ell Laboratories October 1960

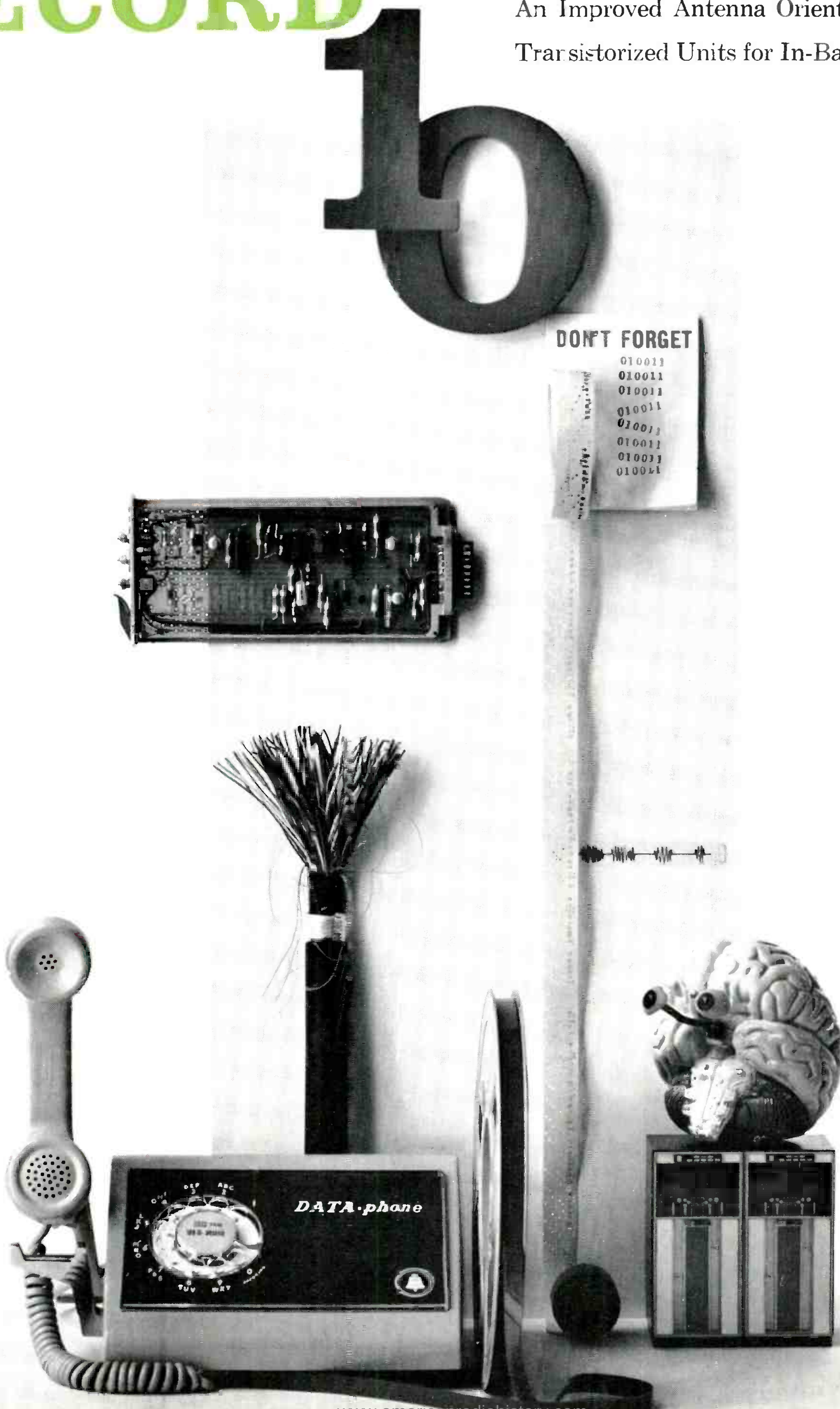
RECORD

An Electronic Artificial Larynx

Sending Data Over Telephone Circuits

An Improved Antenna Orientation Method

Transistorized Units for In-Band Signaling



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Bell Laboratories **RECORD**

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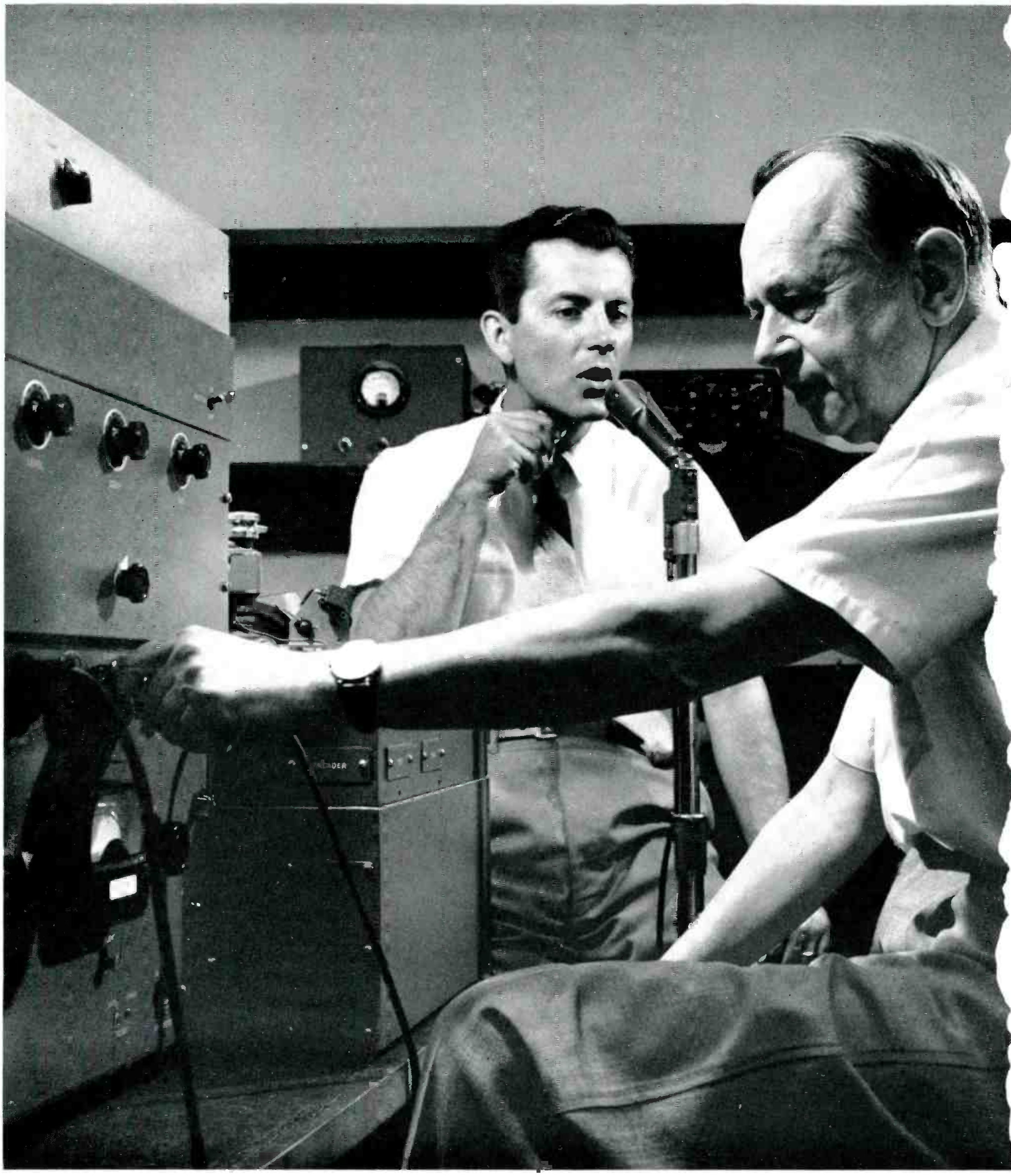
Contents

Cover *Still life in binary code. A symbolic representation of data communication over telephone circuits. Punched tape, magnetic tape, telephone wire, and computer are links in the chain connecting man to machine. Each element in the photograph responds to the "ones" and "zeros" of the binary code. (See article on page 368.)*



D. J. MacLean, left, uses an experimental model of the artificial larynx to produce speech, while the author records it on a sound spectrograph.

Sometimes, in extreme cases, a surgeon must remove the human larynx. Once this is done, the inherent ability to speak is lost. Bell Laboratories has recently developed a new substitute for the vocal cords—a small, electronic source of sound known as the artificial larynx.

F. E. Haworth

An Electronic Artificial Larynx

Each year more than 2500 people in the United States alone must undergo laryngectomy, the surgical removal of the larynx. In such operations, their lungs are closed off from the vocal tract and they breathe through an opening provided in the front of the neck. All means of natural speech—even whispering—are lost. With modern therapy, some laryngectomees can learn esophageal speech, in which controlled vibration of the tissues at the top of the esophagus are produced by expelling swallowed air. This is learned by exacting training and many cannot do it successfully. The ability to speak can be restored immediately, however, by using a mechanical substitute for the vocal cords. One method is to generate a sound of suitable pitch and quality outside the throat and then conduct it into the vocal tract where it may be used in the normal manner to form words and sentences. The device used to generate this sound is called an artificial larynx.

Bell Laboratories became interested in the artificial larynx more than 35 years ago. Dr. Frank B. Jewett, then president of the Laboratories, had a close friend who was stricken with cancer of the throat. Surgery was advised and his entire larynx removed. Dr. Jewett felt that something could be done to help his friend and others suffering from the loss or paralysis of the larynx. This was the start of a Laboratories program to develop a substitute for the vocal cords.

Stretched rubber bands were first tried as vibrators for an air-actuated device, but they proved unsatisfactory. Later, a vibrating metal reed was used to generate a voice tone. (RECORD, *October*, 1929). A rubber tube attached to an opening in the throat channeled air from the lungs to make the reed vibrate. Another tube conducted this sound to the mouth where it was transformed into speech by the vocal tract. Since 1930, this instrument—known as the Model 2A artificial larynx—has been manufactured by Western Electric and distributed by the Operating Companies of the Bell System. With this pioneering device, speech has been regained by thousands of people who have undergone laryngectomy.

The number of such surgical operations has increased steadily in recent years. This increase has resulted in many requests for an improved design utilizing modern components and techniques. The electronic instrument described in this article was developed in response to this need.

Among the more important factors considered in developing a substitute voice were speech volume, speech quality, inconspicuousness, and hygienic acceptability. At the same time, it was desirable to make the unit easy to operate, so that a patient might regain the benefits of vocal communication with his family and friends as soon as possible. Reliability and low cost, of course, were also desirable features.

At first, the possibility of surgically embedding a small transducer in the throat was considered. This solution would require a second operation, and from discussions with surgeons and therapists in this field, it was concluded that further surgery would probably be unacceptable to many potential users.

The much less drastic procedure of placing a small transducer in the mouth was also considered. Such a device might be held in place with a dental plate or be fastened to the teeth. In evaluating this method, comparison tests were made of speech with an artificial tone source in the throat and in the mouth. In the latter case, certain vowel resonances were altered and antiresonances added, resulting in lower speech intelligibility. This effect was confirmed by similar tests using the Electrical Vocal Tract (RECORD, *December*, 1950). Another difficulty with a transducer placed in the mouth is that lead wires would be noticeable and unhygienic.

These considerations led to the conclusion that the substitute voice should be produced by vibrating the throat wall with an external device. This conclusion was contingent on the results of later tests which were designed to show whether speech of adequate volume and quality could be produced in such a manner by a compact, self-contained unit with a suitably long battery life. For natural-sounding speech, the frequency spectrum of a tone source must have strong low-frequency components and a range extending to several thousand cycles per second.

The Model 5 artificial larynx developed by the Apparatus Development Department at the Indianapolis Laboratory for manufacture by Western.

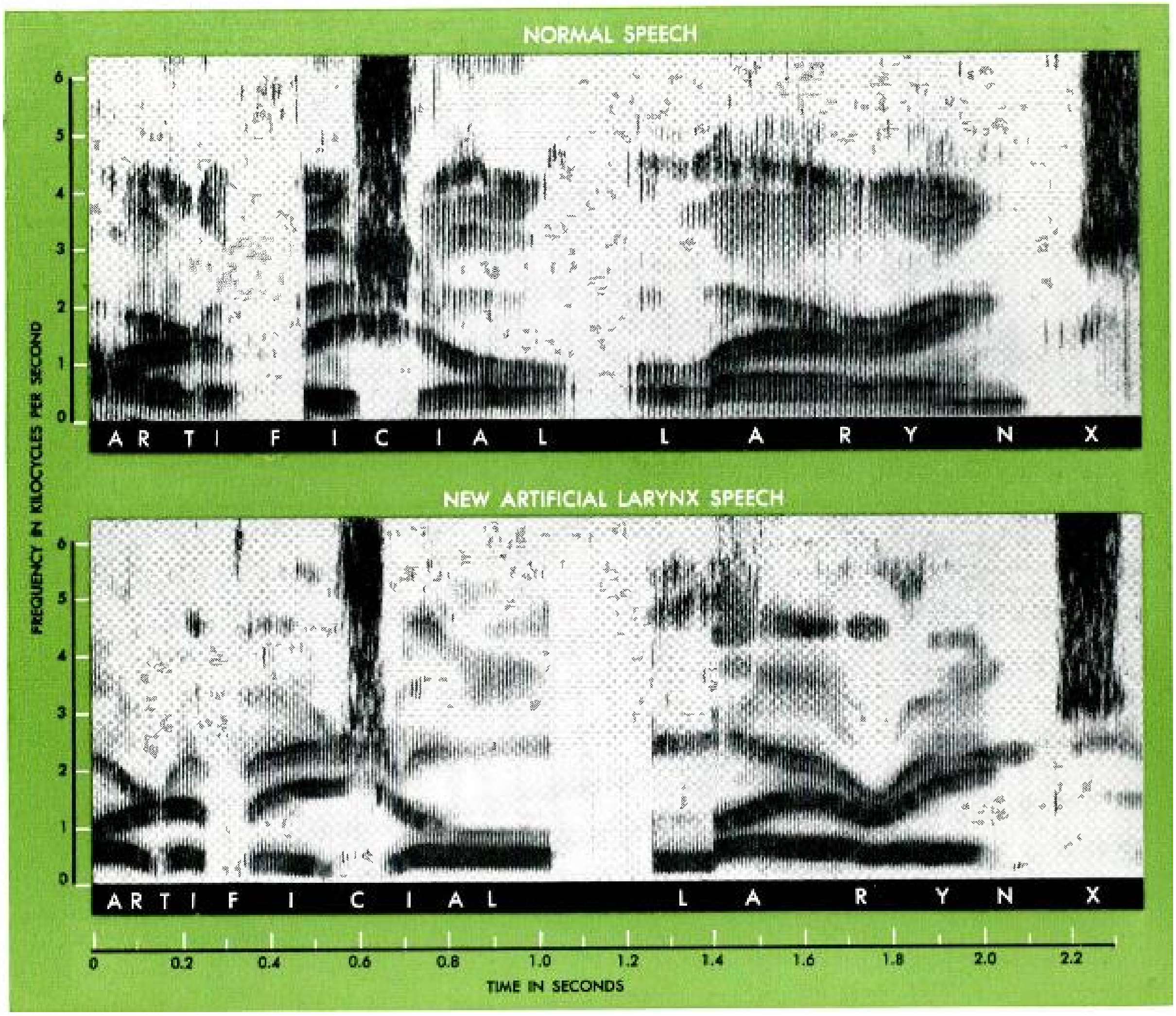
Accordingly, experiments were conducted using a variety of vibrating devices held against the outside of the throat. Some of these devices were constructed especially for the tests, and the rest were obtained from commercial suppliers. Of them all, the HA-1 telephone receiver used in the 300-type telephone set, proved to be the most promising; and a modified version of the HA-1 receiver was used for the experimental model of the artificial larynx described here.

When this modified telephone unit is held against the throat and driven by heavy pulses of short duration, the laryngectomee can speak at a normal conversational volume, with a tonal quality approaching that of natural speech. The description and data which follow are for this experimental model, and alterations in the development of the unit for manufacture may involve some minor differences in performance.

How the Larynx Operates

Small mercury batteries power a transistorized generator from which pulses are derived. This makes it possible to package all components in a small unit that is held in the hand. With the vibrator pressed against the throat, a combined ON-OFF switch and pitch control operated by thumb or forefinger regulates speech inflection. The user forms his words by using teeth, palate, tongue, and lips in the usual manner. By skillful use of the pitch control, one can produce a more natural-sounding speech than has been possible with any previously available artificial larynx.

The pulse-generating circuit is basically a two-stage relaxation oscillator followed by a power stage that drives the HA-1 transducer. The circuit for the experimental model is shown schematically in the diagram on page 366. In this circuit, approximately 75 per cent of the energy derived from the battery is delivered to the transducer. Two transistors coupled together produce a series of short pulses which are transmitted through the semiconductor diode to the base of the power transistor. The pulse rate determines the fundamental pitch of the resulting speech and depends on one of the two time constants of the relaxation circuit. This time constant is adjusted so that the pitch-control switch covers a range of about one octave, with the lowest pitch at 100 cps for men, and 200 cps for women. When the ON-OFF switch just makes contact, the pitch is lowest; and as the knob is pushed farther, the



Visible speech spectrogram comparing natural speech with that made with the artificial larynx.

pitch rises. When released, the knob springs back to the OFF position.

The duration of each pulse is determined by the other time constant. Because pulse duration directly affects the loudness and quality of the speech output as well as the useful life of the batteries, careful measurements were made to find the optimum duration. Shorter pulses mean less average current, and therefore the pulses should be as short as possible without reducing volume and tonal quality. Measurements of the sound level of vowels produced using the artificial larynx with varying pulse duration showed that sound is loudest with pulses of about 0.5 to 0.6 millisecond. Pulses of 0.2 msec reduce the output by 4 db. Increasing the duration to 1.0 msec reduces the output similarly and imparts a somewhat muffled and nasal quality to the vowels. Consequently, an intermediate pulse duration of 0.5 msec was adopted. This pulse length also turned out to produce a satisfactory frequency spectrum.

Power for the pulser comes from two 5.2-volt mercury batteries connected in series. For the 0.5-msec pulses, the maximum current through the transducer is 0.45 ampere, but the low duty cycle reduces the average current from the batteries to about 0.022 ampere. The batteries are rated at 0.25 ampere-hour, but the amount of time per day that an artificial larynx is used varies with each individual. Thus, a reliable estimate of battery life cannot be made at this time.

When used as a throat vibrator, the telephone receiver operates under conditions quite different from those for which it was originally designed. Sharp pulses, rather than speech signals, are fed

LARYNX NOW AVAILABLE

The electronic larynx recently developed at Bell Laboratories was introduced by the Bell System last month. It is being manufactured by Western Electric, and is available at cost, from the Bell System Telephone Companies.

It is being produced in two models—one is high-pitched to simulate the female voice; the other, for men, has a lower pitch. Both models, contoured to fit the hand, have a finger control which enables the user to vary the pitch of his voice over a half-octave range in order to produce more natural inflections of speech and to emphasize words and phrases. After practice, the user can speak with considerable intelligibility and naturalness. Speech volume is equivalent to a person speaking at a normal conversational level.

This device uses transistors and is powered by small mercury batteries of a type available at most radio and camera stores. Battery life ranges up to several months, depending on amount of use.

It is manufactured at the Indianapolis Works of Western Electric and its cost to manufacture—$45—is also the cost to the customer. Information is available at any Bell Telephone business office. Sales representatives, specially selected and trained, have been appointed in each Company.

Aside from the battery replacement, the only other maintenance required is the occasional replacement of the plastic cover that protects the diaphragm from moisture and dust. A guarantee against defects of manufacture is included at the time of purchase, and repair service, also at cost, is provided through the business office of the local Bell System Telephone Company.

For many years the Bell System has provided artificial larynges to laryngectomized persons who are unable to master esophageal speech. The electronic larynx supersedes the earlier models, but parts for the older models are still available.

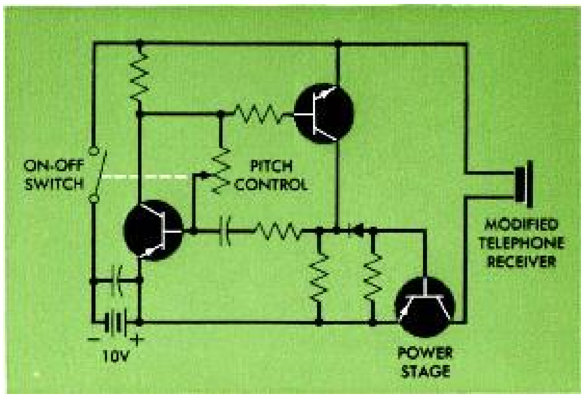
into it, and when the diaphragm presses against the throat, it is working into a medium whose mechanical impedance is about 4000 times that of air. To improve its efficiency under these conditions, several modifications were made.

Tests showed that the speech output level is higher when the pulse current is in a direction that neutralizes the magnetic pull on the diaphragm so that it springs outward, rather than inward. The unit is modified to accentuate this outward motion as much as possible. The magnetic circuit and the diaphragm position were adjusted to maximize the initial inward deflection of the diaphragm. The impedance of the coil windings was reduced until the pulse current was large enough to allow the maximum outward motion of the diaphragm, and the thickness of the diaphragm was changed to give a better match to the mechanical impedance of the throat.

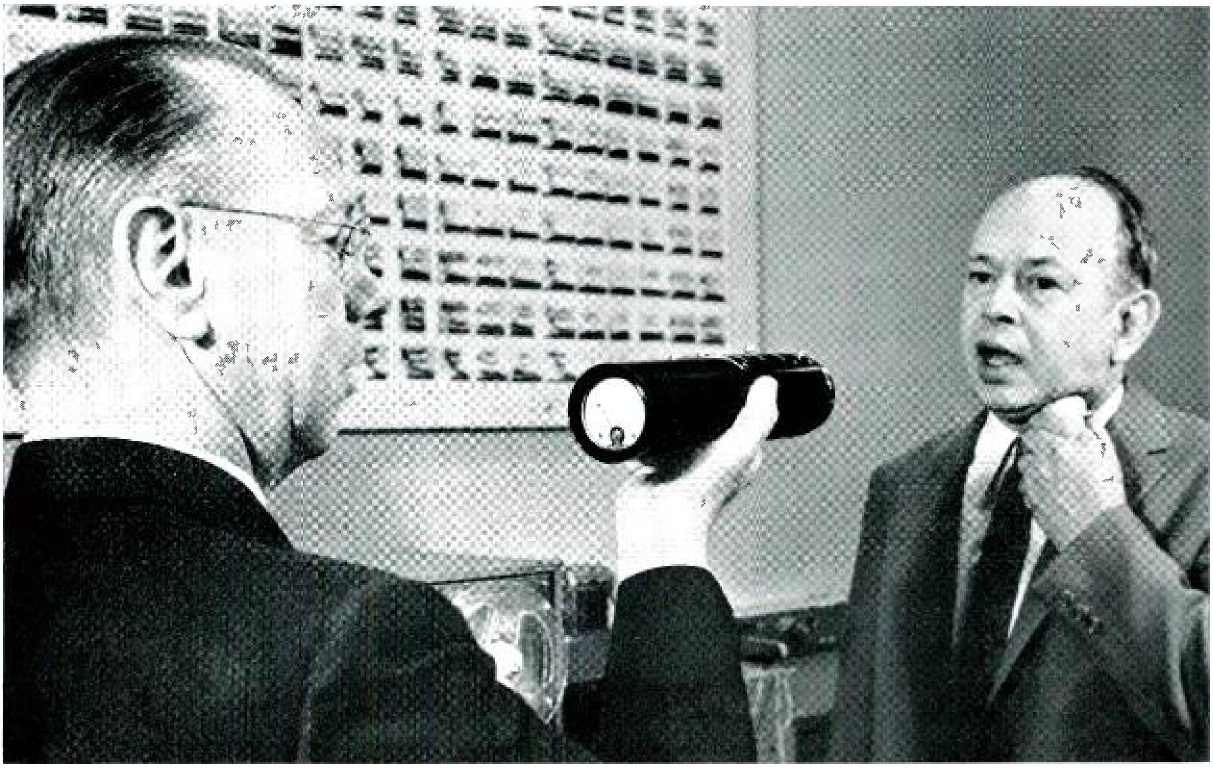
Another series of tests was designed to evaluate acoustic performance, the most important feature of an artificial larynx. These tests, conducted on several persons using the new model, determined speech output volume, frequency spectra, externally radiated interference, and word articulation. And, to obtain the reactions of laryngectomized persons, a limited field trial was conducted.

It was found that a person requires a little practice in finding the proper place and pressure on the throat before good speech output volume can be achieved. With a moderate amount of practice, one can attain a normal conversational level. In any situation requiring speech above the normal level, the speaker should come closer to the listeners or, better still, use some means of speech amplification.

The suitability of the frequency spectrum of the new model was established indirectly since



Schematic diagram of the pulse generator. Volume and pitch depend on the pulses that vibrate the diaphragm of the modified telephone receiver.



Author F. E. Haworth, right, demonstrates the electronic artificial larynx as H. L. Barney takes a reading on a sound meter. Output speech volume is equivalent to that of a normal talker.

the device must be tested in actual use and, because of vocal tract resonances, the spectrum in the throat differs from that measured externally. The spectrum of the natural voice is strongest in the low-frequency harmonics, dropping in amplitude toward the high frequencies at the rate of about 9 db per octave.

A qualitative estimate of whether the sound spectrum of the artificial voice approximates that of the natural voice was made by comparing the frequency spectra of 10 vowels spoken by a subject, using first the new artificial larynx and then his natural voice. For some vocal sounds, the amplitudes of the higher frequencies dropped more rapidly in the natural voice than in the artificial voice, and for others it was the opposite, with a nearly even division. Essentially, this means that the artificial tone source has a suitable spectrum.

Further evidence of good speech quality is found in the "visible speech" (RECORD, *January*, 1946) spectrogram shown on page 365. Here, frequency is displayed as a function of time, with sound intensity indicated by the degree of blackening. A feature of particular interest is the formation of the unvoiced sounds. The "f" and "sh" sounds in the word "artificial" are shorter in duration for the artificial larynx speech than for the normal speech.

With the artificial larynx, the speaker must make such sounds by using the air trapped in his mouth and throat because his normal supply of air from the lungs is not available. This limitation of the air supply tends to shorten fricatives and sibilants. The spectrogram, however, indicates that they can be made satisfactorily, although some practice was required to make the "sh" sound in "artificial" as long as that shown.

Another point demonstrated by the sound spectrogram was that even though the device operated continuously while unvoiced sounds were made, very little of the voicing came through. This is shown by the near absence of the low frequencies in the "t", "f", "sh", and "s" sounds. Thus, for the unvoiced fricatives and stop consonants, the sound transmission path from the throat is evidently nearly closed off, and the user need not turn off the instrument while making these sounds.

Some of the sound produced by the vibrating diaphragm does not pass through the speaker's throat, but is radiated directly by the instrument itself or from areas of the throat around the place where the unit is pressed. This external radiation of the sound interferes with the intelligibility of the speech, and a concerted effort was made to reduce it. In the experimental models, the external buzzing sound from the unit itself was reduced to 25 to 30 db below the intensity level measured when the vowel "ah" is produced. The external sound from vibrating areas of the skin near the unit is a few decibels higher.

A number of users of earlier devices participated in a series of articulation tests. The best two of these devices were compared with the new model in a short articulation test. This test was made with phonetically balanced lists of monosyllabic words recorded on tape. These tapes were played back in a suitably mixed order to a group of listeners who wrote down the words they thought were spoken. The listeners correctly identified 43 per cent of the words spoken using an older throat-type device, 52 per cent of those spoken using the Western Electric reed-type device, and 59 per cent of the words spoken with the new, experimental artificial larynx. Of course, word-identification scores are much higher when words are used in sentences. Thus, a word score of 60 per cent corresponds to a sentence intelligibility of more than 95 per cent.

A limited field test of the new artificial larynx was made in collaboration with the Electro-Larynx Advisory Committee of the National Hospital for Speech Disorders in New York City. Four of the units were used by several laryngectomized patients for four weeks. In all cases the units were well received and favorable comments were made, particularly on the speech quality and the lack of externally radiated buzz. The reactions of friends and relatives of the patients were much the same. These findings were further substantiated in later tests. Battery life was not specifically determined, but users reported from a few weeks' to three months' service from the batteries, depending on their talking habits.

In the course of the work for the project, valuable assistance was received from the medical profession, in particular the Electro-Larynx Advisory Committee set up by the National Hospital for Speech Disorders.

The new artificial larynx has been developed for manufacture by the Apparatus Development Department at the Indianapolis Laboratory. The commercial model, known as the No. 5 type, is shown on page 364. Its distinctive shape, manner of operation, and arrangement of circuit components combine convenience of operation with simplicity of manufacture and repair. This unit is now available through local Bell System business offices.

Machines, speaking the language called data, can use voice-band telephone circuits as an effective channel of communication. To integrate data with a voice-band system, the communications engineer must carefully consider the capabilities of the telephone system.

Telephone Circuits, A New Link in Dat

Telegraphy was the first form of electrical communication. By encoding information in the form of long and short pulses, a message was transmitted over wires. This method of communication was both inefficient and slow, but it served the rather limited communications needs existing at the time of its introduction. Later, teletypewriter transmission was introduced; here, a typewriter-like machine transmits and receives printed information with sufficient speed and accuracy to meet the requirements of most human users. In the past two decades, however, with the growth of various forms of automation, our standards with respect to speed and accuracy have changed.

With the rise in the use of the electronic computer and other automatic control devices has come an almost explosive increase in the need for communications in the "language" of these machines. This situation is largely a result of a new method of handling information—the so-called "central data-processing" concept.

This concept is based principally on the fact that computers tend to be cheaper per unit operation when large-capacity machines are used. Also, an organization can control its data-processing activity better when its computational and data-processing activity is concentrated in large installations. The information to and from such an installation is often brought into and distrib-

J. M. Wier

ommunications

uted from this central computer over considerable distances. Data-communications networks transmit information to the central point from outlying locations and distribute the results.

To meet the need for such communication facilities, Bell Laboratories has been active in developing systems and devices for transmitting data over the most convenient communications network available—telephone circuits. Data-Phone typifies this kind of equipment.

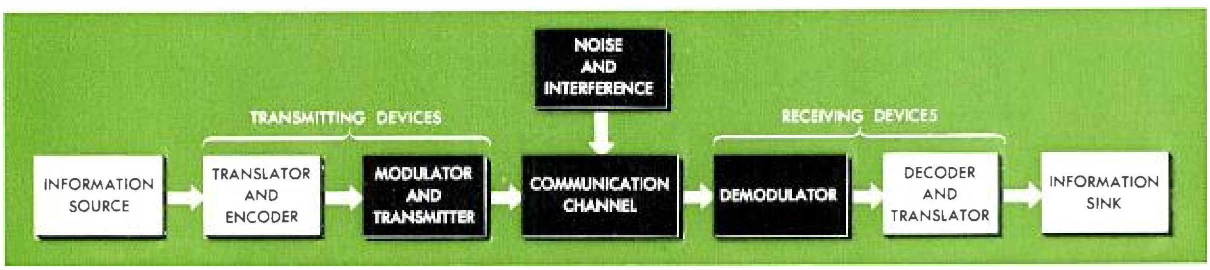
In the developing of such systems, communications engineers must consider the basic principles concerning transmission over the telephone network and the way to integrate data into the existing system. This article covers some of the primary considerations involved in the transmission of data and discusses some of the methods being developed to implement such communication.

One of the most important considerations in data transmission is the data itself. For convenience in machine handling, data is usually represented as a sequence of two-valued, or binary, digits. This means that a sufficient number of binary digits must be used for each symbol so that each one may be differentiated from all others. Binary digits are customarily designated by 0 and 1. The tabulation on page 370 shows how the first few letters of the alphabet might be represented in binary notation. Normally, 50 to 60 symbols are required for convenient communication. And since n binary digits can be arranged in 2^n ways, six binary digits ($2^6 = 64$) are used to represent each symbol.

A data-communications network delivers such symbols to a distant point. The specific function of the telephone system in this connection is to link the points of transmission and reception. This use of telephone facilities, however, raises a number of problems, many of them common to all data-communication jobs, and a few somewhat unique to telephone-circuit transmission.

A typical telephone data-transmission system has seven major parts. As shown below, an information source provides the data to be transmitted. A converter translates this data to a form which is acceptable to the transmitting modulator. The modulator, in turn, produces signals that the communication channel can carry. During transmission, "noise" and interference impinge on these signals. A demodulator at the receiving terminal reproduces the data waveform as well as it can; and, lastly a converter changes the form of these signals so they can be accurately identified and stored in the information sink.

So far as transmission is concerned, the most important items are (1) the modulator and transmitter; (2) the communication channel; (3) noise and interference; and (4) the demodulator. These items are shown in black in the drawing below. The characteristics and behavior of these elements determine the rate at which data may be transmitted and how accurately the data is reproduced at the output of the demodulator.



Typical data-transmission system for voice-frequency telephone circuits. Shaded blocks indicate items most important for effective communication. Noise is very important because it is omnipresent.

BINARY REPRESENTATIONS OF DATA SYMBOLS	
Alphabetic Symbol	Binary Representation
A	010011
B	010100
C	010101
D	010110
E	010111
F	011000
G	011001

The two curves on page 372 describe two important characteristics of a typical communication channel. One of these curves gives the transmission loss as a function of frequency, the other curve gives the signal delay as a function of frequency. With telephone facilities, loss is usually at an acceptably low value from a low-frequency limit in the 200- to 600-cps range to a high-frequency limit in the 2500- to 3500-cps range. The delay variation over this frequency band will vary considerably with the telephone facility. For good data transmission, however, it is desirable to have little difference in the delay between any two frequencies in the transmission band. The effect of variations in delay will be discussed later.

Since the data handled by the communication facility is a sequence of two-state, or binary, elements, the job of the data terminals is to produce and interpret the line signals that represent these two elements. To make these signals successfully pass through a communication channel, it is essential that they occupy the proper frequency range and not be significantly disturbed by interference. Because only binary elements are sent, the transmitter needs to produce, and the receiver to interpret, only two signal states.

The usual method of doing this is to use a two-valued version of one of the classical modulation schemes. Thus, there are amplitude-modulation (A-M) transmitters that give sine-wave signals in one of two different amplitudes, frequency-modulation (F-M) transmitters that give signals of two different frequencies, and phase-modulation (P-M) transmitters that give sine-wave signals of two different phases. Typical signals for each of these three forms along with a dc representation of the signals is shown on page 371.

With standard electronic networks, the A-M system is the simplest to design and least expensive to manufacture. The F-M scheme costs somewhat more; and the P-M system is the most complex and expensive. The choice of one of these three standard modulation schemes depends on the transmission quality required and the funds available for the system. As might be suspected, for a given rate of transmission, phase-modulation performs best in the presence of noise, F-M is next best, and A-M is least tolerant. All three systems are about equally capable of transmitting data at a high rate.

In addition to these three modulation systems, several special transmission forms can be used in a telephone network. One such form is vestigial-sideband carrier amplitude modulation. Here, some of the frequency components are removed from the A-M signals. This results in a decreased tolerance to noise and an increase in the potential transmission rate. A multifrequency F-M system—with more frequencies more closely spaced—is also in use. With this system, the potential signaling speed goes up, and the tolerance to noise goes down. Several multiphase systems are being used, with a resulting increase in feasible signaling speed and a reduction in tolerance to noise.

Speed and Transmission Properties

With the three basic modulation systems, it has been found practical to transmit signals at rates up to about 1500 bits per second through a telephone voice channel. With some of the special transmission forms discussed above, this limit can be raised to about 3000 bits per second, with a corresponding reduction in noise tolerance and increase in terminal cost.

Thus far we have discussed certain general problems associated with data transmission. Now let's examine some of the specific transmission properties which are of importance to the designer in using voice facilities for this purpose.

As in all communication channels, various disturbances impair the quality of a message being transmitted. Such interference includes thermal noise from the elements making up the network, power-line induction, crosstalk from other circuits, intermodulation between channels, echoes within the transmission path, human interferences, and impulse noise. This interference naturally complicates the task of properly interpreting the signal at the receiving terminal. Furthermore, since the sum of these disturbances in some instances may cause an error, a data-transmission system that has a high tolerance to such extraneous influences has a quite decided advantage.

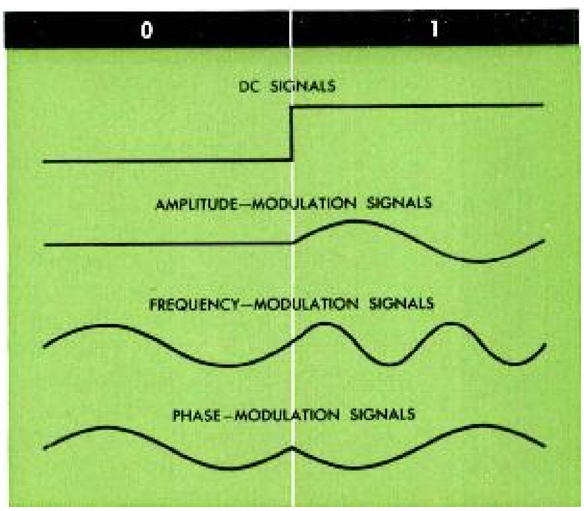
In general, the effect of thermal noise on the transmitted signals is small because of its relatively low power. One of the most serious forms of interference, however, is impulse noise. Typically such noise is a short transient electrical signal introduced into the communication channel from such sources as switching relays or lightning strikes. Impulse noise has a low average power, but often has such a high instantaneous value that it obliterates the signal and causes errors.

The tolerance to noise of any communication system is tied to the ability of the receiver to distinguish the signal from the noise. This ability is usually built into the receiver by having it recognize the difference between the properties of random interference and those of the data signals. By making maximum use of the differences, it can reject noise in favor of the signal.

The relative merits of the various modulation methods discussed above are based on an assumption of random binary data sequences and random noise. However, the efficiency of these modulation methods is qualitatively the same for other practical noise forms.

In addition to the degradation caused by noise, the transmission channel is also subject to various other kinds of distortion that reduce the detectability of the signal. The frequency components of the signal suffer varying degrees of loss in passing through the communication channel. Also, these frequency components take varying times to pass through the channel.

The distortions caused by irregularities in loss are detected by the listener when the telephone link is used for voice transmission. Because of this, the telephone maintenance process may sometimes correct the loss irregularities that affect data transmission.



Representation of dc signals and modulation schemes for a two-valued transmission system.

By dialing a number on a Data-Phone, this secretary can connect a machine—capable of sending hundreds of bits per second—to another machine.

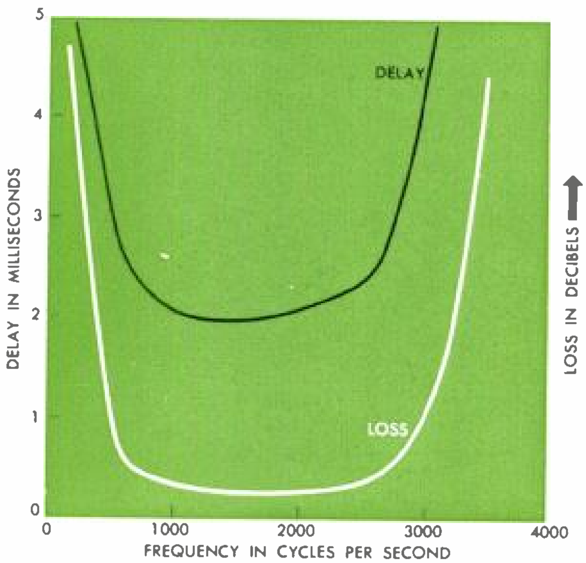
Unfortunately for data transmission, the human ear is relatively insensitive to variations in the time taken for the various frequency components of speech to pass through the communication channel. Because of this, such irregularities are more apt to be tolerated in the original transmission system and are less likely to be corrected if they occur after the system is installed. Delay variations as a function of frequency cause the energy from a given binary digit to be spread out in time so that this energy interferes with other binary signals in its vicinity. This type of interference, known as characteristic distortion, degrades the performance of the system and may increase the probability of incurring errors.

With some of the single-sideband carrier systems used in the telephone plant, transmitted signals sometimes are shifted in frequency and phase. Such shifts result in the degradation of all data-transmission systems that depend on an accurate reproduction of the frequency components and that require the preservation of polarity of the signal. These failures result because the ability to carry accurate frequency and polarity information on the signal disappears during frequency and phase translation. These effects are particularly deleterious to P-M systems requiring an absolute phase reference. Since some of these P-M systems are otherwise quite attractive, this problem at times is somewhat frustrating although satisfactory solutions have been found.

Some errors in transmission cannot be prevented. However, error-control devices appended to the data-transmission equipment can prevent these errors from creating too much confusion. For example, error-control devices can be added to the transmitting and receiving terminals. In this case, the data to be transmitted are encoded in a form that increases the number of binary digits and at the same time puts certain constraints on the possible sequences of binary digits. These constraints are designed so that the most likely types of transmission errors will be obvious to the receiving equipment.

Some devices not only detect error signals but permit the information to be satisfactorily reconstructed. If the system only senses errors at the receiver, the process is called error-detection. Corrections may be made by retransmitting those portions of the message containing errors. If the system reconstructs the proper message from incorrect data, and eliminates the errors directly, the process is called error-correction.

The more reliable error-control schemes are complex, and consequently, costly to instrument. For this reason, a compromise between reliability and cost must be made. Simple error-control schemes (such as adding an additional binary digit to a group of message digits to make the total number of "1s" odd or even) are easy to implement, but are somewhat inadequate in dealing with the general class of errors. On the other hand, some more effective schemes, involving more complex encodings, are often uneconomical.



Characteristics of a typical communication channel. White curve shows how loss varies with frequency and black curve shows the delay variation.

As the individual elements of the data are transmitted, their duration is usually controlled by a timing mechanism. At the receiver, each bit must be recovered once, and only once, to yield the correct message. This recovery process is designed to glean most effectively all of the information from the digit. A clock at the receiver times the recurring operation of the recovery process and the spacing of the output bits.

Information to operate the timer accurately is usually obtained from the signal channel. This is done either by sending special synchronization signals along with the message or by using the natural occurrence of changes from 0 to 1 and 1 to 0 in the message to keep the timer in phase.

Compatibility With Customer Equipment

Finally it is necessary to make data-transmission equipment compatible with the customer's system apparatus. Of course, customers want to incorporate data-transmission equipment into their operations with the least disturbance. The most desirable arrangement, from the customer's standpoint, would be to transmit the information in the form that is available, be it punched cards, paper tape, magnetic tape, or other representations. In practice, various devices can change information from the customer's form to a form compatible with the transmission system.

At the present time, there are few commercial applications that seriously tax the speed capabilities of the voice-frequency telephone plant. As it becomes necessary to transmit large volumes of data, it may be desirable to go first to the more sophisticated modulation system used with the voice channels and then to the wider bandwidth circuits available within the Bell System.

Today, data communications is an accomplished fact. By properly utilizing the various properties of the telephone network, the Data-Phone service has been integrated into voice-band communication channels. By examining the problems indicated here the designers of Data-Phone equipment have insured reliable and convenient operation to meet a wide range of data-communications requirements. In so doing the telephone network is being used even more efficiently than heretofore. Now as well as connecting man to man, these circuits link man to machine, and machine to machine.

The Bell System's continuous vigil on the safe practices of its personnel sometimes results in the improvement of an original equipment design. Such was the case for the horn antenna for a microwave radio-relay system. Methods of antenna construction were simplified in improving their safety.

C. S. Herrmann

AN IMPROVED ANTENNA ORIENTATION METHOD

Bell Laboratories designers often ply their trade right up to the final bolt in the assembled equipment. This results in improved integration of the equipment and its surroundings. Moreover, the practice affords a last-minute opportunity to simplify further methods of assembly or installation, as well as make them safe.

An outstanding example in the Bell System of the thought and effort spent to simplify assembly and reduce risks to workmen can be seen in the horn-reflector antenna. Laboratories engineers designed this antenna for the microwave radio-relay systems that span the United States and Canada. The antenna may be mounted on a building, a concrete tower, or a platform supported by a steel tower as high as 350 feet.

Each antenna must be "aimed" at its counterpart at another relay point many miles away, and adjusted correctly in azimuth and elevation. This orientation, done after the antenna is set in place on its platform, must be completed before the antenna is permanently fastened in position.

At each installation, the 2200-pound antenna assembly is supported on a square mounting frame which, in turn, is mounted on a ring-shaped mounting base. Normally, the contractor who erects the tower installs the mounting base as part of the tower platform. The horn body of the antenna assembly, approximately 20 feet high and about 11 feet across, projects downward through the platform for about seven feet. Here it is met by the end of the waveguide that runs vertically up the tower.

Soon after the first installations began, the Military and Telephone Structures group of the Outside Plant Development Department examined the structure of this antenna to find a satisfactory way to fasten it in position on the platform. Originally, installers prepared to fasten the antenna assembly to the mounting base by drilling eight holes through the lower flanges of the antenna frame and the upper flange of the mounting base—two on either side of the four corners of the frame. These holes could not be

pre-drilled because the exact final position of the antenna is azimuth is not known until it is precisely oriented.

An installer standing on the tower platform could easily drill five of the eight bolt holes. But drilling the remaining three required him to be "outboard" of the tower platform, supported either on a scaffold or auxiliary platform, or swinging in a bo'sun's chair hung from the derrick used to hoist the antenna to the platform. This was a difficult, as well as a dangerous, task.

To overcome this difficulty, Laboratories engineers designed a set of four clamps to replace the eight bolts for fastening the frame to the base. Each clamp assembly is made up of a beam "jaw", a specially designed eye bolt, and a clamp. The assembly is shown in the drawing at the top of the next page.

The construction of this assembly is as follows. The beam jaw is bolted to the side of the antenna frame, the eye bolt is pinned to the beam jaw, and the shank of the eye bolt passes through the body of the beam clamp, where it is fastened by a locknut. The clamp engages the upper flange of the structural steel channel of the mounting base. Four set-screws, with locknuts, hold each clamp in place. Both beam jaws and eye bolts may be installed while the antenna is still on the ground, leaving only the beam clamp and eye-bolt locknut to be installed after the antenna has been hoisted into position.

Not only do the mounting clamps eliminate the need to drill for mounting bolts, but also they make unnecessary the temporary clamps sometimes used when orientation cannot take place immediately after the antenna is installed. Another advantage is that if errors in azimuth adjustment are discovered after the antenna is fastened in position, the installers need only loosen the four beam clamps to turn the antenna. When they have achieved the correct adjustment in azimuth, they then merely retighten the beam clamp set-screws. Heretofore, errors in azimuth adjustment could be corrected only by redrilling the holes for the mounting bolts or by enlarging them by filing.

Once in place, the antenna is roughly oriented by eye to point along the predetermined line of sight to the next relay point. Then a fine adjustment is made with an "azimuth-adjusting screw." Originally, this screw, about 20 inches long, consisted of a threaded rod having one end square for a wrench. The other end rested in a ball bearing in which the rod could be rotated. The ball bearing, in turn, mounted in a cartridge fastened in a bracket welded to the mounting frame. A second bracket bolted on the upper flange of the mounting base held a nut in which the adjusting screw could be turned, thus providing a way to rotate the antenna for fine adjustment in azimuth. Two cartridge brackets were available, one on each side beam, and the adjusting-screw nut bracket was bolted to the mounting base so that the screw could be operated from a safe position on the tower platform.

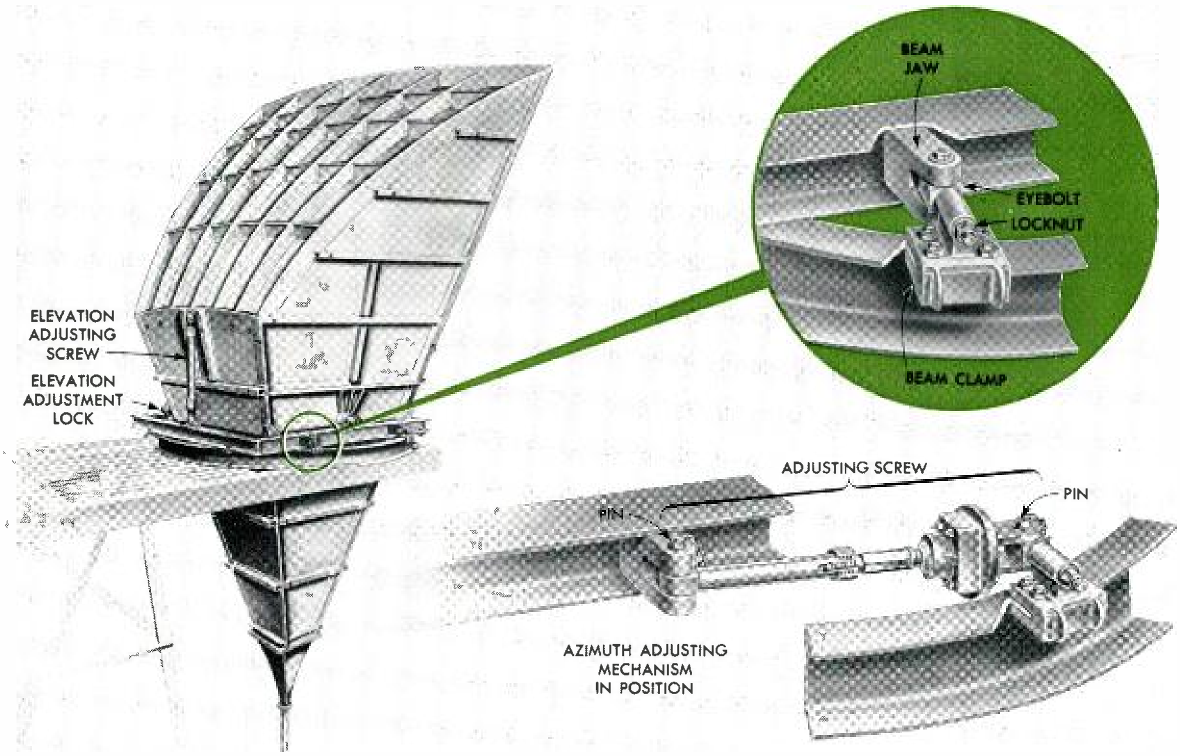
The new mounting clamps make possible a different kind of azimuth adjusting screw, one which is a tool rather than a permanent part of the assembly. This device uses one mounting-clamp assembly to provide the points of attachment to the antenna mounting frame and the mounting base. Since there is no nut bracket, drilling holes for its attachment is not necessary.

The Adjusting Screw

As actually designed, the adjusting screw consists of a steel tube and a threaded shaft, each with suitable end attachments. This assembly is illustrated in the lower right of the diagram. At one end, the steel tube terminates in a square section having a pin hole so that it can be pinned in the beam jaw. The other end has a threaded nut. At one end, the shaft is threaded for several inches. This shaft is screwed into the nut in the steel tube. Adjacent to the threaded length is a hexagonal section for an open-end wrench. The other end of the shaft enters an assembly consisting of a ball bearing, cartridge, and flange similar to that used on the earlier design of adjusting screw. The flange is equipped with two brackets, each with a pin hole, for attachment to the eye of the square-headed eye bolt of the antenna-clamp assembly.

When an installer makes the fine adjustment in azimuth, he first pins the adjusting screw to a beam jaw and its related beam clamp. Then he tightens down the set screws of the beam clamp, leaving the other three beam clamps loose. He makes the adjustment by turning the threaded shaft with an open-end wrench on the hexagonal section. When proper azimuth adjustment has been made, the installer tightens the set screws of the three other beam clamps, removes the adjusting screw, moves the fourth beam clamp so that the eye bolt engages with and is pinned to the beam jaw, and finally, he tightens the set-screws of the beam clamp.

Workmen positioning horn antenna atop steel tower in Texas. Structure is lowered so square frame rests on mounting ring. New methods of attachment permit all work to be done from platform.



Square frame of antenna is fastened to mounting ring of tower platform by specially designed mounting clamps, top right. Orientation of antenna is made with the azimuth-adjusting screw, bottom right. This tool is eventually removed after the antenna has been locked in its final position.

Having thus simplified and made less hazardous the operations of adjusting and locking the antenna in azimuth, the designers examined one more adjustment—that of elevation. This adjustment is made with a screw, somewhat similar in principle to the azimuth-adjusting screw, but mounted in the vertical, rather than horizontal plane. This adjusting screw can be seen at the rear of the antennas shown in both illustrations. Rotating the "elevation screw" on the antenna causes the antenna to "nod" up or down in elevation. To hold the antenna at a certain elevation, installers had to drill through the two side members of the frame and through four tie-angles attached to the four corners of the body of the antenna horn. Then they inserted a bolt in each hole and secured each with a nut and lock washer. A better way of locking the antenna in elevation was also developed. The new procedure is more positive than the bolting method, and it also eliminates drilling. In addition, an installer can lock the antenna from the tower platform.

Designers also modified the antenna tie-angles to form a "seat" for opposing vertical screws mounted in brackets welded to the frame. After the antenna has been set in elevation, the installer turns the opposing screws by hand until they are seated against the antenna tie-angles. He then locks these in position with locknuts. The locking screws are made so that a wrench is not required.

Development work on the horn-reflector antenna was begun to make the operations of installing and orienting, and subsequently of maintaining, the antenna simpler and less hazardous than was previously the case. But unexpectedly, a number of additional benefits have been realized. For example, since no holes need be drilled, the tower platform doesn't need power outlets for electric drills. And, because the operations of clamping and locking the antenna in position can be performed from the platform, it is unnecessary to have scaffolding or other types of rigging. Thus, no extraordinary safety precautions are required, other than safety lines attached to body belts and a firm anchorage on the tower platform. Some saving also results by omitting the permanently installed azimuth-adjusting screw. Moreover, the man hours required to install and orient the antenna has been considerably reduced.

Throughout the Bell System, important economies are being made by converting wire-line exchange trunks to multichannel carrier-transmission paths. Laboratories engineers have contributed to such programs by the development of a versatile new series of transistorized, in-band signaling units.

A. Weaver

TRANSISTORIZED UNITS FOR IN-BAND SIGNALING

Just as people communicate over a telephone connection, so must the telephones and the transmission and switching equipment involved in the connection communicate with each other. To do this, the telephone system is equipped with various signaling arrangements—circuits that send pulses representing dialed digits, busy tone, ringing tone, and the many other signals needed to establish and maintain a typical telephone connection.

These signals have a variety of forms. When a customer lifts the handset of his telephone, for example, the signaling current in his line increases and the central office knows he wants service. Before he gets the receiver to his ear, the customer usually has dial tone—the signal that indicates the switching equipment is ready to receive more information. As he dials, the telephone sends signals, in the form of dial pulses, that say to the switching equipment, "Here is the number of the telephone I want to be connected to." If the local office recognizes that the called telephone is not one of its own, it searches for an outgoing trunk. When it finds a trunk that has a tone or other signal on it, the switching system knows that this indication says, in effect, "I'm idle, you can use me."

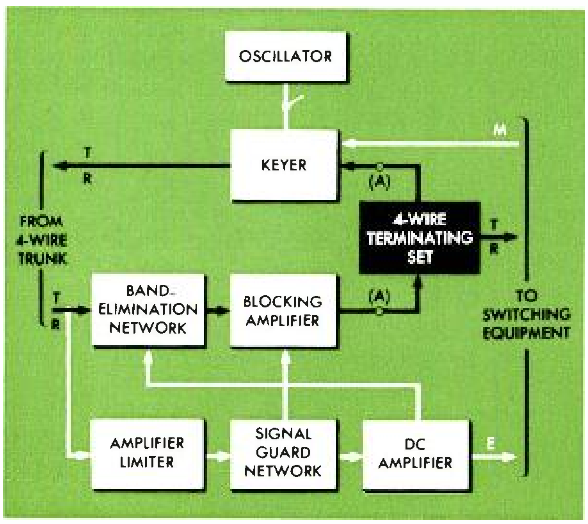
Because of the many types of switching systems and interconnecting trunks used in the Bell System, engineers at Bell Laboratories have devised, over the years, a number of different signaling systems for use on various kinds of trunks. The latest of these is a transistorized, "in-band" system (RECORD, *July*, 1959) designed to complement the latest trends in the design of both intertoll (longer-distance) and exchange trunks. In-band simply means that the signals for a particular connection are sent in the same frequency band as the voice message, not as a dc signal or at a higher frequency.

Most of the long-distance trunks in the Bell System use carrier transmission. This means that over a single pair of wires, a single coaxial cable or one band of radio frequencies, several voice channels are available, because the voice frequencies are first modulated onto a carrier frequency. Since it has proved economical on toll trunks, the carrier principle has recently been extended to both exchange, or local, trunks and toll-connecting trunks. Further, because increases in the local and short-haul traffic handled by these facilities have made necessary an increase in the number of trunks, it has proved more economical to increase the efficiency of existing wire trunks by adapting them for carrier than to install additional cable.

In the design of signaling systems for these new carrier applications, the techniques of solid-state electronics have been used to reduce the cost and the size of the circuits and to lower power requirements and maintenance expense. However, components such as wire-spring and mercury relays were also used to help in achieving low cost.

As mentioned, the Bell System has many types of trunks and switching systems, so the signaling connections to the switching equipment are different for various switching applications. Usually, the signaling facilities are separated from the trunk relay units, but connected with them, by means of two independent leads, historically designated "E" and "M." Signals from the trunk relay circuit to the signaling unit pass over the "M" lead, while signals in the opposite direction pass over the "E" lead. Aside from this, however, the various trunk terminations for toll and exchange are different enough that no one signaling arrangement will meet all conditions. The basic signaling functions are much the same, however, except for "revertive" pulsing —a (digit) signaling system used principally with panel and No. 1 crossbar switching systems. Because the applications vary, present plans call for the development of six different units, each designed for different in-band signaling requirements for various exchange-trunk and toll-trunk arrangements.

The basic scheme of in-band signaling is shown below. In this sketch, the black line is a four-wire voice path, consisting of a tip (T) and ring (R) lead for each direction of transmission. Any incoming tone on a trunk must be amplified and limited and then sent to a signal-guard network. This circuit gives an output to the dc amplifier and the E lead only when the signaling tone is present. If any other frequency is also present, there will be no output. This guard feature renders the signaling receiver nonresponsive to speech.



The basic arrangement of an in-band signaling system. For toll trunks, the 4-wire terminating set is not included, and the 4-wire trunk is connected to the switching equipment at points (A).

In the receiving branch of the voice path, there is a band-elimination network and a "blocking" amplifier. This amplifier prevents noises and tones, generated in the connected switching equipment, from entering the signaling receiver and interfering with its operation. When a signaling tone is first applied to the transmitting end, a voltage is generated in the signal-guard circuit which rapidly opens the voice transmission path in the blocking amplifier.

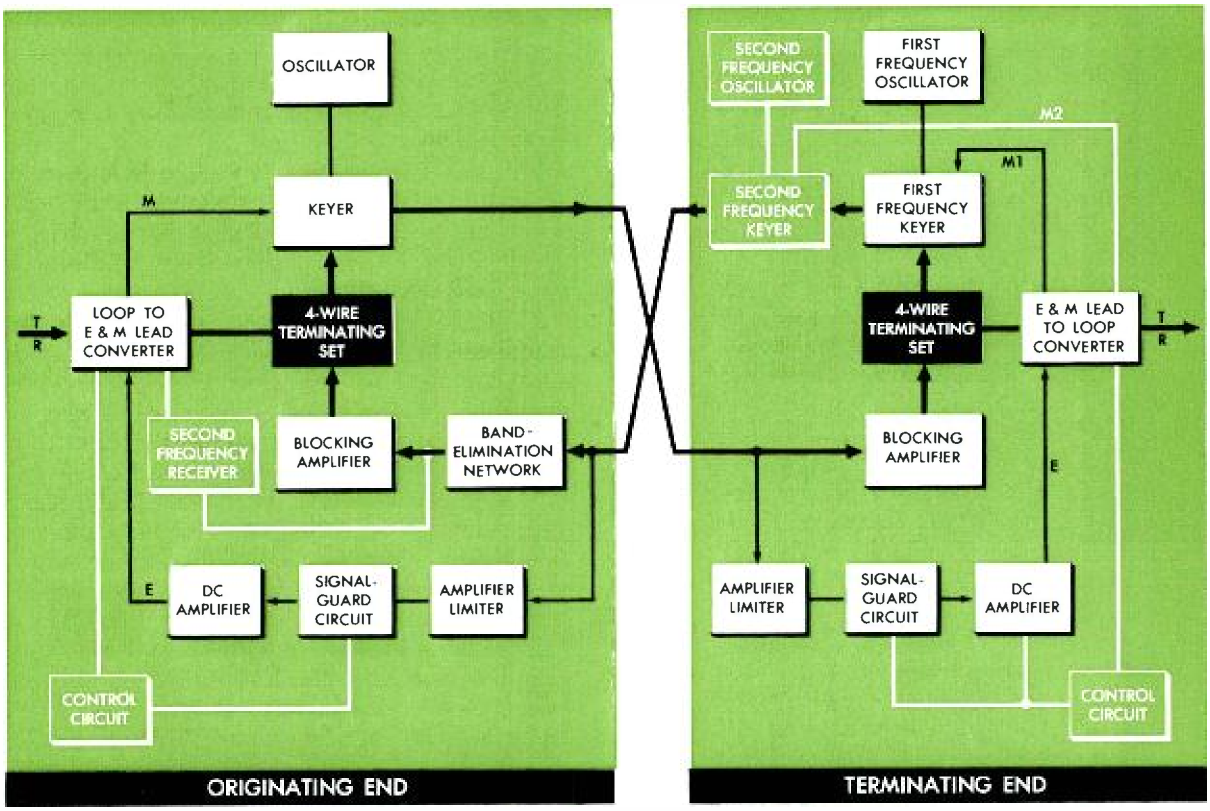
Shortly thereafter, the dc amplifier responds, the band-elimination network is inserted in the voice path, and the talking path is closed through again. These operations prevent signaling tone from being transmitted into a connected trunk and thus interfering with signaling there. Outgoing signaling tone is controlled by a "keyer," which is in turn controlled from a signal received from the switching equipment over the M lead.

On this general plan of operation, six new signaling units have been developed, and all are based on three important characteristics of the existing telephone plant. One characteristic is the distinction, mentioned earlier, between intertoll and exchange trunks. The second is the distinction between two-wire and four-wire transmission—that is, whether the equivalent of two wires or four wires are used on a connection. A final characteristic is the distinction between "one-way" and "two-way" operation. On one-way trunks, calls are always originated at the same end. With two-way trunks, they can originate at either end.

Of the six units that were developed, one is for toll trunks and five are for various types of exchange trunks. Two of the units are for two-way trunks, and these operate as shown in the block schematic below.

For toll use, the four-way terminating circuit is not provided as part of the signaling equipment. Instead, the talking path is connected to the switching equipment at the points marked A on the schematic. In the exchange plant, the four-wire terminating circuit is simpler than the one required for toll use. It can therefore be economically included as an integral component of the signaling unit.

The remaining four units are for exchange application on various types of one-way trunks. There is a unit for the originating end of trunks equipped for dial pulsing and multifrequency (MF) pulsing (RECORD, *December*, 1945; *June*, 1954) and a unit for the terminating end of such trunks. Two other units are for the originating and terminating ends of revertive-pulsing trunks.



The various signaling elements necessary at ends of one-way exchange trunks. White lines and boxes show the components and arrangements needed for revertive-pulsing on such trunks.

The block schematic on this page shows how various circuit elements are put together to perform the necessary signaling operations. This diagram shows both the originating and terminating ends of these one-way exchange trunks. Since these are exchange trunks, the four-wire terminating set is included, and the switching equipment connects at the two-wire branch of the terminating set via the "E and M lead to loop converter."

Briefly, this two-way arrangement works like this. When the trunk is idle, the 2600-cycle signaling tone is transmitted continuously over the line. This tone is removed in the "forward," or originating-to-terminating, direction when the switching equipment seizes the trunk. A little later, the switching system receives a "start-dial" signal and transmits its digital information. When the called party answers, this is the signal to remove the tone in the "reverse" direction. As soon as the connection ends, signaling tone is reapplied in both directions.

In many dial-pulsing trunks, the switching equipment connects over only one pair of wires. At the originating end, this necessitates converting the signaling tone received to the battery reversal needed for the two-wire loop. It also requires the recognition of open or closed conditions in the two-wire loop and the conversion of the existing conditions to keyed tones. Both of these operations are done by the converter and the keyer.

There is also a converter at the terminating end. Here, the signal tone is converted to an equivalent battery signal that closes or opens the two-wire loop to the switching equipment. The converter also has in it a circuit for recognizing a reversed battery condition that comes directly over the loop from the switching equipment. It can then use this battery signal to key the outgoing tone.

The band-elimination network at the terminating end has been deleted. Instead, the transmission path opens at the receipt of an incoming tone and stays open as long as tone is being received. This is permissible, since it is not necessary to pass speech over the line in the forward direction until the trunk has been seized.

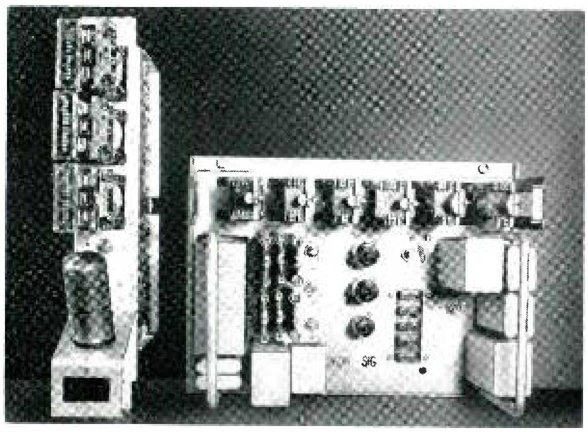
In the diagram, the blocks and lines shown in white are the keyer, oscillator and control circuit that need to be added to transmit, receive and control a third signaling condition (actually, a second frequency) for revertive-pulsing trunks. These trunks work like this: At the originating end a dialed number is first stored, in coded form, in a "sender." This unit then connects, via the originating, line and terminating equipment of a trunk, to the switching equipment at the terminating end. Here, a switch steps along and sends *back* to the originating end a short pulse for each step (hence the term "revertive").

As soon as it has received the proper number of pulses, the originating end sends forward a "stop" signal. After a brief pause, the process is repeated until the switches at the terminating switching center have been properly placed to complete the call.

The control pulses transmitted back to the originating end are keyed in by the "second frequency keyer." This frequency is about 2000 cycles. Supervisory signals, such as the customer's answer or line busy, are transmitted by the first frequency (about 2600 cycles) keyer. The arrangement of these keyers in the signaling unit shows on the diagram.

Another unit that must be added for revertive-pulsing signaling is the control circuit. These speed up the operation of the receivers for the reception of revertive pulses, and slow the receivers down during the time the circuit is used for the reception of speech. This slowing operation prevents false operation of the receivers on speech-generated currents.

In the design of these signaling units, solid-state components were used wherever possible. By contrast, the in-band signaling circuits presently in use contain U-type and Y-type relays, conventional transformers and capacitors, and three vacuum tubes. The physical appearance of the older 2600-cycle SF equipment units and a typical transistorized unit are compared in the photograph below. On the new unit, shown at the left, the relays are the latest wire-spring type. One mercury-type relay is used as a receiving relay because of its sensitivity and speed of operation.



Side-by-side comparison of the new transistorized signaling unit, left, with a similar older unit.

With the new equipment design, it is possible to mount as many as 90 signaling units on a single mounting frame. This compares with a maximum of 30 signaling units per frame for older 2600-cycle units.

At each location where in-band signaling equipment is furnished, it is also necessary to have a source of signaling tone. These tone supplies have also been transistorized. Normally, two of these oscillator circuits supply tone to as many as 45 units. In case of trouble, the load of the faulty oscillator is automatically transferred to the operating one by an automatic transfer and alarm circuit. This new tone-supply unit will be used wherever transistorized signaling circuits are involved.

Aside from the important advantage of smaller size, the new transistorized signaling unit for toll use is expected to cost less and will use only about one-half of the power required by the present in-band circuit. The new units require only a -48-volt power supply rather than the -48-volt and $+130$-volt supplies required for the older circuits. This power advantage is particularly valuable, since many exchange offices do not have $+130$-volt supplies.

The new equipment design also has several attractive maintenance features. Units can be readily removed from the relay rack by simply loosening two captive screws and unplugging the entire assembly. This means that faulty circuits can be rapidly restored to service in cases of trouble, because spare signaling units will be available for rapid substitution. The simplified replacement procedure should result in minimum "down time" on the signaling circuits and should reduce maintenance costs. If the removed units are found to be faulty, they can be forwarded to a central point where the necessary equipment for making tests and repairs will be available.

In a larger sense, these new in-band signaling units represent two important steps in the future of the Bell System. First, they have demonstrated another of the important uses for transistors in existing switching systems. Second, the new signaling units will play an important part in the extension of direct-distance dialing (DDD) by extending the use of the increasingly popular in-band signaling method to the many types of exchange and intertoll trunks intertoll trunks that use carrier transmission.

The ideal transmission area for a microwave repeater station is often on a mountain peak or in the desert. The problem of housing the relay equipment on such remote sites was solved with a special portable building designed by Bell Laboratories engineers.

J. W. Halliday

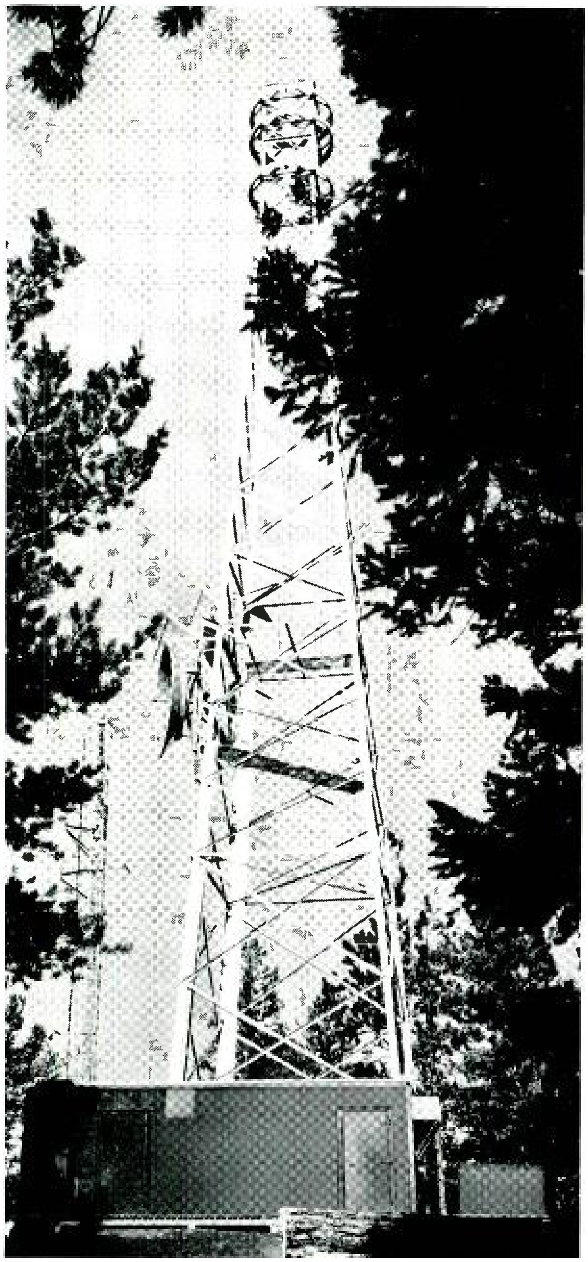
Packaged Buildings for TJ Microwave Systems

The TJ Radio system comprises a frequency-modulated system operating in the 11 kilomegacycle common-carrier band. Basically, it was developed for short-haul transmission of multiplex telephony, monochrome or color video, or other broadband communication signals. Because the system is ideally suited to light-route service, its repeater stations must frequently be located at remote, sometimes mountainous, sites.

Let us consider a case in point. The Mountain States Telephone and Telegraph Company ordered a TJ system for service between Phoenix and Flagstaff, Arizona. Accordingly, sites for the construction of four repeater stations were laid out at Desert Hills, Black Mesa, Mingus Mountain, and Mount Elden *(see photo on page 382)*.

To reach the repeater station situated on Mingus Mountain, you have to follow a winding dirt road 3.6 miles long that climbs over unsurveyed land to an elevation of 7650 feet. Studies indicated that construction of regular buildings and installation of equipment at sites such as these would prove to be quite costly. All of the building materials would have to be hauled up the mountains and assembled by a contractor's crew which either must camp at the site or lose valuable time being transported to and from the nearest town every day. Either situation would be expensive. Radio equipment would have to be similarly installed, with the added risk of damage because of difficult transportation conditions. To solve building and installation problems of this kind, Bell Laboratories, in cooperation with the American Telephone and Telegraph Company, designed and developed a small transportable building.

The building, fabricated by the Freuhauf Trailer Company, a major manufacturer of highway trailers, is similar to the freight containers used by ships, railroads and trucking companies. It consists essentially of a trailer-truck body with no chassis or wheels. Two doors in the side of the body, and a center partition, provide two rooms—one for the power equipment



TJ repeater station located at Mt. Elden, Arizona. prefabricated building at relay tower's base is painted green to blend with its forest setting.

and the other for the radio equipment (*see drawing on page 383*). The partition also offers fire protection between the radio equipment and the gasoline engine in the power room. With its radio and power equipment set in place, the building is hauled to its site and "plugged in."

The TJ Radio system, with its compact equipment arrangements and relatively small power requirements, is well suited to this arrangement because it operates from a normal commercial power line. Should the commercial source fail, a small 5- to 10-kw engine-alternator set powers the radio equipment.

Because packaged buildings may be installed in places where many varieties of weather conditions prevail, provisions were made to control heating and ventilation. Thermostatically controlled electric heaters and fiberglass batting in the walls, ceiling and floor make the building comfortable for maintenance personnel. The heaters also insure proper temperatures for operation of the radio and smooth starting of the gasoline engine. Adequate ventilation for good working conditions and the proper atmosphere for most efficient operation of the radio equipment is achieved with thermostatically controlled fans and air-conditioning units. Extra vents in the floor of the power equipment room permit escape of any dangerous gases from possible carburetor leakage. Finally, a constant-flow type dehydrator using silica gel keeps the antennas and waveguide runs pressurized with dry air.

Interior Wall

The center wall dividing the power and radio rooms gives extra strength and adds to the rigidity of the unit. It also affords a substantial area for mounting the alarm and control equipment. A facing of sheet steel, added to the power room side of this wall, improves the magnetic isolation of the radio equipment. The units are arranged for a waveguide run from the radio equipment to the paraboloidal antennas at the top of an adjacent tower. This required the use of a specially designed waveguide port and a horizontal run of waveguide with an ice shield and provision for the lighting and antenna heating conduits.

Installations in other locations may be furnished with antennas mounted on the building roof and aimed at passive reflectors on top of the tower. The roof must be reinforced for added rigidity and stability of communication during heavy snow conditions. Because of its location on the top of high mountains, the ability to withstand winds of 100 miles per hour with less than one-quarter of a degree sway is a design requirement for the structure.

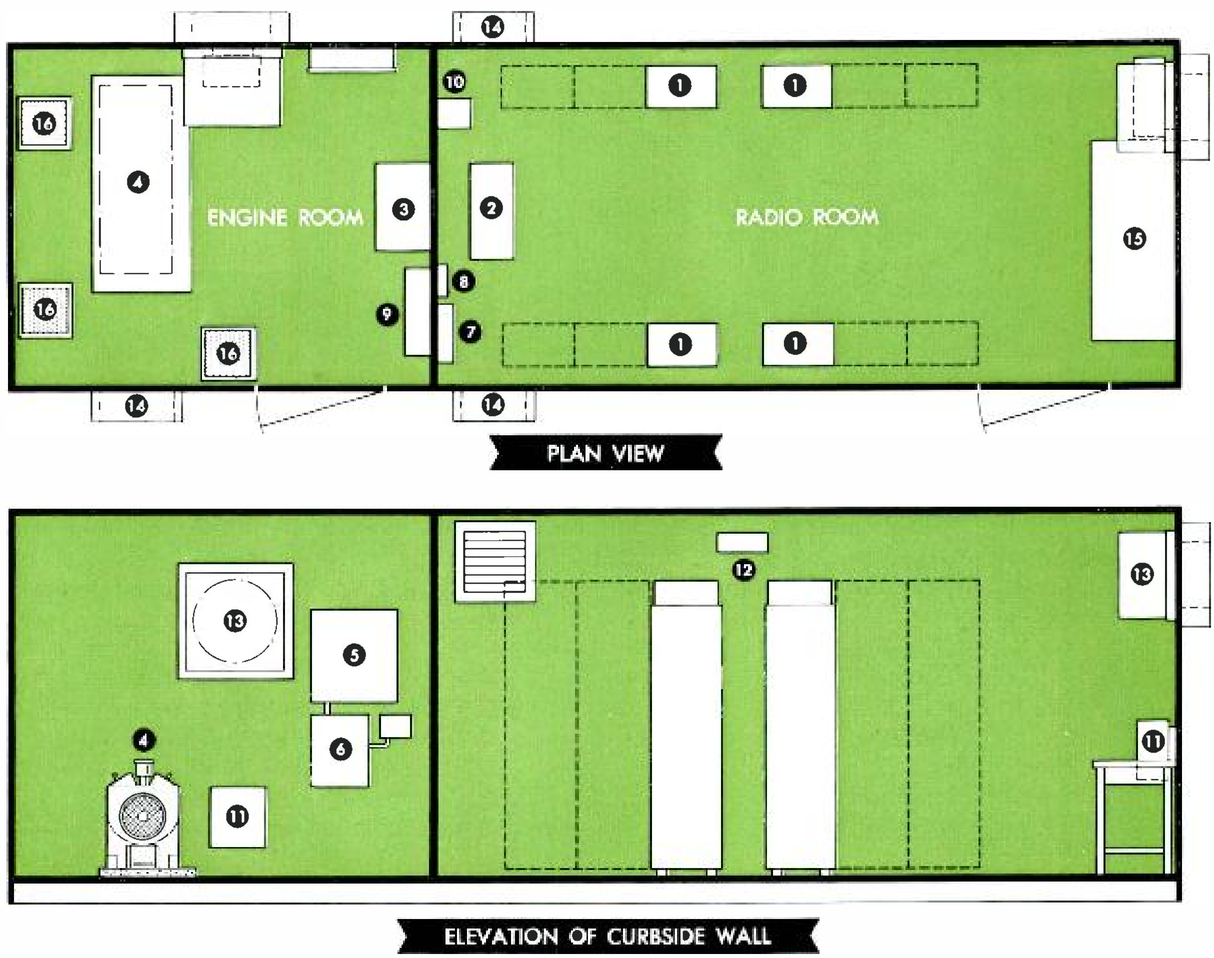
The grounding system for the radio and power circuits is improved because of the all-metal construction of the building. Another advantage of all-metal construction is that it prevents porcupines and other pests from breaking in and possibly damaging equipment.

A workbench having a cabinet for tools and spare parts, plus convenient power outlets, fits in at one end of the radio room. This workbench, plus other power outlets around the radio and power rooms, afford easy maintenance.

Shock and vibration mounts were placed under the radio bays and at the wall fastenings at the rear of the bays. This mounting arrangement gives the necessary flexibility to permit the sensitive radio and alarm bays to withstand the tortuous trails found in the regions where the buildings are to be installed. The shock mounts protected the equipment quite well during delivery of the Phoenix-Flagstaff units. Road speeds up to 50 miles per hour during delivery were possible with no ill effects to the radio equipment.

The engine-alternator set is mounted on a concrete pier that protrudes through an opening in the floor of the power room without making contact with the frame of the building. This arrangement prevents modulation of the output of the radio bays that might be caused by a general vibration of the entire building when the engine is running.

A fitting added at each upper corner of the container accommodates a spreader bar so that a crane can be used to load the buildings on freight cars or trucks and to lower them on the footings at the repeater sites. Special fastenings ease the job of tying down the units to the footings. The latter are predrilled steel plates that protrude 3 inches from the sides and corners of the building. When the crane lowers the building onto



1 RADIO BAYS
2 ALARM BAY
3 REGULATOR BAY
4 5KW POWER UNIT
5 5KW UNIT CONTROL BOX
6 MOTOR START RELAYS
7 POWER DISTRIBUTOR PANEL
8 LIGHTNING PROTECTION EQPT.
9 OBSTRUCTION LIGHTING EQPT.
10 DEHYDRATOR
11 HEATER
12 WAVEGUIDE PORT
13 FAN
14 WALL LOUVER
15 WORKBENCH
16 FLOOR VENTS

Mechanical drawing shows the floor plan and over-all detail of how the packaged building is arranged. Power and radio equipments are housed in separate rooms with individual entrances.

Truck transporting a packaged building for a TJ radio-repeater station must wind up mountain roads. Preceding it is a moderately sized crane that swings the building into place at its site.

the footings, and final adjustments for alignment are made, the mating steel plates are drilled and bolts are installed. Such features were instrumental in saving a great deal of time for the rigging crew. One unit was trucked onto the site, fastened to its footings, had its engine installed, and the rigging equipment removed from the property—all within an hour.

Existing Installations

Four buildings housing the TJ repeater equipment are now installed along the Phoenix to Flagstaff, Arizona, route. Two of them are located in a forest and two are on the desert. The forest units are painted green to blend with the surrounding terrain. Desert units are painted aluminum to reflect as much heat as possible. Based on experience with these four units, indications are that many more repeater stations of this type may be used on similar routes.

These original buildings were freighted two-to-a-flat-car, to Phoenix, Arizona. Here Western Electric installation personnel outfitted them with radio, power and control equipment. After final system checks, the buildings were loaded on trucks and hauled up to their sites, as shown in the photograph above.

Such transportable buildings are not unique in the Bell System. The emergency community dial offices employed in the Bell System and the microwave units designed by some nonassociated companies are similar, although they include a truck type chassis and wheels. For the TJ radio system application described in this article, however, where relatively permanent and rigid installation is required, the added weight and resulting expense are not warranted. But in any future application where portability is an important factor, these packaged buildings may prove highly useful.

The Bell System uses some devices by the millions. Redesigning one of these devices to cut costs by even a small amount can result in important savings to the Bell System. A typical redesign of this kind, on a widely used power resistor, was recently completed at the Laboratories.

R. J. Wirtz

A New Design for Power Resistors

The complexity of a telephone system is due in part to the variety of equipment, devices, and materials it uses. Some of these items are relatively new to the arts of telephone switching and transmission. Germanium or silicon devices, for example, have only recently been incorporated into new designs to any extent. But many of the better known devices—resistors, capacitors, and inductors—have served the telephone system for a long time. Typical of these venerable units in the Bell System are the power resistors known by the code names "18 and 19 Flat-Type Resistors."

These resistors, associated with station apparatus and transmission and switching facilities, are categorized as "general use" items. As such, they have found numerous applications in the Bell System. The first designs were manufactured by the Western Electric Company as early as 1901. Because of their extensive use and unique appearance, flat-type resistors performed a very special service during World War II. At that time, they served to identify equipment manufactured by the Western Electric Company. This expedited a sizable sorting process on the invasion beaches of Europe. The 18- and 19-type resistors have an excellent record of past performance in the telephone plant and have earned the reputation of "old standby."

Physical Dimensions

These wire-wound resistors can dissipate approximately 5 watts of power under normal conditions, and as much as 12 watts, for limited periods, under trouble conditions. They are flat in appearance, measuring approximately 3/8-inch thick by 1¾-inches wide by 4¾-inches long. They can be mounted in banks on 7/16-inch-minimum centers. The 18-type resistors have a single winding and two rigid terminals, while the 19-type resistors have two windings and three rigid terminals. In 1959, demand in the Bell System for these Western Electric resistors was something over six million per year.

Obviously, such a high demand makes it worthwhile to attempt to cut down the cost of these resistors, if it can be done without sacrificing

R. F. Leach, left, and author discuss attributes of the new 19-type resistor. On display board at rear are variety of Bell System resistors.

quality. And so it was that these resistors were completely redesigned in a lengthy program combining efforts of both Bell Laboratories and Western Electric. This program was completed just a few years ago when initial production of the newly designed resistors began at the Kearny, New Jersey, plant of the Western Electric Company.

The primary objectives of this redesign were to eliminate various items of insulators and mounting hardware, and adapt the resistors for modern methods of production. Such factors contribute directly to a substantial reduction in cost, reflected partly in the unit cost of the resistor and partly in the cost of mounting or assembling it into equipment. Moreover, there is a long-term savings attributable to an improved product.

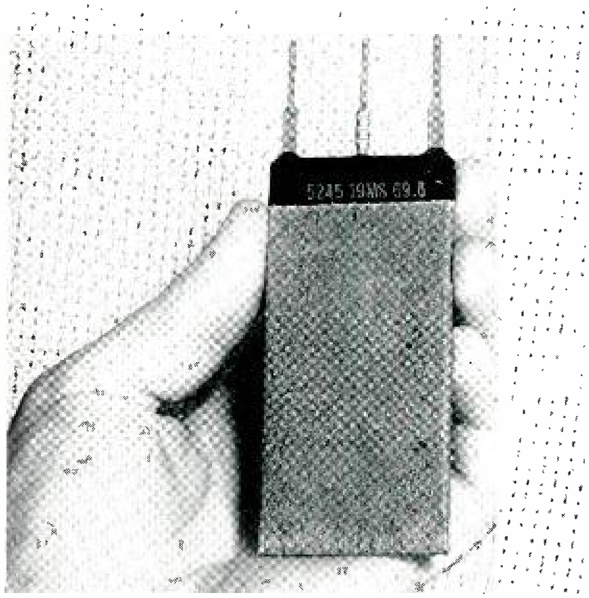
The improvements in design included three major items. First, designers superimposed windings on an insulated metal core and terminated the resistance wire by spot welding it to the core and terminal. Old-style resistors had windings side by side on a phenolized asbestos core with soldered splices and terminations.

Second, they provided an insulated mounting surface for the resistors by assembling a phenolic terminal head molded integrally with the metal core. The old designs required mounting-plate bushings, insulator washers on both sides of the mounting plate, and metal mounting washers.

Finally, the designers secured the new resistors to the mounting plate by a single, centrally located mounting stud for the 18-type resistors. This mounting stud doubles as the third terminal post for the 19-type resistors.

In addition, new design 18- and 19-type resistors have terminals to accommodate either soldered or solderless wrapped wire connections (RECORD, *February*, 1954). The entire body of the resistor is covered with an envelope of phenolized asbestos, completely insulating the structure on the apparatus side of the mounting plate. Old-style resistors had metallic terminal side posts exposed over the entire length of the body. Also, code and resistance-value markings on the new style are stamped on the molded head where they are legible when the resistors are mounted in place. This is in contrast to the old style markings that were printed on a label affixed to the resistor body, where they were unreadable when the resistors were mounted. As with the old style, the resistance-value markings for the 19-type resistor are oriented to identify unequal windings.

The new designs feature detail parts that lend themselves to be fabricated, machined, and assembled by modern production methods. This is especially true of parts such as a metal card that combines the core and the terminals. It is also true of the mounting stud and center terminal, and the molded-phenolic head unit and envelopes of asbestos that encase the resistors.



The redesigned 19-type resistor. Center mounting stud is designed to be a third terminal post.

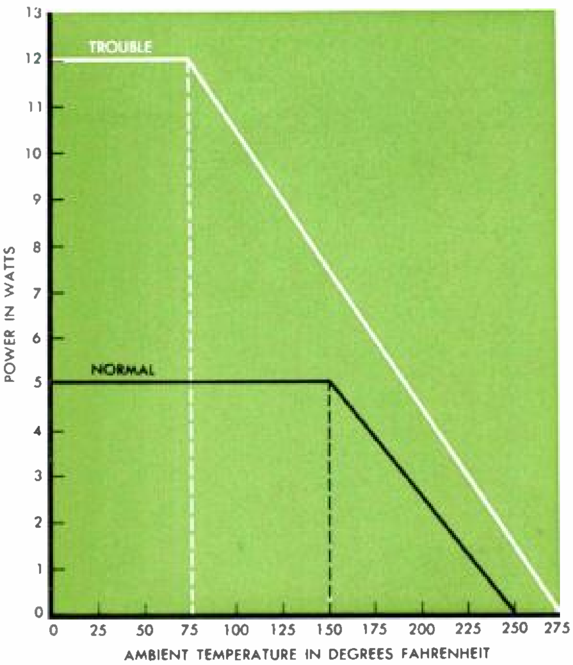
For a given power-dissipation, the operating temperature of the new resistor is lower than that of the old. This is because the metal core acts as a "heat sink," distributing the heat evenly over the entire body of the resistor. The result is lower "hot-spot" temperatures. Based on experimental data, power rating characteristics were derived for the new resistors. These are illustrated in the graph, right. Here, the "normal" power rating is 5.1 watts. For each degree that the ambient temperature exceeds 150 degrees F, the rating decreases about one per cent of the normal rating, or about 1/20th of a watt. "Trouble" power rating is shown as 12 watts with a decrease of about one-half of one per cent, or 1/16th of a watt, for each degree the ambient temperature exceeds 75 degrees F. A trouble condition is a temporary overload condition due to a circuit malfunction. Resistors can be operated at "trouble" power ratings safely for twenty-four hours.

At the time redesigns were contemplated, there was a large quantity of old-style resistors already in the field. It was essential, therefore for the new styles to be designed electrically and mechanically interchangeable with the old. For this reason, the new designs were tailored to have their over-all function and appearance governed by the electrical characteristics and physical dimensions of the old-style resistors.

Electrical Protection

Because of their completely insulated structure, the redesigned resistors have no "live" parts behind the panel on which they are mounted. Therefore, they do not require the insulators and shields normally used on the old-style resistors for electrical protection against the exposed metal side posts and the center post.

The new designs have their terminal insulation integral with the molded head. This eliminates the need for mounting-plate bushings, used for insulating old-style resistor terminals. In the event of a field replacement (where a new-style resistor replaces an old) the bushings must be removed before the new resistor is mounted. With the introduction of the redesigned resistors, the now obsolete insulator bushings are no longer being supplied in newly manufactured mounting plates. Thus, to maintain interchangeability, designers had to devise a way of mounting old-style resistors in the unbushed holes of these new mounting plates. They therefore supplied a new molded-strip insulator to take the place of the bushings. For additional economy, this insulator also replaces two insulating washers formerly required on the apparatus side of the mounting plate.

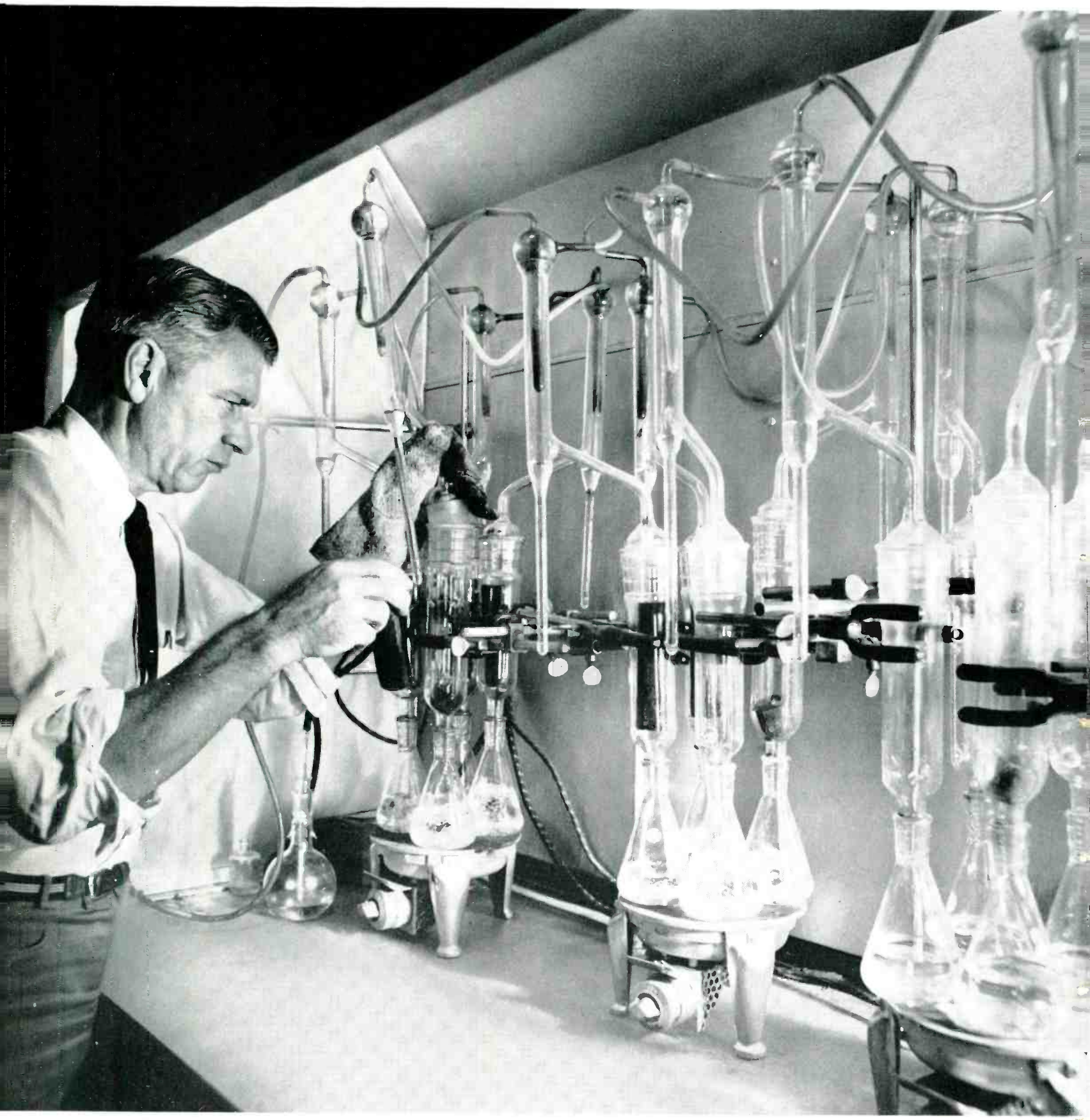


Power rating characteristics of the new resistors show "normal" at 5.1 watts, "trouble" at 12 watts.

Since the new designs are electrically interchangeable with the old, the Bell System has retained the old code designations. This has avoided the expense of a substantial amount of drafting, clerical, and engineering effort that otherwise would have been involved in changing an estimated 100,000 drawings—Bell Laboratories equipment and circuit drawings as well as Western Electric Company equipment drawings and wiring diagrams.

During the period from initial to full-scale production of the new design, the Western Electric Company produced both new- and old-style resistors. However, production of the old style was reduced progressively until today, all requirements for 18- and 19-type resistors are being filled with the new design.

In its redesign program, the Bell System reviews long-existing items and judges them in the light of their present use. It also takes a close look at their quality and reliability requirements, and at their methods of manufacture. Effort devoted to this type of review results in the improvement of components. And for those manufactured in a large volume, such as the 18- and 19-type resistors, it can save much money for the Bell System.



John Leutritz places a wire-mesh basket containing wood wafers into a flask of boiling toluene. As the vapors pass through the wafers, the preservative is removed, and signs of decay can be seen.

Detection of Decay in Treated Wood

When a tree is cut, it is exposed to fungi much as a person with an open wound is exposed to bacteria. In most cases, if you apply an antiseptic to a wound, you can kill all harmful bacteria and preclude infection. This is not true, however, with cut trees. When improperly stored and seasoned, trees cut for telephone poles in the pine forests of the South can become infected with decay-producing fungi before being treated with wood preservative. Most important is the fact that the decay is not only retained after treatment, but also that it is difficult to detect once oil-type preservatives impregnate the wood.

Even when decay is fairly well advanced, the typical cracks and cubical disintegration caused by such storage rots as *Peniophora* are often absent. In tests conducted by the Laboratories, wood blocks were carefully measured at various stages of decay. Outside Plant specialists found that there is no change in the volume of the blocks—regardless of the amount of decay—so long as the wood remains above the fiber saturation point. However, once the moisture content of the wood falls below fiber saturation, shrinkage occurs and cracks and rot become evident. This led to the belief that if the water and the preservative were removed rapidly from the wood, the symptoms of decay could be readily detected.

Studies of seasoning and storage carried on by the Laboratories in the South as early as 1938 showed that fungi entered the cut ends of pole timbers 24 to 48 hours after the trees were felled. In such cases, the spores were evidently drawn along the tree's water-conducting elements and proceeded inward some distance from the cut surface. When the spores germinated, "pipes" of decay formed, and these spread internally in longitudinal and radial directions. This kind of decay started in the six summer months while the untreated poles were in storage.

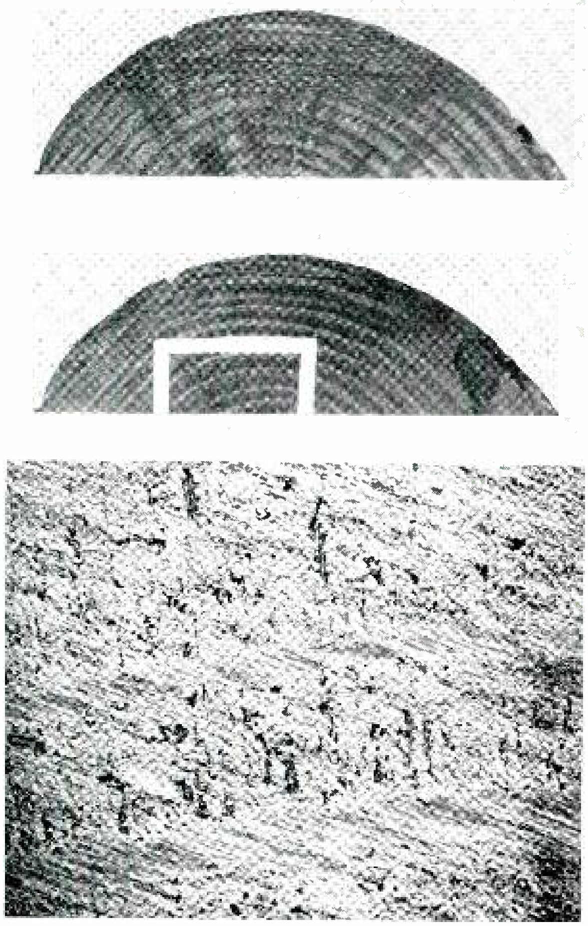
In the course of these studies, the ends of the poles were sawed off prior to treatment until no decay was visible. Then, the poles were treated, and representative discs of wood were cut 1 foot from each end of the poles. To determine the amount and distribution of oil preservative in the wood, Laboratories scientists used a special process known as hot-toluene extraction.

First, four representative sectors are cut from each wood disc. Then, slices are cut from the outer and next ¼-inch zone and thereafter each half-inch zone. After being further sliced into thin wafers, samples from each zone are weighed and placed together in wire-mesh baskets. The baskets are mounted in large flasks containing toluene. During the early stages of reflux, the combined vapors of toluene and moisture (from the wood) rise to the top of the apparatus, condense, and fall into a graduated trap. Because water is heavier than toluene, it falls to the bottom of the trap and can be easily measured. By ascertaining the oven-dry weight of the wafers, the amount of wood preservative can be calculated.

After a recent pole break involving a new, creosoted, southern pine pole, sections near the break were sent to Bell Laboratories for study. In accordance with Laboratories test procedures, a relatively undamaged disc, ¾ inch in diameter, was cut as close as possible to the break. Very dark areas in the unextracted half of the disc indicated either excessive oil retention or heavy sap-stain discoloration. In the latter case, the entrance of fungus spores would be confirmed. To remove both the preservative and water, a hot-toluene extraction of half the disc was carried out.

The hot toluene, by dissolving the oily preservatives from the wood, removed the dark brown discoloration that tends to hide signs of decay. In almost all cases, the wood prior to extraction was at or above fiber saturation. This delayed the appearance of the telltale cubical structure of the rotten wood and masked the decay. Before extraction, there was no evidence of decay. After extraction, the shrinkage cracks, typical of advanced decay, were readily visible to the naked eye. The photographs on the next page show the disc before and after extraction.

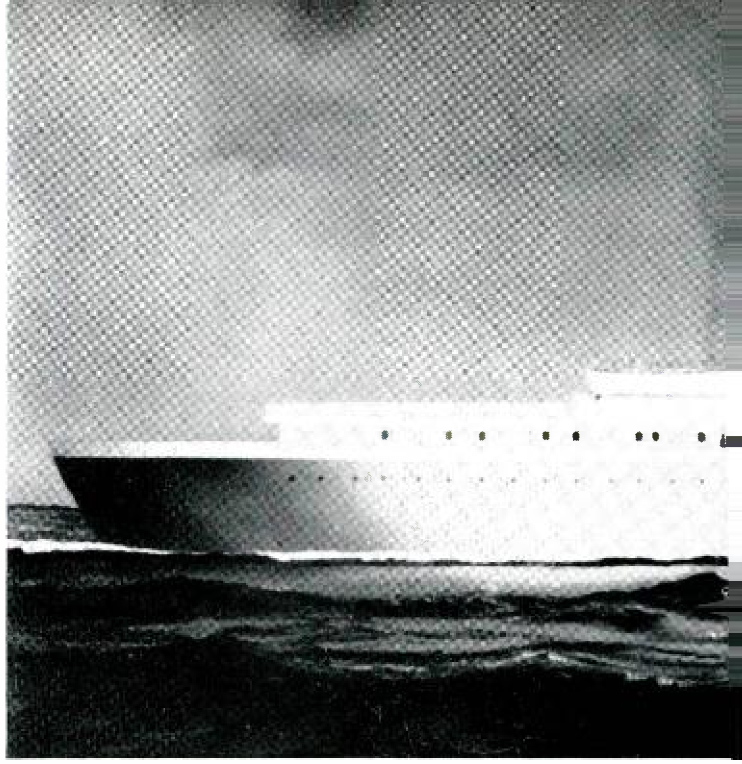
Since the preservative retentions in a disc cut adjacent to that shown in the first photograph were far in excess of the maximum amount of creosote required to prevent attack by wood-destroying fungi, it was concluded that the decay occurred in storage before the pole was treated. This was confirmed by a microscopic examination of sections of the same pole at the U. S. Forest Products Laboratory at Madison, Wisconsin.



Section of decayed telephone pole before and after hot-toluene extraction. In the top photograph shrinkage cracks—typical of decay caused by fungi before the pole is treated with wood preservative—are not visible. After the preservative is extracted from the wood with hot toluene, however, such signs of decay are readily apparent (as shown in the magnified section.)

The hot-toluene extraction technique for determining decay after poles have been treated with wood preservative promises to be a valuable laboratory procedure. It permits a relatively quick, efficient and inexpensive diagnosis of suspect poles returned from the operating plant or of specimens taken from Laboratories test plots. Hot-toluene extraction now takes its place as a reliable supplement to the more conventional and painstaking method of microscopic examination.

J. Leutritz, Jr.
Outside Plant Development



Future Submarin

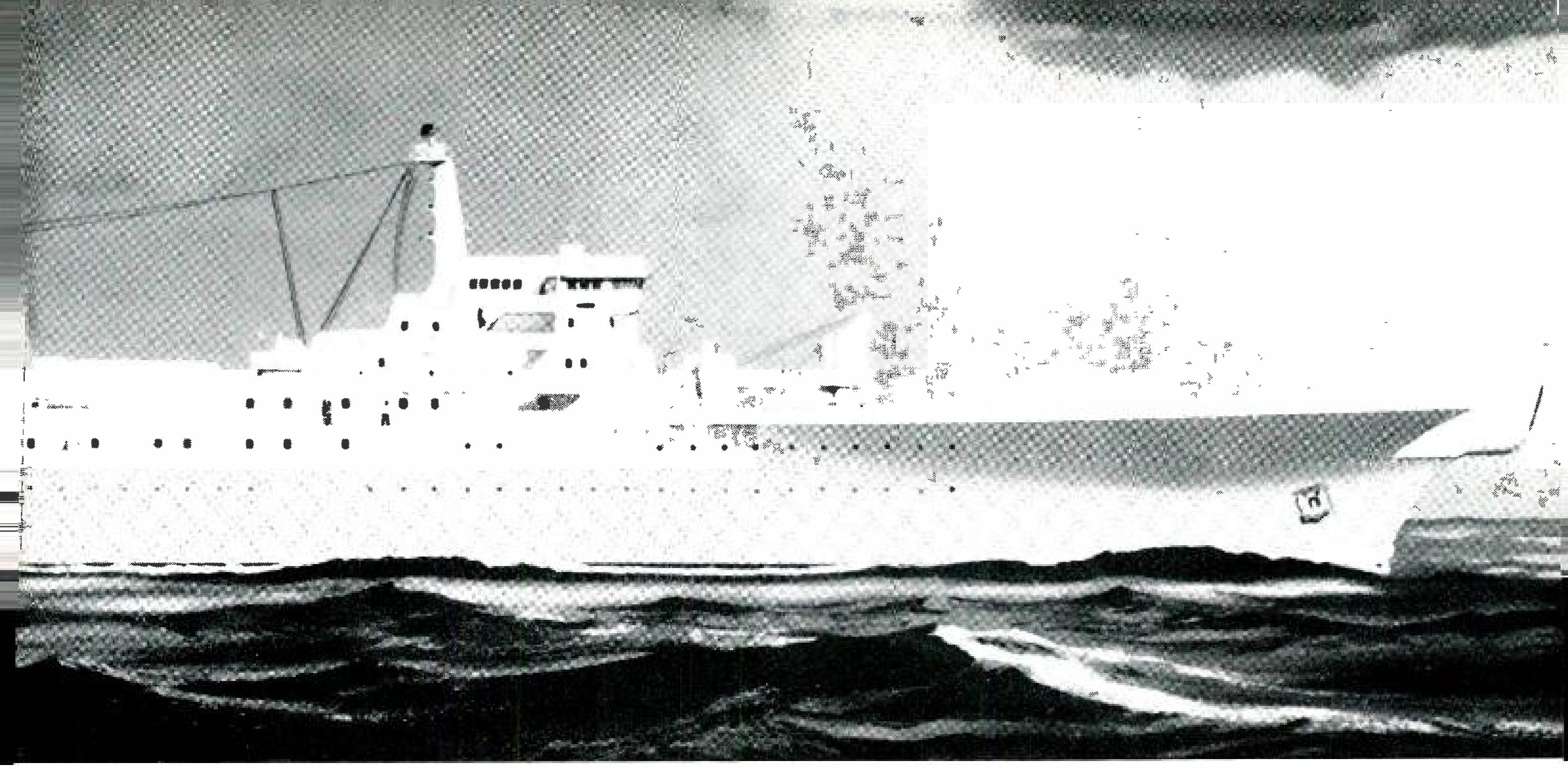
News from the Bell System

Plans for building a Bell System cable-laying ship and for expanding the submarine cable systems between three continents were outlined recently by H. T. Killingsworth, Vice-President of the Long Lines Department of the A.T.&T. Co.

Speaking to the Honolulu Chapter of the Armed Forces Communications and Electronics Association, Mr. Killingsworth said that a new cable ship, being built by Long Lines, should be ready by 1962. This ship, designed with the help of Bell Laboratories to incorporate the most efficient and modern cable-laying techniques, will have laying gear to handle a new two-directional cable and the rigid repeaters that will be used in the new cables.

Deep-sea plans for the early 1960's include: extending the telephone-cable network westward from Hawaii to Japan and other points in the Far East; installing additional cable in the Caribbean area and possibly thence to South America; and a third transatlantic cable going directly from the United States to Great Britain or Europe.

Work, now well along, will increase the capacity of the existing telephone cable system between California and Hawaii. The Hawaiian Telephone



;able Plans Include Cable Ship

Company is cooperating in this project. Long Lines also expects to join British Commonwealth associates in a new cable from Vancouver, B. C. to New Zealand and Australia, via Hawaii.

Factories are being built that will make the new repeaters and the new two-directional cable, Mr. Killingsworth said. This new single-cable system will be used in all major projects being considered. The increased range between power feed points and the increased circuit capacity are the most important advantages of the new system over the twin-cable design, he pointed out.

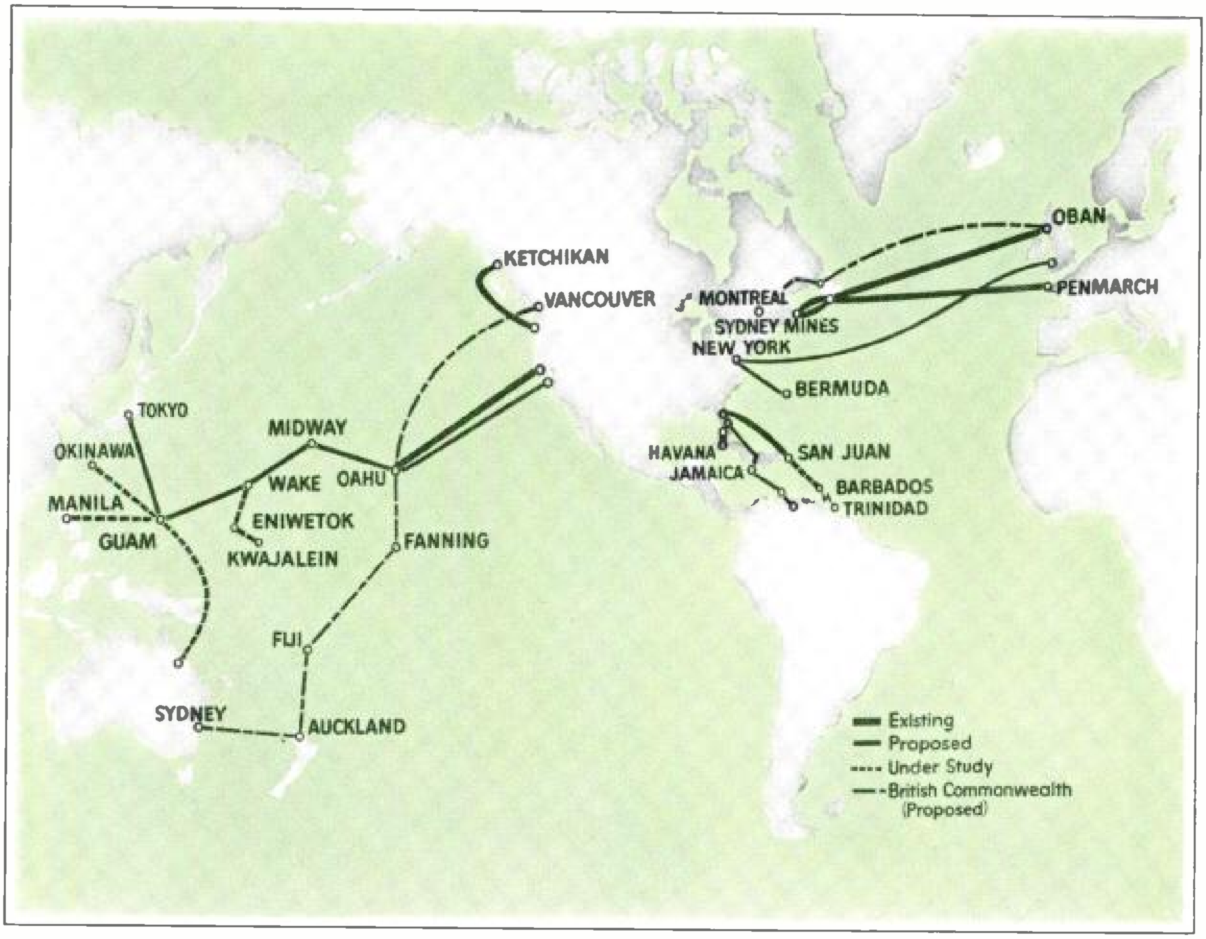
Schedules call for 7,000 miles a year—"equivalent to a California-Hawaii cable every 4 months. Even this very high production rate is not great enough to do all the things we want to do as early as we would like to do them; but if we try to do everything at once, costs would be very high and we might have factories and ships for sale after the first year or so," he explained.

"The first installation of the new cable will be in the Caribbean (about 800 miles of cable). We expect to follow this with an extension to South America where there is great need for improved service. Then will come the third transatlantic—and here the longer range of the new design will make it possible to go directly from the shores of the United States to Great Britain or the European continent, thus avoiding the Newfoundland fishing grounds. This installation has to be completed by 1963 to meet commitments made several months ago for additional circuits to this section.

"Right on the heels of this job will be the cable from Hawaii to Guam. This section will require an intermediate power feed point. Whether this will be on Midway or Wake, or both, depends largely upon the communication needs of the military and is one of the details to be worked out. Whatever is needed in this connection, we can provide. Then we will go on from Guam to Japan and, by that time, relief will be required between here (Hawaii) and the mainland," he said.

Next year plans include a cable to Bermuda. This will be a system of British design which has a capacity between that of the present twin-cable system and the Bell System's new design.

Mr. Killingsworth explained that the present project of increasing the capacity of the California-Hawaii cables is being done in two ways. "Existing terminal equipment in Hawaii and in California is being replaced by newly designed equipment that utilizes the available frequency space more efficiently." Such equipment, already



Undersea telephone cable system discussed by H. T. Killingsworth, Long Lines vice president.

installed on some of our other cables has proved "highly effective," he said. Units for the Hawaiian cable are being manufactured and "it is expected that they will be in service this fall. This will increase the number of telephone-grade channels in the cable by one-third."

The next step is expanding the circuit capacity of the cable through the use of TASI, which will double the message-carrying capacity of these circuits (RECORD, *March*, 1959).

Mr. Killingsworth said, "the British and Canadians plan to complete the route, known as CANTAT, between Great Britain and Canada in 1961. We have arranged for sufficient circuits here to tide us over until our third transatlantic cable is completed in 1963.

"Having circuits in CANTAT will also increase diversity of routes which is so very important in times of emergency."

He also stated that "the Oahu-New Zealand-Australia route will be built from south to north according to present plans, and probably will be completed into Oahu in 1963. Circuits we expect to obtain in this cable will take care of American needs, military and civilian, pending the time when a cable between Guam and Australia is required."

The Long Lines vice president noted that the network he had presented was very comprehensive and would be added to or changed as required by the needs of our customers.

In connection with satellite communications, Mr. Killingsworth pointed out that Bell Laboratories has been working in this field since 1954, three years before a satellite went into orbit.

"I believe satellite communication can be made a practical reality," he said. "But there may be several years of very hard work between now and the completion of the first commercially successful satellite communication system. In the meantime, we propose to go right ahead with the extension and improvement of our cable network because today's needs must be met with today's means and, without qualification, the very best means of trans-oceanic communications today, from a quality standpoint, is submarine cable."

Plastics—the Bell System's number one raw material—is under constant study at Bell Laboratories. This research has led to the discovery of a new class of polyethylene antioxdants that provide excellent protection from thermal oxidation, or degradation due to heat.

New Polyethylene Protectants Discovered

News of Chemical Research

The discovery that certain classes of organic chemicals can behave like carbon black in protecting polyethylene from degradation due to heat was announced last month by two members of the Chemical Research Department. At a meeting of the American Chemical Society in New York City, Mrs. M. A. Worthington and W. L. Hawkins presented data showing that a number of new polyethylene compounds provide excellent protection against thermal oxidation when used in combination with certain sulfur-bearing compounds.

The effectiveness of these combinations as antioxidants is much greater than what would be expected from either compound by itself. This phenomenon, in which the total protection exceeds the sum of its parts, is called "synergism." Previously, only carbon black showed this synergistic effect with sulfur antioxidants.

Carbon black is widely used as a light screen in polyethylene formulations for use outdoors. Telephone cable sheath, for instance, would rapidly lose its strength unless protected from light in this way. Although carbon black is very effective against light degradation (photo-oxidation), it provides relatively little protection against heat. Thus, the addition of thermal antioxidants is generally necessary.

The recently discovered sulfur-containing organic chemicals act as effective thermal antioxidants when combined with carbon black. By contrast, conventional antioxidants generally lose their effectiveness in this combination.

The fact that these sulfur compounds are far more effective in the presence of carbon black stimulated research into the properties of carbon black responsible for the synergistic effect. Mrs. Worthington and Mr. Hawkins observed that the effectiveness of carbon black arises from the extensive "conjugation," or alternating single or double bonding, between carbon atoms. This observation led to attempts to duplicate the carbon-black action with simpler conjugated organic compounds. The effort was successful, and a number of large fused-ring hydrocarbons have proved to be highly effective thermal antioxidants when used with the sulfur-containing compounds.

W. Lincoln Hawkins and Mrs. Mary Ann Worthington test effectiveness of recently developed thermal antioxidants used to protect polyethylene.

Although the Bell System does not intend to replace carbon black as a light screen in polyethylene for exterior applications, Bell Laboratories can use a basic understanding of the mechanism of carbon black activity to improve existing formulations. The non-black antioxidants, however, could be used in transparent polyethylenes for indoor purposes, where oxidation caused by light is not a problem.

"CATENANES" *A New Type of Molecule*

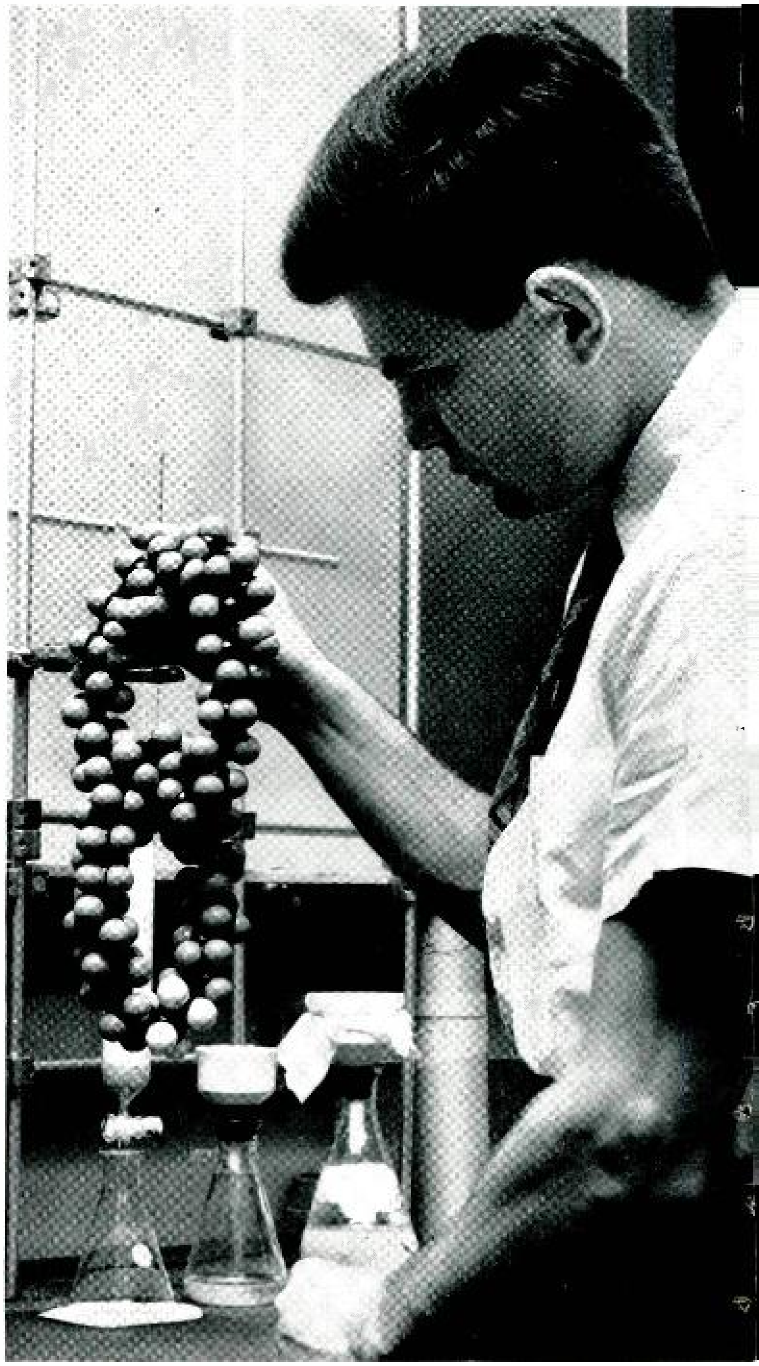
An entirely new class of chainlike molecules was described recently by E. Wasserman of the Chemical Research Department and H. L. Frisch of the Chemical Physics Department. These molecules, tenatively named "Catenanes" from the Latin word for "chain," are composed of large interlocking rings. Physically, a model of the molecule is more similar to a linked chain than are the so-called, "long-chain" molecules, which actually look more like a series of balls strung on a wire.

News of Chemical Research

At a meeting of the American Chemical Society last month, Mr. Wasserman explained that the new compound was synthesized by mixing a compound with straight-line molecules with a large-ring compound. In a small fraction of the mixture, a straight-line molecule would be expected to thread through the center of a ring, simply through mixing. These straight molecules are condensed into rings through reaction of their "end groups." Then, the threaded molecules form an interlocked pair with the ring molecules already present. A statistical analysis by H. L. Frisch indicates that a few per cent of these interlocked pairs should exist. Experiments showed the presence of about one per cent of these paired rings.

Studies of molecular models indicate that a doughnut of carbon atoms must contain at least 20 atoms before the "hole" is large enough to permit another molecule to pass through. In Mr. Wasserman's experiments, the rings contained 34 carbon atoms, as did the straight-line molecules.

The demonstration of the existence of simple twinned pairs introduces the possibility of more complex interlocked systems. It also appears possible that three-ring systems can exist. These could be linked together in several ways. Such interlocking forms will require chemists to take another look at the word "molecule," since the separation of the two rings requires the breaking of a chemical bond, even though the rings themselves are not joined by chemical bonding.



E. Wasserman holds wooden model of newly discovered chain-like molecules, called "Catenanes."

news in brief

J. J. Scanlon Appointed To New A.T.&T. Post

John J. Scanlon, A.T.&T. vice president-revenues, has recently been appointed vice president-planning and development. In this new position, Mr. Scanlon will coordinate the interdepartmental aspects of the planning and introduction of major new services.

Mr. Scanlon began his Bell System career in the general accounting offices of The Bell Telephone Company of Pennsylvania in 1925. After service with the War Production Board and the Army's General Staff Corps in Washington and in Germany during World War II, for which he was awarded the Legion of Merit, he returned to the Pennsylvania Company in 1946, and was named chief accountant, and 3 years later, assistant comptroller of the Company.

He was appointed assistant treasurer of A.T.&T. in 1952 and was in charge of the earnings division, then of the financial division. In September, 1953, Mr. Scanlon was elected treasurer of A.T.&T., and in April, 1959, elected vice president-revenues.

John J. Scanlon

Laboratories Consultant Receives the 1959 Shewhart Medal

Paul S. Olmstead, consultant to the Military Systems Engineering Department at Bell Laboratories, has been honored by the American Society for Quality Control. He was named the recipient of the Shewhart Medal for 1959 for his efforts to advance the science of quality control and the society. The honor was bestowed at the ASQC convention in San Francisco.

The Shewhart Medal was established in 1948 in recognition of Walter A. Shewhart, who retired from the Laboratories in 1956. Previous recipients at the Laboratories have been H. F. Dodge and G. D. Edwards.

A Commercial Use of Desk-Top PBX

The latest development in telephone switchboards—a compact, desk-top unit that features push-button dialing—made an appearance recently as a part of a new telephone communications system for the Irving Trust Company. Five of the tiny consoles (620A sets) are the key to the system serving the 1 Wall Street headquarters and the Woolworth Building branch office in New York City.

Each about the size of a portable typewriter, the PBX console was designed by Bell Laboratories and installed by the New York Telephone Company. The small consoles replace two conventional PBX-cord switchboards that had a total of 10 operator positions. The New York company provided specially designed switching equipment.

M. J. Kelly, R. Kompfner Honored By A.I.E.E.

M. J. Kelly, former Chairman of the Board of the Laboratories, and Rudolph Kompfner, Director of Radio and Electronics Research, have been honored by the American Institute of Electrical Engineers.

Mr. Kelly, "for outstanding contributions in the technology of telecommunications; as a distinguished organizer and eminent leader," will be presented with the first Mervin J. Kelly Award at the winter meeting of the A.I.E.E. Mr. Kompfner, cited for "creative achievements in research and development in the field of electronics and for his leadership in this field," will receive the David Sarnoff Award.

Mr. Kelly became President of the Laboratories in 1951 and retired as Chairman of the Board in 1959 after a 41-year career in the Bell System. Mr. Kompfner joined the Laboratories in 1951. He holds the 1955 Duddell Medal, given by the Physical Society of England for his work on the traveling-wave tube.

Western Electric Board Approves Additional Holmdel Construction

At its meeting last month the Western Electric Company Board of Directors authorized funds to extend the construction contracts to allow full completion of the first two sections of the new Laboratories building in Holmdel, N. J., in the initial phase of construction.

Heretofore, although the exterior shells of both sections were to be completed immediately, the last three cross aisles of one section were not to have been finished off inside. The funds allocated by the Board are intended to include interior completion of these three sections.

As the result of this action by the Western Electric Board, the over-all Holmdel building will be 50 per cent completed initially, rather than about 33 per cent.

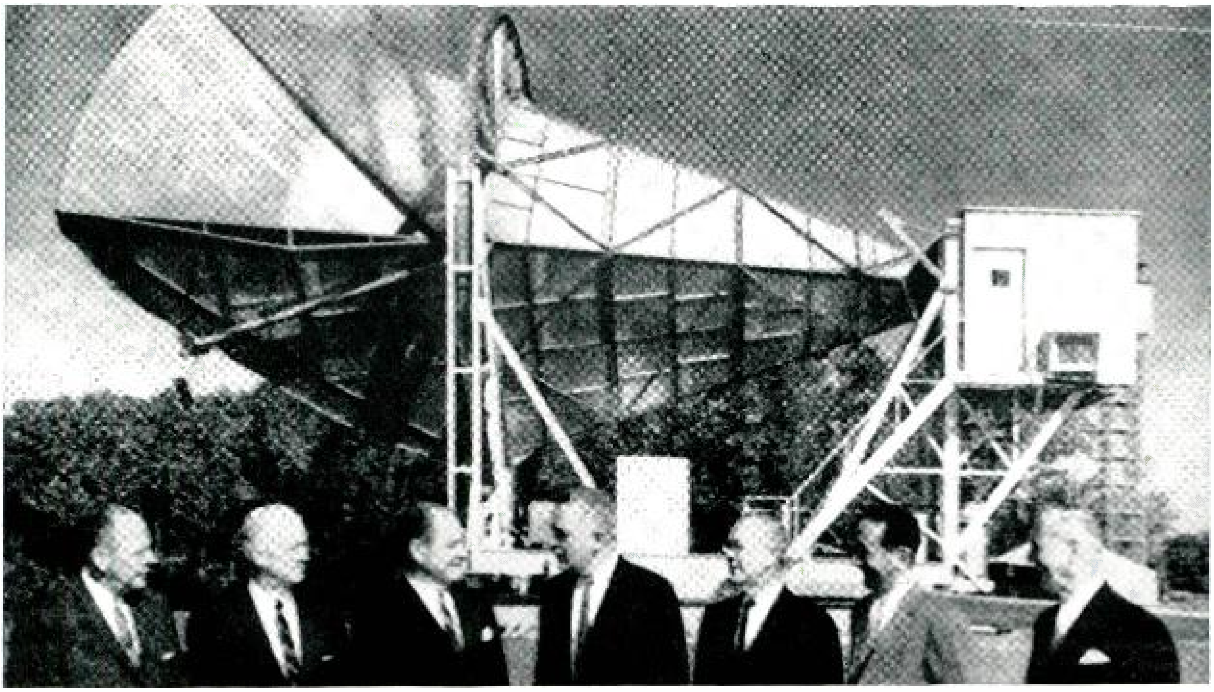
With the final completion of all

piling load tests, the Western Electric Company reported that construction on the new Holmdel building is now proceeding normally.

Foundations for the first two sections have been completed and work is in progress on the superstructures of both. Forms are now being erected for pouring concrete for the second floor of one section.

The Service Building is now roughly 99 per cent finished. Its garage area was turned over to the Laboratories recently for storage of grounds equipment. Paving continues satisfactorily and the roadways are now about 80 per cent completed. Construction has been started on the sewage-disposal plant.

Above, an elevator shaft takes shape at the Holmdel Laboratory.



Members of the Federal Communications Commission are shown here with T. Keith Glennan, Administrator of the National Aeronautics and Space Administration, in a photograph transmitted via NASA's Echo I satellite. Picture was taken at the Holmdel, N. J., location of Bell Laboratories, where the group observed satellite communications first-hand. The photograph was transmitted by landline to the U. S. Naval Research Laboratory at Stump Neck, Maryland, and then bounced off the Echo satellite back to the Holmdel Laboratories.

Left to right, are Commissioners John S. Cross and Rosel H. Hyde, Dr. Glennan of NASA, Frederick W. Ford, chairman of the F.C.C., Commissioners Robert P. Barley, Robert E. Lee and T. A. M. Craven.

Horn antenna shown in the background was used to receive the picture. Telephotograph-transmission equipment for the experiment was obtained through the cooperation of the Associated Press, United Press International, and Times Facsimile.

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Varsanyi, F., Wood, D. L., and Schawlow, A. L., *Self-Absorption and Trapping of Sharp Line Resonance Radiation in Ruby*, Phys. Rev. Letters, 3, pp. 544-545, Dec. 15, 1959.

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

Wood, D. L., see King, J. C.

Wood, D. L., see Varsanyi, F.

PATENTS

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

Abbott, H. H., Rippere, R. O., Williams, R. D. and Williford, O. H.—*Coordinate Switching System*—2,949,506.

Andrews, F. T., Jr. and Mann, H.—*Pulse Modulation System Framing Circuit*—2,949,503.

Andrews, R. J.—*Electronic Switching Network*—2,951,125.

Ashkin, A.—*Traveling-Wave Tube Interaction Circuit*—2,948,828.

Baker, G. H., Mitchell, D. and Reihing, J. V., Jr.—*Telegraph Signal Error Counting Circuit*—2,947,815.

Blackman, R. B.—*Apparatus for the Solution of Plane Triangles*—2,950,863.

Bobeck, A. H.—*Magnetic Core Circuit*—2,951,240.

Bodmer, M. G.—*Traveling-Wave Tube*—2,947,907.

Cadden, W. J.—*Shift Register Counter*—2,951,230.

Clogston, A. M.—*Microwave Mode Suppressors*—2,948,870.

Critchlow, G. F.—*Calibration Indicator*—2,951,200.

Feinstein, J.—*Magnetron*—2,951,-182.

PATENTS (CONTINUED)

Goldstein, E. — *Error-Detecting and Correcting System*—2,951,-229.

Hines, M. E.—*Microwave Frequency Converter*—2,950,384.

Hussey, L. W. and Rieke, J. W.—*Electronic Switching Network*—2,951,124.

Hysko, J. L.—*Telegraph Repeater*—2,947,816.

Kennedy, W. J.—*Shield for Coin Gauge on Coin Collectors*—2,948,377.

Koff, H. H.—*Panel Latch*—2,950,-141.

Kompfner, R. and Quate, C. F.—*High Efficiency Velocity Modulation Devices*—2,949,558.

Lewis, B. F. and Power, J. R.—*Electrical Information System*—2,949,507.

Kretzmer, E. R.—*Reduced Bandwidth Transmission System*—2,949,505.

Mann, H., see Andrews, F. T., Jr.

Marcateli, E. A. J.—*Microwave Devices*—2,950,452.

Marcateli, E. A. J.—*Mode Selective Devices for Circular Electric Wave Transmissions*—2,-951,219.

Miller, S. E.—*Broad-Band Electromagnetic Wave Coupler*—2,-948,864.

Miller, S. E.—*Wave Guide with Polarized Ferrite Element*—2,-951,220.

Mitchell, D., see Baker, G. H.

Pfann, W. G.—*Semiconductor Signal Translating Devices*—2,-950,425.

Pfann, W. G.—*Separation Process*—2,949,348.

Pierce, J. R.—*Low Noise Velocity Modulation Apparatus*—2,947,-905.

Power, J. R., see Lewis, B. F.

Quate, C. F., see Kompfner, R.

Reeves, M. L.—*Frequency Sensitive Electromagnetic Wave Device*—2,948,868.

Reihing, J. V., Jr., see Baker, G. H.

Rieke, J. W., see Hussey, L. W.

Rippere, R. O., see Abbott, H. H.

Scovil, H. E. D. and Seidel, H.—*Passive Signal Intensifier*—2,-950,442.

Seidel, H., see Scovill, H. E. D.

Smith, K. D.—*Toroidal Lens Device*—2,949,819.

Tryon, J. G.—*Switching Circuits*—2,950,461.

Unger, H. G.—*Helix Wave Guide*—2,950,454.

Weiss, M. T. — *Non-Reciprocal Gyromagnetic Device* — 2,949,-588.

Whidden, W. E.—*Universal Telephone Mounting*—2,949,509.

Williams, R. D., see Abbott, H. H.

Williford, O. H., see Abbott, H. H.

Zimmermann, E. P.—*Delay Timer*—2,949,547.

TALKS

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

Batdorf, R. L., *Diffusion Techniques and Related Topics in Ge and Si*, University of Michigan, Ann Arbor, Mich.

Boddy, P. J., Brattain, W. H., and Dewald, J. F., *Interaction of Iodide Ions With a Germanium-Electrolyte Interface*, Gordon Conf. on Corrosion, Colby Junior College, New London, N . H.

Bowers, K. D., *Parametric Amplification*, University of British Columbia, Vancouver, B. C., Canada.

Brattain, W. H., see Boddy, P. J.

Buck, T. M., *Semiconductor Surfaces*, University of Michigan, Ann Arbor, Mich.

Courtney-Pratt, J. S., *Some Unconventional Methods of High Speed Photography*, S.P.I.E. Symposium, Los Angeles, Calif.

Denton, R. T., *A Ferromagnetic Amplifier Using Longitudinal Pumping*, Solid-State Microwave Amplifiers Conf., University of Michigan, Ann Arbor, Mich.

Dewald, J. F., *Analogies and Distinctions Between Semiconductor and Metal Electrodes*, Gordon Research Conf., Meriden, N. H.

Dewald, J. F., see Boddy, P. J.

Dickieson, A. C., *TASI—A Time Assignment Speech Interpolation System*, National Symposium on Global Communications, Washington, D. C.

Ehrhardt, R. A., *Acid Gold Plating*, Am. Electroplaters Soc., Los Angeles, Calif.

Eisinger, J., *An E-H Gradient Spectrometer*, Nuclear Polarization Phenomena Conf., Basle, Switzerland.

Foster, F. G., *Crystallization of Hydroquinone — A Prelude to Time-Lapse Metal Whisker Study*, Microscopy Symp., Chicago, Ill.

Frishkopf, L., see Guttman, N.

Geller, S., *Magnetic Interactions and Distribution of Ions in the Garnets*, Kiel University, Kiel, Germany.

Geusic, J. E., *The Performance Characteristics of Maser Materials*, Eighteenth Annual Electron Tube Research Conf., Seattle, Wash.

Guttman, N., and Frishkopf, L., *'Facilitating Effect' of the Prior Member of a Monaural Click Doublet*, Acous. Soc. Am., Providence, R. I.

Herring, C., *The Current State of Transport Theory*, Westinghouse Research Laboratories, Pittsburgh, Pa.

Kaenel, R. A., *Digital Computer Input Unit for Analysis of Impulse Noise,* U.R.S.I. Spring Meeting, Wash., D. C.

Klauder, J. R., and Kunzler, J. E., *Higher Order Open Orbits and the Interpretation of Magneto Resistance and Hall Effect Data for Copper,* Fermi Surface Conf., Cooperstown, N. Y.

Kunzler, J. E., see Klauder, J. R.

Laudise, R. A., *The Hydrothermal Crystallization of Yttrium Iron Garnet and Yttrium Gallium Garnet and a Part of Crystallization Diagram* Y_2O_3—Fe_2-O_3—H_2O—Na_2-CO_3, Gordon Research Conf. on High Pressure, Meriden, N. H.

Luongo, J. P., *Infrared Spectrum of Polypropylene,* Applied Spectroscopy Symp., Chicago, Ill.

McCall, D. W., *Nuclear Magnetic Resonance Studies at High Pressure,* Gordon Research Conf., Meriden, N. H.

McKim, B., *Vulnerability in Belt Line Networks,* National Symposium on Global Communications, Washington, D. C.

Meibon, S., *Nuclear Magnetic Resonance Studies of Fast Chemical Reactions,* Phys. Chem. Colloq., Univ. of Gottingen, Gottingen, Germany; Phys. Colloq., Max Planck Institute, Stuttgart, Germany, Chem. Soc., Univ. of Munich, Munich, Germany, Badische Anailin u. Soda Fabr. Coll., Ludwigshafen, Germany; Chem. Colloq., Max Planck Inst. für Kohlforschung, Mulheim, Germany.

Meitzler, A. H., *Ultrasonic Delay Lines Using Shear Modes in Strips,* National Ultrasonic Symposium, Stanford University, Stanford, Cal.

Ollom, J. F., *Measurement of Microwave Ferrites at High Signal Levels,* Conf. on Standard and Electronic Measurement, National Bureau of Standards, Boulder, Colo.

Schulz-DuBois, E. O., *Distributed Ferrimagnetic Isolators for Use in Traveling-Wave Masers,* Eighteenth Annual Conf. on Electron Tube Research, Seattle, Wash.

Schulz-DuBois, E. O., *The Three-Level Solid-State Maser,* Am. Soc. for Engineering Education, Purdue University, Lafayette, Ind.

Schulz-DuBois, E. O., *The Traveling-Wave Maser,* Maser Engineering Summer Conf., University of Michigan, Ann Arbor, Mich.

Seidel, H., *Some Transformation Properties of Variable Reactance Networks,* University of Michigan, Ann Arbor, Mich.

Silverman, S. J., *Crystal Growth and Evaluation of Semiconductor Materials,* University of Michigan, Ann Arbor, Mich.

Uenohara, M., *Extremely Low Noise Variable Capacitance Amplifiers,* International Congress on Microwave Tubes, Munich, Germany.

THE AUTHORS

F. E. Haworth

F. E. Haworth was born in Lawrence, Kansas, and received a B.A. degree in physics from the University of Oregon in 1924. He joined Bell Laboratories in 1925, and received his M.A. from Columbia in 1929. His work at the Laboratories until 1941 was principally concerned with x-ray and electron-diffraction studies of magnetic materials. During World War II, he applied these two techniques to several military problems for the Office of Scientific Research and Development. After the war, he conducted studies on the physics of the erosion of relay contacts. In 1956, he transferred to the Visual and Acoustics Research Department and was part of the four-man Bell Laboratories team that did the basic research and development for the new artificial larynx. Mr. Haworth, author of "An Electronic Artificial Larynx," is a Fellow of the American Physical Society, and a member of the Acoustical Society of America and Phi Beta Kappa.

J. M. Wier received the B.S. and M.S. degrees in electrical engineering from Iowa State College in 1949 and 1950, respectively. He was employed in the Digital Computer Laboratory of the University of Illinois from 1950 to 1956 while completing the requirements for the Ph.D. degree at that institution. In 1956, he joined the Laboratories, and since then has worked on problems involving the systems aspects of data communications and data processing—the subject of his article, "Telephone circuits: A new Link in Data Communications," in this is-

J. M. Wier

C. S. Herrmann

sue. Mr. Wier, a resident of Scotch Plains, N. J., is a member of the Institute of Radio Engineers, Tau Beta Pi, Phi Kappa Phi, Pi Mu Epsilon, Eta Kappa Nu, and Sigma Xi.

C. S. Herrmann, a native of New York City, joined the New York Telephone Company in 1921. After graduating from Pratt Institute in 1925, he was assigned as Outside Plant Engineer, New Jersey Area. In 1927 he transferred to the New Jersey Bell Telephone Company and worked on aerial and underground cable construction, motor vehicles, and labor-saving machinery. He served in the U. S. Army Signal Corps during World War II, attaining the rank of Colonel. Mr. Herrmann transferred to the Laboratories in 1951 to work on trailers housing and transporting the ground-guidance equipment of the Nike Weapons System. As a member of the Military and Telephone Structures group he was concerned with special Naval ship-to-shore antennas, as well as vehicles and structures for the Nike-Hercules system. At present he leads the automotive group in the Outside Plant Development Department with responsibility for design and development of specialized motor vehicle equipment and bodies, and heavy work tools for Bell System use. He is a member of the Society of Automotive Engineers and the Society of American Military Engineers.

Allan Weaver, a native of Columbus, Nebraska, received the B.S. degree in E.E. from the University of Nebraska in 1921, and after 13 years with the Development and Research Department of the A.T.&T. Co., transferred to the Laboratories with that group in 1934. His early work, both at A.T.&T. and the Laboratories was centered on the development of telegraph, telephotograph and teletypewriter systems. Since 1945 he has concentrated on toll signaling, particularly the development of single-frequency signaling systems for use in nationwide dialing systems. He is presently in charge of a group engaged in such work. The holder of 37 patents in the fields of telegraphy, telephotography and signaling, Mr. Weaver is a member of the A.I.E.E., I.R.E. and Sigma Xi. In this issue, he is the author of "Transistorized Units for In-Band Signaling."

A. Weaver

J. W. Halliday, author of "Packaged Buildings for TJ Microwave Systems" in this issue, began his Bell System career in 1948 as a switchman with the New York Telephone Company. In 1952 he joined Bell Laboratories where his initial assignment was with the development of toll switching, carrier systems, and television transmission. A native of New York City, Mr. Halliday graduated from Curtis High School. He has completed, at several eastern colleges, a number of special courses in aeronautical engineering, aerology and navigation. Before joining

J. W. Halliday

the Bell System he was a primary flight instructor with the U. S. Army Air Force and following that held positions as navigator and pilot for commercial airlines. Mr. Halliday is now assigned to the Columbus, Ohio, location of Bell Laboratories where he is concerned with current engineering on No. 1 and No. 5 crossbar equipment.

Ralph J. Wirtz was raised in Andover, Massachusetts and attended Phillips Andover Academy before entering the U. S. Army during World War II. In 1950 he graduated from Brown University with a B.S. degree in Engineering. He joined the Component Development Department at the Merrimack Valley location of the Laboratories in 1956 and has been working on the development of resistors. Mr. Wirtz is a member of the American Society of Mechanical Engineers. He is the author of the story on new power resistors in this issue.

R. J. Wirtz