliest days of the telephone, there has been a continuing need for a method of notifying the called customer that he was "wanted on the telephone." Bells have long been the favored mode of notification. For many years these bells, called "ringers," were actuated by an alternating current which the calling customer generated by turning a crank on the side of his telephone cabinet.

The frequency of the alternating current furnished by the magneto-electric generator to which the crank was attached was obviously variable, since it depended on the speed of rotation of the crank. For example, after a stimulating breakfast a customer's young son could easily produce a frequency of 17 to 20 cycles per second. At the end of a hard day, the customer himself would very likely generate less than 15 cps.

As time went on and mechanized telephone exchanges came into being, ringing frequencies were generated by a rotating machine (1000 rpm) in the central office, and a standard frequency of 16⅔ cps was adopted. Around 1920 or so, the operating speed of the machine was increased to 1200 rpm, and this raised the ringing frequency by the same ratio—from 16⅔ to 20 cps. Since then, 20 cycles has been the accepted standard for ringing frequency.

There is no hard and fast rule fixing the ringing frequency at this rate, however, and from time to time limited exceptions have turned up. In general, however, the ringing frequency and its prominent harmonics should be below the normal transmission range of speech. Also, its transmission over telephone lines should be good, and this property improves as frequency decreases.

In the 1930's, the Bell System began to make improved private branch exchanges available to customers, as well as versatile multi-line station arrangements called "key telephone" systems. These key systems—starting with the 1A and 1A1—have gained widespread acceptance. The latest of these, the 6A system, uses multi-button key sets including the Call Director, and offers such services as conferencing, pushbutton signaling and intercom dialing (RECORD, *March*, 1958).

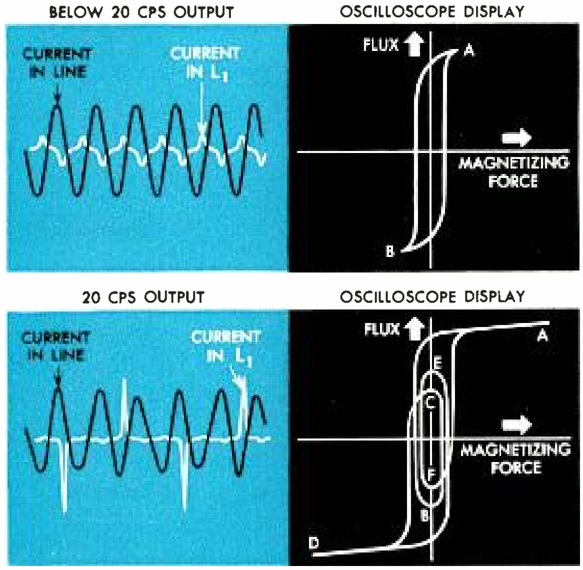
Key systems are of course located on the customer's premises; thus supplying operating power and ringing power from the central office to the several sets that make up the system is difficult and expensive. Therefore, when the key systems were originally designed, small power plants suitable for installation on the customer's premises were developed as an integral part of the system equipment.

Primarily, these power plants furnish local power for talking and signaling as well as ringing power of the proper frequency. This article describes the development of a static frequency generator—the 107-B—designed for the latest version of the packaged power plant, the 101-G. This generator has no moving parts, hence the term "static."

The basic job of the frequency generator is to produce 20-cps ringing current, for local ringers and ring-down signaling in key systems, from the standard 60-cps power available at the customer's premises. Static ringing supplies generate this 20-cps current by using the nonlinear characteristic of a saturable magnetic core to convert energy from the line frequency (60 cps) to several related frequencies. One of these related frequencies is a subharmonic of the line frequency. By proper tuning, the desired subharmonic (20 cps) can be selected. Messrs. J. M. Manley, E. Peterson, L. R. Wrathall and others at the Laboratories explained this phenomenon some years ago and proposed basic circuits. Commercial designs of the circuit were developed by the Power Apparatus Department.

To explain the principle of operation briefly and simply, let us consider the equivalent circuit of the generator. This circuit has two meshes with a common element. Mesh 1 comprises a saturable inductor and a tuning capacitor. Mesh 2 comprises the same saturable inductor, the power source, a fixed inductor and a tuning capacitor. Operating conditions require that network impedances be adjusted so that two sinusoidal components besides the applied current are allowed to flow through the saturable inductor. This produces oscillations at two separate frequencies, f2 and f3. The sum of frequencies f2 and f3 is equal to twice the applied frequency, f1.

For this circuit, f1, f2 and f3 are, respectively, 60, 20 and 100 cps. Thus, Mesh 1 is tuned to 100 cps, and Mesh 2 is tuned to 20 cps. The inductance of the saturable inductor is not constant, however, so the two circuits are tuned correctly only for that value of inductance corresponding to its degree of magnetic-core saturation in the working circuit. Fortunately, the tuning of these circuit meshes is broad, and the circuit functions over a



Top: line and inductor current (left) and hysteresis loop (right) for saturable inductor (L_1) in ringing frequency generator before 20-cps output begins. Same curves during output are shown below.

range of adjustment of the tuning elements.

Since correct tuning involves an inductance value for the saturable inductor that is a function of its degree of saturation, the circuit will not behave normally when the degree of saturation is too low. Thus, this circuit will not produce ringing current at an input voltage below the operating region. This fact lets us demonstrate how the circuit works in its operating region.

The line current at f1 and the current in the saturable inductor, for an input voltage below the threshold at which the circuit will start to "work," are shown in the diagrams above. Line current in the upper left diagram is virtually sinusoidal and inductor current shows a "pip" at each succeeding half cycle. (These illustrations contain six complete wavelengths at 60 cps. The pips alternate and occur once each half cycle.)

At a slightly higher input voltage, the circuit works in the "normal" manner, that is, it produces the desired 20 cps. The current waveform immediately below shows what has happened to both line current and inductor current. The line current is no longer sinusoidal, but its pattern shows one repetition in three full 60-cps waves. In other words, the line-current pattern repeats at a 20-cps rate.

The inductor, or coil, current also shows some revealing changes. Every third pip is highly exaggerated, while the two intervening pips are much lower than those above, even though the 60-cps input voltage is higher. It is convenient to think of this as an accurate counting operation.

Idealized hysteresis loops of the saturable inductor show that this counting mechanism is related to the flux changes during each period of the 60-cps input. Typical hysteresis loops corresponding to the current and voltage curves are shown on the right in the diagrams.

In the upper-right loop, a very small change in flux results from a large change in magnetizing force, indicating that the penetration into saturation at points A and B is slight and is repeated twice each cycle. In the lower-right loop, this penetration into saturation is very deep, and occurs only twice in three cycles of the input. These hysteresis loops have been somewhat distorted to show more clearly the nature of successive loops.

Counting Operation

The counting operation may be visualized from this loop display. From saturation at point A, the flux change in the first half cycle of the input frequency is only sufficient to bring the flux to point B, which is short of saturation. In the second half-cycle, the flux changes in the opposite direction to point C. In the third half-cycle, the flux once again goes to saturation at point D. During the next three half-cycles, the flux changes similarly to points E, F and A successively. To change the flux from its value at point A, through these six steps and return to point A, requires three complete cycles of the input frequency.

The wave shape of coil current shown at the lower left is a powerful source of odd harmonics. And since two sets of alternating "spikes" are shown within the time span of six 60-cps waves, the spike pattern must be occurring at a 20-cps rate. Accordingly, all odd harmonics of 20 cps are being produced. The circuit meshes are therefore tuned to approximately 20 and 100 cps, so that the 20-cycle "fundamental" and the fifth harmonic (100 cps) components will be the most prominent in their corresponding circuit meshes.

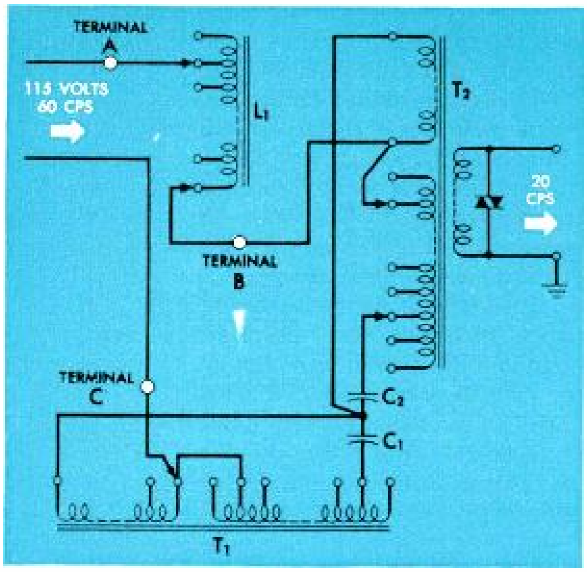
Since the capacitive reactance of the tuning capacitor in the first diagram varies inversely with frequency, the voltage drop across this capacitor will be chiefly 20 cps, with the third and fifth harmonics present at correspondingly reduced amplitude. A 20-cps output suitable for ringing power can then be taken off at this capacitor.

In an actual generator circuit, the circuit elements should be used near their full ratings in the interest of economy and good design. Also, the 20-cycle output should be isolated from the nonpolarized input. Both requirements can be met by using transformers. The actual circuit of the 107-B generator is shown on this page.

Physically, the new frequency generator is small and compact, and as mentioned earlier, is a component part of the 101-G power plant. It has two output terminals, and the flexible input connection can be readily plugged into any standard 117-volt, 60-cycle outlet on the customer's premises. In service, it is designed to ring eight average high-impedance (B-1-A) ringers without capacitors, two such ringers with capacitors at 75 volts or over, or six ringers with capacitors at 60 volts or above. A modified version of the 107B generator (coded 107C) will ring eight such ringers without capacitors or six ringers with capacitors at a voltage of 75 or above.

An important advantage of the new circuit design is "paralleling." That is, if more load-carrying capacity than that furnished by a single generator is required, it is possible to connect in parallel as many generators as are needed. The only qualification is that all input and output leads be poled alike. Only generators of the same code can be operated this way, however.

Static ringing-frequency generators are small, light-weight and easy to install. They are low-cost, have no moving parts or electron tubes, and require no maintenance. At current production rates of over 1000 units per week, they lend effective support to the Bell System's merchandising efforts on multi-button key systems.



Circuit of the 107-B generator. Transformers T1 and T2 are used in the commercial circuit. 20-cps output is taken off a winding on T2, at the right.

In a recent lecture at the American Iron and Steel Institute, Dr. J. B. Fisk said methods the Laboratories developed to achieve reliability in ocean cables will be applicable in the field of satellite communications.

Sapphires To Protect Telephone Satellites From Space Hazards

Thousands of pieces of man-made sapphire will cover the surface of the communications satellites now being developed by Bell Telephone Laboratories. The sapphires are expected to protect solar cells from space radiation, enabling "working" telephone satellites to endure the rigors of space for 10 years or more.

Dr. J. B. Fisk, President of Bell Laboratories, delivering the fifteenth annual Charles M. Schwab Memorial Lecture to the American Iron and Steel Institute, cited the sapphire protection as an example of the thorough-going measures that are being taken to achieve long-life reliability for satellites.

News of Satellite Development

As an old hand at problems of reliability, the Laboratories is using an approach it evolved in developing submarine cable systems. With these exacting methods, Dr. Fisk said, the Laboratories developed a submarine cable system that has an expected life length of 20 years or more. Some 1500 electron tubes have functioned under the oceans for the past two to six years without a failure.

The methods developed for the cable system are now being applied to satellites. "The result," said Dr. Fisk, "should be a shipshape, spaceworthy communications relay station."

The Bell System has previously announced plans to develop a satellite communication system and put it into operation as soon as possible. A ground station in Maine will be ready early next year. The first test satellite will be ready at the same time if the government designates a launching vehicle soon. The Bell System has offered to pay costs of the rocket and launching.

One big problem in operating a radio receiver and transmitter in space is the source of electrical power. At present the solar cell, a Laboratories invention which converts light from the sun directly into electricity, is used. Thousands of these cells will be placed on the surface of the satellite and used to recharge a battery which, in turn, is a continuous source of power.

Because they are exposed on the surface of the satellite, the solar cells are vulnerable to radiation damage, particularly electron bombardment and proton bombardment. The sapphire sheathings will protect the solar cells from the deteriorating effect of these bombardments, and, at the same time, will admit light to the solar cells.

Two different sizes of satellites are being considered, Dr. Fisk said. One will be 27 inches in diameter, the other, four feet. Each, roughly spherical in shape, may have as many as 60 gem-like facets. These facets will equalize the amount of light falling on each solar cell. More than half the surface of the smaller satellite will be covered by over 4000 solar cells; the larger one, by 12,000 cells. Each cell will be covered by a slice of the man made, crystal-clear sapphire.

Other protective materials—high-quality glass, or high-quality quartz, for example—are being considered, but sapphire appears most promising. It does not cost significantly more than other materials (it is only about one third of the cost of the solar cells themselves) and it has other advantages. For one, it will convey heat away, preventing the solar cells from being overheated in long periods of continuous sunlight.

Another advantage is that the use of sapphire helps solve a problem involved with thermal expansion. In space, changes of temperature on the surface of the satellite will be rapid and extreme, possibly hundreds of degrees in a few minutes. With a few exceptions, all substances undergo a change of dimensions when they are heated. However, this change, or expansion, occurs at differing rates for different substances and some substances will expand more than others.

If the difference in expansion is too great between two materials which are fastened together, they will separate. Therefore, the thermal characteristics of the sapphire should match those of the materials used to fasten it to the satellite. On the experimental satellite, the sapphire slices will be brazed to platinum sidebars which will be soldered to a special ceramic base. These materials all expand at very nearly the same rate.

Dr. Fisk pointed out another unique and interesting problem—the antenna. The experimental satellite antenna will receive signals from the ground, and, after they are amplified and changed to a new frequency, transmit them again. The satellite being developed at the Laboratories will use an equatorial antenna; its opening will be a slot around the middle of the satellite. (See photograph on this page.)

This antenna radiates energy in all directions. It poses a problem in that only a small fraction of this energy reaches the ground. Although even this fraction will be sufficient for the extremely low-noise ground receivers developed at the Laboratories, if the antenna could be always pointed at the earth we would have a more efficient receiving and transmitting system.

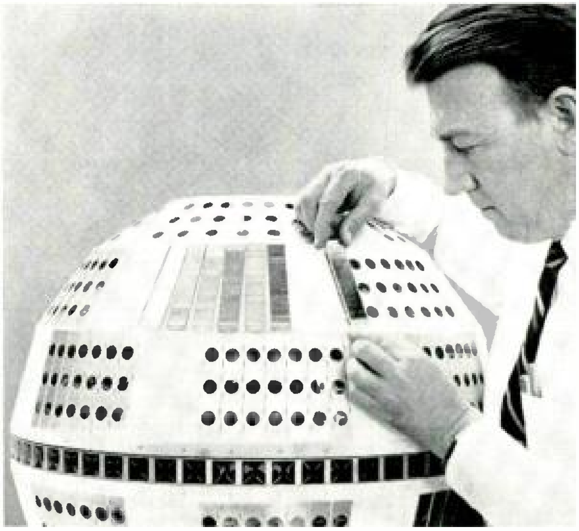
Bell Laboratories engineers have proposed methods of doing this that involve sensing the direction of the earth by magnetic field or horizon detection. Other methods would employ various kinds of motors or jets to turn the antenna. One interesting idea "lets nature do the job."

Two equally weighted objects, connected together like a dumbbell, would be put in orbit, one end nearer the earth than the other. Because of the pull of gravity on the closer object, the dumbbell would point toward the earth and sweep through its orbit in that attitude. The closer of the two parts of the dumbbell would always show the same face to the earth. The antenna would be placed in that face.

Ground Station Progress

Work is also proceeding rapidly on ground stations, Dr. Fisk noted. At Rumford, Maine a horn-reflector antenna is being constructed which is three times as large as the one used for the original Echo experiments at Holmdel. This antenna will be a 250-ton steel and aluminum rotating structure, 177 feet long and 94 feet high. Used for both transmitting and receiving, it will transmit signals to a satellite and receive signals relayed by the satellite from overseas.

The shape of this antenna must be maintained very precisely no matter which way it points so that it will not miss the tiny satellite some 7000 miles away. Thus, the horn must be extremely stiff. The broad surfaces of the horn will be made of aluminum with a honeycomb core. This



R. J. Nielsen sets into place an assembly of solar cells with a transparent covering of sapphires.

structure will provide the necessary rigidity and, at the same time, will be relatively light weight to facilitate the antenna rotation.

To protect the antenna from adverse weather conditions a radome, which Dr. Fisk described, is being built. A basic requirement of the material to be used for this structure is that it be transparent to radio energy. Dr. Fisk said that we plan to construct a radome of synthetic rubber and plastic which will be the largest inflated structure yet built. It will be a 20-ton structure, 161 feet high and 210 feet across and would cover three acres if it were laid out flat.

The first experimental satellite will help fill the pressing need for a real life-test in space. It will serve to life-test the components planned for a working satellite system and also to gain more precise information on the environment of outer space. For example, it will be used to take more precise measurements of the exact amounts of radiation in the Van Allen belts at various altitudes and under varying circumstances.

Dr. Fisk recalled that at the time of the first Echo experiment, less than a year ago, satellite communication work "was considered research." However, progress has been so rapid that the Laboratories is now principally concerned with evaluating possible alternative methods for best handling various aspects of a satellite system.

"Satellite communications," he said, "has now moved into the field of systems planning and development, although research continues in the never-ending effort to find new principles and methods for the long-range future."

SERVICE QUICKLY RESTORED AFTER REPEATER STATION BLASTS

News of the Bell System

Early Sunday morning, May 28, the TD-2 repeater stations at Wendover, Nevada and Cedar Mountain, Utah, and the K repeater station at Knolls, Utah, were blown up and virtually destroyed, interrupting both the central transcontinental microwave and K-carrier routes. More than 2200 telephone and telegraph circuits and four television channels were interrupted.

Two thirds of the telephone circuits, all critical services and all TV and radio circuits were made good by rerouting within a few hours after the blasts. The radio systems were rerouted around the damaged section by way of Los Angeles within two hours. By Sunday evening all circuits affected by the explosions had been made good, using spare facilities and protection radio channels.

Pre-arranged emergency service restoration plans worked smoothly. In less than 30 minutes after word was received, men and materials were moving to the three stations. Portable microwave equipment and truck-mounted towers were flown to the two radio relay locations.

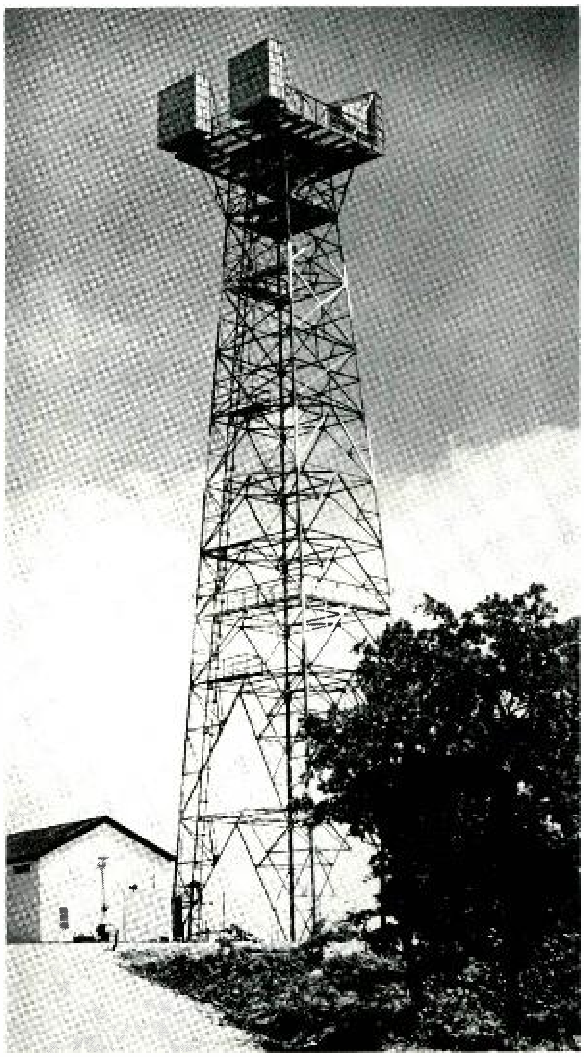
Despite the high number of circuits blanked out, the effect on traffic was light. Many military private line circuits were not affected at any time by the explosions because of alternate routings. Also, many other private line circuits were individually rerouted with minimum delays.

One two-way TD-2 channel was made available between Salt Lake City Junction and Los Angeles Tuesday night, May 30, by expediting installation of new channels that were nearing completion. This released some of the protection channels that had been used for reroutes.

Portable TE Microwave equipment was brought in to restore service across the breaks. By June 2 four TE channels had been set up, two for message service, one for TV, and one for protection. Five K-1 systems were restored by cutting the cable through at Knolls and using additional amplifiers at the adjacent stations.

Temporary buildings have been constructed at the three sites, and a temporary installation of TD-2 equipment has been made at the two radio sites to serve until permanent rebuilding can be done. This installation was completed by June 4. Permanent restoration is expected to be completed at all three locations before September 1.

As a precautionary measure, National Guardsmen had been posted quickly at all unattended K-carrier and radio-repeater stations in the area. They were replaced by Bell System guards a few days later. Many normally unattended stations in Utah, Nevada and California are continuing to be attended or guarded.



A view of a typical TD-2 microwave relay station.

news in brief

New Instrument Measures Punching Pressure

Paper perforator tape is used in large quantities in the Bell System to record and transmit information by teletypewriter. The accuracy of such information depends in a large measure on the "punching characteristics" of the paper. Recently, the Chemical Research Department devised an instrument that measures pressure required to punch a hole in perforator tape. With this instrument, engineers can determine whether various tapes can be perforated at a certain pressure to produce a uniformly clean hole. Because tapes have specific pressure requirements, this instrument should be an important tool in providing a fast, accurate check on one of the characteristics of teletypewriter paper.

D. J. Nitti with instrument to measure paper tape punching pressure.

W. O. Baker To Serve On President's Board

W. O. Baker, Laboratories Vice President, Research, was recently selected by President Kennedy to serve on the re-established President's Foreign Intelligence Advisory Board. The Board was organized in 1956 by former President Eisenhower "to conduct independent review of the foreign intelligence and related activities of the government." Mr. Baker also served on the Board during the Eisenhower administration.

Columbia University Chair Named for Former Chemical Director

A Robert R. Williams chair, named in honor of the former Chemical Director of Bell Laboratories, has been established at Columbia University. Endowed by a $500,000 fund from the Research Corporation of New York, the chair is established in the Institute of Nutrition Sciences, part of Columbia's School of Public Health and Administrative Medicine. Mr. Williams, who is best known publicly for his work in first synthesizing Vitamin B-1, also made important contributions to industrial chemistry during more than 20 years' service with the Laboratories. He retired in 1946. To mark the creation of the Columbia Chair and to honor Mr. Williams, 200 public health leaders and business officials gathered at a dinner in New York recently.

A.T.&T. Will Have Biggest Industrial Exhibit At World's Fair

A.T.&T. last month contracted to become the largest single exhibitor in the industrial section of the 1964-1965 New York World's Fair. A.T.&T. signed a lease for a 105,000-square-foot site on which the Bell System will begin construction of the exhibit building next spring. Henry Dreyfus, the noted designer, and the architectural firm of Harrison &

Abramovitz, noted for its work on the U. N. Building and other large projects, will collaborate on the building and the exhibit. The exhibit will feature the latest communications services and a look into the future.

Two from Laboratories Honored by NAS

The National Academy of Sciences recently elected to membership W. O. Baker, Vice President, Research, of the Laboratories and J. W. Tukey, Assistant Director of Research-Communications Principles. The Academy was established in 1863 as a private, non-profit organization of scientists to advance science and advise the government on scientific and technical matters. Among its Laboratories members are Dr. J. B. Fisk, H. W. Bode, J. R. Pierce, W. H. Brattain and three retired presidents of the Laboratories, Dr. M. J. Kelly, the late Dr. O. E. Buckley, and the late Dr. F. B. Jewett.

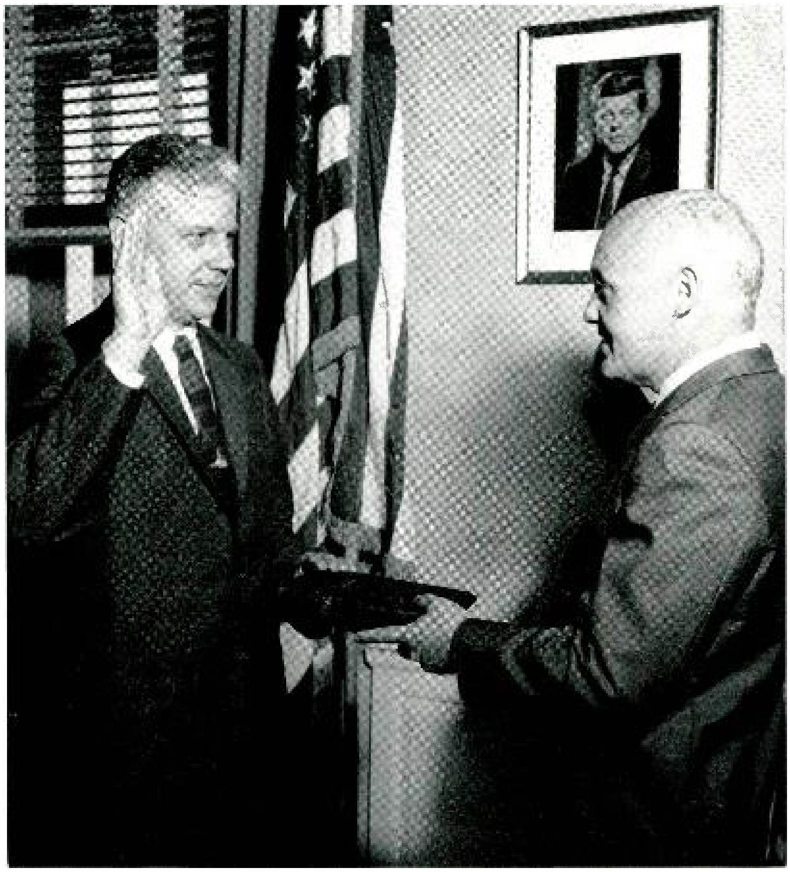
Two Universities Honor J. R. Pierce

Two honorary degrees were awarded in June to John R. Pierce, Bell Laboratories Director of Research-Communication Principles.

Northwestern University bestowed an honoray Doctor of Science degree on Mr. Pierce, citing him as an "electrical engineer of international distinction," and lauding him for his work in the development of the Echo satellite. The citation also called to attention his many books and articles as evidence of his professional standing.

At a ceremony in Newark, N. J., the Newark College of Engineering awarded the Doctor of Engineering Degree to Mr. Pierce. He was cited for his work as a research scientist in developing the beam traveling-wave tube and in originating the concept of satellite communications.

B. McMILLAN TAKES AIR FORCE POST



Brockway McMillan, at left, is sworn in as Assistant Secretary of the Air Force by Air Force Secretary Eugene M. Zuckert.

Brockway McMillan, Director of Military Research since 1959, has resigned from the Laboratories to accept an appointment as Assistant Secretary of the Air Force for Research and Development. Mr. McMillan joined the Laboratories in 1946 as a research mathematician. He became Assistant Director of Systems Engineering in 1955 and four years later was named Director of Military Research. His work in statistics and communications theory has won six patents on computing devices and amplifier circuits. Mr. McMillan has previously served the government as a consultant or member of various agencies. He has been associated with the Office of the Special Assistant to the President for Science and Technology, the Office of the Assistant Secretary of Defense for Research and Development, the Office of Defense Mobilization, and the Weapons System Evaluation Group of the Joint Chiefs of Staff. He is a graduate of the Massachusetts Institute of Technology having earned a Bachelor of Science degree there in 1936 and a Ph.D. in mathematics in 1939. He served for several years as an instructor at M.I.T. and at Princeton University before going on active duty with the U. S. Navy in 1943.

PAPERS

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

Barnes, W. C., *Band Elimination Filter Employing Quartz Crystal Units*, Thesis, Northwestern University Library.

Barrett, W. A., *Demagnetization of Twistor Bits*, J. Appl. Phys., 32S, pp. 35S-36S, Mar., 1961.

Bennett, W. R., and Froehlich, F. E., *Some Results on the Effectiveness of Error-Control Procedures in Digital Data Transmission*, Trans. I.R.E., CS-9, pp. 58-65, Mar., 1961.

Bogert, B. P., see Kramer, H. P.

Brown, S. C., see Buchsbaum, S. J.

Buchsbaum, S. J., Gordon, E. I., and Brown, S. C., *Experimental Study of Plasma Column in a Microwave Cavity*, J. Nucl. Energy, Part C: Plasma Physics, 2, pp. 164-168, 1961.

Bugnolo, D. S., *Stochastic Processes and Beyond-the-Horizon Propagation*, Trans. I.R.E., AP-9, pp. 226-227, Mar., 1961.

Burgiel, J. C., Jaccarino, V., and Schawlow, A. L., *Nuclear Quadrupole Resonance in an Antiferromagnet*, Phys. Rev., 122, pp. 429-436, Apr. 15, 1961.

Denton, R. T., *Theoretical and Experimental Characteristics of a Ferromagnetic Amplifier Using Longitudinal Pumping*, J. Appl. Phys., 32, pp. 300S-307S, Mar., 1961.

Dillon, J. F., Jr., *A New Characteristic in the Temperature Dependence of Ferrimagnetic Resonance Line Width in Some Rare Earth Doped Yttrium Iron Garnets*, J. Appl. Phys.—Proc. Conf. on Magnetism, 32, pp. 159S-160S, Mar., 1961.

Freeland, P. E., see Trumbore, F. A.

Froehlich, F. E., see Bennett, W. R.

Fuller, C. S., *Kinetics of Donor Reactions in Oxygen-Doped Germanium*, The Phys. & Chem. of Solids, 19, pp. 18-28, Apr., 1961.

Gianola, U. F., *Possibilities of All-Magnetic Logic*, J. Appl. Phys., 32, pp. 27S-34S, Mar., 1961; Electronics, 34, pp. 61-67, May 5, 1961.

Gibbons, D. F., *On the Observation of de Haas-van Alphen Type Oscillations in the Acoustomagnetic Attenuation of Zinc*, Phil. Mag., VI, pp. 445-448, Jan., 1961.

Gilbert, E. N., *Design of Mixed Doubles Tournaments*, Am. Math. Monthly, 68, pp. 124-131, Feb., 1961.

Gordon, E. I., see Buchsbaum, S. J.

Gordon, J. P., see Yariv, A.

Gray, M. C., *Bessel Functions of Integral Order and Complex Argument*, Communications of the A.C.M., 4, p. 169, Apr., 1961.

Grubbs, W. J., *A Unidirectional Amplifier with Esaki Diodes*, Trans. I.R.E., ED-8, pp. 163-169, Mar., 1961.

Guldner, W. G., *A Review of the Determination of Oxygen, Hydrogen, Nitrogen and Carbon in Metals*, Talanta, 8, pp. 191-202, Apr., 1961.

Hagelbarger, D. W., see Kramer, H. P.

Harmon, L. D., see van Bergeijk, W. A.

Jaccarino, V., *NMR and the Conduction Electron Polarization in Rare Earth Metals*, J. Appl. Phys.—Proc. Conf. on Magnetism, 32, pp. 102S-106S, Mar., 1961.

Jaccarino, V., see Burgiel, J. C.

Jenkins, H. M., *The Effect of Discrimination Training on Extinction*, J. Experimental Psychology, 61, pp. 111-121, Feb., 1961.

Koehler, D. C., *Four New Random-Access Memories for Digital Work*, Product Engg., pp. 51-54, May 1, 1961.

Kramer, H. P., Bogert, B. P., and Hagelbarger, D. W., *Stability of Pressure Supported Molten Zones in Horizontal Sheets*, J. Appl. Phys., 32, pp. 764-763, May, 1961.

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

Kurpis, G. P., *Directional Channel Separation Filters*, Northeastern University Library.

Labuda, E. F., and LeCraw, R. C., *New Technique for Measurement of Microwave Dielectric Constants*, Rev. Sci. Instru., 32, pp. 391-392, Apr., 1961.

LeCraw, R. C., see Labuda, D. F.

Lewis, J. A., *Generalized Thermal Resistance*, Quart. Appl. Math., 19, pp. 76-80, Apr., 1961.

Lewis, J. A., and Pollak, H. O., *Photoelastic Calculations by a Complex Variable Method*, Zeitschrift für Angewandte Mathematik und Physik, XII, pp. 30-37, 1961.

Logan, R. A., see Trumbore, F. A.

McSkimin, H. J., *Effect of Diffraction on Velocity of Sound*, J. Acous. Soc. Am., 33, p. 539, Apr., 1961.

Meitzler, A. H., *Mode Coupling Occurring in the Propagation of Elastic Pulses in Wires*, J. Acous. Soc. Am., 33, pp. 435-445, Apr., 1961.

Meitzler, A. H., *Ultrasonics. Part 1: Principles of Ultrasonics, Part 2: Application of Ultrasonics*, International Correspondence Schools, 1961.

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

Murphy, R. B., *On the Meaning of Precision and Accuracy*, Materials Res. & Standards, 1, pp. 264-267, Apr., 1961.

Nelson, L. S., and Kuebler, N. A., *Heterogeneous Flash Pyrolysis of Hydrocarbon Polymers*, Proc. Conf. on Phys. Chem. in Aerodynamics & Space Flight, pp. 61-67, 1961.

Nesbitt, E. A., Williams, H. J., Wernick, J. H., and Sherwood, R. C., *Magnetic Moments of Compounds of Cobalt with Rare Earth Elements Having a Cu₅Ca Structure*, J. Appl. Phys., 32, pp. 342S-343S, Mar., 1961.

Pappalardo, R., *Cubic Field Splitting and Cubic Symmetry Orthonormal Sets of Wave-Functions for J-Manifolds (J Half-Integer)*, J. Chem. Phys., 34, pp. 1380-1388, Apr., 1961.

PAPERS (CONTINUED)

Peter, M., see Sugano, S.

Pierce, J. R., *Some Practical Problems of Satellite Communication*, Astronautics, 6, pp. 34-35, 90, 92, 94, 96, May, 1961.

Pollak, H. O., see Lewis, J. A.

Reed, E. D., *Diode Parametric Amplifiers: Principles and Experiments—Part II;* Semiconductor Products Mag. 4, pp. 35-42, Feb., 1961.

Remeika, J. P., see Geschwind, S.

Sanders, R. W., *A Crystal-Tunnel Diode Oscillator*, Northeastern University Library, Mar. 20, 1961.

Schawlow, A. L., see Burgiel, J. C.

Schmidt, P. H., see Merritt, F. R.

Sherman, P. M., *Table Look-At Techniques*, Communications of A.C.M., 4, pp. 172-173, 175, Apr., 1961.

Sherwood, R. C., see Nesbitt, E. A.

Spitzer, W. G., Wernick, J. H., and Wolfe, R., *Electrical and Optical Properties of $CdSnAs_2$*, Solid State Electronics, 2, pp. 96-99, Mar., 1961.

Sugano, S., and Peter, M., *The Effect of Configuration Mixing and Covalency on the Energy Spectrum of Ruby*, Phys. Rev., 122, pp. 381-386, Apr. 15, 1961.

Trumbore, F. A., Freeland, P. E., and Logan, R. A., *Distribution Coefficient of Antimony in Silicon from Solvent Evaporation Experiments*, J. Electrochem. Soc., 108, pp. 458-460, May, 1961.

van Bergeijk, W. A., and Harmon, L. D., *What Good Are Artificial Neurons?* Bionics Symposium, Wright Air Development Div., 60-600, pp. 395-406, Dec., 1960.

Walsh, W. M., *The Effects of Hydrostatic Pressure on the Paramagnetic Resonance Spectra of Several Iron Group Ions in Cubic Crystals*, Phys. Rev., 122, pp. 762-771, May 1, 1961.

Wernick, J. H., see Nesbitt, E. A.

Wernick, J. H., see Spitzer, W. G.

Williams, H. J., see Nesbitt, E. A.

Wolfe, R., see Spitzer, W. G.

Yariv, A., and Gordon, J. P., *Experimental Procedures for the Determination of the Number of Paramagnetic Centers*, Rev. Sci. Instr., 32, pp. 462-463, Apr., 1961.

PATENTS

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

Becker, F. K.—*Nonlinear Integrating Control Circuit*—2,982,885.

Blecher, F. H.—*Prevention of Overload Instability in Conditionally Stable Circuits*—2,986,707.

Blount, F. E.—*Fast Response Gating Circuit*—2,985,769.

Bobeck, A. H.—*Magnetic Translating Circuit*—2,985,768.

Cadden, W. J.—*Code Translator*—2,982,953.

Cagle, W. B.—*Semiconductor Trigger Circuit*—2,982,869.

Chasek, N. E.—*Frequency Modulation Reception Circuits*—2,984,791.

Darwin, G. P.—*Synchronization in a System of Interconnected Units*—2,986,723.

Gardner, L. A.—*Carrier Telegraph Switchboard Supervisory Systems*—2,985,717.

Godfrey, J.—*Fabrication of Semiconductor Devices*—2,984,897.

Herriott, D. R.—*Modified Optical System for Off-Axis Flying-Spot Scanners*—2,984,750.

Hysko, J. L., see Gardner, L. A.

Jaeger, R. P.—*Negative Resistance Oscillator*—2,986,724.

Jamison, H. M.—*Insertion of Framing Information in Pulse Modulation Systems*—2,984,706.

Kalnins, I. L.—*Process for Etching a Glass-Containing Surface*—2,982,626.

Kamps, P. J.—*High Leakage Resistance Electromagnetic Relay*—2,985,733.

Ketchledge, R. W.—*Pulse Length Controlled Servo System*—2,985,808.

Matthias, B. T.—*Monoclinic Glycine Sulfate and Isomorphs*—2,986,681.

Maurushat, J. Jr.—*Alarm and Test Equipment for Carrier Systems*—2,986,610.

May, J. E.—*Delay Line*—2,982,926.

McKim, B.—*Dial Telephone Office Arranged for Resistersender Control of Two-Motion Step-by-Step Switches Having Multilevel Trunk Groups*—2,986,604.

Meacham, L. A.—*Telephone Signaling Apparatus*—2,986,603.

Moore, E. F.—*Sorting Method and Apparatus*—2,983,904.

O'Brien, J. A.—*Pulse Monitoring Circuit*—2,984,789.

Ostendorf, B. Jr., see Cadden, W. J.

Pearson, G. L.—*Semiconductive Device*—2,983,854.

Priebe, H. F. Jr.—*Transistor Waveform Generator*—2,983,878.

Prim, R. C., see Darwin G. P.

Ross, I. M.—*Electroluminescent Switching Apparatus*—2,984,749.

St. John, G. E.—*Low-Noise Electron Gun*—2,985,789.

Sauer, H. A.—*Controlled Atmosphere Cabinet*—2,985,497.

Sullivan, M. V.—*Treatment of Semiconductive Bodies*—2,983,655.

Terry, N. S.—*Automatic Determination of Toll Call Charges*—2,984,704.

Vroom, E., see Terry, N. S.

Wegel, R. L.—*Wave Translating Systems*—2,982,924.

Wick, R. F., see Wegel, R. L.

Wilson, R. L., see Jamison, H. M.

Wolfe, R. M.—*Electrical Circuit Employing a Ferroelectric Capacitor*—2,984,754.

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

ACOUSTICAL SOCIETY OF AMERICA MEETING, Philadelphia, Pa.

Bateman, T., see Mason, W. P.

Bateman, T. B., see McSkimin, H. J.

David, E. E., Jr., see Flanagan, J. L.

David, E. E., Jr., see Lochbaum, C. C.

David, E. E., Jr., see Mathews, M. V.

Dunn, H. K., *Methods of Measuring Speech Formant Bandwidths.*

Flanagan, J. L., David, E. E., Jr., and Watson, B. J., *Binaural Lateralization of Cophasic and Antiphasic Clicks.*

Flanagan, J. L., see Guttman, N.

Gardner, M. B., *Binaural Detection of Single Frequency Signals in the Presence of Noise.*

Gerstman, L. J., see Kelly, J. L., Jr.

Guttman, N., *On Defining the Range of Pitch Perception.*

Guttman, N., and Flanagan, J. L., *Pitch of High-Pass Filtered Periodic Pulses.*

Hudson, A. R., see McSkimin, H. J.

Kelly, J. L., Jr., and Gerstman, L. J., *An Artificial Talker Driven from a Phonetic Input.*

Lochbaum, C. C., David, E. E., Jr., and Mathews, M. V., *Decision Functions for Voiced-Unvoiced-Silence Detection.*

Mason, W. P., McSkimin, H. J., and Bateman, T., *Third Order Elastic Moduli of Germanium.*

Mathews, M. V., Miller, J. E., and David, E. E., Jr., *An Accurate Estimate of the Glottal Waveshape.*

Mathews, M. V., see Lochbaum, C. C.

McSkimin, H. J., Bateman, T. B., and Hudson, A. R., *Some Measurements of Wave Velocities and Elastic Moduli for Cadmium Sulphide.*

McSkimin, H. J., see Mason, W. P.

Meitzler, A. H., *Attenuation of High Frequency Elastic Modes of Propagation in Strips of Polycrystalline Metals.*

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

Pfafflin, S. M., *Simultaneous vs. Successive Observation Intervals in Signal Detection.*

Watson, B. J., see Flanagan, J. L.

AMERICAN PHYSICAL SOCIETY MEETING, Washington, D. C.

Bozorth, R. M., Davis, D. D., and Wernick, J. H., *Magnetism of Dilute Solutions of Iron Group Elements in Platinum Metals.*

Buchsbaum, S. J., see Platzman, P. M.

Davis, D. D., see Bozorth, R. M.

Geller, S., Williams, H. J., and Sherwood, R. C., *Magnetic and Crystallographic Study of Neodymium Substituted Yttrium and Gadolinium Iron Garnets.*

Hensel, J. C., *Effective Mass Shifts in Cyclotron Resonances in Uniaxially Stressed Silicon.*

Kunzel, J. E., *Superconductivity in High Magnetic Fields at High Current Densities.*

Pfann, W. G., *Semiconducting Stress Transducers Utilizing the Transverse and Shear Piezoresistance Effects.*

Platzman, P. M., and Buchsbaum, S. J., *Effect of Collisions on Landau Damping of Plasma Oscillations.*

Sherwood, R. C., see Geller, S.

Sikorski, M. E., *Tunnel Diode Hydrostatic Pressure Transducer.*

Walker, L. R., *The Interpretation of the Isomer Shift in Fe^{57}.*

Wernick, J. H., see Bozorth, R. M.

Wernick, J. H., see Wertheim, G. K.

Wertheim, G. K., and Wernick, J. H., *Iron 57 Mossbauer Effect in Cu-Ni Alloys.*

Williams, H. J., see Geller, S.

OTHER TALKS

Ahearn, A. J., *Mass Spectrographic Studies of Impurities in Solids and Liquids,* Phillips University, Enid, Okla.; Phillips Petroleum Co., Bartlesville, Okla.

Ahearn, A. J., *Solid State Mass Spectroscopy,* General Motors Spectrographic Committee Conf., Warren, Mich.

Alexander, S., *Exchange Narrowed Line Shape,* Harvard University, Cambridge, Mass.

Babington, W., Clitherow, W. R., and Miller, E. E., *Meeting the Challenge of High Reliability,* Am. Foundrymen's Soc., San Francisco, Calif.

Barnes, C. E., *Broadband Isolators and Variable Attenuators for Millimeter Wavelengths,* National Symposium, I.R.E., PGMTT, Washington, D. C.

Barnes, C. E., *A Field Displacement Isolator at 57 kmc,* National Symposium, I.R.E., PGMTT, Washington, D. C.

Becker, J. A., *Field Emission Microscopy,* Princeton University Conf., Princeton, N. J.

Benes, V. E., *A Class of Stochastic Programming Problems,* Columbia University, Dept. of Statistics, N. Y. C.

Bennett, W. R., *Broadband Problems and Techniques,* I.R.E. 1961 Spring Lecture Series, Boston, Mass.

Bogert, B. P., *Seismological Data Collection and Processing,* Summit Association of Scientists, Summit, N. J.

Bozorth, R. M., *Dilute Magnetic Solutions,* Naval Ordnance Lab., Washington, D. C.

Brillinger, D. R., *Asymptotic Means and Variances in the k-Dimensional Case,* IMS Meeting, Ithaca, N. Y.

Brown, W. L., *Semiconductor Radiation Damage in Space,* Space Nuclear Conf., Gatlinburg, Tenn.

Buchsbaum, S. J., *Ion Plasma Waves,* Massachusetts Institute of Technology, Cambridge, Mass.

Bugnolo, D. S., *Information Theory and the Electromagnetic Field,* Cornell University Colloquium, Ithaca, N. Y.

Burton, J. A., *Silicon p-n Junction Crystal Counters*, Bartol Research Foundation Seminar, Franklin Institute, Swathmore, Pa.

Chisholm, D. A., *Millimeter-Wave Traveling-Wave Tubes*, Syracuse University, Syracuse, N. Y.

Clitherow, W. R., see Babington, W.

David, E. E., Jr., *Speaking with Computers*, Second National Symposium on Human Factors in Electronics, Arlington, Va.

David, E. E., Jr., *Speech Analysis and Recognition*, I.R.E., Philadelphia, Pa.

Desmond, R. A., see Legg, W. E.

Drenick, R. F., *Adaptive Systems*, I.R.E., PGCT, Philadelphia, Pa.

Egerton, L., see Jaeger, R. E.

Enloe, L. H., and Ruthroff, C. L., *Threshold Effects of the FM Demodulator with Feedback*, U.R.S.I./I.R.E. Joint Meeting, Washington, D. C.

Fox, A. G., *Resonant Modes in a Maser Interferometer*, Berkeley, Calif.

Fuller, C. S., *Interactions of Impurities in Ge and Si*, University of Florida Chemical Department Seminar, Gainesville, Fla.

Germer, L. H., *Electron Diffraction Studies of Adsorbed Gases*, Cornell University, Ithaca, N. Y.; Manhattan College, N. Y. C.; Esso Research Lab., Linden, N. J.

Geusic, J. E., *Physics of Masers*, Ohio State University, Columbus, Ohio.

Gianola, U. F., *Magnetic Logic*, Electrical Engineering Department Seminar, Princeton University, Princeton, N. J.

Gibbons, D. F., *The Interaction of Acoustic Waves with the Conduction Electrons*, Yale University, New Haven, Conn.; University of Pennsylvania, Philadelphia, Pa.

Gibson, W. M., and Miller, G. L., *Charge Collection in Semiconductor Radiation Detectors*, International Atomic Energy Commission Meeting, Yugoslavia.

Gnanadesikan, R., *Probability Plots for the Gamma Distribution*, Institute of Mathematical Statistics, Cornell University, Ithaca, N. Y.

Gresh, M., see Schwartz, N.

Gupta, S. S., *On Selecting a Subset Containing the Population with the Smallest Variance*, Institute of Mathematical Statistics, Cornell University, Ithaca, N. Y.

Guttman, N., *The Voice—A Mechanism*, Intercollegiate Musical Council, Columbia University, N. Y. C.

Hansen, R. H., *Problems in the Preparation of Expanded Polypropylene Insulation*, Diamond Alkali Co. Research Center Seminar, Painesville, Ohio.

Hansen, R. H., Hawkins, W. L., Matreyek, W., and Winslow, F. H., *The Morphology of Semicrystalline Polymers. II: Oxidation of the Amorphous Region*, Am. Chem. Soc. National Meeting, Atlantic City, N. J.

Hanson, G. H., *A Survey of Recent Progress in the Development of High-Frequency Transistors*, Seventh Regional I.R.E. Conf., Seattle, Wash.

Harmon, L. D., *Computers and Brains*, Watchung Regional High School, Watchung, N. J.

Harmon, L. D., *Artificial Neuron Studies*, Michigan State University, E. Lansing, Mich.; Mental Health Research Institute, Ann Arbor, Mich.; University of Michigan, Ann Arbor, Mich.

Hawkins, W. L., see Hansen, R. H.

Hayes, J. S., *Electron Beam Microanalyzer: New Tool for Electron Device Development*, Benjamin Franklin Hotel, Philadelphia, Pa.

Herriott, D. R., *Optical Properties of the Cavity and Output Beam of a Continuous Gas Maser*, Quantum Electronics Conf., Berkeley, Calif.; Optical Soc. of Am. New England Section, Boston, Mass.

Hittinger, W. C., *Graduate Speaks for Industry*, Business-Education Day, Bethlehem High School, Bethlehem, Pa.

Hogg, D. C., *Noise in Microwave Antennas*, I.R.E. PGMTT, N. Y. C.

Holt, H. O., *Programmed Self-Instruction*, The Park School, Buffalo, N. Y.; Summit Assoc. of Scientists, Fairleigh-Dickinson University, Madison, N. J.

Holt, H. O., *Books as Teaching Machines: Some Data*, Midwestern Psychological Assoc., Chicago, Ill.

Hostetler, W. E., *The 5-Type Artificial Larynx*, Service to Mankind (SERTOMA) Club, North Indianapolis, Ind.

Hunt, L. E., *Performance Characteristics of a Horn-Reflector Antenna*, Seventh Regional Conf. I.R.E., Phoenix, Ariz.

Ingram, S. B., *The Engineer in Soviet Industry*, Engineers Club of Vicksburg, Vicksburg, Miss.

Iwerson, J. E., *Recent Advances in Semiconductor Devices*, Johns Hopkins University, Baltimore, Md.

Jaccarino, V., *Nuclear Magnetic Resonance in Superconducting Intermetallic Compounds*, Duke University Physics Colloquium, Durham, N. C.

Jackson, W. H., see Spector, C. J.

Jacobs, I., *Theoretical and Practical Limitations of Weak-Signal Processing Techniques*, Second International Space Science Symposium, Florence, Italy.

Jaeger, R. E., and Egerton, L., *Hot-Pressing of Alkali Niobates*, Am. Ceramic Soc. Annual Conv., Toronto, Ontario, Canada.

Jakes, W. C., *Tracking Echo I at Bell Telephone Laboratories and Jet Propulsion Laboratories*, COSPAR Meeting, Florence, Italy.

Javan, A., *Optical Maser Oscillations in a Gaseous Discharge*, Columbia University, N. Y. C.;

Princeton University, Princeton, N. J.; Harvard University, Cambridge, Mass.

Jaycox, E. K., *Participation in an Optical Emission Clinic*, Twelfth Annual Symposium on Spectroscopy of Soc. for Appl. Spectroscopy, Chicago, Ill.

Koonce, S. E., see Williams, J. C.

Laudise, R. A., *Hydrothermal Crystallization*, Union Carbide Research Center, Cleveland, O.

Lawrence, W. A., Jr., *Negative Resistance of Anodically Passified Iron*, Fairleigh Dickinson University, Rutherford, N. J.

Legg, W. E., and Desmond, R. A., *Project Echo*, Wall Township High School, Belmar, N. J.

Lowry, W. K., *Machine Applications to Library Functions*, American Cyanamid Co. Annual Library Meeting, Metuchen, N. J.

Mason, W. P., *On Semiconductor Strain Gages*, Soc. for Experimental Stress Analysis, Hudson-Mohawk Section, Rensselaer Polytechnic Institute, Troy, N. Y.

Matreyek, W., see Hansen, R. H.

McLean, D. A., *Tantalum Film Capacitors and Resistors*, A.I.E.E./I.R.E., Ogalalla, Neb.

McNamara, M. L., *Anomalous Breakdown Characteristics in Silicon Diffused Junctions*, Electrochem. Soc., Indianapolis, Ind.

Meitzler, A. H., *Transmission Characteristics of Longitudinal-Mode, Strip Delay Lines Having Asymmetrically Tapered Widths*, 1961 I.R.E. International Conv., N. Y. C.

Miller, E. E., see Babington, W.

Miller, G. L., see Gibson, W. M.

Montgomery, H. G., *Fluctuation Phenomena in Solids*, Fifth Fluctuation in Solids Symposium, Armour Research Foundation, Chicago, Ill.

Moore, E. F., *Machine Models of Self-Reproduction*, Mathematical Problems in the Biological Sciences Symposium, N. Y. C.

Mumford, W. W., *Some Technical Aspects of Microwave Radiation Hazards*, I.R.E. Prof. Gp. on Microwave Theory and Technique and Antenna and Propagation, Ohio State University, Columbus, Ohio.

Pfahnl, A., *Preparation and Properties of ZnO Phosphors*, Electrochem. Soc., Indianapolis, Ind.

Pierce, J. R., *Satellites and Television*, International Television Symposium, Montreux, Switz.

Pierce, J. R., *Some Practical Problems of Satellite Communication*, The British Interplanetary Soc., London, England.

Pollak, H. O., *A Mathematical Theory of Defense*, University of Illinois, Urbana, Ill.

Pollak, H. O., *On the Nature of Applied Mathematics*, University of Illinois, Urbana, Ill.

Reed, E. D., *Solid State Maser*, Westchester Subsection of I.R.E., Westchester, N. Y.

Rosenthal, C. W., *Automating the Design of Digital Systems*, Seminar on Modern Topics in Communications and Control, Electrical Eng. Department, New York University, N. Y. C.

Rowen, J. H., *Solid State Devices*, Soc. for Industrial and Applied Mathematics, Monterey, Calif.

Ruthroff, C. L., see Enloe, L. H.

Schawlow, A. L., *Fine Line Spectra of Chromium Ions in Aluminum and Magnesium Oxide*, Physics Department, Stanford University, Palo Alto, Calif.

Schawlow, A. L., *Optical Masers*, I.R.E. Prof. Gp. on Electron Devices, N. Y. C.; Stanford University, Physics Colloquium, Palo Alto, Calif.

Schwartz, N., and Gresh, M. *Polarity of Tantalum Oxide Printed Capacitors*, Electrochem. Soc., Indianapolis, Ind.

Scovil, H. E. D., *Solid State Masers as Low Noise Amplifiers*, I.R.E., PGMTT, Wash., D. C.

Sinclair, W. R., see Williams, J. C.

Slichter, W. P., *The Study of Glass Transitions by Nuclear Magnetic Resonance*, Polytechnic Institute of Brooklyn, N. Y.

Spector, C. J., and Jackson, W. H., *Tantalum Film Circuits*, Electronics Components Conf., San Francisco, Calif.

Stockbridge, C. D., *A Vacuum System for Mass and Thermal Measurement*, Second Conf. on Vacuum Microbalance Techniques, Washington, D. C.

Stockbridge, C. D., see Warner, A. W.

Sumner, E. E., *The 24-Channel PCM Exchange Carrier System*, Hillside School, Northern New Jersey Institute of Radio Engineers, Montclair, N. J.

Thurston, R. N., *A Review of Some Russian Papers in Ultrasonics Engineering*, I.R.E. International Conv., N. Y. C.

Treves, D., *Limitations of the Kerr Technique in the Observation of Magnetic Domains*, Minneapolis, Minn.

Trumbore, F. A., *Distribution Coefficient of Antimony in Silicon from Solvent Evaporation Experiments*, Electrochem. Soc., Indianapolis, Ind.

Turner, D. R., *Electrochemistry of Semiconductors and Its Applications*, Electrochem. Soc., Detroit, Mich.

Warner, A. W., and Stockbridge, C. D., *Mass and Thermal Measurement with Resonating Crystalline Quartz*, Second Informal Conf. on Vacuum Micro-balance Techniques, National Bureau of Standards, Wash., D. C.

Wertheim, G. K., *Some Applications of the Mossbauer Effect in Magnetism*, Naval Research Lab., Washington, D. C.

Williams, J. C., Sinclair, W. R., and Koonce, S. E., *Preparation of Thin Alumino-Silicate Films*, Am. Ceramic Soc., Toronto, Canada.

Williams, W. H., *Generating Unbiased Ratio and Regression Estimators*, Columbia University, N. Y. C.

Winslow, F. H., see Hansen, R. H.

Wintringham, W. T., *The Principles of Color Television*, Thirtieth Annual Meeting of Inter-Soc. Color Council, Rochester, N. Y.

Yokelson, B. J., *Electronic Switching System*, A.I.E.E., N. Y. C.

Zacharias, A., *A Precise Method for Measuring the Incremental Phase and Gain Variations of a Traveling-Wave Tube*, 1961 I.R.E. International Meeting, N. Y. C.

THE AUTHORS

H. J. Michael

H. J. Michael, a native of Long Island, joined the Laboratories in 1929. He has engaged in studies relating to transmission quality, including the physical characteristics of speech and the structure of telephone conversation, signaling and switching development, and during the war, the design of underwater weapons. Since the war, Mr. Michael has engaged in the design and development of the No. 5 crossbar system. He joined the American Telephone and Telegraph Company in 1952, and after two years in its Administration B Department, he rejoined the Laboratories in the Special Systems Engineering Department. He now heads a group concerned with studies of private line switching and signaling systems and station switching systems. Mr. Michael is a graduate of New York University with degrees of B.A. in mathematics and M.S. in physics. He is co-author of the article "SAC's Primary Alerting System" in this issue of the RECORD.

H. M. Pruden

Harold M. Pruden, co-author of "SAC's Primary Alerting System," joined the Western Electric Company's Engineering Department in 1919. This group was later incorporated as Bell Laboratories. He has specialized in the development of signaling systems for long distance telephone circuits, and for transoceanic, ship-to-shore and mobile radiotelephone systems. He also contributed to the development of remote control devices for unattended repeater stations along coaxial cable and microwave telephone transmission routes. During World War II, Mr. Pruden was engaged in work on radar and short-wave radio transmission for the armed forces. He later returned to work on mobile radio-telephone systems and remote control systems and also took part in work on the Nike missile project. He is currently on field assignment in California. Mr. Pruden has been granted 17 patents for his work in signaling and radio telephony and has written numerous technical articles. He is a Senior Member of the Institute of Radio Engineers.

O. Myers

C. A. Dahlbom

Oscar Myers, co-author of the article on Overseas Dialing, was born in Hartford, Connecticut. Immediately after receiving the degree of Bachelor of Chemistry from Cornell University in 1921 he joined Western Electric. In 1924 he transferred to the Engineering Department of the Company which became Bell Laboratories. Mr. Myers helped design and develop No. 1 Crossbar, No. 5 Crossbar, Toll Crossbar Systems, and Crossbar tandem. He holds 39 patents received in connection with this work. He was a member of the Bell System team which planned and negotiated arrangements for dialing to Europe over ocean cables. He also worked on the planning of the Hawaiian and Alaskan cables. At present Mr. Myers is Switching Systems Engineer in charge of a number of projects among them the planning of switching and numbering for world-wide dialing. He is one of the Bell System representatives to the CCITT.

Carl A. Dahlbom, a native of Brooklyn, New York, has been a member of the Laboratories since 1930. His first assignment was in the Telegraph Department where he worked on transmission and circuit development. During World War II he was engaged in the development of military telegraph and speech secrecy systems. Following that he was assigned to work in design of single and multifrequency signaling systems. At present Mr. Dahlbom is Signaling Systems Engineer and is responsible for formulation of signaling systems requirements for toll, exchange and subscriber line facilities. Mr. Dahlbom received the degree of B.E.E. from Brooklyn Polytechnic Institute in 1941. He is a senior member of I.R.E. He is co-author of the article on Overseas Dialing in this issue.

J. M. Jackson, the author of "Air-Drying Apparatus for Microwave Systems" is a native of Fanwood, N. J. Shortly after joining the Outside Plant Development Department of Bell Laboratories in 1942, he entered the Navy where he served until 1945.

J. M. Jackson

In 1945 he returned to the Laboratories and was associated with projects on joining and maintenance methods for telephone cables.

During the Korean war he was recalled to Naval service for two years. Since his return to the Laboratories in 1952, Mr. Jackson has been engaged in the design of equipment for supplying dry air to waveguides and antennas of radio-relay networks and to cable systems. While working at the Laboratories, Mr. Jackson attended Rutgers University and was made a Member of Technical Staff in 1957.

W. M. Fox

W. M. Fox, the author of "A Self-Protecting Transistor for The E-6 Repeater" in this issue, is a native of Bethlehem, Pennsylvania. He received undergraduate and graduate degrees in Physics, the B.S. from Muhlenberg College in 1951 and the M.S. from St. Lawrence University in 1953. From 1953 to 1957 Mr. Fox was associated with the Research and Development Laboratories of the Franklin Institute where he did basic research in solid-state physics. In 1957 he joined Bell Laboratories and was assigned to the Allentown Laboratory where he has been working on the final development of transistors. Mr. Fox is a member of the Research Society of America and of Sigma Phi Sigma.

Walter F. Kannenberg, author of "Static Frequency Generators for Ringing Power," was born in St. Paul, Minnesota. He graduated from the University of Minnesota with the degree of B.S. in E.E., in 1923, and an M.S. in 1925, following a year of service with the Northwestern Bell Telephone Co. in Minneapolis. He joined Bell Laboratories immediately thereafter.

Throughout his telephone career, Mr. Kannenberg specialized in development of equipment associated with carrier systems and he took part in work on the first submarine telephone cable between Cuba and the U.S. He was "loaned" to the Western Electric Co. in 1942 to aid in setting up a new factory to manufacture parts for carrier systems.

During most of World War II Mr. Kannenberg was engaged in work on microwaves and radar for military applications. In 1946 he turned to work on acoustic problems and took part in development of systems related to restaurant music installations. From 1950 to his retirement in September, 1960, he engaged in studies of magnetic problems for military and civilian applications.

Mr. Kannenberg holds more than 30 patents relating to many phases of his work. He is a member of the American Institute of Electrical Engineers, the Acoustical Society of America, and Sigma Xi.

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