February 1959

Bell Laboratories RECORD

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

Bell Laboratories **RECORD**

Volume 37 • Number 2 • February 1959

Contents

Cover *W. L. Feldmann, left, and G. L. Pearson inspecting ferroelectric domains delineated by new powder-pattern technique. See News Notes item, p. 72.*

In the Bell System, short-distance carrier systems have become more versatile in economically supplying a variety of services over extended ranges of operation. Bell Laboratories, in cooperation with the A.T.&T. Company, has brought about this expansion through a careful program of systems study and development.

J. J. Mahoney and D. T. Osgood

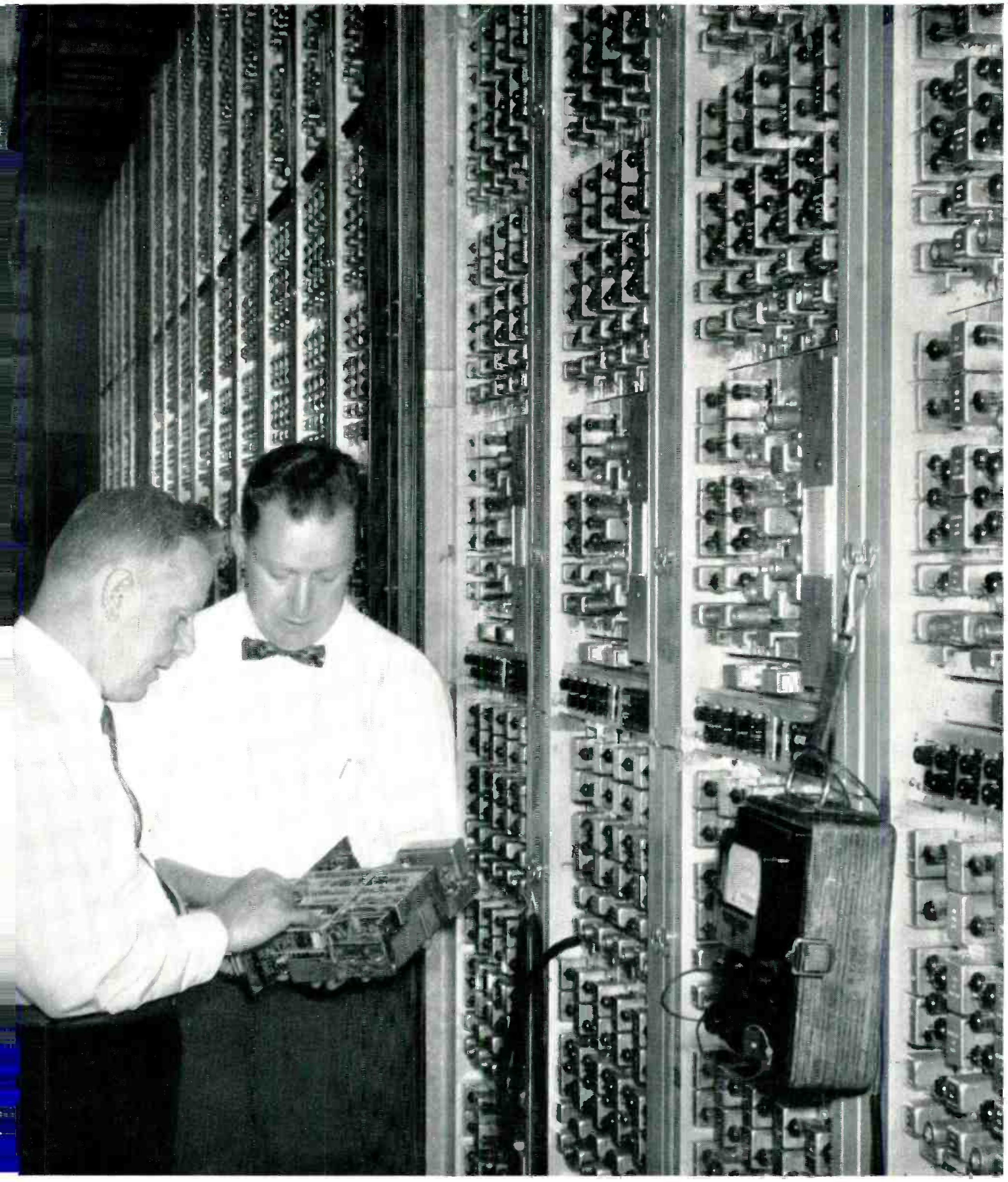
New Uses for Short-Haul Carrier

The national emergency of World War II prevented the normal growth of telephone service. As in many other industries, materials and manpower were diverted to more urgent purposes. Consequently, as the war ended, the pent-up demand for additional telephone circuits was acute, and development work was soon started at Bell Laboratories to relieve this situation by expanding Bell System carrier services.

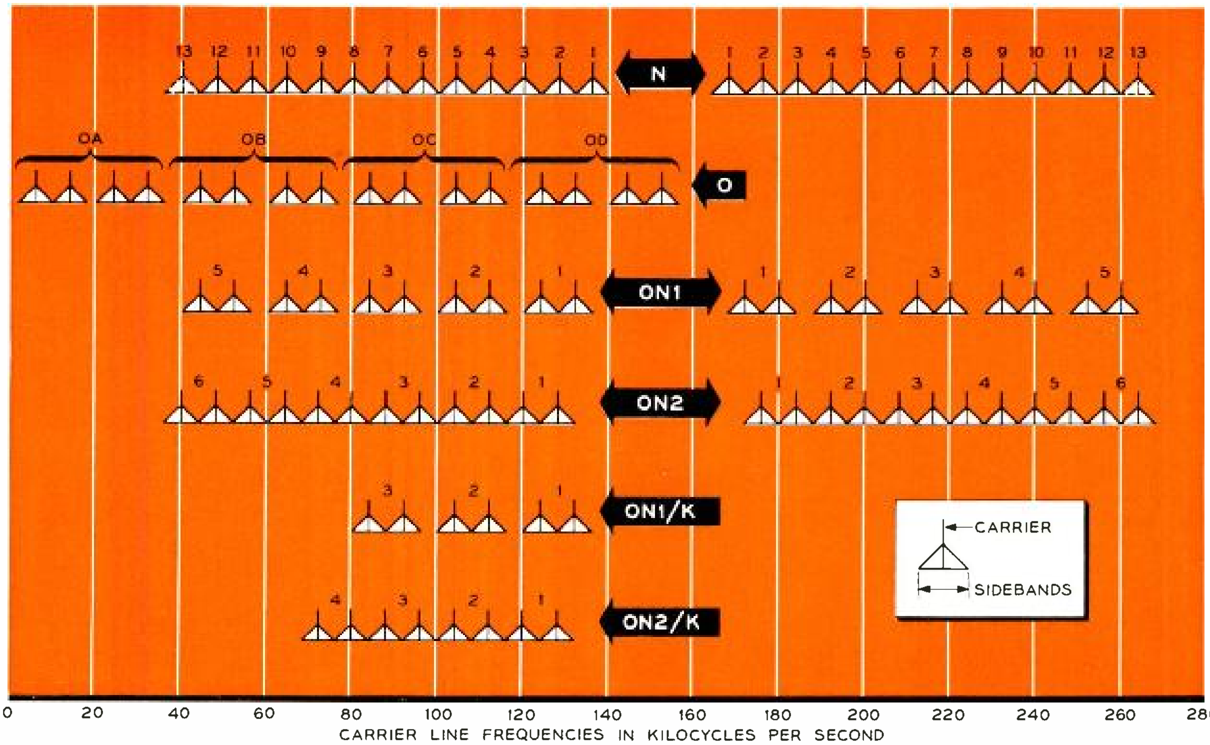
The first of the economical, short-haul carrier telephone systems was the 12-channel type N1 carrier system (RECORD, *July*, 1952) developed for use in cables. Next, the type O carrier system (RECORD, *June*, 1954) was developed as a similar system for use on open wire. The carrier technique applied to these systems is the familiar one of "stacking" many conversations at various frequencies on a single pair of wires — in type N systems 12 conversations are carried over two pairs of wires, and in type O as many as 16 can be stacked on one pair.

Over the longer distances, this stacking technique has been in use for a number of years. because here the lengths of the circuits could justify the high costs of terminal equipment. During the post-war period, demand for additional telephone circuits in the short-haul field increased considerably, but the cost of providing them with existing types of carrier systems would have been prohibitive. Furthermore, the price of copper and the cost of labor to construct the outside plant rose considerably during and after the war. Therefore, an important objective in the design of the short-haul systems was to reduce the cost of carrier equipment to the point where, even at the short lengths, the systems would be more economical than the construction of additional outside plant. With these new designs, the necessary economies were realized in many ways.

Initially, short-haul carrier systems were restricted to transmitting telephone messages. This was done to avoid the need for meeting the more rigid requirements for all possible types of special services, since the demand for such services was not controlling at the time. With miniaturized construction and plug-in techniques, equipment and maintenance costs were reduced to the extent then permitted by the art. And, by designing the system for a maximum length of about 200 miles, many of the basic transmission



G. A. Roe of the Laboratories, left, discusses channel unit with J. H. Porter, New York Telephone Co., at large installation of type N equipment.



Line frequencies of short-haul carrier transmission systems. Note the division into high-frequency and low-frequency channel groups in some systems, and the use of "guard spaces" between groups. Starting with the original type O and type N systems, Bell engineers have extended such "short-haul" services until they now can be used in a wide variety of transmission situations.

requirements were less severe. In comparison, some of the longer-haul systems are designed to operate up to 4000 miles.

Built-in compandors make it possible to operate high-quality telephone circuits over lines not originally intended for carrier transmission. Compandors ("compressor-expandors") are circuits that compress signal strengths to a narrow range for transmission, and then reconstitute the original signal range at the receiving end. In this way, noise and crosstalk were minimized and expensive rearrangement or new installation of outside plant was avoided. The compandors also permitted more lenient requirements for filters and other equipment, which usually represent an appreciable part of the cost of carrier terminals.

Several additional engineering aspects of type O and type N carrier should be mentioned as being relevant to the extension of these services. First, line frequencies (*see drawing on this page*) are inverted and modulated from one frequency group to another — that is, "frogged" — at each repeater to permit operation in a single cable or open-wire line. Frogging also reduces the need, in either open wire or cables, for expensive equipment to equalize attenuation and to suppress crosstalk. Second, built-in signaling equipment is included in these systems for transmitting supervisory and dial-pulse signals without the expense of separate signaling equipment.

A third important engineering feature of type O and type N is that carrier frequencies are transmitted along with the sideband or "intelligence-carrying" frequencies. This avoids the need for having carrier supplies of highly accurate frequencies at both terminals. It also permits the equivalent of regulating each individual channel by controlling the power level of the carrier itself. Also, when carriers are transmitted, repeaters can be regulated under the control of the total power in all of the channel carriers. Hence, a more costly system of regulation with "pilot" frequencies is not required.

In many cases, particularly between some larger cities and outlying towns, the telephone plant may consist of cable for a considerable part of the distance and open-wire construction for the remainder. Short-haul carrier would therefore require type N in the cable and type O over the open-wire pairs, which means that the carrier terminals would have to be connected "back-to-back" with connection between systems at voice frequencies. For such interconnections, "thru" channel units have been developed to lower costs and improve over-all performance.

Further savings in cost and improvements in transmission were realized for such conditions with an arrangement whereby conversion between type O and type N can be made at carrier frequencies. This arrangement is known as the ON system (RECORD, *November*, 1956) and uses the economical type O grouping of single-sideband channels and inexpensive type N line repeaters. Since its original conception, however, the ON system has found additional applications, and several forms have been developed. Thus, by the expenditure of a moderate amount of development effort, the flexibility and economy of the short-haul systems were greatly enhanced.

There are several members of the type ON family, as listed in the table on this page. The type ON1 carrier system, while originally designed to interconnect cable and open-wire at carrier frequencies, has found its greatest use in providing a 20-channel cable carrier system. The system can be used over the same lines intended for a 12-channel N system, hence deferring, in many cases, the construction of additional outside plant.

The use of available equipment for the ON1 system was expedient to meet the immediate need for a large number of circuits, without diverting a large amount of development effort from other urgent projects. However, this system did not make the most efficient use of the available frequency spectrum, because the 4-channel type O groups were separated by 4 kc "guard spaces" between oppositely directed groups over an open-wire line. This space is not needed when adjacent groups are transmitted in the same direction, as in the ON system. For this reason, the type ON2 system has recently been made available; it consolidates the 4-kc blank spaces into an additional 4-channel group.

Nevertheless, the ON1 system satisfied the most urgent need for additional cable circuits and will be retained to meet the original need for carrier systems which must operate partly in cable and yet be extended by open wire. To make the ON2 system satisfactory for this purpose would require the use of expensive filters, since the guard spaces mentioned above are not present.

Another member of this family, the ON/K carrier system, is a combination of ON terminal equipment with newly developed repeaters and line filters. It permits the addition of 12 type ON1 or 16 type ON2 channels to cable pairs already occupied by 12 long-haul K channels. Hence, the capacity of these pairs is increased to 24 or 28 channels. This system has realized important economies by providing short-haul circuit relief along K carrier routes without the need for additional cable. It has also permitted long-haul expansion by releasing type K channels which had already been diverted to meet the need for short-haul circuits.

Type ON terminal equipment, supplemented by repeater equipment derived from the basic N types, has also made it possible to combine up to 48 ON channels for transmission over light-route

Features of Type ON Carrier Systems

System	No. of Channels	Use	Feature
ON1	20 on cable 16 on open wire	On N Repeatered Cable Pairs and Open Wire Extensions	Drop or insert groups at intermediate points
ON2	24	On N Repeatered Cable Pairs	Efficient use of frequency space
ON/K	12-16	Cable pairs already occupied by K carrier	Economy of outside plant in special cases
ON Radio Multiplex	80-96	Multiplex for light route radio system	Flexibility. Can extend channels over wire lines beyond radio terminal

Channel Units for Short-Haul Carrier Systems

Unit	Use	Feature
Standard message	Message circuits	Built-in compandor and 3700-cycle signaling
"Thru" channel	Direct VF interconnection between channels of two carrier systems	No compandor or signaling, but 3700-cycle signals are connected through passive transmitting path
Special services	Data transmission	No compandor or signaling
Schedule A & B program	High quality program channel (Schedule A & B) N carrier only at present	5000-cycle program bandwith, no compandor or signaling, external compandor
Schedule C & D program	High quality program channel (Schedule C & D) N carrier only at present	3500-cycle program bandwith, built-in compandor, no signaling
Program reversing	Two-way signaling for remote reversing of direction of program transmission	200-kc signaling circuits (transmit and receive) operate direction reversing relays of associated program channel
Channel No. 13	To replace any other standard N-carrier channel made inoperative	Standard message-channel unit with 264-kc carrier frequency
Channel without signaling	For trunks with external single-frequency signaling	Standard message-channel unit with signaling removed but compandor retained

radio, and a newly developed frequency-translating unit allows the combination of up to 96 channels for this same purpose. A notable example of this type of application is the use of ON terminal equipment to multiplex 96 channels for the recently developed TJ microwave radio system (RECORD, *April*, 1957).

Although the new carrier systems were developed primarily for short-haul service, it is difficult at times to divide telephone circuits into the "long-haul" and "short-haul" categories. Specific needs of the individual Operating Companies often lie in an intermediate region where one kind of system might provide circuits more economically at a length where another system is generally used. Thus, in specific cases, it might be more economical if the new carrier systems could be made to work satisfactorily at lengths greater than 200 miles.

One of the factors in such extended use of the N system is the existence of minute deviations from an ideal transmission-frequency characteristic in each repeater. These deviations are not important in the shorter systems, but they accumulate to serious proportions at lengths that require many repeaters. In successive repeater sections, the channels are transmitted first in a low group of frequencies and then in a high group. Consequently, one source of such deviations is the filters used to suppress the unwanted group, which may enter the repeater by way of line crosstalk coupling. As the length of the system increases and as more repeaters are added, the small deviations in filter characteristics accumulate and first affect the operation of Channel 1. This channel is nearest to the "cut-apart" region, so that after a certain length is exceeded, it becomes inoperative.

To avoid impairment from this cause on longer systems, another channel (No. 13) was developed. It is placed at the edge of the spectrum farthest from cut-apart, where it is less affected by the repeater filters.

This additional channel has another advantage. Occasionally an N system will be used in an area close to a powerful airway-radio beacon or other long-wave radio transmitter whose frequency coincides with that of one of the N channels and may thus interfere with its operation. The availability of channel 13 makes it possible to use this channel in place of the one affected by interference and retain a 12-channel system without the need for costly measures designed to suppress the foreign signal.

Another factor affecting performance of N systems, and of ON systems also, is the accumulation of a second kind of small deviation in the attenuation-frequency characteristics of the repeaters. These are deviations that change with the temperature of the repeaters, some two-thirds of which may be mounted in pole boxes subject to outdoor temperatures. Line characteristics are also affected by outdoor temperature changes, and the effects of both are multiplied as the length of the system is increased. As a result, the total deviations may exceed the range of the channel regulators. A "dynamic deviation regulator" was therefore developed. This is a unit that can be installed at intervals along an N or ON system to compensate automatically for the accumulated deviations.

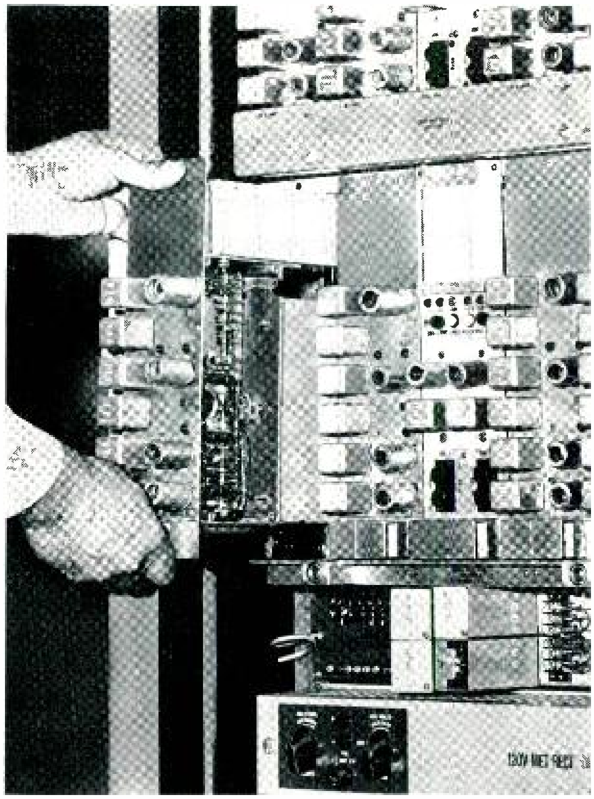
It is now possible, with the use of the deviation regulator and channel 13, to operate type N carrier systems satisfactorily at lengths up to about 500 miles. To do this, however, it is necessary to employ the higher grades of cable plant and a conservative system layout. Eventually, the higher-capacity ON2 system can also be used up to these distances by similar techniques. The frequency allocation for ON2 was chosen with such extension in mind; thus, severe distortion near the "cut-apart" region was avoided, and use of the type N deviation regulator became possible.

As the new carrier systems found their way into the short-haul plant, they began to occupy more and more of the cable and open-wire pairs formerly used for voice-frequency transmission. As a result, the availability of these pairs for special services — such as voice-frequency telegraph, voice-frequency program circuits and data transmission — is gradually disappearing in many areas. Therefore, although the objectives for the design of the new carrier systems specifically excluded special services, the need for adapting them for such uses has become important.

To meet these needs, additional types of channel units have been designed, as shown in the second table (opposite). Also, more refined engineering techniques have been worked out for use by the Operating Companies to enable the systems to meet the more rigid transmission requirements for special services.

As an example, consider a problem of transmission with the built-in compandor. This unit makes it possible to operate speech channels over poorer grades of circuit that would otherwise have introduced excessive noise and crosstalk. This device is of greatest benefit, however, when operating on electrical signals destined for the human ear. The compandor time-response is designed to be slow enough to follow only the syllabic rate of speech, and therefore cannot follow the rapidly fluctuating signals of voice-frequency telegraph and high-speed data transmission.

Because the compandor offers no benefit and may even degrade data transmission, a new channel unit, called the "special services channel unit," was designed without a compandor. To lower the noise level for operation without compandors, special engineering measures have been worked out, such as segregating the carrier pairs into cables that are separate from other pairs on which disturbances are present. Such segregation



Repeater unit being inserted into a type O mounting. "Plug-in" nature of the equipment was a major factor in achieving economical designs.

Installing a Bell System cable: with both cable and open wire, carrier systems can be applied to permit many conversations over a pair of wires.

is continued through separate cabling within the central office. Outside, the separate cables generally extend about one mile from the office, and in many cases they avoid the need for shortening repeater sections to increase carrier levels to override the noise. Also, special devices have been made available to suppress static noise from open-wire pairs which enter a cable where carrier levels are low.

Another development that increases the versatility of Bell System short-haul carrier service is the special channel unit designed for program transmission (radio programs, for example) over N1 carrier (RECORD, *November*, 1954). This unit increases the bandwidth over that required for message use, and it also meets the more rigid requirements for allowable distortion in high-quality program circuits. Where program material up to 5 kc must be transmitted, the program signal encroaches on the frequency space of the two adjacent message channels, which then cannot be used for telephone traffic. Thus, one 5 kc program channel displaces a total of three telephone channels, one of which may be recovered by the use of the channel 13 described earlier. When the direction of transmission must be reversed by remote control, part of the unused frequency space is reserved for switching signals. For this purpose, another channel unit, called the "program reversing" unit, has been developed. This unit converts dc signals received from the program-control location into signals at carrier frequency, and vice versa, to operate switches at remote points of a program network.

As discussed before, one of the measures included in short-haul carrier systems to keep costs low is the built-in signaling feature (that is, built into the carrier terminal). Since the original design of external single-frequency equipment, however, advances in the art have reduced the cost of this latter type of signaling. Also, such units can now be made to function with a variety of signaling methods used in the local plant. Therefore, by developing another type of channel unit without signaling for use with newer types of external signaling units, the field of use of the short-haul carriers has been expanded into the local plant. Here they provide interoffice and tandem exchange trunks. This new channel unit without signaling also reduces the cost of an N, O or ON channel when it is used in tandem with a channel of another type of system using single-frequency signaling. In this way, the external single-frequency units are needed only at the extreme ends of the multi-link trunk, and the signals pass from one system to another without the need for signaling converters.

All of these additional developments have increased the flexibility and usefulness of short-haul carrier without changing basic system designs. Development effort was minimized by the plug-in nature of the equipment so that particular units could be modified without major redesign of the system. By plugging new channel units into existing systems, individual channels can be made suitable for certain special services. Later, they can be converted back to message use. Hence, these new uses for the short-haul carrier systems are obtained with only minor increases in system cost.

These accomplishments have thus been of great help in satisfying the tremendous post-war demands for telephone service. The result is that, today, of all the carrier channels in the Bell System, about half are of the N, O or ON types. Additional effort is being directed toward further reductions in the costs of terminals, so that N carrier may become attractive at shorter lengths. If this can be done, it could be used in the local exchange, where there are vast opportunities for an economical carrier system.

Throughout the Bell System, recorded time and weather information services have proved very popular. To extend the scope of such special services, engineers at Bell Laboratories have recently devised a versatile, reliable and economical system that will permit newspapers and similar organizations to offer many types of recorded messages of current interest.

D. J. Gagne

The New 9A Announcement System

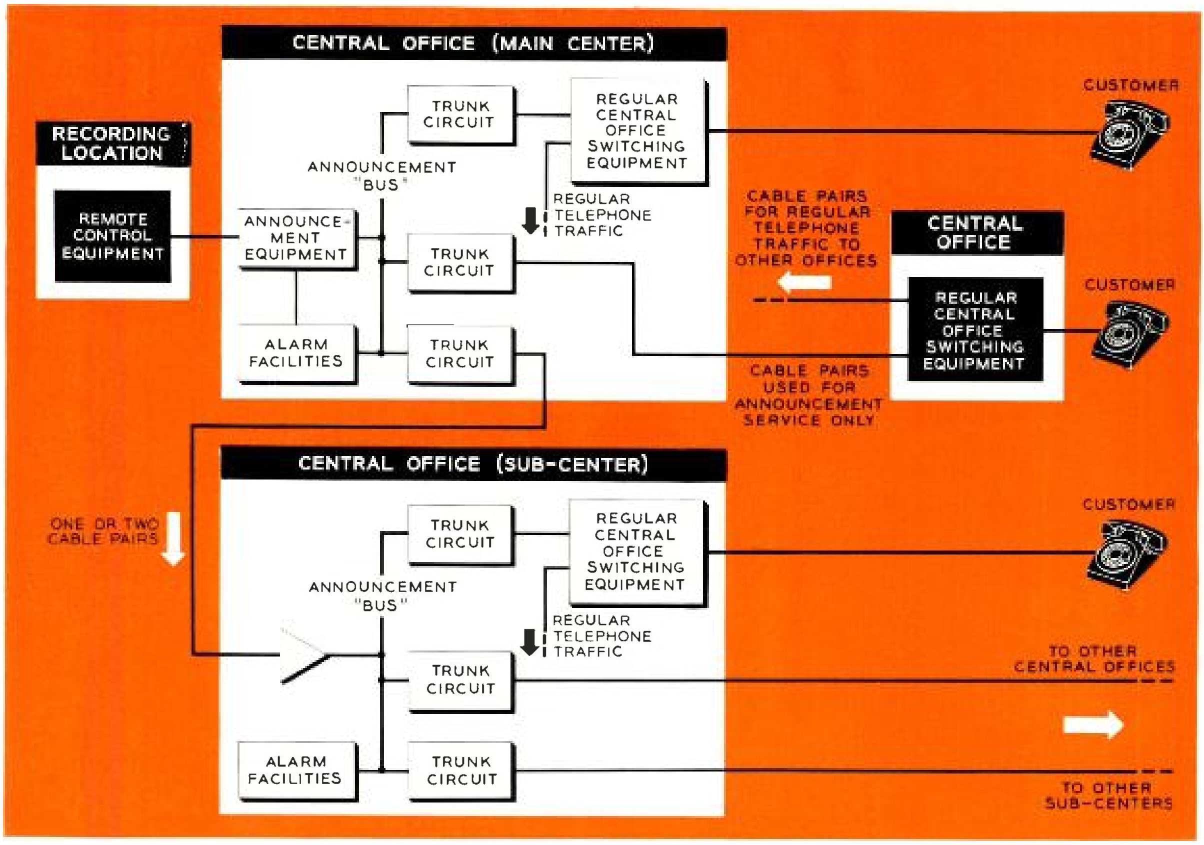
Has another satellite missile been launched yet? How is the election going? Who's ahead in the seventh inning? In cities and towns throughout the country, the Operating Telephone Companies will soon be able to offer a service that will give telephone customers the answers to questions such as these.

In response to a few turns of the dial, the customer's telephone will be connected, through the new 9A announcement system, to a machine which functions much like a home tape recorder. This machine — the voice of the system — "plays back" over the customer's line previously recorded, up-to-the-minute information on news, sports contests, election results or similar events of current interest. These announcements will generally be accompanied by a "commercial" for the sponsoring organization.

In the telephone plant, extensive facilities are required for this service. Along with the machine which furnishes the recorded message, the announcement system requires a comprehensive network of special circuits. And wherever possible, these circuits separate calls to the announcement service from calls through the "regular" telephone network. This separation is desirable because under certain conditions, calls for recorded information may reach extremely high levels of usage at unpredictable times, and could seriously interfere with regular telephone traffic.

Recorded-message services, or "announcement" services as they are usually called, have been a part of the comprehensive communication services offered by the Bell System for almost twenty years. A weather announcement system—designated "the 3A Announcement System" — was first installed in New York City in 1939 (RECORD, *November*, 1939). Similar weather information services have since been installed in many cities in all parts of the United States. These services are currently handling large numbers of calls. In New York, for example, as many as 200,000 calls have been completed to "Weather" in a single day.

The success of the weather and time information services over the years has been remarkable. Based on this experience, the logical next steps have been taken — extending the scope of announcement facilities to include other types of information, and developing a system which can be easily operated by members of organizations that sponsor the messages. A study of some of the system problems involved in extending this service indicated that an improved recording and playback machine (generally called the "an-



Block diagram of the new recorded-announcement system. Diagram shows the important system elements located at the distributing centers. Wherever possible, calls to the announcement service are separated from trunks handling "regular" traffic. Lines to the sub-centers require amplifiers.

nouncement machine") would have to be developed, along with additional features in the circuits which make up the network.

Since both the new machine and the circuit changes were fairly basic departures from existing apparatus, Bell Laboratories has devised an entirely new system — designated the 9A Announcement System. The new arrangement will offer versatile and reliable announcement service at the lowest possible cost consistent with quality service. The essential elements of the system and the way in which these elements are coordinated with "regular-service" telephone equipment are shown in the accompanying block diagram. Basically, the system consists of an announcement machine and its associated controls, alarm facilities, and a network of special trunk circuits.

The announcement machine — shown in the photograph (*next page*) along with its control equipment — uses a "magnetic rubber" recording medium, similar to the drum used in the telephone-answering set, instead of the magnetic tapes made of paper or plastic that are used in home tape recorders. It is possible to control the machine and record on it either locally or from a considerable distance.

The remote controls have been simplified to facilitate operation by non-technical people, since many of the new announcement machines in 9A systems will be operated by employees of "sponsors." An example of this simplicity is a feature of the machine which permits messages of varying length to be recorded without making changes in the machine. This feature also prevents such messages from causing an objectionable silent interval between messages. The machine can also be controlled locally from the central office, or "announcement center," by maintenance people, since the care of the machine will remain the job of the Bell System.

To change the recorded information on the machine, the announcer turns on the remote control equipment (the small control panel, handset and relay unit shown at the right in the photograph) adjusts the speaking level to the correct volume, which is indicated by a needle on a meter, and then operates the "dictate" key. This automatically "erases" the previous recording. When this is done, a visual "start" signal lights. The announcer then speaks into the handset and records a new message on the machine (roughly, the two large units on the table in the photograph) in the main center. The announcer can also play back the newly recorded message to check accuracy and clarity.

Customers call the recorded information service by dialing a standard, 7-digit number. Calls are connected to the announcement machine by a network of trunk circuits, as shown in the block diagram. There are enough trunk circuits to ensure that, under normal conditions, almost every call can be connected to the announcement system without excessive delay.

Calls can come either from customers served by central-office switching equipment in the same building with the announcement machine, or from customers served by other central offices. In either case, the calls for recorded information are eventually switched to a group of trunks that carry only calls to the announcement machine.

Larger outlying central offices may require a separate trunk group to gain access to the recorded message at the main announcement center. In some cities, where the announcement system must cover a wide area, the excessive length of separate trunks can be expensive. It is more economical in such cases to furnish a direct connection to an outlying office, and establish in that building an announcement-distributing point, or "sub-center."

Here, either one or two cable pairs can be used, depending upon the degree of reliability desired. As indicated in the system diagram, the sub-center uses the main center's trunk-circuit and alarm-circuit facilities and has amplification in the incoming line. To a limited degree, a sub-center can also feed other sub-centers. With such an arrangement, a single announcement machine can make a message available to customers in a wide geographical area.

Numerous safeguards are built into the 9A system to prevent voice failure in the machine, and to prevent service interruptions due to difficulties in the interconnecting cable pairs. Circuits in the machine and on the announcement busses at both main centers and sub-centers sound an alarm in the event of voice failure. If this occurs an arrangement in the trunks prevents false charges against the calling customer.

The new 9A system will make it possible for the Operating Companies to offer a wide variety of recorded information services, using a standard announcement system. This system — a versatile yet simply operated recorder together with integrated trunking arrangements — will reduce the costs involved in engineering, installing, operating and maintaining the increasingly popular recorded-announcement services.

H. M. Owendoff, right, of the audio-facilities development group, and the author listen to a recorded message. Mr. Owendoff uses control equipment similar to that at a recording location.

A "Dry-Land" Ocean at Chester

Engineers at Bell Laboratories will soon have a new and unique "laboratory" for testing submarine cables. This laboratory, called the "dry-land ocean" is being built at the test location of the Outside Plant Department at Chester, N. J. Its primary purpose will be to test submarine cables over a long period of time in a physical environment similar to that found 12,000 feet under the sea. This will determine if the electrical characteristics of a cable change with time — a phenomenon generally called "aging."

O. D. Grismore of the Transmission Systems Development Department and J. W. Phelps of the Outside Plant Development Department designed the simulated ocean — the only one of its kind in the world. The Chester "ocean" will eliminate testing for aging in the actual undersea environment. It will permit more accurate control of measurements at only a quarter the cost of actual undersea cable testing.

Submarine telephone cables are becoming increasingly important in modern communications. Within the past two years the Bell System has led the way in spanning the Atlantic (RECORD, *October*, 1956) and has connected Hawaii and Alaska to the U.S. Mainland by cable (RECORD, *January*, 1957; *November*, 1957). Thus, cable engineers at the Laboratories are interested in exactly how the sea affects this important and expensive transmission medium.

Because long life is necessary to dependable deep-sea cables, engineers want to know about cable aging — its magnitude, why it takes place, what physical changes in the cables constitute aging. A simulated ocean for testing cable designs must therefore reproduce the temperatures, pressures and chemical composition of the ocean floor.

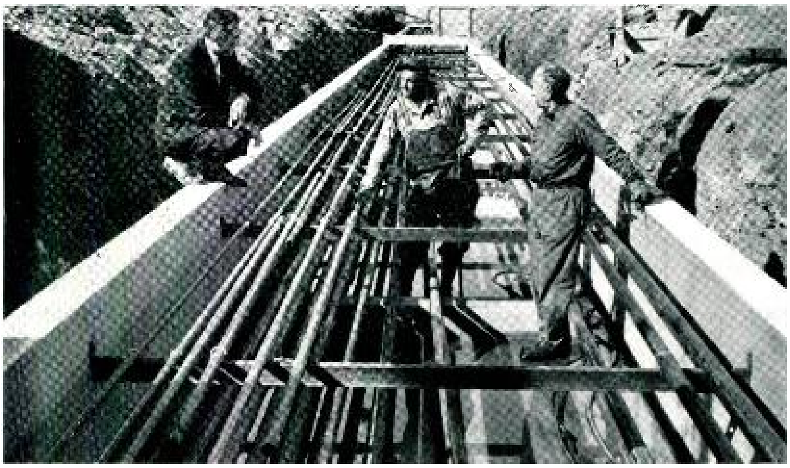
The "ocean" at Chester is essentially a buried concrete trough, three feet deep, about eight feet wide and 315 feet long. Pre-cast concrete slabs will serve as a cover for the trough, which lies seven feet below the surface. This depth will assure reasonably constant temperatures the year round.

The trough will be filled with water kept at 37 degrees F — the average temperature of the ocean at the bottom. This temperature will be maintained by a network of cooling pipes cast within the walls of the troughs. When engineers are conducting measurements, this temperature must not vary more than one-tenth of a degree.

Ten steel tubes, arranged in pairs, will be supported in the middle of the trough. Each tube will be large enough in diameter to hold a typical undersea cable completely surrounded by salt water with a salinity approximately that found 12,000 feet beneath the ocean's surface. Simulated pressure at the same depth will come from an hydraulic system that will distribute a pressure of 5000 pounds per square inch inside each tube. Each cable sample, 630 feet long, will be "looped" in a pair of tubes. With this arrangement, engineers can take their measurements at one end of the trough where both ends of a cable will appear together.

The new ocean laboratory will also be able to simulate the stresses on the cable caused by the cable-laying operation. Tension will be applied for a short period after the cable has been placed in its tube. This tension will be slowly reduced, as pressure is increased, simulating conditions encountered as the cable leaves the ship and settles onto the bottom of the ocean.

Cable samples will lie in the simulated ocean and undergo various tests for periods of from five to ten years. This unique, dry-land ocean laboratory should be completed soon, and the initial tests are scheduled to begin shortly.



Construction work on the trough for the dry-land ocean. Trough will be covered with earth to help maintain constant temperature within.

Military preparedness in this country has focused much attention on the science of the guided missile system. Nike-Ajax — an outstanding example of this science — became the first operational missile system through the combined efforts of Bell Laboratories, Western Electric, Douglas Aircraft, the Army Ordnance Corps and a number of engineering companies.

J. L. Troe

NIKE-AJAX:

An Integrated Guided-Missile System

Nike, once familiar as Greek mythology's goddess of victory, to many now suggests something much more dramatic — a guided missile. The tactical version of Nike — the Nike-Ajax guided-missile system — is, at this moment, defending the United States against surprise air attack. This system represents many years of effort by numerous military and civilian organizations — effort spearheaded by research and development work at Bell Laboratories.

The Nike story started during the closing days of World War II when the Army Ordnance Department and the Air Force selected the Laboratories to determine the practicability of developing a ground-based guided-missile system. At that time, it appeared that only a new weapon of this kind could defend against bomber aircraft capable of the advanced performance foreseen for the future. The Laboratories report, made in mid-1945, led to the beginning of a long-term research and development program aimed at demonstrating the feasibility of Project Nike.

Engineers at the Laboratories undertook the design of the ground-control aspects of this program. Specifically, they concentrated on the development of the radars, the computer, and the guidance and control system of the missile. As a major subcontractor, the Douglas Aircraft Company was charged with the design of the missile itself and certain associated equipment for launching, handling and testing. Other military and civilian subcontractors were assigned additional specific development problems. Bell Laboratories as development organization on behalf of the prime contractor, Western Electric, exercised technical control of the complete research and development phase of the project under the auspices of the Army Ordnance Corps.

This research and development eventually resulted in the installation of an experimental system at White Sands Proving Ground, New Mexico. By 1950, successful demonstrations in the first phase of the test program proved the feasibility of the basic concepts of the program.

When the Korean War broke out, the Laboratories was requested to develop a tactical version of the system — eventually to be called Nike-Ajax — well in advance of that which would normally follow such an experimental program. Therefore, the same team of companies and military agencies, with the Laboratories again in control of development, set up a crash program to

P. L. Hammann, left, and J. L. Troe examine front panel of computer. Panel is mounted on hinges to permit easy access to components in rear.

develop Nike-Ajax concurrent with the Nike experimental program.

The goal in 1950 was to design immediately an integrated anti-aircraft guided-missile defense unit — namely, a guided missile battery. This unit was to have all of the supporting features necessary for ground troops to use the system effectively in the field. The decision to base the tactical version on the results of the partially completed research and development program involved a certain amount of compromise, speculation and risk. For example, decisions had to be made on major production designs before these designs could be confirmed by the experimental program. Despite such obstacles, the resulting Nike-Ajax system was developed and delivered for operational use by 1953.

Relatively rapid development and early deployment of Nike-Ajax was possible because the project leaders decided early that the system should use, as far as possible, devices, methods and techniques of engineering that were already available and well understood. Therefore, the program did not await development of such innovations as ramjet engines, radically new fuels, or new guidance and homing techniques. Furthermore, the expendable missile was kept as simple and economical as possible, even though the permanent ground equipment had to be more complex and expensive.

And just what is the guided-missile system that resulted from all of this effort? Nike-Ajax is a command-guidance, surface-to-air, guided missile system. Its "battery" equipment continuously surveys an assigned area for all airborne targets within effective range, at the same time it engages selected targets. Nike-Ajax can also accept remote designation of targets from a distant fire-direction center.

As a basic plan, an "acquisition" radar continuously scans a volume of air space about the battery site, detects the presence of enemy targets and furnishes the information necessary to transfer selected targets to a target-tracking radar. From this precision radar, a computer obtains data on the continuously changing position of the target to provide information for the officer in charge of the battery. From this information, he determines the most effective instant to launch a missile. A second precision-tracking radar tracks the missile to furnish information on its position continuously to the computer. This radar also transmits computer-generated steering orders to the missile throughout its flight. Among the many duties of the computer is the generation of a "burst" order at the optimum moment for maximum damage to the target.

A Nike-Ajax battery consists of two basic parts. One part is the guidance-and-control equipment, physically deployed in the ground-guidance area. The other part is the missile launching-and-handling equipment, deployed in the launching area. Normally, these two areas are about one mile apart.

The ground guidance-and-control equipment consists of three radars — an acquisition radar, a target-tracking radar, and a missile tracking radar. It also includes battery-control and radar-control vans which house the operating consoles, the computer, and auxiliary facilities. The missile launching-and-handling equipment consists of the launchers. missile-storage and handling equipment, electrical-control consoles and a van from which are coordinated the activities of the launching area.

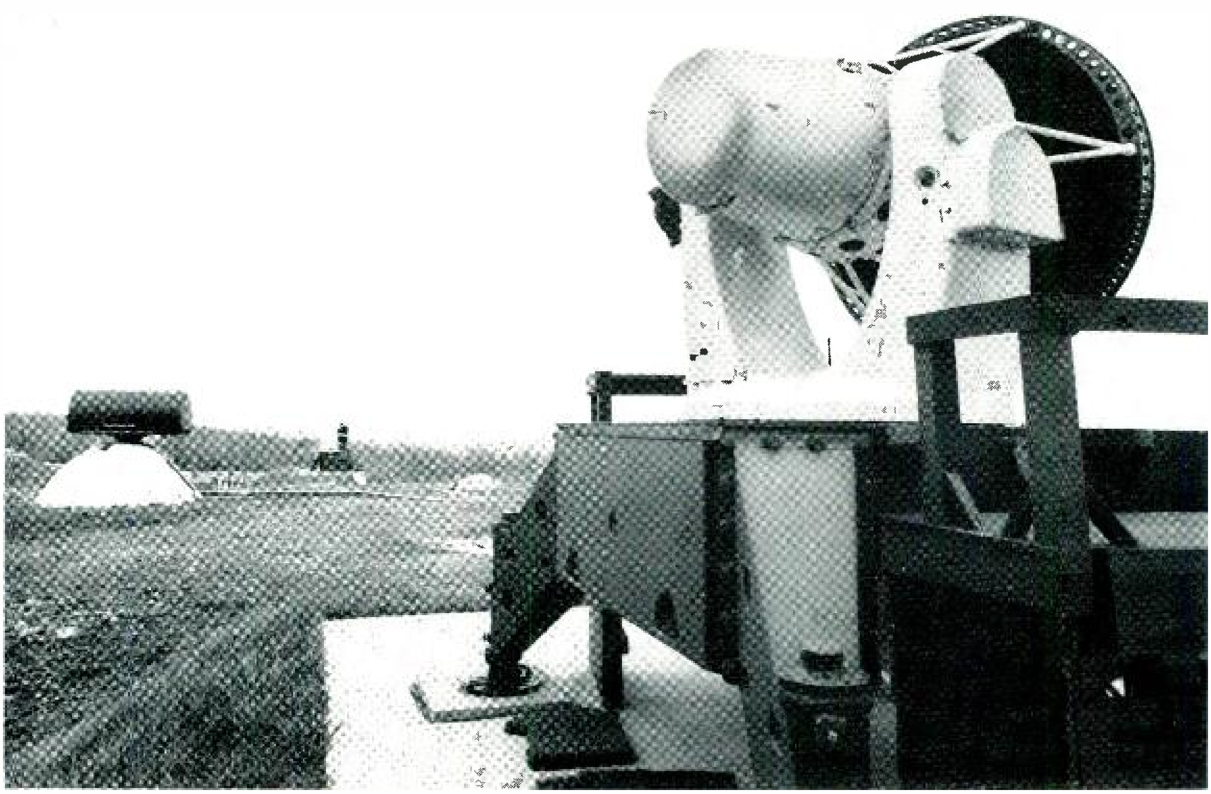
The antenna of the acquisition radar is enclosed in a rotating radome about 15 feet long. This radome is mounted on a tripod support that surrounds a cylindrical equipment-enclosure. The cylinder contains the antenna-rotating motor and certain of the components of the high-powered radar transmitter. The remaining acquisition equipment is located in the battery-control trailer, where the antenna is remotely controlled.

All targets detected by the acquisition radar are displayed on a "plan position indicator" in the battery-control trailer. From this complete display, the officer in charge of the battery selects a particular target and designates it to the operators in the radar-control trailer as the specific hostile target to engage.

The target-tracking radar is designed for extreme resolution and accuracy. The antenna is a circular metal-plate lens six feet in diameter. This antenna radiates a very narrow symmetrical beam. The method of angle detection used for target tracking is the so-called "monopulse" type. With this method, complete target-position information is obtained from each transmitted pulse of energy, rather than from the demodulation of a long series of pulses as in more conventional radars. The monopulse system was a revolutionary and challenging new development in the radar art. It permits the Nike target-tracking radar to obtain tracking accuracies never before attained.

The target-tracking radar is monitored and controlled in azimuth, elevation and range by three operators in the radar-control trailer. A large portion of the precision-radar equipment is located inside this trailer. The lens assembly and associated transmitter and receiver components, however, are packaged in a special mount on a flatbed trailer. Unusual precision was required to level, and to align mechanically and electrically, the tracking-radar mount. This called for the solution of extremely difficult mechanical problems. For rigidity, the complete mount base is cast as one magnesium casting — the largest ever fabricated. Precision optical levels and level-adjusting mechanisms also had to be developed. In addition, special procedures were needed to "boresight" and "collimate" the radars — an adjustment

Acquisition radar (left) stands between two tracking radars of a Nike site. At semi-permanent installations tracking radars are removed from trailers; acquisition radar is installed in an "igloo."



The author (standing) observes the work of the battery commander (seated in center position) and his assistants. View shows the inside of a control van, the nerve center of a Nike missile site.

similar to that required of a precision transit.

The missile-tracking radar is visually identical with the target-tracking radar. It differs electrically in that it tracks a signal transmitted from the missile. Furthermore, it permits a communication link, via the radar beam, for the transmission of steering and burst signals to the missile. Signals returned from the missile are presented on a range indicator in front of an operator in the radar-control trailer.

The functions of the computer are separated into two general phases — the pre-launch phase and the steering, or flight phase. For both, the input data to the computer includes the position of both the target and the missile — data obtained from the tracking radars. During the prelaunch phase, the computer calculates a continuously changing *predicted* intercept position from the target's course, speed and maneuvers. This information is plotted (automatically) on automatic plotting boards, and the missile-control system is readied for flight of the missile. The plotting board, and other indicators, furnish the battery commander with the information he needs to judge when best to fire the missile. During the flight phase, control orders are computed and transmitted to the missile to steer it on its best course to the target-intercept point.

During the flight of the missile, the computer becomes one element in a large servo loop. This loop consists of the missile-tracking radar that transmits missile position to the computer; the computer, generating steering signals; the radar, transmitting these steering signals to the missile; and the missile, aerodynamically responding to these control signals. The control and stabilization of this so-called "grand loop" was one of the major challenges of the Nike design program.

Adjacent to the launching area is an assembly area where the missiles and boosters are prepared and assembled on the launching rails. One missile, one booster and one rail are transported as a unit to the launching area and placed on the launcher. The launcher has facilities to erect this unit when a missile is about to be fired. It also has storage racks for a number of "ready" and rejected missiles and for empty (used) rails.

The launcher consists of a box-type base structure with two pivoting legs that form a tripod support. Jacks on the outer end of the base and legs level the structure and permit the removal of the wheel assembly used for transport.

To fulfill its function in the Nike system, the Nike-Ajax missile must deliver a warhead to within lethal-burst distance of the target. This requires a supersonic vehicle capable of accurate execution of commands from the ground, and furthermore, a vehicle superior in performance to the attacking aircraft. This missile is rapidly accelerated to supersonic velocity by a booster unit having a solid-propellant fuel. When the booster fuel is exhausted, the missile and booster separate. Then a liquid-fuel motor system carries the missile quickly to a high altitude where "drag" is low. The missile follows a supersonic semi-ballistic trajectory to fly efficiently and rapidly to the intercept point.

The body of the Nike-Ajax booster is approximately 16 inches in diameter and 12 feet long. Three large "fins" are located at the rear end to stabilize the missile-booster combination.

The Nike-Ajax missile is approximately 12 inches in diameter and 20 feet long. Four large, fixed fins are mounted at the rear end with ailerons for roll stabilization, referenced to gyros. Two pairs of small steering fins, located in the forward part of the missile, are actuated by an electric-hydraulic servo driven by signals from the missile-borne guidance section. The guidance section decodes the steering commands transmitted from the ground.

The rocket-power plant in the missile burns kerosene and nitric acid. In flight, stored compressed air forces the fuels from sealed storage containers in the missile into the burning chamber of the motor. Missiles on tactical sites are fueled for instant use when needed.

The Nike missile rises on its launcher. At near-vertical position, it will await signal to launch it.

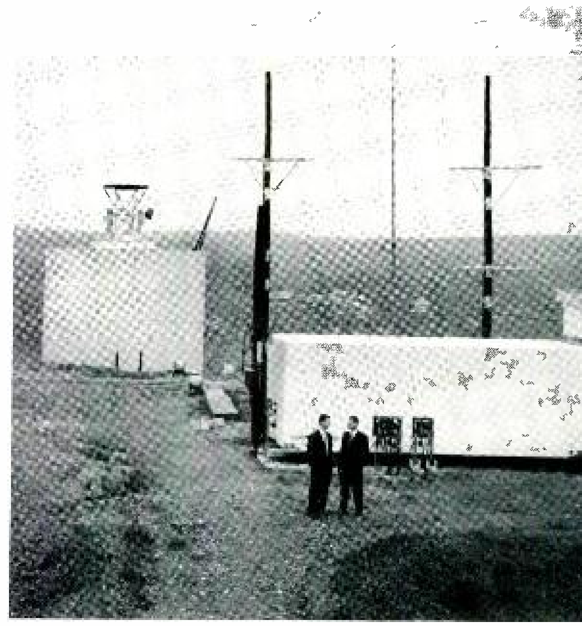
Special safety and arming devices prevent the missile warhead from exploding prematurely. These devices arm the warhead for detonation after the missile has reached a safe altitude. Once the warhead is armed, its firing system is ready for detonation upon command from the ground. In addition, a "fail safe" system in the missile detonates the warhead if it senses that command guidance has failed in any way.

The Nike-Ajax system was designed for semi-mobile use by a field army. Thus, all major components of the system were either designed as part of four-wheel trailers or constructed for easy assembly and disassembly in the field. To date, however, the major deployment of Nike-Ajax systems has been on semi-permanent fixed sites about major cities in this country. For reasons of economy and safety, concrete storage boxes are built underground, in which the missiles are stored. This has meant less land had to be procured at each site to meet the military safety standards for stored explosives.

The ground-guidance area in a typical defense site looks much as it would in a field-army emplacement. An exception is that the wheels are usually removed from the operating vans and the tracking-radar mounts are removed from the transporting trailers. Fixed-site systems, however, can be readily reconverted to mobile systems.

Operation of Nike-Ajax perhaps can be best illustrated by describing a typical engagement. Let us assume that an "alert" signal, indicating possible enemy planes in action, was sent to our Nike site by a higher defense-echelon. Upon receiving this signal, the crew energized the system. Presently, a target came within range of the acquisition radar, and a radar operator observed its presence on the plan position indicator at the battery-control console. An identification device, called IFF (Identification, Friend or Foe) defined the target as an enemy. When the target appeared to be moving into the assigned defense sector, the battery-control officer designated it to the operators of the target-tracking radar who commenced tracking operations.

The battery-control officer monitored the automatic plotting boards that were presenting the predicted intercept point as calculated by the computer. Concurrently with the performance of target-acquisition operations at the ground guidance and control area, the launching-area crews were preparing missiles for launching. The missile-tracking radar "locked on" the signal being transmitted from the missile designated for the first firing. At the instant when a satisfactory predicted-intercept point was determined, the battery-control officer fired the attacking missile.


At semi-permanent Nike sites, the battery- and radar-control vans are removed from their undercarriages. Equipment such as tracking radar at site also are set up as semi-permanent equipment.

After the missile was launched, the present positions of both the target and missile were continuously displayed on the plotting boards in reference to the geographical area of the combat zone. The battery-control officer continued to monitor the boards to ascertain the effectiveness of the engagement. When the missile reached the point of optimum destructiveness, the computer automatically initiated the burst order and the "enemy" was destroyed.

This, then, is Nike-Ajax. Over our country there are many Nike installations where the Army operators stand ready, on a moment's notice, to defend against any possible aggressor from the air. Most of the sites have frequent "open house" for the public during which military guides explain the highlights of the non-classified areas of the installation.

Nike-Ajax, however, is not the end of the Nike story. Another system, Nike-Hercules, designed to cope with the ever-increasing capabilities of the target threat, is now in production and being delivered for tactical deployment (RECORD, *September*, 1958). Moreover, the anti-ballistic-missile system known as Nike-Zeus is now being developed by the same Nike team. Thus, the Laboratories and Western Electric continue to contribute to the efforts to protect this country from any conceivable attack by an airborne enemy.

Fittings for Underground Conduit

A considerable portion of the Bell System cable plant is underground. Some cable is merely buried in the earth, while other portions of the underground network — particularly in urban areas — are contained in conduit. This extensive conduit system, although out of sight, is never out of mind. Conduit components are frequently modified or augmented because of changes in telephone traffic, maintenance considerations, or other reasons.

In general, changing traffic conditions mean an increasing demand for telephone service. More service requires larger cable, and as a result certain conduit fittings become — almost literally — "bottlenecks." These fittings are called "couplings," and join main cable ducts with subsidiary ducts. For older cables, which were generally smaller, these couplings had ample inside diameter. But with the increasing use of larger cable, the inside dimensions of the connecting fittings became dangerously snug. Placing cable under these conditions is very difficult because there is almost no working margin between the size of the cable and the inside diameter of the fitting.

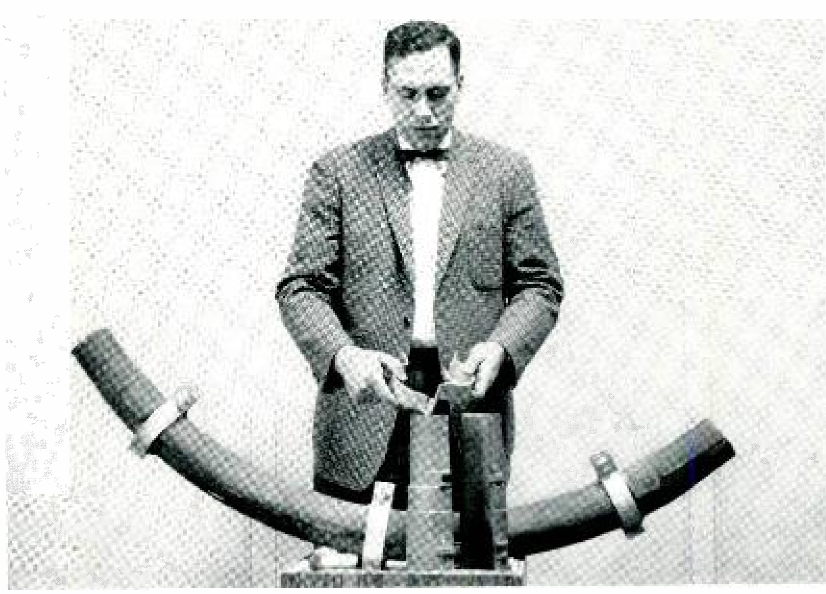
To overcome this problem, which was occurring frequently throughout the telephone plant, engineers at Bell Laboratories redesigned the couplings to open the "throats" of the fittings. These new fittings can be used without altering or interfering with the other parts of the conduit run.

Maintenance problems, as well as increasing traffic, frequently bring about the redesign of conduit fittings. A recent example concerns the installation and maintenance of "bends." These fittings, shown in the accompanying photograph, are used to bring underground cable to the surface in places where it is to be strung on telephone poles for aerial distribution. Ground-line corrosion and mechanical damage to existing bends, along with conduit rearrangements and pole moves, created a need for a new fitting which could be installed without disturbing the cable.

The basis of the new fitting was a "split" bend — essentially a bent pipe cut lengthwise — adopted by the Illinois Bell Telephone Company. After working out a suitable clamping-band arrangement for easily securing the two halves of the bend together, this fitting was standardized. To make the bands compatible with the field-installation conditions — men working in cramped quarters with a minimum of tools — the circular bands were designed as two-piece units with identical halves. One end of the curved half-band is formed to mate with the other half in a slip-joint hinge. The other end has a flange with a bolt hole in it for bolting the band together securely.

Some situations where cables are brought to the surface require additional length on one end of the bend. A split extension, shown in two pieces in the illustration, was designed to care for such situations. The basic design of the fitting and the clamping bands is the same as the bend.

J. A. TAYLOR, *Outside Plant Development*



The author shows how clamping bands work. Split bend fitting and extension, separated to show split construction, are standing in foreground.

The Laboratories has developed for the U.S. Army Signal Corps the first twelve-channel military carrier telephone system. Performance is equivalent to commercial services, yet components are individually light enough to be carried by one or two men. The terminal is easily set up and maintained, and it operates over a broad range of temperatures and humidities.

B. A. Fairweather

Terminal for Twelve-Channel Military Telephone

A number of articles have appeared in the RECORD describing specific features of the new four- and twelve-channel carrier telephone systems developed by Bell Laboratories for the Signal Corps. These systems are significant contributions to military communications because they achieve the desirable requirements of lightness of weight, ruggedness sufficient for rough handling both in transit and in operation, and good electrical performance over an extremely wide range of temperatures and humidities.

The discussion here concerns the terminal of the twelve-channel system, designated Telephone Terminal AN/TCC-7. Several of the earlier articles have dealt with various aspects of this terminal — specifically its application in wire communication networks and in conjunction with radio sets, the equalization arrangements, and the modulator-demodulator or "Modem" unit. Before we consider other features, however, it is well to describe briefly the carrier system in which this terminal functions.

In a twelve-channel military communication network, which may extend for about 1000 miles or more, terminals will be located at the ends of each 200-mile link. Between the terminals in each link, attended repeaters are spaced at about 40-mile intervals, and between the attended repeaters, unattended repeaters are spaced at intervals of about 5¾ miles. Transmission is over "spiral-four" cable — four conductors wound spirally in the cable — employing two diagonally opposite wires in a section for one direction of transmission and the remaining two for the other direction. The terminals can also be associated with radio sets. In either application, facilities are provided for the simultaneous transmission and reception of twelve telephone conversations and a maintenance or order-wire channel.

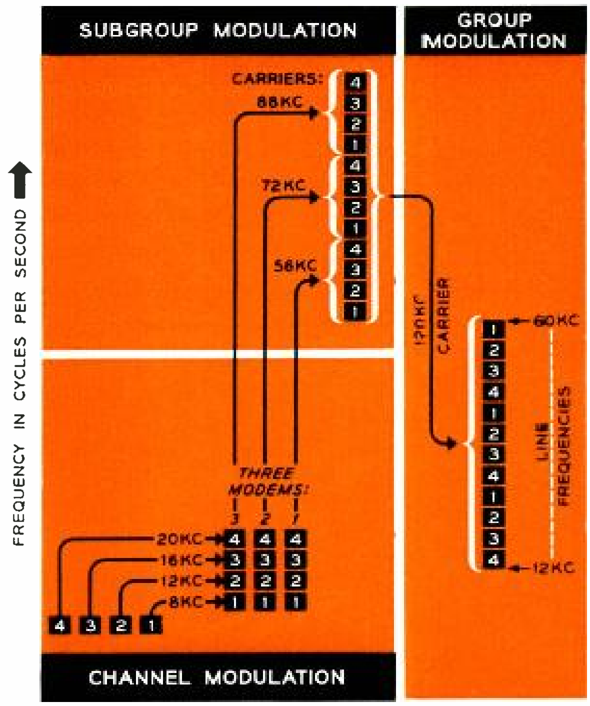
In the terminal, basic Modem units supply groups of four channels, each occupying a band of frequencies from 4 kc to 20 kc, and these groups are further modulated to provide twelve channels in a 12-kc to 60-kc band for transmission over the cable. The frequencies required for the modulation processes are furnished by a carrier-supply unit.

Because the energies at different frequencies suffer different amounts of attenuation during transmission over a wire system, the terminal and repeaters include equalization and regulation circuits to restore the received signals to the equal-level or "flat" condition. Another feature of the system is that order-wire and test circuits are included. The order circuit is a voice channel separate from the twelve message channels and is used by operating personnel for such purposes as adjusting the gain or equalization (line-up), locating faults with the aid of the test circuits, and performing the many other duties required to set up and maintain continuous service.

With these general features in mind, we may now look at some of the particular arrangements of the twelve-channel terminal. The basic problem in providing twelve-channel transmission is to take the twelve separate bands of voice frequencies and translate each of them to its assigned place in the higher frequency spectrum. For this purpose, use is made of the familiar single-sideband type of amplitude modulation with successive carrier frequencies to provide the desired band. When two frequencies are allowed to modulate or mix together, the products, among others, ordinarily consist of the original frequencies, the sum of the two, and their difference. Thus, to translate a particular group of frequencies to some other range, it is necessary to supply the modulating carrier, and then to filter out or otherwise remove the unwanted components, leaving only the desired signals.

In the twelve-channel terminal, this modulation process is accomplished in three steps. The first step occurs in the Telephone Modem, of which there are three identical units. In the Modem, each of four voice channels is modulated with a carrier frequency of 8, 12, 16 or 20 kc to produce lower sidebands (difference frequencies) with suppressed carriers. The sidebands are "stacked" in a band extending from 4 to 20 kc. The Modem is the same basic unit used in the four-channel military system, and it exemplifies a design trend in which circuit "building blocks" are interchangeable among a number of systems.

In the second step of translation, the channel Modem-supplied 4- to 20-kc band is considered a subgroup of four channels, and use is made of what are termed "subgroup modulators." Three subgroup modulator circuits are provided, each associated with a particular channel Modem. The modulators are similar in their circuitry, except that each uses a different carrier frequency — 56, 72, or 88 kc. The 4- to 20-kc bands from the first step are modulated with the subgroup carriers and, in this instance, the upper sidebands



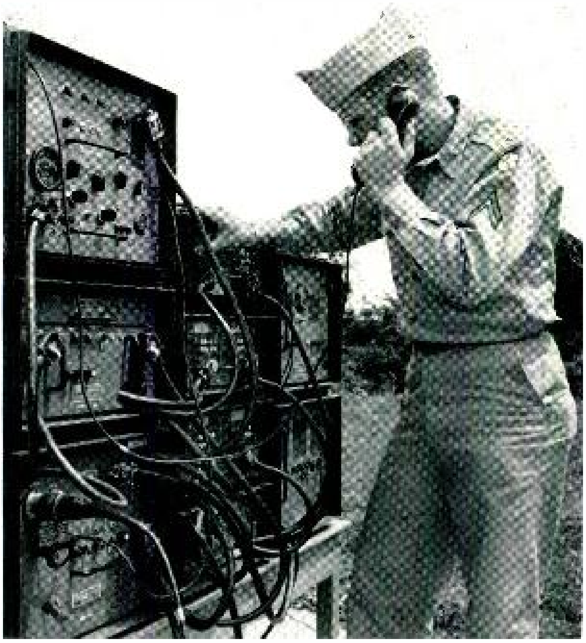
Modulation steps of the twelve-channel military telephone system: channels from three Modems are translated to the 60-108 kc band; then the band is modulated into the line 12-60 kc range.

or sums of the frequencies are selected by band filters. As in the first step, the carriers are suppressed. If we perform the addition of the 4- to 20-kc bands to the 56-, 72-, and 88-kc carriers we see that we now have three sidebands containing the twelve channels, in the three frequency ranges 60 to 76 kc, 76 to 92 kc, and 92 to 108 kc. This 60-108 kc region is an internationally recognized group band.

The third and last step translates the 60-108 kc range into the desired 12-60 kc band. In a "group modulator," the 60- to 108-kc frequencies are modulated with a 120-kc carrier, which produces a lower sideband of 12 to 60 kc. The lower sideband is selected by a low-pass filter, and the carrier is again suppressed. After amplification, the complete twelve-channel 12- to 60-kc signal is transmitted to the line circuit.

In the receiving direction, the order of steps is reversed. The line signals first pass to the group demodulator, then to the three subgroup demodulators, and finally to the three telephone Modems, from which they emerge as voice frequencies from the twelve channels.

Up to this point, the discussion has concerned telephone message channel service, but the modu-



The units of a telephone terminal, normally under cover but here in open for demonstration.

lation scheme also permits several special applications. Telegraph, low-speed telephoto, facsimile, and other services may be transmitted over any telephone message channel. Services requiring a wider band of frequencies, such as high-speed facsimile and data transmission, may be provided in place of message-channel service. For these wide-band services the signals are introduced directly into the subgroup modulators (4- to 20-kc band), into the group modulator (60- to 108-kc band), or into the transmitting amplifier circuits (12- to 60-kc band), depending on the frequency band required. In other words, there is a choice of two bandwidths, 16 or 48 kc, for wide-band special service use.

Another feature of the terminal is that the transmission levels and impedances associated with the group connection are the same as those of commercial twelve-channel banks. Thus, in an emergency it is possible to interconnect commercial channel banks with the AN/TCC-7 Terminal group circuits or the AN/TCC-7 Terminal telephone modems and subgroups with commercial group circuits.

From the above outline of the modulation process, it can be seen that eight separate carrier frequencies are required. These, plus a 68kc "pilot" frequency (to be discussed later) and a 28kc test frequency, are obtained from a carrier-supply panel. A technique involving the division of a primary frequency into a lower frequency and the production of harmonic frequencies is used. This process is similar to that employed in commercial carrier supplies.

The primary frequency is 64 kc, and is generated by an oscillator controlled by a quartz crystal. This oscillator is stable to plus or minus 40 parts per million. The 64 kc is divided in four halving steps to produce 4 kc, which is the fundamental frequency for the generation of the others. The 64-kc oscillator, as we shall see later, permits use of a convenient method of matching the frequencies at the two terminals of a system.

The 4 kc from the dividers is amplified and applied to a saturable-inductor ("kick coil") harmonic-producer circuit. Here a sharply peaked wave form is generated, rich in odd harmonics of the 4-kc fundamental. This wave is applied to band filters which select the desired odd harmonic components (as 12, 20, 28, 68 kc). Even harmonics of 4 kc are obtained by rectifying the peaked wave and applying the rectified wave to band filters which select the even-harmonic components (as 8, 16, 56, 72, 88, and 120 kc). All of these frequencies, except 68 kc, are amplified to proper voltage levels for distribution to the various modulators or test circuits. The 68-kc pilot frequency is fed to the input of the transmitting amplifier, where it is amplified for transmission over the line circuit.

The two terminals in a system are each equipped with a carrier-supply unit. If the two supplies differ in frequency, the carrier frequencies applied to the modulators at the transmitting terminal will differ from those applied to the demodulators at the receiving terminal, resulting in a frequency shift through the system. To avoid such a shift, an arrangement has been incorporated in the AN/TCC-7 terminals which effectively joins the two carrier supplies into one supply system.

The 68-kc line pilot frequency provides a "link" between the two carrier supplies. At the terminal whose frequency is to be controlled, the 68-kc pilot frequency is picked off the line circuit by a selective filter. Modulation with 4 kc produces a frequency of 64 kc, which by switching arrangements replaces the 64 kc from the local oscillator. The 4 kc employed in the modulator is the frequency obtained by subdividing the 64 kc itself as previously described. Thus, the carriers are generated from the received pilot frequency, and are identical in frequency with those generated at the controlling terminal.

As mentioned earlier, the AN/TCC-7 terminal can be used in conjunction with a radio link or spiral-four cable as the carrier transmission medium. When used with a radio link to provide channel circuits for the radio sets, the transmission is normally arranged to be "flat" or equal level at all transmitted frequencies. When used with spiral-four cable, additional transmission features are required.

Transmission through spiral-four cable depends upon the length and the temperature of the cable. These two factors influence both the absolute transmission loss through the cable and the loss-frequency characteristic of the cable. To compensate for differences from the normal section of 5¾ miles, cable "building-out" networks are provided in both the transmitting and receiving portions of the terminal. To permit adjustment for loss-frequency characteristic during line-up, flat, slope and bulge controls are used in the receiving portion of the terminal.

As the temperature of the cable varies after line-up, the change in strength of the received 68-kc pilot frequency is used to control the transmission through a regulating network. This network is so adjusted as to correct for almost all of the residual temperature effects up to the receiving terminal. As a result of this automatic regulation, transmission will vary less than plus or minus 3 db in a 200-mile system for a 30°F change from the temperature at which the line-up was made.

Initial adjustment and routine maintenance of the terminal and system is simplified through the use of a test panel. Circuits for making particular tests are readily established by operating controls whose designations correspond to the test points of interest.

Each terminal has two power supplies. Both require 60-cycle ac inputs, at either 115 or 230 volts. One furnishes a regulated output of 200 volts for the plate circuits of the terminal electron tubes, and voltages for the order-wire circuits and tube heaters. The second power supply is a regulated current supply which furnishes power over the spiral-four cable circuit to the unattended repeaters.

The AN/TCC-7 Telephone Terminal is housed in nine standard transit cases. No case weighs more than 108 pounds, and the total weight is about 750 pounds. Each case can be carried by one or two men, and all are designed to "nest" on top of one another to form two or three stacks, as desired, at the terminal location. The circuits are assembled in drawer-type chassis which are shock-mounted in the cases. Covers can be clamped on the cases to make them weather resistant for storage or transportation. In use, the terminal with all covers removea is normally set up in a shelter.

It is thus seen that this terminal has been developed to meet the severe requirements of military use. Despite the dual objectives of ruggedness and portability, performance is equivalent to that of commercial systems. In addition, considerable emphasis was placed on the "building-block" technique of assembly for ease of maintenance. The terminals have been manufactured by the Western Electric Company, and tests by the U.S. Army Continental Command have shown that performance is very satisfactory.

Terminal equipment being inspected by the author (right) on a Western Electric production line.

With two new systems based on the model 28 teletypewriter, network operators can send teletypewriter messages with greater convenience and efficiency. Both systems solve the "redundancy" problem, and one also solves the problem of contention for the circuit of a teletypewriter network.

C. J. Votaw

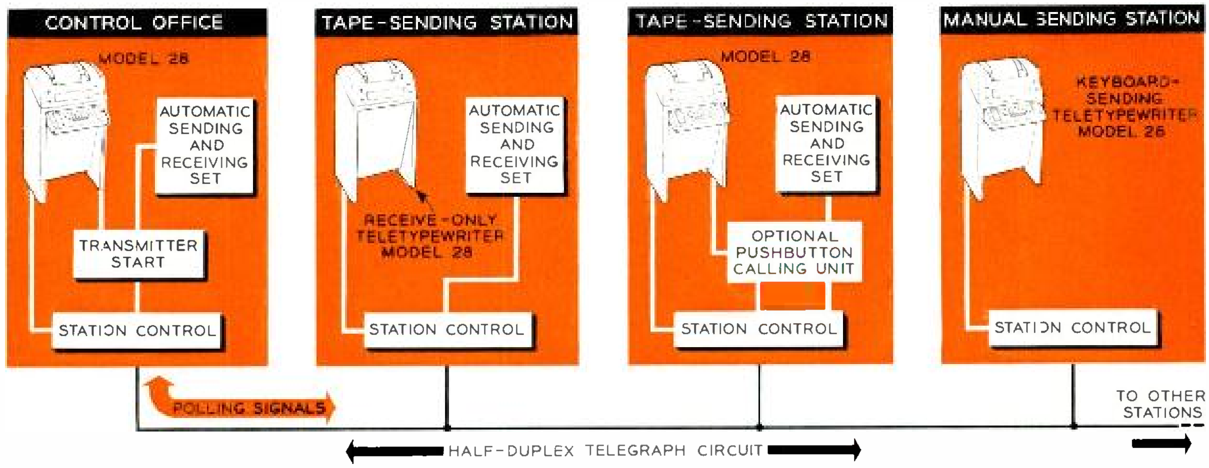
Selective-Calling Teletypewriter Systems

Historically, three basic problems have been encountered in the operation of a network of teletypewriter stations. One of these can be called the problem of "message redundancy" — that is, a message may be delivered to all stations in a teletypewriter network, even though the message may be intended for only one destination. A second problem, known as "contention," results from the fact that only one message at a time can be on a circuit. Contention arises as the various station attendants attempt to break in to send their messages, which sometimes causes garbling. Third, the teletypewriter attendant often has a problem of "assurance" — assurance that the message he sends actually reaches the desired station or stations.

The first and second of these problems can be satisfactorily solved, and the third is solvable in various degrees. All can be handled by designing systems with a "selective-calling" feature — a method of directing messages only to particular teletypewriter receivers. Recently, by using the capabilities of the new model 28 teletypewriter (RECORD, *July*, 1953), two modern and efficient selective-calling systems have been designed. The first, termed the 83A1, is a relatively simple system that solves the redundancy problem and reduces contention by providing "circuit busy" indications at each station. The 83A1 system requires no equipment other than the regular teletypewriter components. A second and more elaborate system, the 83B1, solves the redundancy and contention problems and also gives a high degree of circuit assurance.

In the past, selective-calling systems have been only partly satisfactory, and one of their principal disadvantages is that they have used various code signals that are different from those of the standard teletypewriter characters. Circuitry external to the teletypewriter has generally been required to recognize code sequences and to perform associated functions. This has resulted in one or more of the following objections: costly installation and maintenance, slowness of operation, and signals separate from, and incompatible with, the teletypewriter.

The 83A1 and 83B1 systems are based on the "stunt box" of the model 28 teletypewriter. This is a unit capable of a wide variety of functions; in response to predetermined teletypewriter characters or sequences of characters, the stunt box opens and closes electrical contacts and performs



A control office in an 83B1 selective-calling teletypewriter system with various types of stations. The control office eliminates contention for the teletypewriter circuit by a "polling" operation: transmitters waiting to send messages are all started one by one, and in a predetermined order.

mechanical operations within the teletypewriter printer. Full use of these functions has made improved selective teletypewriter calling possible.

The manner in which attendants use the new selective-calling equipment can be described simply. With the selective-calling feature, each station is assigned its own "CDC" (call-directing code). As with other telegraph systems, attendants either type out messages manually on a keyboard or prepare a punched paper tape for automatic transmission. In either case, the transmission will begin with the CDC of the originating station and the CDC or CDC's of the receiving station or stations. This constitutes the "address" of the message and is followed by a two-character "end-of-address" code. The teletypewriter operator indicates this code by striking the two keys marked CAR RET (carriage return) and LINE FEED on the keyboard.

The stunt boxes of the various stations will respond to the CDC's of their respective stations and will start operation of their receiving machines. Upon receipt of the end-of-address code, the stunt boxes will cease to look for further CDC's. The message will follow and will appear only at the desired stations. The message ends with an "end-of-message" code — the three teletypewriter keys marked FIGS, H and LTRS. This code puts all of the stunt boxes back into condition to respond to their respective CDC's.

The 83A1 system with keyboard sending thus relieves station attendants of scanning large amounts of copy to find messages intended only for them. The teletypewriter circuit, however, is exposed to the possibility of contention, and in addition there is a lack of circuit assurance.

The 83B1 system eliminates contention with a "transmitter starting" arrangement associated with one station on the line, designated the control station. *(See diagram above.)* With a system of "polling" signals, transmitters waiting for the use of the circuit are started one by one in a predetermined order. In addition, the 83B1 practically overcomes the circuit-assurance difficulty by providing for "response" signals from each station when polled, and for "answer-back" signals from each station when it is attached to receive a message. The response to polling assures that the station is on the line, and the answer back gives reasonable assurance that the message is being delivered.

In operation, the transmitter-start circuit at the control office waits for the circuit to become free. It then begins polling the stations by sending the two-character transmitter-start codes (TSC's) of the stations on the line A maximum of 38 stations can be served on a line. Which one of the waiting stations will be started will depend upon its polling order and whether its message requires regular or priority service. The attendant requests priority service for a message by pressing a "priority" button.

The polling operation in effect asks each station in turn, on the first round of polling, "Do you have a priority message to be transmitted?" And if each station answers "No," the control office on a second round of polling asks "Do you have either a priority or regular message to be transmitted?"

The stunt boxes of the stations are capable of

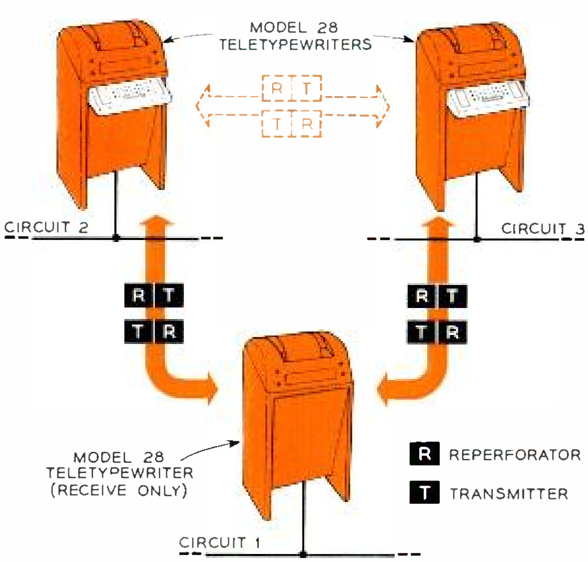
E. E. Barrett (left) placing key and lamp panel on a 28KSR station while L. M. Kolensky tips the typing unit forward to inspect the stunt box. New model teletypewriter unit has permitted improved systems that help solve the problems of "redundancy," "assurance" and "contention."

responding to the respective TSC's of the stations. In response to its TSC, a stunt box will cause one of three things to happen. If the station has a priority message, sending will start immediately. If it has no message at all, a character "V" will be transmitted back to the control office as a "no-traffic" response. If a regular message is waiting at the station, the V is sent, and at the same time a "count" of one is registered in the station. The station then waits for the next round of polling.

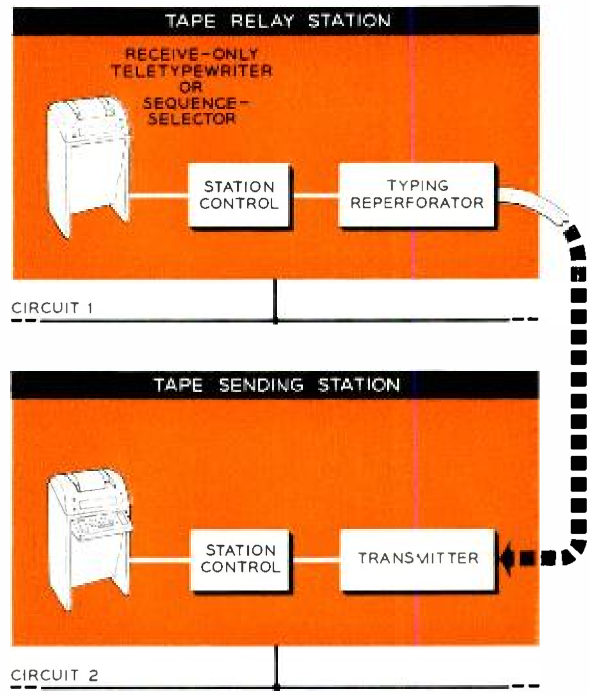
If another station sends a priority message before the station having a regular message receives its second poll, the registered count is cancelled and a new round of priority polling is started with the next station. After one complete round of priority polling with no priority messages, transmission starts either for a priority message introduced since the last poll or for a regular message that has been waiting.

When a station transmitter is started, it sends the CDC's that direct the message to the proper stations. The sending of a CDC stops the transmitter at the sending station, which waits for an answer back from the called station. This answer back is also a letter V, but it now indicates that the machine at the called station is ready to receive a message. The arrival of the V at the sending station restarts the transmitter for the sending of the rest of the message.

At a keyboard sending station, the station attendant indicates that there is traffic to send by pushing a "keyboard send" button which makes a bid to send. This is equivalent to placing tape in the transmitter at a tape-sending station. In this case, when the station is polled a LTRS character is sent back to simulate the start of sending. An audible alarm is also sounded to tell the station attendant that there is a 10-second period during which keyboard sending must begin. If there is no sending in 10 seconds, the transmitter-start circuit will automatically send an end-of-message code followed by a V. The station attendant must then wait until the station is polled again.



The "interline" switching arrangement used for interchanging traffic among two or more circuits.



With station arranged for relaying messages, tape is taken from a reperforator and is then transmitted over another teletypewriter circuit.

Optional equipment is available to permit station CDC's to be sent by operating pushbuttons instead of punching tape or sending them by keyboard. If a message is to go to a number of stations, all of the required CDC's may be set up in the pushbutton circuit before the tape is inserted in the transmitter. They will then be sent, ahead of the material in the tape, when the station next receives a proper poll.

Relays and stepping switches code and program the CDC's, and an auxiliary distributor applies the signals to the line. At a keyboard sending station, the use of pushbuttons is the same as at a tape sending station. After the pushbutton unit has sent an end-of-address code, it remains idle and the operator has ten seconds in which to start sending. When the pushbutton unit first starts sending CDC's, the alarm sounds to alert the attendant to the fact that his station has been polled and that he can send after the remaining CDC's have been transmitted.

Any station on a line may be used for relaying messages to and from another line. This arrangement is shown in the drawing at the top of page 67. A typing reperforator is arranged to be called in by a suitably assigned CDC, and the message for relaying to another line is received in punched tape. This tape is torn off the reperforator and is carried manually to the transmitter of the line for which it is intended.

Any station on a line may also be used as an automatic "interline" switching point for the interchange of traffic with another similar line or with more than one. This type of setup is illustrated in the diagram at the bottom of page 67. Messages are relayed with reperforator transmitters, and each line requires one reperforator transmitter for each additional line in the system. Like any other station on the line, the receiving portion of each reperforator transmitter is arranged to be called in by a suitably assigned CDC. The transmitter portion of each reperforator transmitter is assigned a TSC on the line to which the message is to be relayed. Also like any other station on the line, this transmitter will therefore be started in its proper order and will send the message stored in the teletypewriter tape.

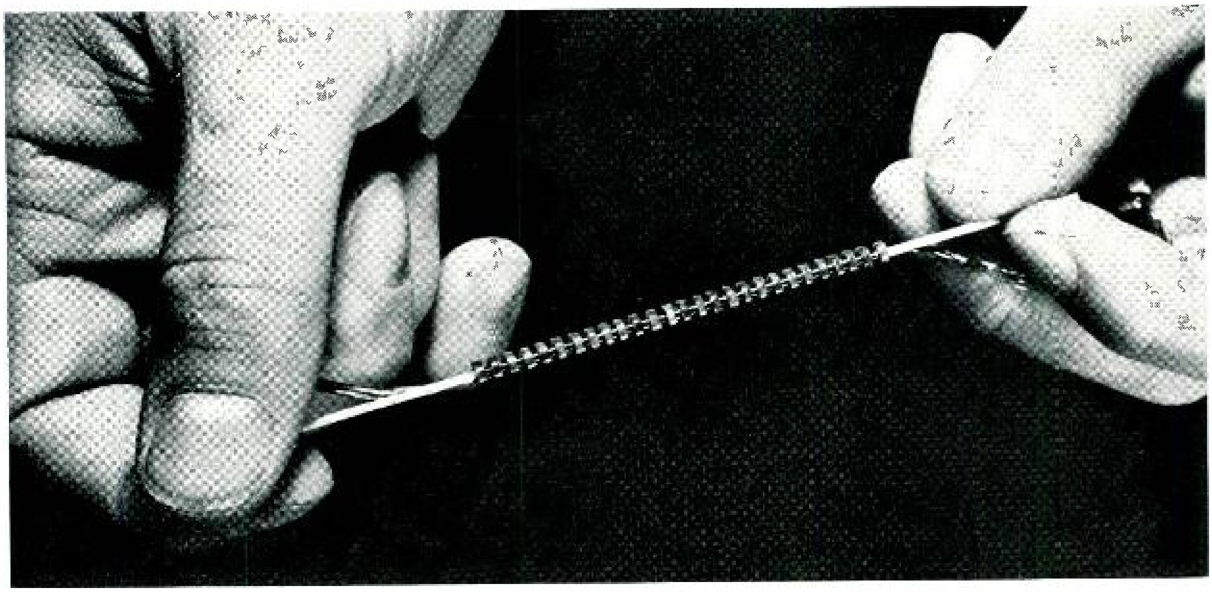
If a pushbutton unit is used, the operator presses the buttons corresponding to the stations to which the message is to be directed. The pushbutton unit sends all codes for its own line, for the reperforator station, and for the stations on other lines.

The system has several features that prevent its automatic operation from being stopped by trouble affecting only part of the system, such as trouble in one or more individual stations. These features cause an alarm to indicate the location of the trouble, while operation of the rest of the system proceeds normally. If no response is received from a TSC, the transmitter-start circuit times out for two seconds, sounds an alarm, and resumes the polling cycle with the next station. This alarm is momentary, but it repeats each time the station in trouble is polled. For positive identification, the attendant, by throwing a key, can cause the polling to stop on the next round at the station which does not respond. This causes an alarm with a fixed light and continuous buzzer. The attendant may then operate a "skip key" for that station, which prevents it from being polled again until the trouble is found and until the station has been restored to service.

The author (right) and T. A. Marshall discussing the stunt box in control station equipment.

In addition to the teletypewriters required, the 83B1 system includes units of control equipment — relays, stepping switches, electron tubes and associated equipment, together with power supplies, all mounted in apparatus cabinets. Also, mounted on a teletypewriter table or the console, are small key and lamp cabinets which include the various signal lamps, control keys and pushbuttons used in the operation of the system.

The 83B1 system is expected to fill a growing need for improved teletypewriter service in cases where station selection on party lines, with the elimination of circuit contention, is important. The system will have particular appeal because of its flexibility and its consequent capability of being adapted to many diverse uses. For the future, new equipment designated the 83C1 selective-calling system is now under development. This is a full-duplex system permitting outlying stations to send and receive simultaneously to the control office.



New Shift Register Uses "Twistor" Principle

A new shift register that uses a single magnetic wire as the memory element is currently under development at Bell Laboratories. This new device is reversible and does not use diodes, and promises to be cheaper to build than conventional shift registers. It was described at the recent Conference on Magnetism and Magnetic Materials in Philadelphia in a paper prepared by A. H. Bobeck and R. F. Fischer of the Solid-State Device Development Department.

Shift registers are used in most electronic computers and in other memory applications. They are essentially temporary storage devices and perform somewhat the same function as delay lines, except that the stored information, in the form of pulses, can be shifted along at will.

The new shift register takes advantage of the "twistor" technique recently developed at Bell Laboratories (RECORD, *December*, 1957). In the twistor, a twisted wire of magnetic material can be magnetized most easily in a spiral direction and can store pulses when subjected to a suitable magnetizing field. The amount of twist regulates the magnetic interactions between zones of the wire. These magnetized zones, which are essentially storage areas, can be slid along the wire under the control of externally applied "advance" pulses.

In the experimental shift register, information "bits" are written in and slid along by means of tiny eight-turn solenoids, each 0.075-inch long and spaced 0.075 inch apart. These coils are wound on a ceramic tube, and the magnetic wire (0.002-inch diameter permalloy) is stretched through the center of the tube.

Simultaneous pulsing of three adjacent coils inserts a magnetized zone, or information bit, into the register. Two coils must be pulsed to slide this zone along the wire. For example, if a bit is stored by pulsing coils 1, 2 and 3, it can be moved along one space by properly pulsing coils 1 and 4. The pulse current in coil 4 required for the advance operation is about 140 ma. To clear the wire after a bit has been advanced, coil 1 is pulsed with about 240 ma.

To read out the signal at the end of the register, a pulse of about 170 ma is passed through three special "read-out" coils. If a bit is present, a voltage pulse appears across the magnetic wire. In the absence of a bit, there is no voltage.

Present registers are capable of storing three bits per inch, and calculations have shown that the capacity can be increased to about ten bits per inch. This register can easily be made to propagate information in either direction. Since diodes are not required, the drive power is considerably reduced. The upper limit on the bit rate has not yet been established, but it is believed that a rate of several hundred thousand bits per second should be possible.

F. R. KAPPEL DESCRIBES BELL DEFENSE PROJECTS

Stresses Laboratories Developments

The communication arts play a vital role in national defense, A.T.&T. President Frederick R. Kappel recently told members of the New York Chamber of Commerce. Speed and control, and speed of control, are essential to military operations, he said, and it is these essentials which a modern system can provide.

The over-all telephone network is of basic importance, Mr. Kappel stated. "This total network is enormous. The Bell System operates over 100 million miles of circuits within cities and more than 60 million miles between cities, and every inch can be linked together and the network also connects with the lines of other telephone companies."

By-Pass Routes

Intercity lines are diversified so that more than one route connects principal cities, and just as important, there are alternate routes around cities. "This is to protect the communication system so we can handle emergency messages under any circumstance whatever," he said. Recently the Bell System has built thousands of miles of cross-country lines that skirt critical target areas, and has also built communication arcs or circles around big cities. All connect with existing routes.

"This diversity, the great size of the total network, and its complete interconnection, are the nation's prime asset to insure uninterrupted communication — control — command. The reason is not hard to understand. If any control system, civil or military, depends on a single communication facility which is separate from all the rest, then its destruction leaves no option. The communications it was intended to provide are gone, period. What is essential is that all facilities be integrated, so that if one part is lost another can be used."

Warning Lines

Within the big network are numerous special networks for military and other defense agencies. For example, Western Electric and Bell Laboratories contributed heavily to the technology of the DEW Line. Another special network is White Alice — the Alaskan communication system that covers 3100 miles of the most rugged country in the world. This system serves not only as a warning net, but also as a connection by telephone for the more remote sections of Alaska.

The special networks vary in many ways, Mr. Kappel explained. Some are voice networks and some are teletypewriter networks, while others carry complex data. They bring intelligence from the DEW Line and White Alice, radar lines in Canada, picket ships, patrolling radar planes, and from Texas Towers at sea.

Some converge on NORAD in Colorado, headquarters of North American Air Defense. Other networks radiate from SAC (Strategic Air Command) headquarters near Omaha. A voice network is ready to warn 300 cities simultaneously of the location and speed of approaching aircraft. "In all these operations, the need for dependability is paramount," Mr. Kappel emphasized.

This is also an absolute must in the complex SAGE (Semi-Automatic Ground Environment) system now being built to automate air defense to a very considerable degree. As Mr. Kappel pointed out, "the SAGE system was deliberately designed by the Lincoln Laboratory at M.I.T. to *take advantage* of the existing telephone network.

"In developing and manufacturing telephone equipment," Mr. Kappel said, "our goal has always been to get the most reliable and economical *use* — not to sell the most articles in the fastest time. This emphasis on dependability fits right in with military needs. To illustrate: any electronic system you put in a missile, a few feet away from a screaming rocket engine, has to be rugged to say the least.

"Again, Bell System people are accustomed to bringing a lot of things together to form complex systems. Any dial system for example is fairly complex, and long distance dialing is remarkably so. Experience of this sort is useful in creating military warning and weapon systems, which are very complex indeed."

Seagoing telephone cables are also important to defense. Mr. Kappel pointed out that they have capabilities of a much higher order than overseas radiotelephone circuits. "These are among the most sophisticated developments in the whole art of communications. . . . They are not subject to interruption by magnetic storms. They cannot be jammed."

Missile Systems

Mr. Kappel also cited the Nike missile systems developed at Bell Laboratories and built by the Western Electric Company. Nike Ajax (*see page* 53) was the first operational ground-to-air guided missile in the United States. "Now we are producing a new Nike called Hercules. This has a much longer range and can carry nuclear warheads."

We are now working on a new Nike called Zeus, Mr. Kappel said. "It is an anti-missile missile — to find and destroy an attacking ICBM. . . . Radars for Zeus are completely new in design and use materials never before employed for such a purpose. Without exact knowledge of how these materials will behave, we wouldn't dare to use them. This illustrates . . .

the usefulness of having basic research and other functions combined in a single organization."

Mr. Kappel also talked about other defense work:

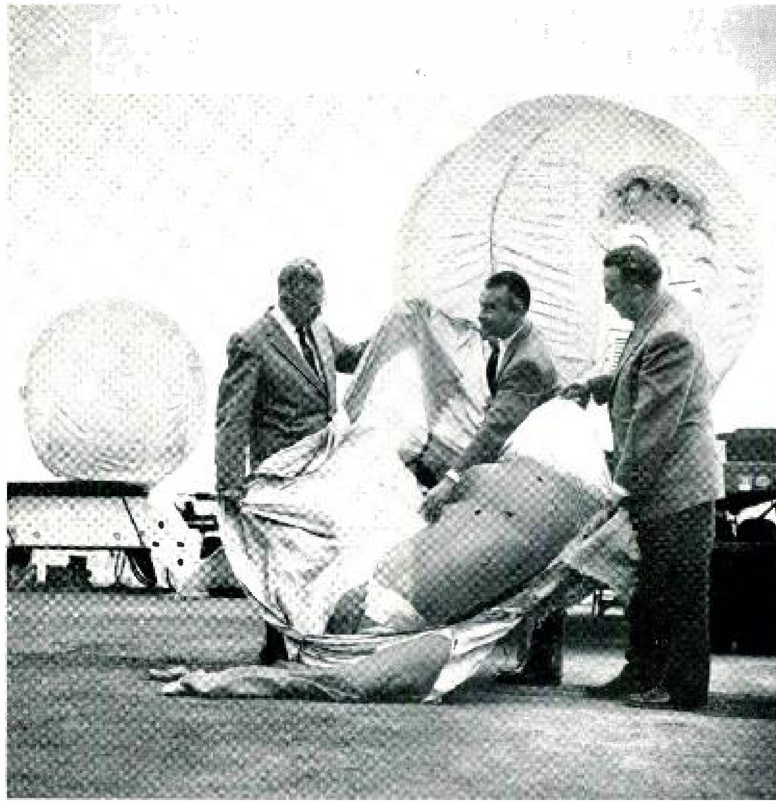
- A guidance system for the Titan ICBM being tested at Cape Canaveral;
- Communications for BMEWS (Ballistic Missile Early Warning System) being developed for the Air Force — another project that reaches to the far North;
- Work at the Sandia Laboratory, which the Western Electric Company manages on a non-profit basis for the Atomic Energy Commission;
- The 1370-mile ocean cable from Cape Canaveral to Puerto Rico that transmits data on missile test flights back to Canaveral.

Mr. Kappel said that Bell Laboratories research, including invention of the transistor and formulation of "communication theory" has already had decisive influence on the future of communications, including military systems.

"All guidance systems for ICBM's, for example, use transistorized computers," Mr. Kappel said; "in fact, nearly all new military computers are being designed around transistors and related devices. . . . TRADIC, developed at the Laboratories, pointed the way. . . . Our Zeus and Titan missile guidance systems likewise make extensive use of communication theory.

Mr. Kappel pointed out that transistors are in the communication equipment that ties Nike batteries together. "They convert radar signals into data. They are in a Navy system which permits an aircraft carrier to direct operations of a hundred planes simultaneously over a single radio channel. They send word back to earth from our satellites in space."

"Out of basic research in communications," Mr. Kappel said, "have come some of our strong reasons for hope and confidence that the country will successfully meet its military challenges."



NIKE HERCULES TEST — In the first test of its lethal capability at an altitude of more than 100,000 feet, the Nike Hercules missile — fired by a Bell Laboratories-Douglas Aircraft team — successfully intercepted and destroyed its target. Examining the parachute which served as a target for this historic kill are L. W. Morrison, Director of Guided Missile Development, right, H. G. Och, Director of Missile Systems Development, left, and R. W. Benfer, Military Development Engineer who supervised the successful shot at the White Sands, N. M., Missile Range. Mr. Benfer is pointing to the holes in the parachute that prove a direct hit. In the background are two tracking radars used for guiding the supersonic Hercules missile.

A second encouraging report on the performance of the Hercules missile was also received recently. The Army revealed that a Hercules missile — also fired by a Laboratories-Douglas team — had destroyed a supersonic target flying faster than 1,500 miles an hour and more than 12 miles high. This, the Army said, was the first time any air-defense missile had scored a "kill" at this speed and range. This and the altitude test were some of the latest of more than 200 tests of the Nike Hercules under many different target and intercept conditions. The Hercules has a range of about 75 miles.

Bell Laboratories, at its Whippany, N. J., location, has over-all responsibility for the design and development of the Nike Hercules System. Western Electric, the prime contractor, produces the electronic equipment and Douglas produces the missile.

news notes

Dr. Kelly Appointed to Study Science Agencies of Commerce Department

Dr. M. J. Kelly, Chairman of the Board of Bell Laboratories, has recently been named head of a special committee appointed by the National Academy of Sciences to study the scientific programs of the U. S. Department of Commerce, and to recommend new steps to gear these programs to the rapidly changing needs of science and industry. Announcement of the appointment of the special committee, composed of scientists and research administrators, was made by Lewis L. Strauss, Secretary of Commerce, and Dr. Detlev W. Bronk, President of the National Academy of Sciences — National Research Council.

Secretary Strauss and Dr. Bronk stated that the committee will study the requirements of science and industry for services of the type the Department of Commerce can provide and will investigate new or improved means of meeting these requirements. The committee will also study assured methods of relating the Department's programs to the improving techniques afforded by progress in the fields of science and technology.

The National Academy of Sciences — National Research Council is a private organization of distinguished scientists dedicated to the furtherance of science and its application to the general welfare. Under its Congressional Act of Incorporation, the organization is called upon to advise the Federal Government, upon request, in relation to all matters that are of scientific and technical interest to the nation.

New Powder-Pattern Technique Delineates Ferroelectric Domains

A new method for delineating the domain structure at the surface of ferroelectric crystals was described recently by G. L. Pearson and W. L. Feldmann of the Solid-State Electronics Research Department in a paper presented to the American Physical Society in Chicago. This new tool will be very valuable to physicists and physical chemists exploring the fundamental structure of matter, and has been used to delineate domain structures in great detail on a wide variety of crystals in which domains have never been observed before. The powder-pattern method should be applicable to the study of charged surfaces of piezoelectric and pyroelectric crystals as well as ferroelectric materials.

The basis of the new technique is the use of colloidal suspensions of electrostatically charged powders in an insulating organic liquid. A few drops of this suspension are applied to the face of the crystal and the charged powder is immediately attracted to the entire area of the ferroelectric domains carrying an opposite charge (*see cover photograph*).

The most effective charged powders are commercial, spray-grade sulfur and red lead-oxide, each suspended in hexane — a fluid of low viscosity and low dielectric constant. The sulfur deposits on the negatively charged domains, while the lead-oxide deposits on the positively charged domains. Each of the suspensions is applied separately; the second is not applied until the hexane in the first has evaporated.

If the two suspensions mix on the crystal surface, each may lose its charge. In this event, no pattern is formed. The powders are fixed in place indefinitely by their electrostatic charges after the hexane evaporates. The yellow sulfur and red lead-oxide provide brightly colored delineation of the positive and negative domains, and the resultant pattern shows great detail.

The physical basis of the new technique lies in the fact that although the colloid as a whole is electrically neutral, individual particles acquire a diffuse, double-layer charge when brought in contact with the liquid. Under the influence of this "built-in" electric field, the colloidal particles are attracted either to the positive or negative domains, depending on the orientation of their dipole layers.

This new technique has provided the first information available on the domain structure of a number of crystalline ferroelectrics, including triglycine sulfate and guanidinium aluminum sulfate hexahydrate. Previous optical determinations made on Rochelle salt, and domain-etching procedures on barium titanate, have also been confirmed by the new method.

Bell System Made Large Gains in Service in 1958

Bell System earnings for 1958 should show an improvement over 1957, F. R. Kappel, president of the A.T.&T. Co. indicated in a year-end statement.

He said: "Earnings of the System in 1958 have been running ahead of 1957 and we expect this improvement will be further reflected in the full year's results. Important factors in earnings progress have been increased efficiency in operations, increases in telephone rates in some states and broadening effort to promote and sell what we believe is more and more useful and attractive service."

Telephone growth slowed temporarily in the early months of

1958, but turned upward in the summer, Mr. Kappel noted, and he also pointed out that the increase in telephones for the full year will be near 2,500,000. About 2,815,000 telephones were added to the Bell System in 1957.

"To expand telephone facilities and continue our program of service betterment, the Bell Companies spent 2.2 billion dollars this past year for construction," Mr. Kappel said. And he added that the Bell System, for the fourth consecutive year, expects to spend more than 2 billion dollars for construction in 1959.

Regarding the recently proposed split in A.T.&T. stock, Mr. Kappel said, "the A.T.&T. Company has announced that it will propose a three-for-one stock split at the Annual Meeting of share owners on April 15. The reasons for this proposal were stated at the time of the announcement. If it is approved it is expected that the first quarterly dividend on the split shares will be paid in July at the rate of $0.825 a share, which would be an annual rate of $3.30 per share. As always," he concluded, "it will be our continuing policy and effort to safeguard the interests of our share owners, who now number more than 1,600,000."

Three Laboratories Men Lecture on Televised Course in Physics

W. H. Brattain and A. N. Holden of the Physical Research Department, and G. Weinreich of the Solid-State Electronics Research Department, presented lectures recently on the NBC network's "Continental Classroom," a college-level physics course. Mr. Brattain's talk was telecast January 30 and Mr. Weinreich's on February 2. Both talks in this two-lecture series were about semiconductors and their applications.

Mr. Brattain's early studies of semiconductors led him and fellow researchers to the discovery of the transistor effect, and brought them the 1956 Nobel Prize in Physics. In his lecture, Mr. Brattain performed experiments on semiconductors and discussed the background concepts leading to the p-n junction. Mr. Weinreich's discussions, which also included several demonstrations, covered the p-n junction and later transistor devices.

Early in December, Mr. Holden's half-hour talk on crystals described where they are found and how they are constituted. Mr. Holden also helped plan the "Continental Classroom" course, designed to provide students — primarily high-school science teachers — with up-to-date information on new developments in atomic-age physics.

Laboratories Cited for Brussels Fair Exhibits

Bell Laboratories has received a citation from the U. S. Department of State for assistance in the preparation of exhibits for the Brussels Fair. The citation reads in part: "It was through contributions such as yours, generously and willingly made in the public interest, that the United States could present to the world, at Brussels, a representative picture of our land and our people."

Similar individual citations were also presented to Vice President W. O. Baker, R. O. Grisdale of the Chemical Research Department, and H. J. Kostkos, exhibit supervisor in the Publication Department. The Laboratories exhibits at the Fair featured various phases of semiconductor and crystal research.

The Call Director

A compact and versatile new telephone — the "Call Director" — was introduced throughout the Bell System early last month. The new instrument, developed at Bell Laboratories, is a multi-button unit designed principally for people who make a lot of calls or who answer telephones for a number of people.

The call director was conceived for two general purposes: as a replacement for the wood "key boxes" now in use; and as a versatile new station instrument for use with new intercommunication systems like the 6A Key Telephone System (RECORD, *March*, 1958). With these new systems, the call director can be used to arrange conference calls, "camp-on" busy extensions, "add-on" extensions to incoming calls, and furnish many other intercommunication services.

Circuitry for the call director was developed under the direction of L. H. Allen of the Station Apparatus Development Department. The mechanical design and design-for-manufacture were done at the Indianapolis location of Bell Laboratories under the direction of W. G. Turnbull.

The new set is being offered in two models — one with 18 push buttons and one with 30 — and in four colors: light gray, moss green, ivory and beige.

Soil-Test Program For Materials, Structures

Bell Laboratories engineers have recently started an "outside plant materials and structures soil-burial program" to test the effects of burial on various items of outside-plant equipment. The program involves the actual burial of nearly 11,000 telephone items in 11.5 acres of moist, rich earth near Bainbridge, Georgia.

Plans now call for digging up replicates of these materials and structures after approximately 1, 2, 4, 8, and 16 and 32-year periods to see how they have withstood the rigors of burial. They will have no protection against the moisture and high biological activity which are common to the soil in this area.

Nine thousand small samples — mostly laminates, adhesives, plastics and various types of rubber — are buried on vertical polyethylene tubes in a five-acre portion of the tract. Nineteen hundred insulated wire coils, with voltage on half of them, are buried two feet below the surface of the ground in a quarter of the plot. The remainder of the area is given over to a variety of larger pieces of apparatus, including several 200-foot lengths of energized cable, laid in undulating lines to see how they will react to burial at different depths.

Plans call for acquiring a second tract in the Southwest, where the same kinds of materials can be tested under the different conditions found in alkaline soil. Results from both plots will help "bracket" conditions to which these materials may react when buried throughout the United States.

The program stems from a growing interest in "buried distribution": the burial of telephone wires and cables without the extra protection provided by conduit. There has been a sharp rise in the burial of telephone facilities in the last two years, and this trend is expected to continue.

The soil-burial program is being conducted by the Environmental Protection Group in the Outside Plant Development Department at the Murray Hill, N. J., location of the Laboratories. The Chemical Research Department, which made up most of the 10,000 small materials and wire samples, is cooperating in the test program.

W. W. Bradley heads the Environmental Protection Group and is supervising the burial program, which is being carried out under the direction of R. A. Connolly. L. R. Snoke has over-all responsibility for the project.

Sandia to Continue Under A.E.C. Contract

A contract has been signed under which Sandia Corporation, a subsidiary of Western Electric, will continue operation of the Sandia Laboratory at Albuquerque, New Mexico, and Livermore, California; the contract is for a period of five additional years.

The contract enables Sandia Corporation to draw as required upon all divisions of Western Electric and Bell Laboratories and other Bell companies for scientific services, technical and managerial assistance.

Sandia Corporation operates the Sandia Laboratory for the Atomic Energy Commission on a nonprofit basis as a design and development agency in the nation's nuclear weapons program. At the request of the A.E.C., the Western Electric Company established the Sandia Corporation in 1949 to operate Sandia Laboratory, which up to that time had been a branch of the Los Alamos Scientific Laboratory. The Laboratory has since grown to a $73,000,000 facility employing more than 7700 persons, approximately 500 of whom are located at Livermore. It is the A.E.C.'s major laboratory for the ordnance phases of nuclear weapons research and development.

North Carolina Cited For Quality Control

The Quality Control and Assurance Program at Western Electric's North Carolina Works received recognition from U. S. Army Ordnance recently, as the Army announced that it will discontinue its regular inspections and rely almost entirely on the company for quality assurance in future production of Nike missile components.

The Ordnance Quality Assurance Program, under which the Army will reduce its inspection schedule to occasional spot checks, is a new concept of the government's reliance on industry's ability to control quality of items throughout the various production phases, in preference to the outmoded and costly process of screening defective material after completion.

The new procedure is in line with a Bell Laboratories recommendation to the Ordnance Department regarding companies which have their own reliable quality assurance technique. The Laboratories is a consultant to the Ordnance Department on matters of quality assurance in the development and manufacture of the Nike system.

Speaking at a recognition ceremony in Winston-Salem, an Army official stated that "to the knowledge of the Greensboro Ordnance Office, this is the first instance in which the production and inspection system of a major contractor producing a complex guided missile system, which is fully operational, has received initial formal approval."

The World's Telephones

The 1958 edition of *The World's Telephones*, an authoritative report on telephone statistics compiled and released by the A.T.&T. Company, shows that the United States averaged 460 conversations per person during 1957, but trailed the Canadian average of 497 and the Swedish conversation rate of 491. These figures relate to the beginning of 1958, since it takes almost a year to gather the information from the 200 countries surveyed.

Geographically, the most talkative telephone area in 1957 was Alaska, where each person averaged 581 conversations. Iceland also ranked high, with an average of 452 calls a person. The world in general — including people who have never seen or heard of a telephone — averaged 56 telephone conversations per person. This compares with 51 for the preceding year.

The world telephone survey records a world total of 117,800,000 telephones in service on January 1, 1957, a gain of nearly 8,000,000 over 1956. The United

States, with 63,621,000 telephones, led the countries with the largest systems. The United Kingdom was second with 7,354,000. Canada reported 4,816,118; the German Federal Republic (West Germany), 4,731,945; Japan, 3,886,327; and the U.S.S.R. reported 3,558,000. The Russian statistics were the first to be reported from that country since 1936.

Based on the statistics, the new edition of *The World's Telephones*, also shows:

- For each 100 persons, the U. S. had 37 telephones as of January 1; Sweden had 33; Canada, 29; and Switzerland, 27. The United Kingdom had about 14; West Germany, nine; Japan, four; and the U.S.S.R., two. For the entire world, the figure was four telephones.
- Two cities — New York with 4,204,007 telephones and Chicago with 1,800,103 — had as many telephones as there were in all of Asia, where more than half of the world's people live. New York City alone had more telephones than there were in France. Among the foreign cities, London, with 2,149,000 telephones, had the largest number.
- Washington, D. C., with 70 for each 100 persons, had the greatest telephone saturation for metropolitan areas. Stockholm, with 57, occupied a similar first place among cities outside the United States. Moscow, with 454,000 telephones, had nine for each 100 persons.

Contents of January, 1959, Bell System Technical Journal

The January, 1959, BELL SYSTEM TECHNICAL JOURNAL contains the following articles:

Logic for a Digital Servo System, by R. W. Ketchledge.

Logic Synthesis of Some High-Speed Digital Comparators, by M. Nesenbergs and V. O. Mowery.

The Laddic — A Magnetic Device for Performing Logic, by U. F. Gianola and T. H. Crowley.

Radio Attenuation at 11 kmc, by S. D. Hathaway and H. W. Evans.

Space-Charge Wave Excitation in Solid-Cylindrical Brillouin Beams, by W. W. Rigrod and J. R. Pierce.

Space-Charge Wave Harmonics and Noise Propagation in Rotating Electron Beams, by W. W. Rigrod.

An Experimental Visual Communication System, by F. K. Becker, J. R. Hefele and W. T. Wintringham.

The Z Transformation, by H. A. Helm.

Radio Transmission into Buildings at 35 and 150 mc, by L. P. Rice.

On Trunks with Negative Exponential Holding Times Serving a Renewal Process, by Václav E. Beneš.

High-Frequency Gallium Arsenide Point-Contact Rectifiers, by W. M. Sharpless.

Paramagnetic Spectra of Substituted Sapphires — Part I: Ruby, by E. O. Schulz-DuBois.

Paramagnetic Resonance Spectrum of Cr^{+++} in Emerald, by J. E. Geusic, Martin Peter and E. O. Schulz-DuBois.

R. W. Hamming Named To Paris Conference on Information Processing

Richard W. Hamming, a member of the Mathematical Research Department at Murray Hill, has been appointed a rapporteur for the First International Conference on Information Processing to be held in Paris next June. Mr. Hamming is one of five persons from the U. S. and thirteen throughout the world chosen for their knowledge of computers to keynote the conference sessions. His topic will be error detection and corrections.

The conference is being sponsored by the United Nations Educational, Scientific and Cultural Organization.

W. O. Baker Serves In Two Advisory Posts

W. O. Baker, Vice President—Research at Bell Laboratories, has recently been named to serve in advisory positions with the National Science Foundation and the American Chemical Society.

As announced by Alan T. Waterman, Director of the National Science Foundation, Dr. Baker will serve as a member of the Science Information Council, composed of scientists, leaders in the field of scientific documentation, and representatives of the lay public. The Council will act as consultants to the Foundation's Science Information Service, set up by The National Defense Education Act of 1958. The purpose of this Service is to make scientific literature in all languages more readily available and thus shorten the time spent by scientists and engineers in searching for needed information. The Service also seeks to bring about effective coordination of the various scientific information activities within the Federal Government and to improve cooperation between government and independent scientific information programs.

The American Chemical Society has also announced that Dr. Baker has accepted membership in the Society's group advising on information matters. The group serves as a consulting body for the ACS Applied Publications and the ACS News Service.

C. Herring Receives Oliver E. Buckley Prize in Physics

Conyers Herring, a member of the Physical Research Department at the Murray Hill location of Bell Laboratories, has been named winner of the 1959 Oliver E. Buckley Solid-State Physics Prize of the American Physical Society. He received the prize at the Society's annual banquet, January 30, in New York City. As winner of this year's prize, he will deliver the Oliver E. Buckley Lecture at the Society's March meeting in Cambridge, Mass.

The award was established in 1952 with a $50,000 trust fund provided by the Laboratories and is named in honor of its former President and Chairman who retired that year. It is presented annually to a person making a most important contribution to the advancement of knowledge in solid state physics within the five years immediately preceding the award. Mr. Herring, a specialist in theoretical physics of the solid state, will be cited for his interpretation of the transport properties of semiconductors.

Previous Buckley prizewinners include William Shockley and John Bardeen, former Laboratories members, who won it in 1953 and 1954, respectively.

M. B. McDavitt Wins A.I.E.E. Prize for Paper

A paper written by M. B. McDavitt, Director of Transmission Development, has been awarded first prize among those authored by members of the Communications Division of the American Institute of Electrical Engineers. The paper, "6,000-Megacycles-Per-Second Radio Relay System for Broad-Band Long-Haul Service in the Bell System," was published in the A.I.E.E.'s *Communications and Electronics* magazine for January, 1958.

Mr. McDavitt originally presented the paper in Rome in June, 1957, at a Symposium on Radio Links held under the patronage of the National Research Council of Italy (*see* RECORD, *July*, 1957). The paper was presented again in Chicago in October, 1957, at the A.I.E.E.'s fall general meeting.

Mr. McDavitt received the award February 2 during the A.I.E.E.'s winter general meeting in New York City.

PATENTS

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

Abbrecht, R. L. and Vroom, E. —*Record-Controlled Computing Recording System* — 2,865,568.

Albersheim, W. J. — *Electromagnetic Wave Equalization System* — 2,863,127.

Anderson, J. R. — *Pulse Signaling Circuit* — 2,864,079.

Anderson, O. L. — *Treatment of Glass* — 2,865,139.

Blake, J. T. and Ely, A. L. — *Diode Gate and Sampling Circuit* — 2,866,103.

Boyle, W. S. and Smith, J. L. — *Velocity Measurement of Relay Contacts* — 2,864,054.

Burns, F. P. — *Piezoresistive Acoustic Transducer* — 2,866,014.

Cook, J. S. — *Traveling Wave Tube* — 2,863,086.

DeLange, O. E. — *Microwave Pulse Circuits* — 2,864,953.

Dimond, T. L. — *Automatic Wiring System and Apparatus* — 2,862,671.

Dunning, S. F. and MacPherson, D. H. — *Telephone Service Concentrator* — 2,863,950.

Ely, A. L., see Blake, J. T.

Franz, E. E. — *Electrical Network Assembly* — 2,862,992.

Kater, J. A. and Weeks, J. R., Jr., — *Method of Clearing Electrical Capacitors* — 2,865,083.

Kock, W. E. — *Wave Guide Elbows* — 2,865,008.

Kronacher, G. — *Multipole Pair Resolver* — 2,866,913.

Locke, G. A. — *Teletypewriter Exchange System* — 2,863,936.

MacPherson, D. H., see Dunning, S. F.

Mallina, R. F. — *Automatic Wiring Apparatus* — 2,862,670.

Matthias, B. T. — *Superconducting Compounds* — 2,866,842.

Miller, R. A., Nickerson, C. A. and Taris, C. M. — *Automatic Telephone Answering and Message-Recording System* — 2,866,852.

Moore, E. F. — *Relay Selecting Circuit* — 2,864,008.

Nickerson, C. A., see Miller, R. A.

Pierce, J. R. — *Tapered Wave Guide Delay Equalizer* — 2,863,126.

Potter, R. K. — *Electric Printer for Magnetic Codes* — 2,863,712.

Robertson, S. D. — *Traveling Wave Tube Structure* — 2,863,085.

Smith, J. L. — *Protection Circuits for Activated Contacts* — 2,864,976.

Smith, J. L., see Boyle, W. S.

Straube, H. M. — *Transistor Detector* — 2,864,002.

Sumner, E. E. — *Transistor Circuit for Operating a Relay* — 2,864,975.

Taris, C. M., see Miller, R. A.

Tillotson, L. C. — *Microwave Calculators, Isolators and Branching Filters* — 2,866,949.

Vroom, E., see Abbrecht, R. L.

Weeks, J. R., Jr., see Kater, J. A.

Williford, O. H. — *Tone Applier Circuit* — 2,866,854.

Wirth, H. J., Jr. — *Relay* — 2,866,030.

Zupa, F. A. — *Relay Mounting* — 2,863,102.

PAPERS

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

Ashkin, A., Bridges, T. J., Louisell, W. H., and Quate, C. F., *Parametric Electron Beam Amplifiers*, 1958 I.R.E. Wescon Convention Record, Part 3, pp. 13-22.

Benson, K. E., see Wernick, J. H.

Benson, K. E., see Lovell, Miss L. C.

Blattner, D. G. (Retired), and Ricker, R. H., *A New Design of Multicontact Connector of Low Insertion and Withdrawal Forces*, Reliable Electrical Connections, pp. 259-267, Nov., 1958.

Bozorth, R. M., *Origin of Weak Ferromagnetism in Rare-Earth Orthoferrites*, Phys. Rev., Letter to the Editor, 1, pp. 362-363, Nov. 15, 1958.

Bridges, T. J., see Ashkin, A.

Buck, T. M., and McKim, F. S., *Effects of Certain Chemical Treatments and Ambient Atmospheres on Surface Properties of Silicon*, J. Electrochem. Soc., 105, pp. 709-714, Dec., 1958.

Clogston, A. M., *Structure of the Metastable State of Mn^{++} and Fe^{+++}*, J. Phys. and Chem. Solids, 7, pp. 201-206, Nov., 1958.

Closson, H. T., Danielson, W. E., and Nielsen, R. J., *Automatic Measurement of Small Deviations in Periodic Structures*, Rev. Sci. Instr., 29, pp. 855-859, Oct., 1958.

Collins, R. J., and Thomas, D. G., *Photoconduction and Surface Effects with Zinc Oxide Crystals*, Phys. Rev., 112, pp. 388-395, Oct. 15, 1958.

Corenzwit, E., see Matthias, B. T.

Danielson, W. E., see Closson, H. T.

Easley, J. W., *Comparison of Neutron Damage in Germanium and Silicon Transistors*, 1958 I.R.E. Wescon Convention Record, Part 3, pp. 148-156.

Eisinger, J. T., *Properties of Hydrogen Chemisorbed on Tungsten*, J. Chem. Phys., 29, pp. 1154-1160, Nov., 1958.

Fuller, C. S., see Wolfstirn, Miss K. B.

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

Guerard, J. P., and Weissmann, G. F., *Effect of Hydrostatic Pressure on SR-4 Strain Gauges*, Proc. of the Society for Experimental Stress Analysis, 16, pp. 151-156, Dec., 1958.

Herriott, D. R., *Recording Electronic Lens Bench*, J. Opt. Soc. Am., 48, pp. 968-971, Dec. 1958.

Hrostowski, H. J., and Kaiser, R. H., *Absorption Spectrum of Arsenic Doped Silicon*, J. Phys. and Chem. Solids, 7, pp. 236-239, Nov., 1958.

Irvin, H. D., *Sibyl: A Laboratory for Simulation Studies of Man-Machine Systems*, 1958 I.R.E. Wescon Convention Record, Part 2, pp. 277-285.

Kaiser, R. H., see Hrostowski, H. J.

Knab, E. D., *Connections Made To Printed Circuit Boards Through Resistance Fusing*, E.I.A. Con. on Reliable Electrical Connections, Compendium of Papers, pp. 181-189, 1958.

Laudise, R. A., *Hydrothermal Crystallization*, Growth and Perfection of Crystals (Book), John Wiley and Sons, Inc., 1958, pp. 458-467.

Louisell, W. H., see Ashkin, A.

Lovell, Miss L. C., Wernick, J. H., and Benson, K. E., *Dislocation Etch Pits in Tellurium*, Acta Met., 6, pp. 716-720, Nov., 1958.

Matthias, B. T., Suhl, H., and Corenzwit, E., *Ferromagnetic Superconductors*, Phys. Rev., Letter to the Editor, 1, pp. 449-450, Dec. 15, 1958.

McKim, F. S., see Buck, T. M.

Monk, N., and Guernsey, E. D. (Ohio Bell), *Personal Signaling, a New Telephone Service*, 1958 I.R.E. Wescon Convention Record, Part 8, pp. 76-83.

Mowery, V. O., *Theoretical Surface Conductivity Changes and Space Charge in Germanium and Silicon*, J. Appl. Phys., 29, pp. 1753-1757, Dec., 1958.

Nielsen, R. J., see Closson, H. T.

Quate, C. F., see Ashkin, A.

Ricker, R. H., see Blattner, D. G.

Rigterink, M. D., *Ceramic Electrical Insulating Materials*, J. Am. Ceramic Soc., 41, pp. 501-506, Nov. 1, 1958.

Suhl, H., see Matthias, B. T.

Tartaglia, A. A., see Trumbore, F. A.

Thomas, D. G., see Collins, R. J.

Trumbore, F. A., and Tartaglia, A. A., *Resistivities and Hole Mobilities in Very Heavily Doped Germanium*, J. Appl. Phys., Letter to Editor, 29, p. 1511, Oct., 1958.

Unger, S. H., *A Computer Oriented Toward Spatial Problems*, Proc. I.R.E., 46, pp. 1744-1750, Oct., 1958.

Weissmann, G. F., see Guerard, J. P.

Wernick, J. H., see Lovell, Miss L. C.

Wernick, J. H., Geller, S., and Benson, K. E., *Constitution of the $AgSbSe_2$—$AgSbTe_2$—$AgBiSe_2$—$AgBiTe_2$ System*, J. Phys. and Chem. Solids, 7, pp. 240-248, 1958.

Wolfstirn, Miss K. B., and Fuller, C. S., *Comparison of Radio-Copper and Hole Concentrations in Germanium*, J. Phys. and Chem. Solids, 7, pp. 141-145, Nov., 1958.

TALKS

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

I.R.E.-A.I.E.E. 2nd NATIONAL SYMPOSIUM ON GLOBAL COMMUNICATIONS, St. Petersburg, Florida.

Gambrill, L. M., *System Planning for Global Military Communications.*

Tidd, W. H., *White Alice System — Design and Performance.*

Tidd, W. H., *Transmission Objectives for a World-Wide Military Communications Network.*

THIRD ELECTRONIC INDUSTRIES ASSOCIATION CONFERENCE ON RELIABLE ELECTRICAL CONNECTIONS, Dallas, Texas.

Baker, R. G., *Coatings for Contact Surfaces.*

Knab, E. D., *Connections Made To Printed Circuit Boards Through Resistance Fusing.*

Kuch, F. C., *A New Design of Multicontact Connector of Low Insertion and Withdrawal Forces.*

OTHER TALKS

Anderson, E. W., see McCall, D. W.

Anderson, O. L., *Adhesion of Metals in Air at Room Temperature,* A.S.M.E., Wilmington Section, Wilmington, Del.

Becker, J. A., *The Use of the Field Emission Electron Microscope to Study the Adsorption of Hydrogen and Acetylene on Tungsten,* Fordham University, New York City, N. Y.

Benes, V. E., *A New Approach to Queueing and Related Problems,* Operations Research Seminar, M.I.T., Cambridge, Mass.

Brattain, W. H., *Physics of Semiconductor Surfaces,* California Institute of Technology, Pasadena, Calif.

Crawford, R. V., *Transmission Tests on a Trial System of Telephone Service for Aircraft,* 9th National Conference of the Professional Group on Vehicular Communications of the I.R.E., Chicago, Ill.

David, E. E., see Schroeder, M. R.

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

Evans, D. H., *Multiplex Sampling,* A.S.Q.C. Princeton Conference, Princeton University, Princeton, N. J.

Feher, G., and Gere, E. A., *Electron Spin Relaxation Times in Phosphorous Doped Silicon,* American Physical Society, Los Angeles, Calif.

Ferrell, E. B., *Communications Research at Bell Telephone Laboratories,* Student Branch of the A.I.E.E.-I.R.E., University of Arkansas, Fayetteville, Ark.

Finch, T. R., *Components for Data Processing Systems,* A.I.E.E.-I.R.E., University of Colorado, Boulder, Colo., and University of Arizona, Tucson, Ariz.

Foote, H. L., Shair, R. C., and Smith, D. H., *Electrical Storage of Solar Energy,* Annual Meeting of American Society of Mechanical Engineers, New York City, N. Y.

Frisch, H. L., *Surface Tension of High Polymer Solutions,* Wyandotte Chemicals Corporation, Wyandotte, Mich.

Gere, E. A., see Feher, G.

Harmon, L. D., *Analogs and Models of the Human Visual System,* American Academy of Optometry, Boston, Mass.

Hopfield, J. J. *Band Structure and the Theory of Edge Emission in ZnO and CdS,* American Physical Society, Los Angeles, Calif.

Horn, F. W., *Even Count Polyethylene Insulated Cable,* Signal Corps Symposium, Asbury Park, N. J.

Ketchledge, R. W., *The Flying Spot Store,* Society of Motion Picture and Television Engineers, Rochester, N. Y.

Laudise, R. A., *Hydrothermal Crystallization,* Summit Association of Scientists, Summit, N. J.

Liehr, A. D., *The Coupling of Vibrational and Electronic Motions in Degenerate Electronic States of Inorganic Complexes,* R.C.A., Princeton, N. J.

Louisell, W. H., *Parametric Amplifiers,* Applied Physics Laboratory, Johns Hopkins University, Silver Spring, Md.

Mayo, J. S., *Optimum Switching Servomechanisms,* Meeting of the Eastern North Carolina Subsection, I.R.E., Raleigh, N. C.

McCall, D. W., Douglass, D. C., and Anderson, E. W., *Diffusion in Ethylene Polymers, IV,* American Physical Society, Chicago, Ill.

Miller, R. C., *Domain Wall Motion and Barkhausen Pulses in Barium Titanate,* Solid - State Physics Group, Brookhaven National Laboratory, Upton, Long Island, N. Y.

Raspanti, M., *Switching Logic,* C.C.N.Y., New York City, N. Y.

Reiss, H., *Chemical Interactions Among Defects in Semiconductors,* University of Iowa, Iowa City, Iowa.

Reiss, H., *Hard Sphere Fluids,* University of Wisconsin, Madison, Wis.

Reiss, H., *Hard Sphere Fluids and Influence of Solutes on Self Diffusion in Solids,* University of Chicago, Chicago, Ill.

Ruppel, A. E., *Systems Engineering*, Polytechnic Institute of Brooklyn, New York.

Schroeder, M. R., and David, E. E., *A Vocoder and its Application to the Transmission of High-Quality Speech Over Narrow-Band Channels*, 56th Meeting of the Acoustical Society of America, Chicago, Ill.

Shair, R. C., see Foote, H. L.

Smith, D. H., see Foote, H. L.

Sobel, M., *On Group-Testing with a Finite Population*, Seminar, Department of Mathematical Statistics, Columbia University, New York City, N. Y.

Stansel, F. R., *Transistors and Other Semiconductor Devices*, Central Catholic High School, Lawrence, Mass.

Suhl, H., *Superconductivity and Magnetism*, Watson Scientific Computing Laboratory, Columbia University, New York City.

Talpey, T. E., *High Figure-of-Merit Electron Tubes and their Use*, Cornell University, Ithaca, N. Y.

Unger, S. H., *A Computer Oriented Toward Spatial Problems*, 1958 Western Joint Computer Conference, Los Angeles, Calif.

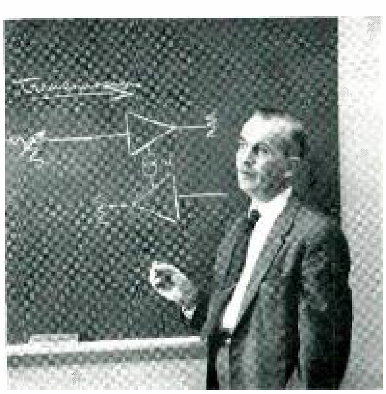
Williams, I. V., *Bell System Experience with A.S.T.M. Standards*, 9th National Conference on Standards, New York City.

Wolontis, V. M., *Electronic Mechanization of Bell System Revenue Accounting*, Western Electric Computer Applications Symposium, Princeton, N. J.

Wood, Mrs. E. A., *Sugar and Spice and Everything Nice*, Conference on Participation of Women in Science, A.A.A.S. Meeting, Washington, D. C.

THE AUTHORS

J. J. Mahoney, Jr., a native of New York, joined the Development and Research Department of A.T.&T. in 1926. He attended Pratt Institute. His early work at test stations in and near the Long Lines Building in New York was concerned with equipment and arrangements for field testing, and in 1934 he transferred to the Laboratories. A few years later, as a Member of the Technical Staff, he was concerned with studies of telephone electrical protection systems. During World War II, he was engaged in the design of radar test oscilloscopes. After the war, Mr. Mahoney returned to transmission engineering studies involving protection, exchange-area telephone and coaxial cable. He also was concerned with short-haul carrier systems, the subject of the article of which he is co-author in this issue. Later, he worked on the formulation of requirements for the transmission of high-speed digital data, and he now heads the group responsible for the transmission engineering aspects of toll systems. He is a member of the A.I.E.E.



J. J. Mahoney, Jr.

D. T. Osgood, a native of Nashua, N. H., received his B.S. and M.S. degrees in E.E. from M.I.T. in 1930. He then joined the A.T.&T. Co., where he worked on inductive coordination studies, transferring in 1934 to the Laboratories. Subsequently, he was concerned with problems involved in furnishing rural carrier service over power lines. From 1942 to 1946, he served in the Signal Corps in the European Theater, and was awarded the Bronze Star for meritorious service. Following the war, Mr. Osgood continued work on rural power line carrier, and later headed a group doing systems engineering work on the N and O short-haul systems, the subject of his and Mr. Mahoney's article in this issue. At present, he supervises a group concerned with studies of transmission maintenance and objectives. He is a professional engineer in the State of New York, an Associate Member of the A.I.E.E. and presently is Chairman of the Wire Communication Systems Committee of the A.I.E.E.

D. T. Osgood

D. J. Gagne, author of "The New 9A Announcement System," joined the Laboratories in 1945. During his first year, he was associated with the Apparatus Development Department on problems involving underwater sound apparatus. In 1946, he transferred to the Switching Development Department where he assisted in the development of intercommuni-

AUTHORS (CONTINUED)

cating facilities for television network systems, alarm circuits for carrier systems, and later, the development of local- and toll-trunk facilities for the No. 5 crossbar system. Mr. Gagne became associated with the Special Systems Engineering Department in 1954, on problems related to automatic telephone answering equipment and various recorded announcement systems. A native of Richmond Hill, L. I., Mr. Gagne received the B.E.E. degree from Pratt Institute in 1943.

D. J. Gagne

J. L. Troe, author of the Nike-Ajax story, received a B.S. in E.E. degree from Iowa State College in 1948. This college training had been earlier interrupted by three years in the Navy, instructing electronic technicians. He joined the Laboratories in 1948 as a student in the first class of the Communications Development Training Program. Since 1949 he has been associated with the development of Army Ordnance fire control systems. In 1951 he was reassigned to Whippany to do system engineering on the Nike-Ajax system, followed later with similar assignments on the Nike-Hercules. In 1957 he was put in charge of Nike computer design. Recently he managed the contractors' portion of the Task Force Snodgrass air defense tests in Florida. Mr. Troe,

J. L. Troe

a native of Bloomfield, Iowa, is a member of Tau Beta Pi, Eta Kappa Nu, Phi Kappa Phi and Pi Mu Epsilon.

B. A. Fairweather, of the Military Communication Systems Engineering Department, was born in Sheboygan, Wisconsin, and received a B.S. in E.E. degree from the University of Wisconsin in 1928. He joined the Toll Systems Department of the Laboratories in the same year, and was initially concerned with the development of voice-frequency repeaters for toll and program-network applications. Later he was engaged in the development of open-wire and coaxial carrier terminal circuits. During the war years he was associated with various military projects and in 1954 transferred to the Military Communication Systems Engineering Department. Mr. Fairweather is a member of I.R.E., A.I.E.E., Eta Kappa Nu and Tau Beta Pi. He is the author of the article on terminals for a military communication system in this issue.

B. A. Fairweather

C. J. Votaw

C. J. Votaw, a native of Winona, Ohio, entered the Bell System in 1928 when he joined the Long Lines Department of the A.T.&T. Co. at Fort Wayne, Indiana. He spent twelve years in various toll testroom assignments while carrying on part-time studies at Indiana University Extension and Indiana Technical College. From 1941 to 1943 he taught technical courses for Bell System employees and for the Army Signal Corps. For the next ten years, Mr. Votaw was engaged in staff work on telegraph transmission and testroom operating methods in the General Plant Manager's office at New York. During this time he attended evening classes at the Graduate School of Polytechnic Institute of Brooklyn. He has been with Bell Laboratories since 1953 and has been concerned with the application of the new 28 teletypewriter to Bell System service, including the development described in the article "Selective-Calling Teletypewriter Systems" in this issue.