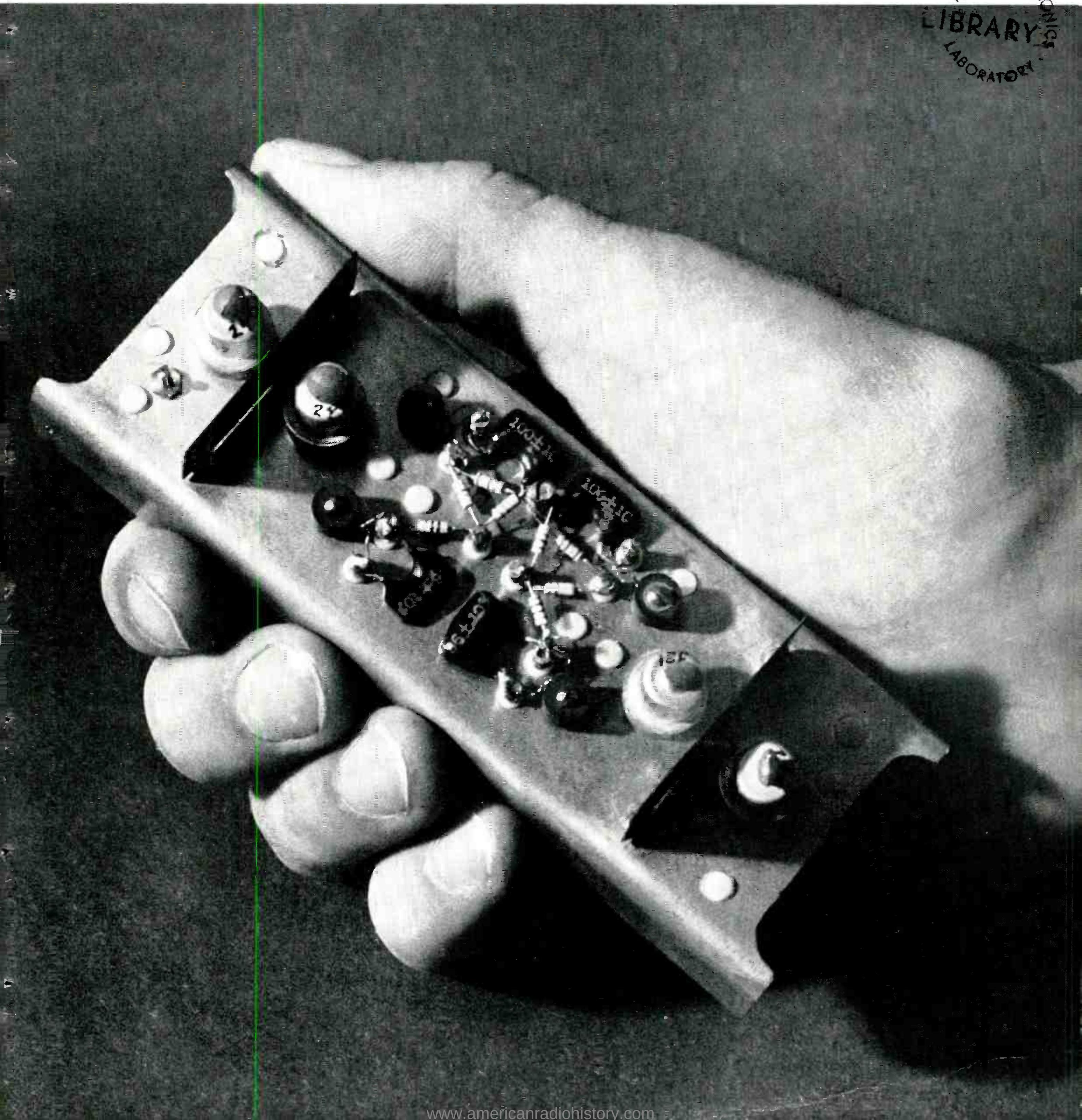
July 1960

# Bell Laboratories RECORD







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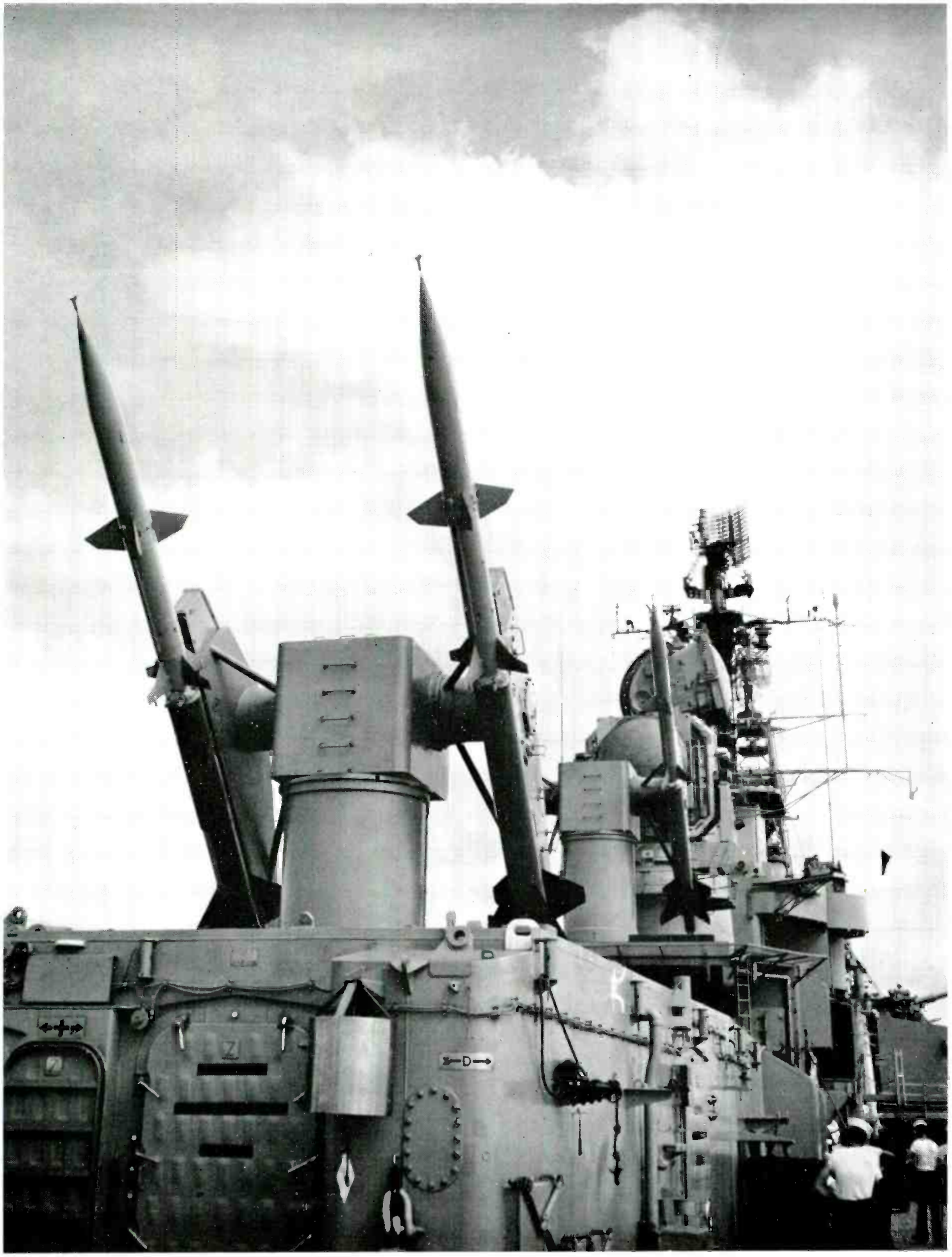
*Bell Laboratories* **RECORD**

*Volume 38 • Number 7 • July 1960*

## Contents



Cover *Although this experimental repeater can be held in the hand, semiconductor components make it capable of transmitting a band of frequencies wide enough for television signals (see p. 253).*




*The* USS Canberra*—one of two naval ships on which are presently installed operational versions of the Mark 65 equipment for direction of gun and guided-missile fire against attacking aircraft.*

*Revising military tactics to improve them is no small undertaking. Thus Bell Laboratories devoted a great deal of time and effort to finding for the United States Navy a completely new concept in air defense for the fleet.*

H. W. Augustadt

# The Navy's New Defense Against Air Attacks

During the short period at the close of World War II in which the Japanese launched their kamikaze attacks, the United States Navy lost more of its fleet than it had in all the sea actions of the war. The success of these suicide missions pointed up an immediate need for the Navy to revise its philosophy of defense against air attack. Accordingly, in 1945 Bell Laboratories was asked to study the problem and to recommend a course of development. The project eventually came to be known as the "Mark 65 Program."

The war itself had brought forth the first evidence that the evolution of adequate air defense was seriously lagging that of new offensive weapons. For example, as the war progressed dive and torpedo bombers greatly increased their speed and maneuverability. But during the same period, improved methods came more slowly for detecting, tracking, and destroying targets.

The manner in which Laboratories engineers attacked the problem of air defense for ships may best be described by an excerpt from their first report to the Navy:

> "An antiaircraft system is like a jigsaw puzzle; the pieces are all related to one another in a very specific, though complex way: Before starting to put this puzzle together, it is well to study the pieces. A good way to proceed is then to lay down all the corners and edges of the puzzle: these are the boundaries beyond which the designer knows no pieces will lie."

Studying the pieces and laying down the corners and edges first required an information-gathering survey to define clearly the elements needed to fight off an air attack. This survey was begun by investigations of the characteristics of such shipboard elements as the surveillance systems—search radars as well as lookouts with binoculars — fire-control radars and, of course, the weapons.

To understand how the Navy's air defense system was revised requires first a brief description of the methods it had been using. On a typical ship, long-range "search" radars scanned the skies for targets. Those that appeared on a radar oscilloscope were identified, electronically, as "friendly" or "unfriendly." Unfriendly targets were then evaluated manually as to their potential threat. When these reached a certain range, they were "designated" to more precise radars associated with the guns—the "fire-control" radars.

These radars acquired and automatically tracked the targets until they reached a range where the guns could effectively open fire. Information on the continuously changing range and bearing went from the fire-control radars to a computer, and thence to the gun machinery. The ultimate aim, of course, was to point the guns in the appropriate direction.

This defense was coordinated by a ship's organization, formed during World War II, known as the Combat Information Center. But CIC was poorly equipped for this job. Most of the threat evaluation and target tracking from search-radar data was done as grease-pencil notations on a glass screen. Targets were designated by talkers to gun directors over a sound-powered telephone circuit between CIC, far below the main deck, and an officer in the fire-control director, four or five decks above, and as much as 400 feet away.

The Laboratories study indicated that CIC, although equipped to control interception of threatening targets with fighter aircraft, did not effectively handle the defense with the ship's own weapons. Basically, CIC had no way to give the fire-control radars precise information on the position of the targets they should acquire and track.

### Coordination Weakness

This weakness in coordination was one of the major problems to be solved. Therefore, the Laboratories recommended development of a control system to perform this function. The activities to be coordinated included air surveillance, evaluation of the threat of the target, assignment of fire-control radars to targets, assignment of weapons to targets, and assessment of target kill.

As an aid in achieving this coordination, the Laboratories recommended that the new control system include a display of the tactical situation. This would show: (1) the positions of threatening targets about the ship as detected by the search radars; (2) targets being tracked by the fire-control radars; and (3) targets under fire by guns or missiles. Through such a display, the ship's gunnery officer would be able to use his weapons most effectively.

The study also considered new developments both in weapons for offense, such as faster attacking aircraft, and in weapons for defense, such as guided missiles. These, the engineers foresaw, would require quicker threat evaluation and decision making when the ship was under air attack.

For these reasons, the Laboratories study team made a second major recommendation—automating the tools of defense. This meant automatic operation, such as had been used by fire-control computers and tracking radars, was to be extended to the decision-making equipment. There was a conviction that many of the processes and techniques developed through years of Laboratories work on telephone switching systems would apply in the design of automatic decision-making equipment.

In putting forth these ideas, Laboratories engineers realized they were suggesting new doctrines for the conduct of antiaircraft warfare. The basic ideas resulted from detailed consideration of the sequence of events as portrayed in the illustration on the facing page. The situation is somewhat analogous to a telephone traffic problem in which the number of customers (attacking aircraft) exceeds the number of available trunks (radars and guns). Thus, the system was designed to provide automatic processing of information to insure that the highest priority customers (the most threatening targets) would be given first call on the available trunks (the radars and the guns).

Convinced these proposals were sound, the Navy accepted them, and requested that the Laboratories begin to build the control equipment and study and analyze in detail the various approaches that might be used. Realizing the difficulties and expense of conducting actual field trials, the engineers decided to test their ideas by simulation.

For this purpose, they built a device to simulate an attack on a ship by a number of aircraft. This "air-attack" simulator made it possible to conduct "war games" against a ship, based on programmed air raids, by different numbers of aircraft and different methods of attack. From this, the engineers could assess the effectiveness of their proposed control equipment. Equipment with automatic decision-making functions was also designed and tested with the air-attack simulator. This automatic simulation equipment, primarily relay circuitry, was called the ATEWA, or Automatic Target Evaluator and Weapon Assignor.

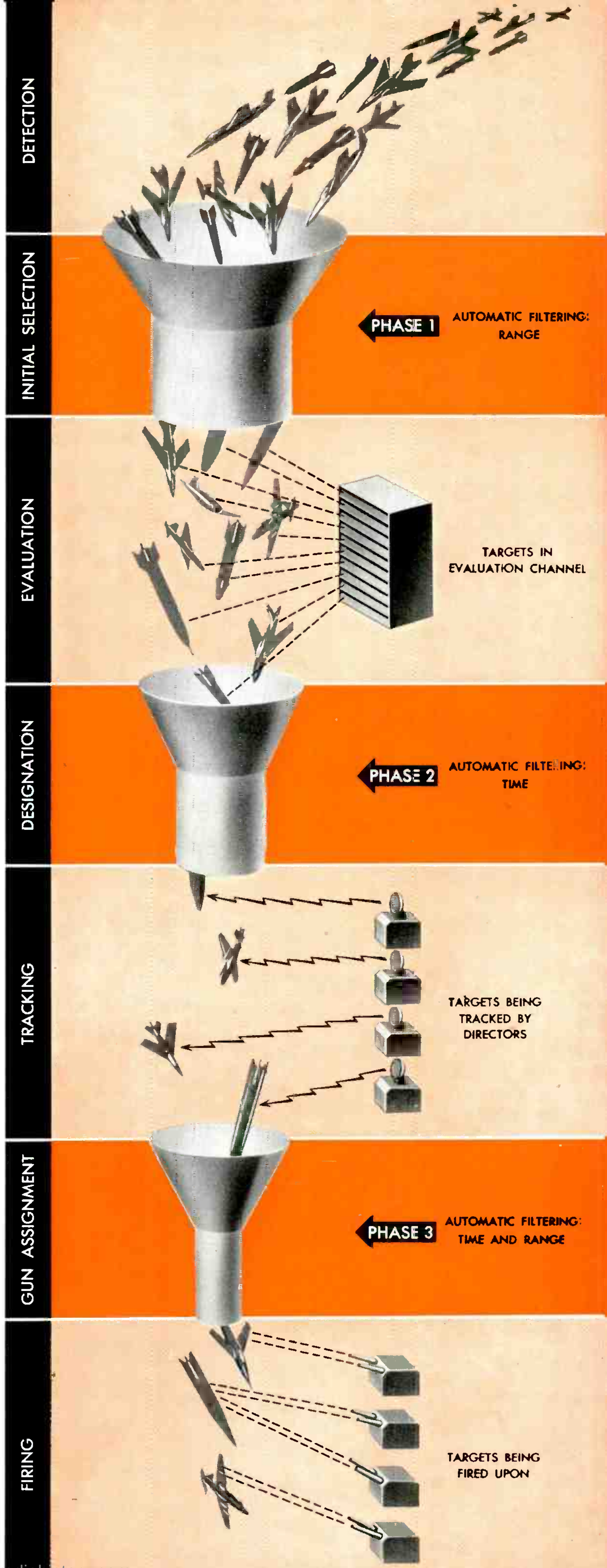
During a simulated engagement, ATEWA would determine the threat of approaching "targets" and assign a priority to each. From this priority, the targets were then automatically "designated" by ATEWA to the fire-control radars. After a fire-control radar had acquired the target, gun groups were automatically assigned to the radar. ATEWA also made this decision, based on the priority of a target and the ability of the guns to bear on it.

### *Displays*

Ships' personnel need displays that present tactical information clearly. Many human factors are involved in assessing a tactical situation because the information characterizing it is so extremely diverse. For example, the "blips" on a search-radar oscilloscope indicate the positions of both friendly and enemy planes. Hence an operator must have some way of distinguishing between them. Also, targets seen on the radars and those picked up by lookouts with binoculars must be correlated. Furthermore, the positions of targets being tracked by the fire-control radars must be precisely known so that when friendly fighters are in the area, fire is directed at enemy planes only. Finally, the status of missile launchers—whether ready to fire or not—must be known at all times.

In addition to the human factors, development of a tactical display required a study of what should be presented, and how. The important objective here was proper interpretation, especially under many confusing situations. Also associated with this work was a way to physically present the selected information to the fire-control operators.

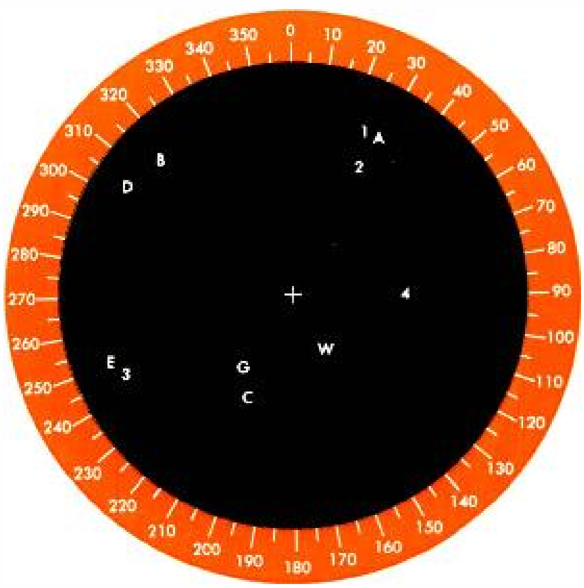
At first, the engineers used optical projectors to display tactical information. But subsequently, they developed cathode-ray tube equipment with much more versatility. An example is illustrated




*A weapon-direction equipment operates to filter progressively the incoming enemy traffic to make sure the ship's defensive equipment—guns or missiles—fire first on the most threatening targets.*

in the figure below. This is a "north-oriented" plot of the positions of targets attacking the ship. These positions are obtained by tracking the targets on the search or fire-control radars. In the illustration, the targets tracked by search radars are represented by alphabetical letters. Those tracked by fire-control radars are represented by numerals. Letters "x" to "w" show the positions of targets being tracked by the lookouts with binoculars. And numerals next to letters show fire-control radars in the process of acquiring targets designated to them from the search radars.

Displays are one of the many devices used for feedback information—an important function for both manual control and supervision of an air attack. As an example, the activity of each fire-control radar is displayed continuously and automatically, making it possible to monitor the position in space where the radar is scanning or tracking a target. Therefore, when a radar is assigned to a target, operators can observe it "slewing" to position by the motion of its numeral toward the letter location representing the target. Subsequent field experience confirmed the importance of feedback of information. This provision has been praised by the operating people in the fleet who use the equipment.




*Plot of targets attacking a ship (top of figure is true north). Letters are targets acquired by search radars; numerals those acquired by fire-control radars. Letters next to numerals show targets "passing" from search to fire-control radars.*

Laboratories engineers realized early that they had to consider the growth of the air-defense system to meet future developments in air warfare. This is particularly important because usually four to six years elapse between a development and the introduction of equipment in the field. In weapon system developments, this time lapse may prove crucial unless plans are made with a great deal of foresight.

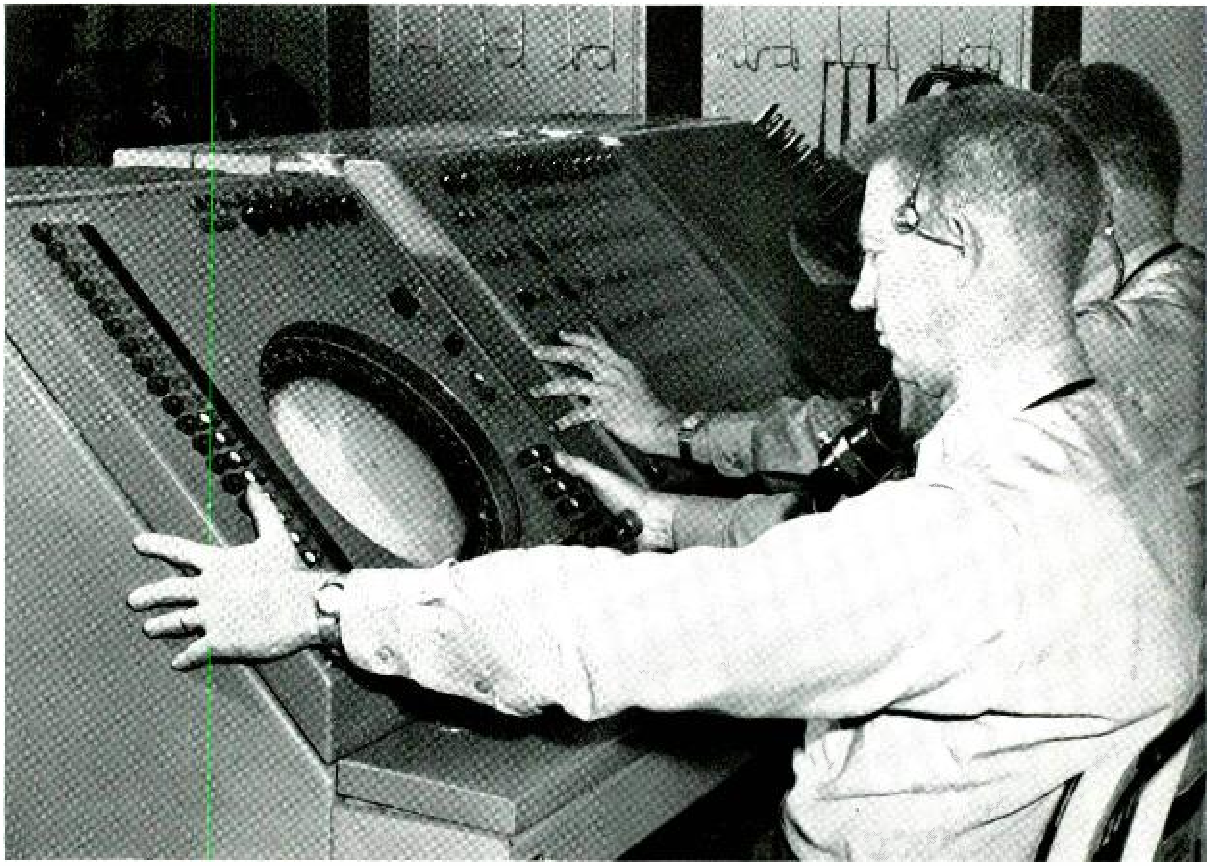
Thus, early in the development program the Laboratories directed its study toward concepts that would be applicable when guided-missile systems materialized. As a result, the rapid decline of the gun and its replacement by the guided missile has not outmoded the concepts developed under the Mark 65 Program nor materially affected the equipment it uses.

### First Sea Test

Normally, a new weapon system would not be considered for shipboard use until it had been subjected to a test on land. However, the world political situation in the early 1950's indicated that every effort should be made to put the equipment on board ships as soon as possible. Accordingly, the Laboratories bypassed the land test and immediately constructed control equipment for the *USS Northampton* — a naval command ship with gun armament. This equipment incorporated the ATEWA to test the effectiveness of the automatic decision-making equipment under actual field conditions.

The Laboratories and the Navy evaluated the installation aboard the *Northampton* by planning and executing a number of war games in which the *Northampton* was placed under simulated air attack by actual aircraft. Precise methods of assessing the success of the defense had to be devised because the "kills," of course, could be only simulated.

During the evaluations, which lasted about six months, aircraft flew approximately 1500 "raids" against the ship. In some of these raids, as many as 25 aircraft were employed simultaneously. U. S. Navy personnel operated the equipment throughout this period, and Bell Laboratories engineers on board helped make up test plans and observed and assessed the operation of the equipment. The evaluation indicated that the recommendations of the study were valid and, specifically, that a centralized control system would greatly increase the effectiveness of the defenses of a ship under air attack. These conclusions were wholeheartedly endorsed by the ship's personnel.



*Naval and Marine Corps personnel intensively studied equipment during evaluation period. This officer is monitoring a typical display of tactical information on enemy and on defense status.*

Prior to completion of the evaluation, the Navy requested new equipment of the type adapted to control guided-missile fire to be installed on the first guided-missile ships—The *USS Boston* and the *USS Canberra.* The changes in design required for this new weapon equipment were made expeditiously—a tribute to the versatility of those conducting the program. Today, the equipment aboard the *Boston* and the *Canberra* directs, under tactical conditions, the fire of eleven gun groups and two guided-missile launchers employing the Terrier missile.

### Production Begun

Because of the results of the experimental system aboard the *Northampton* and the working equipment aboard the *Canberra* and *Boston,* the Navy requested the Laboratories to develop, and the Western Electric Company to supply, a substantial number of weapon-direction systems for the fleet. This equipment will be used primarily on destroyers, cruisers, and aircraft carriers for direction of guided-missile fire of the Navy's Terrier or Tartar missiles.

The widespread acceptance of the philosophy and concepts developed under this program proved its basic soundness. Subsequently, other defense activities have been organized on the pattern developed from Bell Laboratories work in this field. Representative concepts from this program are found in missile-control systems for the Army and the Air Force, as well as the Navy.

To show its appreciation for the success of this program, the Navy awarded the Laboratories a citation. In part, this citation reads:

> "Bell Telephone Laboratories brought to completion a highly complex family of devices which permit full utilization of anti-aircraft armament of the Navy's guided missile ships. Reports from Fleet Commands attested to the remarkable performance of designation equipment Mark 7 and the high calibre of the development program."

*For some years, transmission engineers have been seeking ways to increase the traffic capacity of submarine cables. TASI is one method of doing this. Another method, designed by British engineers, is a highly efficient, double-modulation scheme that will increase the capacity of present cables from 36 to 48 circuits.*

R. S. Tucker

# SIXTEEN-CHANNEL BANKS FOR SUBMARINE CABLES

In 1937, H. A. Affel, then Director of Toll Transmission Development at Bell Laboratories, described to an international meeting in Paris the Bell System plans for the frequency range of circuits in broad-band carrier systems for long-distance telephony (BSTJ, *October*, 1937). These plans were so well-conceived that they are still the standard for American and European countries. Affel's concept specified individual telephone channels with a frequency band from somewhat below 200 to about 3500 cycles per second. Twelve of these channels are stacked side by side in the carrier frequency band from 60 to 108 kilocycles, with each channel allotted a total space of 4000 cycles.

Spacing, stacking and modulating on the channel-carrier frequencies are done by the transmitting part of a "channel bank"—the network of filters and modulators at each end of the carrier system. The receiving part of the channel bank accepts the group of 12 channels after it has been transmitted over the carrier line and divides it into 12 separate audio channels for forwarding to listening customers.

These same channel banks have been used with submarine-cable telephone systems (RECORD, *February*, 1957). But for these systems a change is now in the making. The increase in telephone traffic with Europe since 1956, when the first transatlantic cable system was opened for service, has been so great that the demand for circuits will shortly outrun the supply, even though a second 36-channel cable system to Europe went into service last September (RECORD, *November*, 1959).

Because of the demand for these circuits and because of their high cost—about one million dollars per channel—engineers at Bell Laboratories and in Europe have for many years been working on ways of getting more telephone conversations on the existing cable systems. Actually, research on this general problem started long before the advent of undersea voice transmission, but the transatlantic cables are only now justifying the first practical applications of this work.

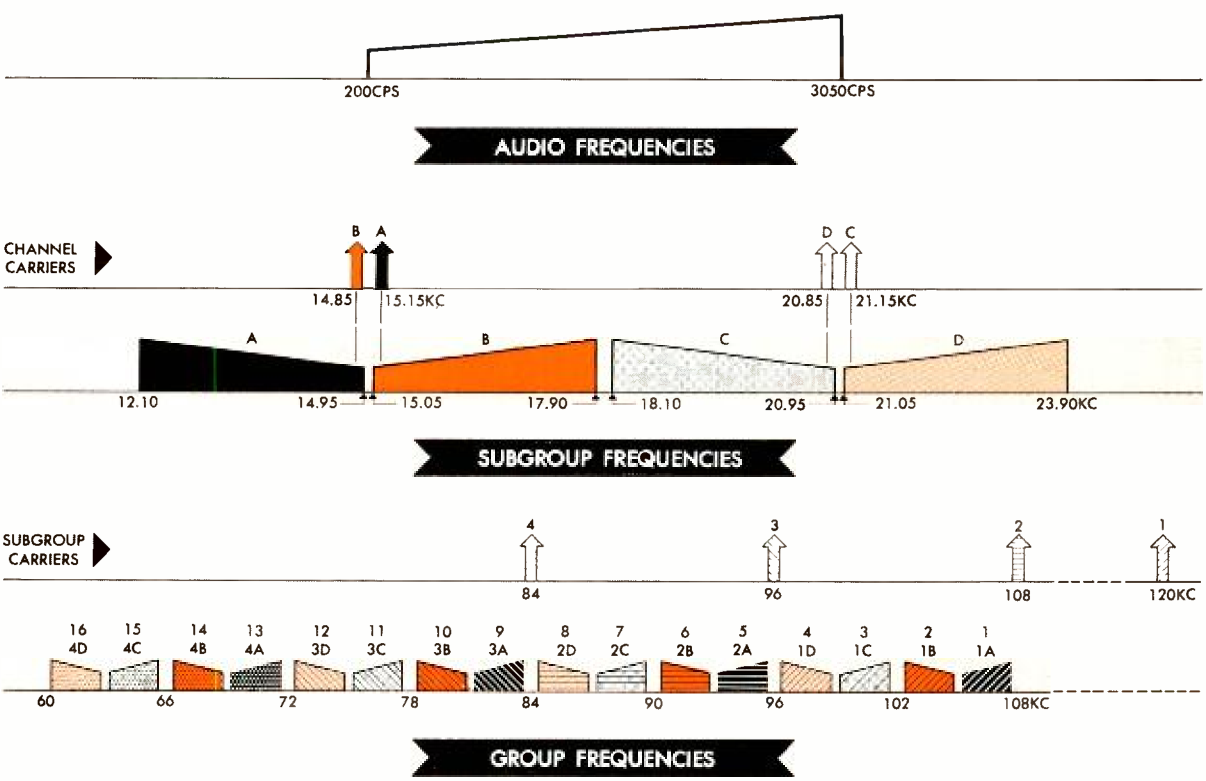
One method of increasing the number of circuits is TASI (RECORD, *March*, 1959). This system makes more efficient use of the cable's channels by very careful time-assignment of even small spurts of transmitted speech. Another method is the new double-modulation, 16-channel bank with 3-kilocycle channel spacing. This new channel bank is a contribution of the British Post Office, and increases the capacity of the cable by more efficient use of the gross frequency band assigned to each carrier channel. This article describes engineering aspects of this new double-modulation channel-bank system, with emphasis on the channel banks themselves.

Bell Laboratories engineers have been working with the British to make this 16-channel system suitable for transatlantic use, and for use with TASI. As usual, it turns out that other changes in the plant are needed to make the whole system (including land lines to White Plains and London) workable on the basis of 3-kc transmission in the undersea portion. On the first transatlantic system, this part of the job has been divided between the British and American partners.

In terms of telephone channels, the new channel banks will increase the capacity of the transatlantic cable from 36 two-way voice paths to 48. This increase is in the same proportion as 3 kc—the new channel spacing—is to the original 4-kc spacing. The principal trick used to achieve this increase in channels lies in the double-modulation scheme. Double modulation—the principle of twice transposing the original frequency position of an audio channel before transmitting it—is used in many Bell System carrier systems. But this new system is the first one in the Bell System that will double modulate with a single bank.

### *The Frequency Arrangement*

The channels of this new double-modulation bank have an audio pass-band extending from approximately 200 to 3050 cycles. It is interesting to see how this is possible with a gross bandwidth of only 3000 cycles per channel. The diagram on this page shows the frequency plan of modulation. The slightly clipped triangle on the top line represents the audio band, with the lower part of the triangle starting at about 200 cycles. In the first step of modulation, four of

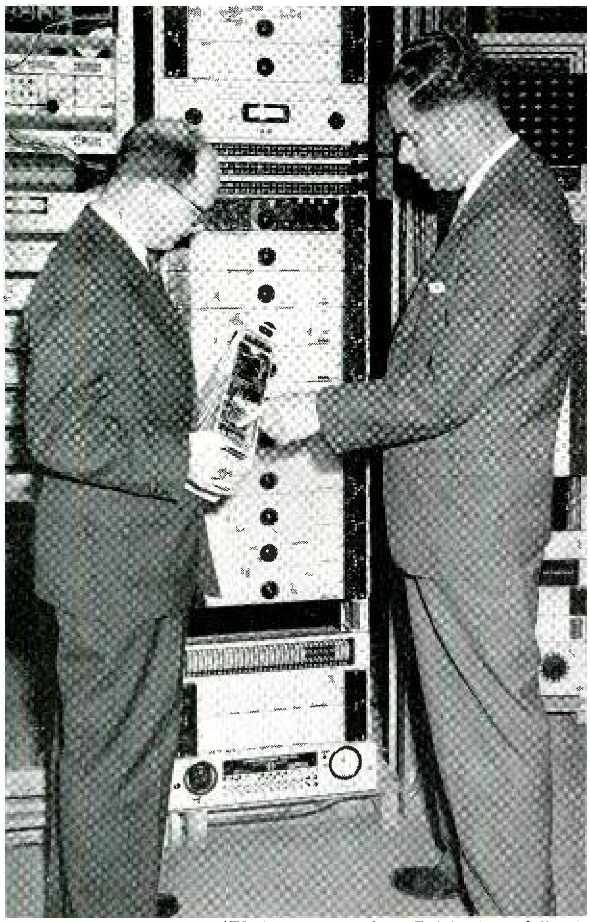



*This diagram shows the frequency plan of modulation for the new 16-channel banks. Frequency-band triangles are sloped to indicate lower and higher audio frequencies, hence their sideband.*

these audio channels are individually shifted to higher frequency ranges on the four channel carriers in the second line. Alternate lower sidebands and upper sidebands are selected from the products of this modulation, and the results are combined to form the "subgroup" that appears in the third line.

As this line of the diagram shows, this close "stacking" of channels is accomplished by using carriers that are each shifted by 150 cycles from multiples of 3000 cycles. For example, carrier A, at 15.15 kc, is modulated with audio channel A, and the lower sideband—12.10 to 14.95 kc—becomes carrier channel A in the subgroup.

The diagram also shows that the carrier of channel A—if the triangle were completed—would fall within the sideband of channel B, and vice versa. Therefore, the "carrier leak" must be cleaned out very thoroughly before channels A and B are combined. If this were not done, each channel would have an unwanted 300-cycle tone in it.



(Photo courtesy of the British Post Office.)

*W. G. Simpson, left, and H. B. Law, both of the British Post Office, examine one of the plug-in channel packages of a prototype 16-channel bank.*

One can also see from the subgroup diagram that the band edges of the adjacent channels are very close to each other. For example, the edges of channels A and B are separated by only 100 cycles, and the edges of channels B and C are only 200 cycles apart. To make such close spacing practical, it is necessary to have very "steep," or sharp-cutoff, filters so that the channels do not spill over into each other.

### The Final Stage of Modulation

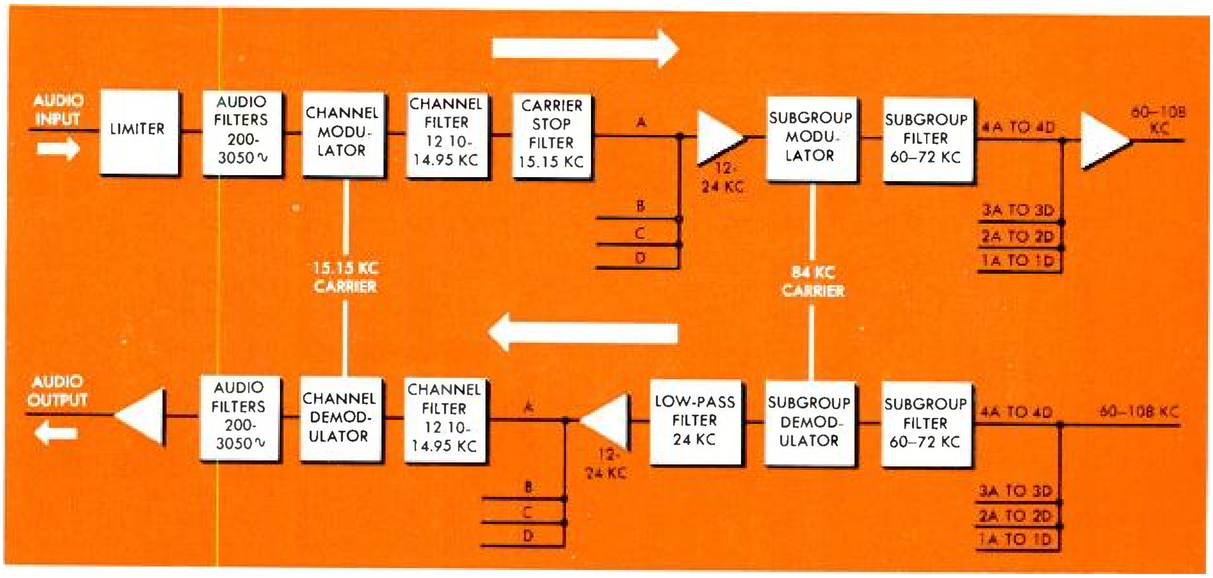
The subgroup formed from channels A, B, C and D in the band from 12 to 24 kc is then modulated to its final position in the "group" frequency band by the second stage of modulation. Carriers used for this step are shown on the fourth line of the chart. In this step, the lower sideband is used in all cases.

The resulting "stack" of channels in the group frequency band, namely 60 to 108 kc, appears in the bottom line of the diagram. Here, we see that the individual channels are alternately lower sideband and upper sideband as they are applied to the high-frequency line, and that high audio-channel frequencies are adjacent to the lower (60 kc) and upper (108 kc) edges of the group frequency band.

This double-modulation scheme makes it possible to use about 95 per cent of the gross frequency band. To achieve such high efficiency, it is necessary to: (1) offset, or shift, the first-stage carrier frequencies by a small amount (150 cycles) from a multiple of the specified 3-kilocycle spacing, as explained above; (2) allocate losses due to filters carefully between the audio filters and the various carrier-frequency filters; and (3) pay close attention to other details of the design, such as the impedance relationships of points within the equipment where channels or subgroups are paralleled.

A block schematic on the next page illustrates the equipment used to implement this efficient double-modulation plan. Following the "audio input" at the upper left, we see an "amplitude limiter" that protects the system from very high input powers, and then an "audio filter," which passes the frequency band from about 200 to 3050 cycles. This block is actually made up of a steep-sided, high-pass filter and a steep-sided, low-pass filter in tandem.

Then comes the "channel modulator," which performs the first step of modulation. The dia-




*The components of the 16-channel, 3-kc banks developed by the British Post Office. Audio signals are twice modulated by the transmitting components, left to right in the top line, and demodulated by receiving components. Each subgroup, such as 4A through 4D, contains four channels.*

gram shows the 15.15-kc carrier supply for channel A. Following the channel modulator is a bandpass filter that passes the appropriate sideband and a stop filter that eliminates the 15.15-kc carrier leak. Channels are combined with the aid of hybrid coils, which, along with other elements like attenuators, have been omitted to simplify the diagram.

After the four channels have been combined, they are translated to their final position in the group band by a second stage of modulation in the subgroup modulator. The carrier—in this case for subgroup No. 4—is 84 kc. The lower sideband of this carrier passes through the "subgroup filter" in the range from 60 to 72 kc, and is then combined with the three other subgroups to give the complete 60- to 108-kc band. In this illustration, the channels are numbered from 1A to 4D as an aid to understanding the modulation process. The numbers 1 to 16 will be used in practice, to conform with the numbering method for 4-kc channels. In the bottom portion of the diagram, the transmitted audio signals are demodulated and separated into 16 channels as they move to the left.

Two British firms provided channel banks of this type for installation late in 1959. One set is in use on the Florida-Puerto Rico cable and the other set on the first transatlantic cable. These installations have an audio band extending from 300 to 3150 cycles, with corresponding differences in the frequency plan shown in the first illustration. A photograph of the prototype of the first set of channel banks is shown on page 250. Later models will use the 200-to 3050-cycle allocation, and the first (present) installations may later be changed to this type. For the second transatlantic cable system, French engineers are designing similar 200- to 3050-cycle banks. These are to be installed this summer at both the French and American terminals.

### Limitations of the New System

Although this double-modulation method makes efficient use of the available bandwidth, there is a transmission penalty exacted for the use of the 3-kc system. Subjective tests at the Laboratories indicate that the transmission impairment, due to loss in speech quality and naturalness, on a single link of the 200- to 3050-cycle channel, as compared to the channel obtained from a 4-kc bank, would be equivalent to about a 2-db loss in power. For the 300- to 3150-cycle channel, it would be somewhat over 3 db. Two or more links in tandem would tend to increase the impairment, although not in direct proportion to the number of links.

The major part of the impairment on the 300- to 3150-cycle channel is caused by the loss of low frequencies. It is for this reason that the change to 200 to 3050 cycles is being made. Judgment tests made independently by the

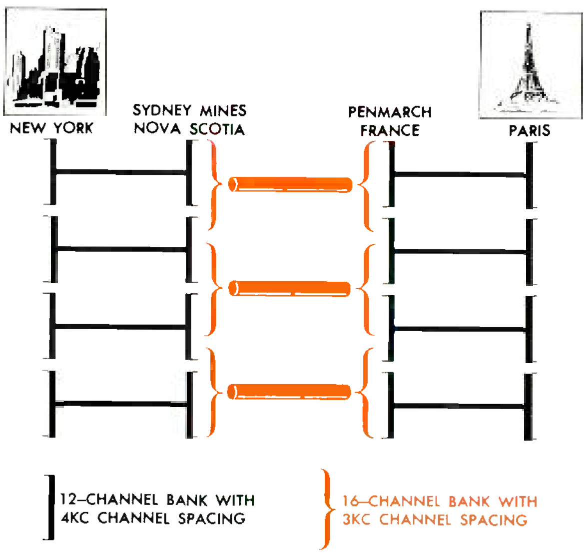
British Post Office tend to corroborate these conclusions.

This new type of channel bank is designed for submarine cables and is not recommended for use on other broadband systems in the United States. There are three general reasons for this. First, the 2-db impairment from a single link is by no means negligible, in view of the constant effort being made to improve over-all Bell System transmission. How much the impairment might increase with several such links in tandem is not yet known.

Part of this problem is the effect of transients. The sharp cutoff of the filters necessary to realize a useful band covering 95 per cent of the gross bandwidth inevitably produces delay distortion near the edges of the pass-band. This creates some transients in the received speech. Listening tests have indicated that with two 3-kc links in tandem the effect is not objectionable to most people. But what the effect would be like with several such links is questionable. In the future, as more and more submarine cables are installed, it may be possible that several 3-kc systems will be linked in tandem.

A second important reason for not using the double-modulation banks generally in the Bell System is that they are inherently more costly than the standard single-modulation banks.

The third reason for not generally adopting 3-kc channels is that when a 4-kc system is changed to a 3-kc system, other parts of the basic transmission plan besides the channel banks must also be changed. Prominent among these are "pilot frequencies" and unwanted carrier-frequency "tones."




*Four 4-kc, 12-channel banks on the land line portion of the system will work into three 3-kc, 16-channel banks on the undersea link between.*

Pilot frequencies for the type-K cable-carrier system, for example, are 60, 64, 92, and 108 kc, when expressed in terms of equivalent frequencies in the 60- to 108-kc band. Two of these—64 and 92 kc—would fall within 3-kc channels, as can be seen by a close look at the bottom line in the frequency-plan diagram. The pilot frequency would cause a single-frequency tone in the channel, and the pilot filters would cause a slot of transmission loss in the channel. This slot would be near 1000 cycles for both the 64-kc and the 92-kc pilots. The 92-kc pilot is used in all Bell System broadband, long-distance transmission systems except type-J open-wire carrier, and would produce noise and a slot of loss in one of the 3-kc channels if such voice channels were generally applied.

### *Use Limited to Undersea Channels*

By the same token, tones would appear in various 3-kc channels because of carrier leaks or modulation products at frequencies that are multiples of 4 kc but not of 3 kc. Such tones exist in present transmission systems, but do no harm since they fall between 4-kc channels. Many of them, however, would fall within 3-kc channels and produce unwanted tones. A large-scale clean-up effort would be needed to remove them from the present land telephone system.

In the transatlantic systems, which are actually a mixture of land plant and undersea plant, these three reasons, and other difficulties in the land plant, have led to the decision that 3-kc channels will be used only in the submarine sections. Standard 4-kc channels will continue to be used on land. A simplified schematic of how this combination of the two schemes will work on the White Plains-to-Paris system when it is converted is shown on this page.

The engineering of these new channel banks to fit into the over-all transatlantic system, including TASI, and other work on the complete 3-kc system (not described in this article), have required close cooperation among telephone engineers in the three countries most directly involved: Great Britain, the United States and France. A firm background for this cooperation among the three countries was well established in the course of the joint work on the engineering, development and installation of the submarine-cable systems themselves.

*Research engineers at Bell Laboratories have developed an experimental carrier system for closed-circuit television that demonstrates the feasibility of using transistors and other miniature components in TV repeaters and terminal equipment.*

L. G. Schimpf

# TRANSISTORIZED CARRIER SYSTEM FOR TV

Since the advent of television, Bell Laboratories and has been vitally concerned with television transmission and is constantly striving to improve this important service. In recent years, the application of solid-state devices in experimental television circuitry has reduced the size of such TV apparatus and decreased the amount of power needed to generate and transmit high-quality television signals.

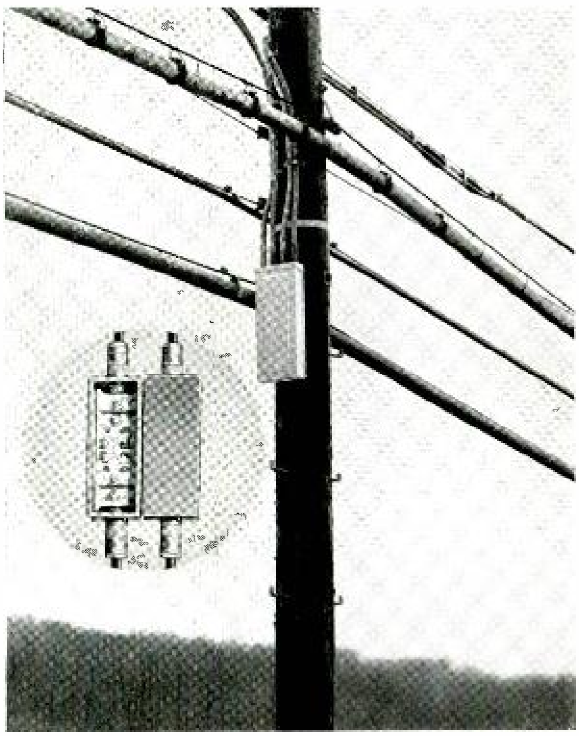
This article explains how transistors are used to transmit television signals over the coaxial-cable portion of a TV transmission system. More specifically, it discusses the advantages of transistors and some of the engineering factors involved in designing a transistorized system for short-distance transmission.

The system used for these experiments is an experimental hook-up between the Holmdel, New Jersey, and Murray Hill, New Jersey, locations of Bell Laboratories. This transmission system consists of a transmitting terminal at Holmdel connected by three miles of coaxial cable to a microwave terminal on Crawford's Hill which beams a signal to a microwave tower and receiving terminal at Murray Hill. The output of this microwave receiver is connected to the TV terminal in the Murray Hill laboratory by one-half mile of coaxial cable. As shown in the upper portion of the system diagram on page 255, a transistorized repeater is spliced into the coaxial line midway between Holmdel's transmitter and its microwave terminal. Transistors are also used in the terminal equipment at both ends of the system, as shown by the shaded blocks on the diagram.

There are two major advantages of this experimental system over present commercial equipment: (1) the apparatus is much smaller, and (2) power requirements are considerably reduced. It achieves these advantages chiefly through the use of simple transistorized amplifiers (*see cover*). The amplifier circuit for this system is less complex than those employed in long-distance television transmission, principally because of relaxed transmission requirements for closed loop service.

Low power requirements eliminate the need for a local power supply and permit the operating power for the amplifiers to be transmitted over the cable. This results in a small amplifier that can be mounted on poles or installed underground without complex housings. A pole-mounted amplifier is shown below. In light of their low power requirements and adaptability, transistorized repeaters may be particularly applicable to closed-loop television service in the future (RECORD, *January*, 1960).

The most common method of sending television signals over short spans of coaxial cable is to transmit a baseband video signal—a direct electrical analog of the picture information—without altering it in any way. The frequency band for such a signal ranges from 30 cps to 4.5 mc. Although the transistors for transmitting a baseband video signal are comparatively inexpensive and easily procured, the very low (30-cps) frequency cutoff requires large transformers. Further, because the attenuation characteristics of the cable change drastically over such a wide range of frequencies, the equalizer design for a baseband system is quite complicated. For these and lesser reasons, a carrier system rather than a baseband system was selected for the experimental setup.



*The housing mounted on the telephone pole above contains a pair of transistorized repeaters (shown in inset). These repeaters are part of the experimental Holmdel-to-Murray Hill system.*

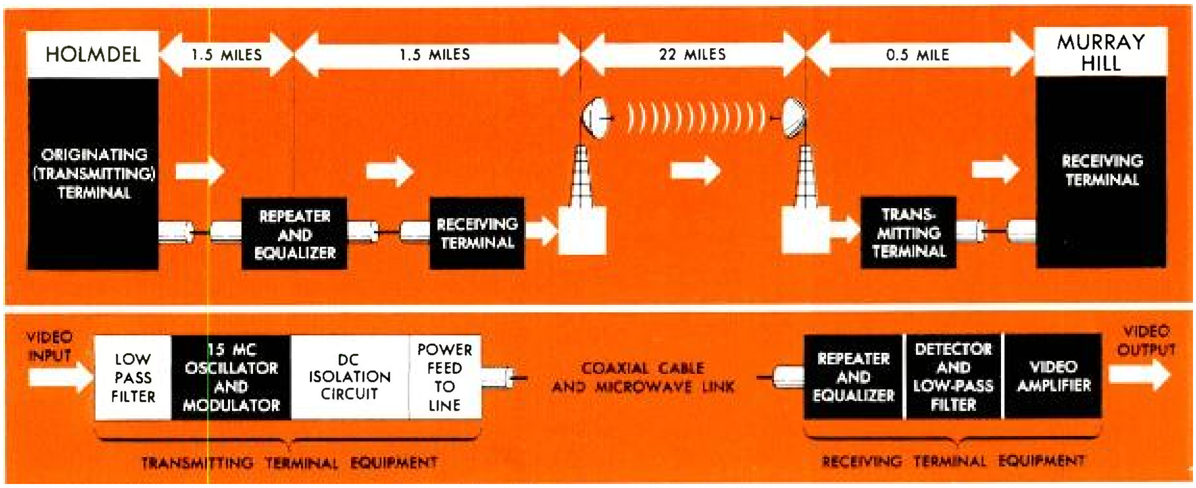
Both double-sideband and vestigial-sideband carrier systems were considered. A double-sideband system requires about twice the bandwidth of a vestigial system. However, the distances involved in closed-loop and local transmission systems are usually short. This means that the terminal equipment constitutes a large part of the cost. To simplify the terminal equipment and consequently reduce this cost, the designers chose a double-sideband system.

In double-sideband transmission, picture information is sent on both sides of the carrier frequency, allowing the use of simple modulators and detectors. This method also eliminates special filters and shaping networks, which are an essential part of a vestigial-sideband carrier system. Video signals carried by the double-sideband system are recovered at the receiving terminal by passing them through a rectifier (detector) and a low-pass filter. These units and the other elements of the Holmdel-to-Murray Hill system are shown in the lower portion of the diagram opposite.

Having selected the double-sideband system, the designers had to consider several factors before deciding on the carrier frequency. In carrier transmission, lower carrier frequency means lower cable loss; this allows repeaters to be widely spaced and consequently reduces the cost of the system. At the same time, the carrier frequency must be high enough to prevent the lower sideband from overlapping the baseband video input. A baseband signal of 5 mc therefore requires a minimum carrier frequency of 10 mc. And to provide a "guard channel," which prevents this type of interference, the carrier frequency should be a little higher. To meet these demands, a 15-mc carrier frequency with an ultimate bandwidth of 10 to 20 mc was chosen. Although the loss is greater, this higher carrier frequency has an advantage in that it results in a simpler equalizer design.

To this point, we have discussed the advantages of the transistorized transmission system and some of the engineering considerations in its design. Now, with the help of the lower portion of the block diagram on page 255, let us see how a television signal is transmitted through the system, and consider some of the interesting factors underlying the behavior of the components.

The carrier frequency is generated at the transmitting terminal by a crystal-controlled transistor oscillator. The output is modulated by passing the video signal through a modulator designed




*Holmdel-to-Murray Hill transistorized TV system is represented in the upper portion. The black blocks in the lower part of the diagram indicate sections of the system that contain transistors.*

with semiconductor components. A low-pass filter prevents interference products from entering the input circuit. As shown in the diagram, the signal then passes through a dc isolation circuit before being fed to the cable. The isolation circuit permits dc power to be applied to the repeaters without short-circuiting the ac carrier signal. After passing through a length of coaxial cable, the signal is amplified by a transistorized repeater. The repeater gain characteristic compensates for the electrical losses in the cable.

At the receiving terminal, the signal is passed through another repeater. This repeater makes up for the loss in the final section of cable and amplifies the signal so that it may directly operate a detector which demodulates the video signal. A low-pass filter following the detector removes the carrier from the video output. From this point, the signal is passed through the video amplifier to the television monitor.

Repeaters are designed on the basis of loss characteristics through the system. In other words, the repeater must compensate precisely for the attenuation of the signal as it passes through a given length of cable. The required gain is obtained by using a two-section feedback amplifier designed to have a flat frequency characteristic. An equalizer between the two sections of the amplifier compensates for the attenuation characteristic of the cable. Miniature inductors and transformers, 0.25 inch in diameter, are used in the repeaters. Ferrite cores in these components result in a desirable frequency characteristic in the 10-to-20 mc range.

The crystal-controlled, transistorized oscillator supplies the carrier power. A diffused-base transistor connected in a common-base circuit is the only active element of the oscillator. A miniature transformer, similar to one used in the repeater, makes possible the efficient transfer of 5 milliwatts of carrier power from the oscillator to the modulator.

A balanced modulator, consisting of four gold-bonded diodes, is used to eliminate some unwanted signals in the output. Since this also balances out the carrier, it is necessary to feed some carrier-frequency power from the oscillator directly into the output to obtain double-sideband operation. This modulator circuit is arranged so that the video frequencies need not be transmitted through the transformers. Carrier level is adjusted to give a favorable signal-to-noise ratio and a minimum of distortion. The peak-power level at the output of the modulator is about 1 milliwatt.

For demonstration purposes, a 6-mile experimental system over coils of coaxial cable was set up at the Murray Hill location of the Laboratories. The three general circuit classifications for this hookup were the transmitting terminal, the cable repeaters, and the receiving terminal. A monitor was arranged so that it could be connected to either the input or the output of the system. Most observers watching the screen could not tell the difference between a television signal sent directly from the input and a signal sent through the 6-mile link. In fact, the video response of the 6-mile system was down by less than 2 db at 6 mc. These results, plus the operational reliability of the Murray Hill-to-Holmdel system, represent the successful application of the solid-state art to television transmission.

*In an emergency, our first thought is the telephone. To make emergency telephones available to the general public, Bell Laboratories has developed the direct-line, Emergency-Reporting System, a fast and convenient communication system based on the simplicity of manual switching.*

F. M. Pearsall, Jr.

# The Direct-Line Emergency Reporting System

It is an axiom in fire fighting that the first few minutes of a fire are of paramount importance. More lives and property are saved by the prompt action of trained firemen than by the number of men and quantity of equipment that ultimately get to the fire. Actually, this is a truism in all types of emergencies where dangerous conditions or serious injuries endanger life and property. If precious moments are lost in communicating with the civil authorities equipped to handle emergencies, tragedy may result.

Because speed is so essential, many communities have found that a convenient, easily recognizable, fast and reliable communication system is a necessity for adequately safeguarding life and property. In many towns and cities across the country, the Bell System provides such a system, based on the most familiar means of communication known to the public—the telephone. This system is known as the Emergency-Reporting System (RECORD, *August*, 1956).

Bell Laboratories engineers have developed two types of reporting systems: the direct-line system and the concentrator system. This article will describe only the direct-line system.

Fundamentally, the reporting system consists of telephone sets (570-type) mounted in metal, weather-proof boxes that are conspicuously marked and placed at convenient public locations. Each of these telephone sets is connected by a pair of conductors to emergency headquarters. Here, the telephone circuit terminates in both jack and key appearances at a PBX switchboard (520-type). So far, this description is similar, in some respects, to a telephone private branch exchange (PBX).

When dealing with emergencies, however, safeguards are also necessary, even in a relatively

*Headquarters attendant answers call at switchboard of direct-line installation at North Bergen, N. J.*

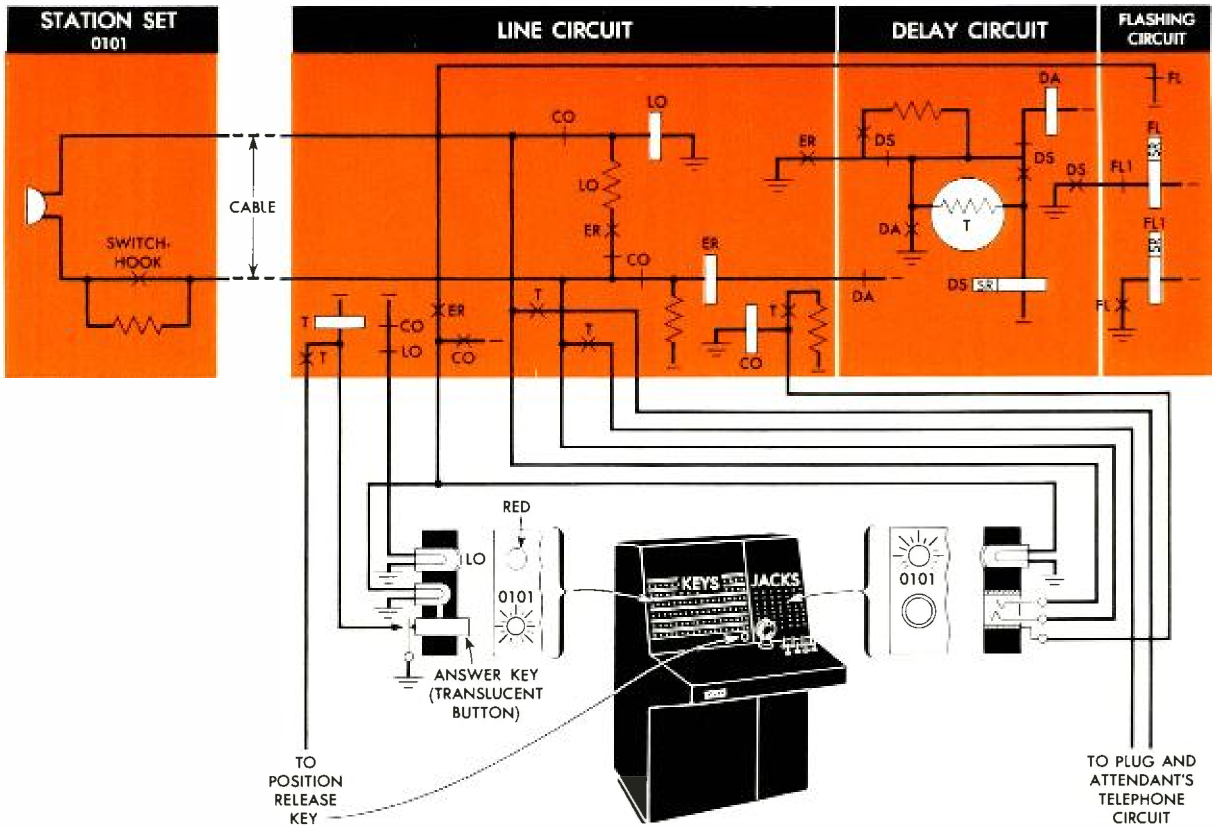



*Diagram shows the principal circuits of the direct-line reporting system and some of the details of the dual appearances at the switchboard. The answer keys light, as do colored indicator lamps.*

simple manual telephone system. These safety, or reliability, features are the distinctive characteristics of the emergency system, and their purpose and implementation will be the principal concern of this article. But before describing these safeguards in detail, it would be well to outline first the general operation of the direct-line system.

Let us assume that a fire has been discovered in the vicinity of emergency box 0101. This box and the basic circuits of a direct-line emergency system are shown in the diagram on this page. When a caller lifts the telephone handset, a path is closed, through the line and delay circuits, from an interrupted battery source in the flashing circuit to the lamp associated with line 0101 on the switchboard at emergency headquarters. In concert with the flashing lamp, an audible alarm (not shown) signifies the arrival of an emergency call. No dialing or signaling is required.

The headquarters attendant can answer the call by two methods. Normally, he momentarily presses the "answer" key, which connects the attendant's telephone circuit to the calling line. The attendant may also insert the plug of an answer cord in a jack, and then operate the associated "talk" key to converse. This method is usually used only when it is necessary to "extend" incoming calls. In either case, the attendant's answer changes the flashing lamp to a steady light. This light then remains as an indication of which box is calling until the attendant releases the call. By answering the call, the attendant restores the flashing circuit to normal, and makes it available for subsequent calls.

Direct communication with the person at the scene of the emergency allows the attendant to get valuable information regarding the type of fire and its exact location. With such information, he can dispatch the most efficient aid in the speediest manner. When the person reporting hangs up, either the supervisory lamp associated with the answer cord, if cord answered, or the "position-release" lamp, if key answered, lights as a visual signal to the attendant. The attendant can disconnect either by removing the cord or by operating the "position-release" key. A typical emergency switchboard installation is shown in the photograph on page 257.

Each line from an emergency telephone has *two* terminations in the switchboard, one in each section. This arrangement—"dual-line appearances" — is one of the important safety features of the system. Each appearance has its own line lamp as protection against the failure of a single lamp. A single attendant still has two methods of answering a call at his disposal: namely, by key or jack.

As an extension of the dual-circuit protection feature, two position circuits and two attendant's telephones are furnished, and both are under the control of a "position-release" key. Normally, one position circuit and one telephone circuit are in use with the left section of the switchboard and one of each with the right position. By moving the release key to the left or right, however, a single attendant can put all lines under the control of his position and telephone circuits.

### Some Protective Features

Some emergency telephone sets are in isolated locations. In such situations, the danger of damage by accident or vandalism always exists. Since such damage could result in inoperative lines, it is imperative that the condition be detected immediately. To ensure this, each line is constantly monitored electrically.

For line-monitoring, a "loop-open" relay is added in the line circuit of each telephone. This relay releases if the line is opened or grounded, and causes a red alarm signal to light at the line appearance on the headquarters switchboard. The attendant can then place a guard at the defective telephone set immediately, and repairs can be made subsequently by a Telephone Company maintenance crew.

Each line of the system also has a "lock-in" feature to compensate for the often unpredictable actions of excited people. In emergency situations, it is inevitable that someone will lift the handset, shout "fire" or "police," and then hang up before the operator has had time to acknowledge the call. In regular telephone systems, this would be an abandoned call and the circuits involved would release immediately. Here, however, the calling signal is locked-in, or held, to ensure that the attendant can identify the telephone set and take proper action. He may ring back to the telephone set, send an investigative team to the scene or both.

The system also includes a "signal-delay" feature that minimizes the effects of electrical disturbances of short duration — often called "hits" or surges — which occur occasionally on telephone lines. This feature delays signals on their way to the switchboard long enough to cover the surge interval but not long enough to interfere with the lock-in arrangement. A simplified schematic of this circuit appears on the first drawing.

The signal-delay circuit uses the negative-resistance characteristic of a thermistor to delay the operation of a relay long enough to cover surge times. During this delay, a second relay removes battery from the emergency-reporting relay, which releases. When the thermistor-delayed relay operates, battery is reapplied. If the initial action of the emergency-reporting relay was a legitimate call and not a hit, ground will still be present and the relay will operate. On hit-initiated action, no ground is available, and the emergency-reporting relay and the circuits restore to normal.

In some communities, it is desirable to have separate headquarters for emergency reporting and for police reporting, both routine and emergency. For such arrangements, the emergency telephones can serve a dual-purpose and eliminate the duplication of these outside telephones and their cable conductors. A nonlocking key in the 570 set and a "selective-routing" circuit located at the central office provide the transfer feature required to direct calls to fire or police headquarters. The schematic on page 261 shows such a selective-routing arrangement, as installed in Indianapolis.

A double-wound line relay, whose windings are in the line loop, is the important element in the selective-routing circuit. Both of its windings have equal turns, but since they oppose one another, normal loop current creates no effective ampere turns to operate the relay. With the selective-routing relay unoperated, calls are directed to emergency (fire) headquarters.

Now, suppose a policeman wishes to call police headquarters. Before lifting the telephone, he presses the "police" key, which is part of the emergency telephone set. This sends current through only the secondary winding of a selective-routing relay, which operates, and in turn operates the transfer relay. This relay transfers the line loop to police headquarters and at the same time connects the two windings of the selective-routing relay in "series-aiding."

With the windings series-aiding, the selective-routing relay remains operated when the telephone is off hook and the police key can be released. A relay in the police line circuit operates and initiates the lamp signal to the police switchboard. The signal-delay circuit prevents alerting the primary emergency headquarters.

In selective-routing installations, the lines are continuously monitored at only the primary emergency headquarters. Consequently, an important part of the function of the transfer relay is to prevent the loop-open, or line-monitoring, relay from releasing when a call is routed to police headquarters. Such action would falsely alarm the primary emergency headquarters.

The police headquarters switchboard also has dual line lamps, and is equipped for both key and jack answering. Since all calls to this switchboard are originated by trained personnel, the lines do not require the lock-in feature. Also, the flash delay and loop-open alarm features are not provided at police headquarters, because no hits or loop-open signals can be transmitted to the switchboard with the circuit "normal."

### *"External" Reliability Features*

Emergency-reporting systems also have two "external" reliability features to ensure against the loss of valuable, though sometimes hastily given, information in an emergency. Both of these, which are basically recording methods, can be appended to any switchboard of the 520 type.

The first is voice recording. Where desired, the emergency-reporting system can be easily arranged to record conversations automatically by a tape recorder. The recorder is normally connected across the position circuit at the switchboard. Answering a call automatically starts the recorder, while disconnecting stops it. At each position, there is a key which disconnects the recorder when held in the operated position.

In the other recording feature, a printed record is made of each call. This records line identity, date, and time-of-day. The printed record is made by either a 1A ticketer or a teletypewriter. A typical printed record for a call is shown below.

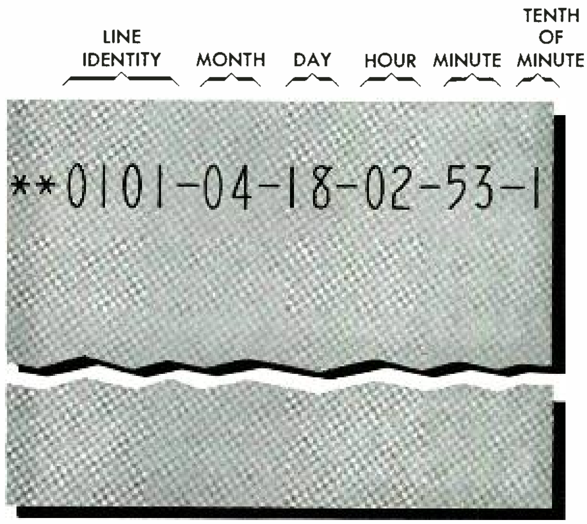
The reporting systems also offer other versatile communication services needed in emergencies. For example, the headquarters attendant can alert any fire house or police station, any group of these, or all such locations at once, through a "paging" circuit. A "paging-line" key connects the attendant's position to the associated fire house or police station. When he operates the "paging-tone" key, an alerting tone is transmitted. If the attendant wants to page all stations at once, he operates another key. To release the paged lines, he momentarily presses the "paging-release" key.

On some occasions, connection to the paging facilities may be requested by the fire chief, police chief, or some other authority calling headquarters from an outside location. In such cases, the attendant answers the incoming call with the answering cord and uses the calling cord to plug into the paging jack. This cuts off the attendant's position, but completes the transmission path to the paged location.

Trunk circuits are provided to give the emergency-reporting system access to the telephone central office. Through these, incoming calls can be received from, or outgoing calls can be originated to, any telephone destination. The central-office trunk circuits also have dual appearances and may be answered by either jack or key.

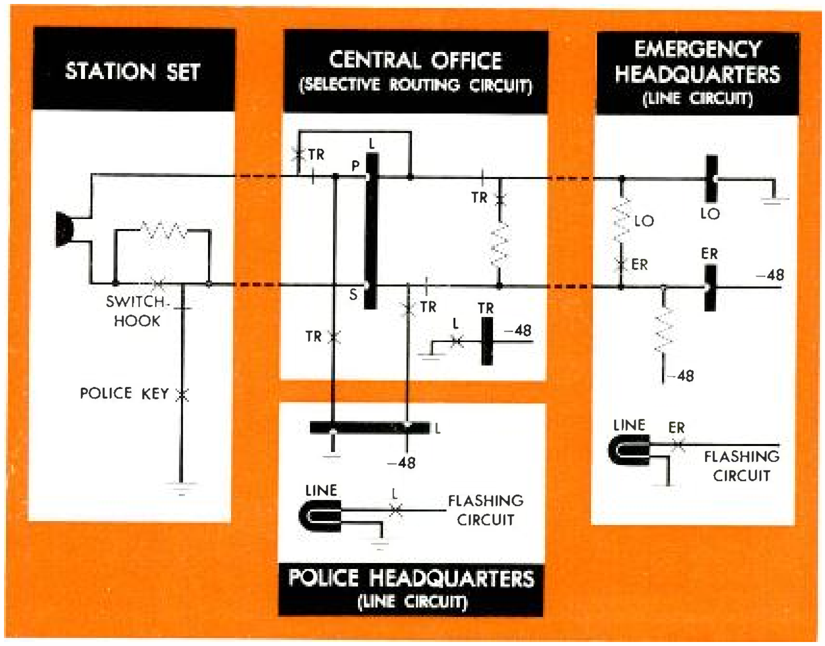
On key-answered calls, arriving on one of these trunk circuits, it may be convenient, or even necessary, to maintain a regular connection while the attendant handles an emergency-reporting line, so a hold key is provided for each central-office trunk circuit. Momentary operation of this key disconnects the attendant's talking circuit, but holds the connection to the calling party. This puts a distinctive "winking" signal on the trunk lamp as an indication that the trunk is being held. The attendant can re-establish the connection by momentarily operating the trunk key.

The headquarters attendant, in addition to being the focal point for emergency information, is always faced with the problem of knowing the whereabouts of the various pieces of emergency equipment at his disposal. This can become a rather complex problem when serious fires occur and fire-fighting equipment is dispersed over several areas. To ease the attendant's problem, the




*The printed record of a call to emergency headquarters, along with the meaning of the printed numbers. This record was printed by a 1A ticketer.*

*Diagram of a typical selective-routing arrangement. All lines go through the central office, and calls are routed to police or emergency headquarters.*




emergency-reporting system is equipped with "status indicators." This indicator presents dispatching information visually. When equipment "rolls," its associated red lamp is lighted at the indicator by a signal that may be automatically initiated by the movement of the equipment. As long as this light remains, the equipment is not available, and if necessary, some other fire house must be called upon to answer a fire call.

When equipment is ready to return to its station, the information is radioed to headquarters, and its associated status key is pulled out. This lights a green lamp and the combination of lighted red and green lamps is a visual indication that the fire-fighting apparatus is enroute to its regular location. When it arrives the red lamp is extinguished, signifying that the station is again "ready." The attendant then returns the status key to "normal" and this extinguishes the green lamp.

The emergency attendant also receives visible and audible alarm signals for various trouble conditions. These include: circuit-fuse operation, line open, ringing-power failure, time-of-day or ticketer-motor power failure, or time-of-day or ticketer-motor fuse operation. If the ticketer is used to record calls, a lamp lights if the paper supply drops below a pre-selected minimum value. The same lamp also lights when a trouble occurs in the teletypewriter and control circuit if a teletypewriter is used.

There are cutoff keys for silencing both the audible alarm and call signals. Since the latter is the signal given whenever an emergency call is received, an amber lamp is provided as a warning that the audible signal is "cut off." The switchboard can also be equipped with a "deadman" alarm. With this feature, if a specific call is not answered for three minutes, an audible and visual alarm is initiated.

### *Important System Features*

The Emergency Reporting System can be readily expanded or contracted with population shifts or zoning changes. The public emergency telephone sets can be easily moved or added because of the extensive cabling network of the Telephone Companies. The Companies also assume responsibility for maintenance.

The Bell System's fire and police reporting system offers versatility, reliability and simplicity of operation and maintenance. Principally, however, it furnishes the essentials of emergency reporting: calling-telephone identification; direct communication with those reporting the emergency for determining its exact location and nature; line-identity recording; and where desired, voice recording. The system was designed with the strict specifications of the fire underwriters in mind, and installation often results in a reduction in fire-insurance rates on both municipal and individual properties.

*Solid-state devices are used extensively in the power supplies for TJ Radio. By employing silicon junction diodes and magnetic amplifiers, designers have achieved long-term reliability at low cost.*

R. H. Small

# Power Supply for TJ Repeaters

The microwave radio-relay system used by the Bell System for telephone and television transmission in the 11,000 megacycle band is called TJ Radio (RECORD, *April*, 1959). The greatest use for TJ radio is as a short-haul, low-density system capable of transmitting 240 telephone circuits or a television program over distances of 100 to 250 miles.

For flexibility each transmitter-receiver bay needs a separate power supply to convert the primary ac power to several regulated dc and ac voltages. The power supply designed for TJ radio represents the results of several new approaches to design of power supplies.

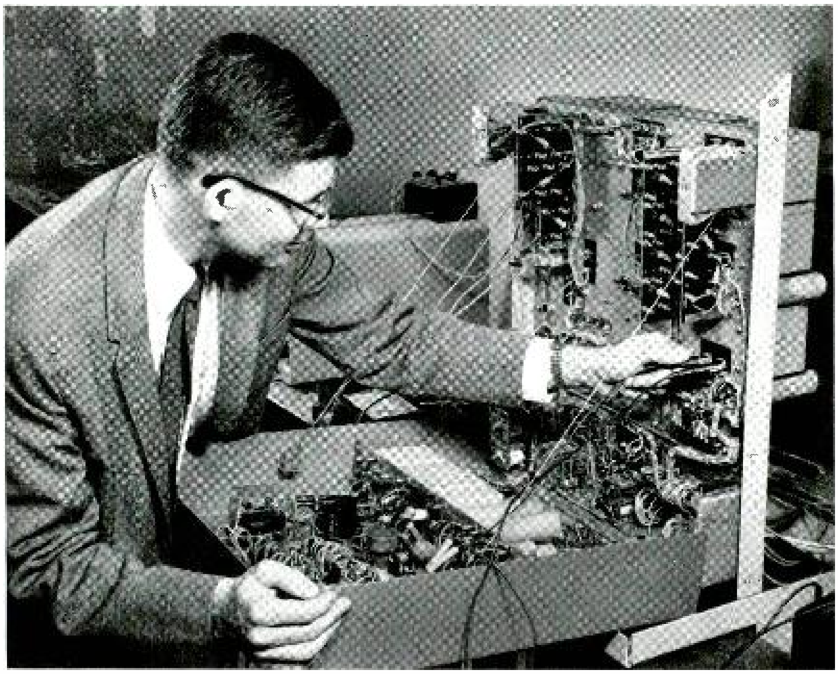
The major design objectives were long-term reliability and a minimum over-all cost for manufacture and maintenance. Included in these objectives are efficiency. accurate regulation, long life, safety, ease of operation, ease of maintenance, compactness and attractive appearance.

Equipment in the TJ system is supplied by four regulated dc outputs: 600, 400, 200 and —400 volts, with three independent ac filament voltages. These outputs are all furnished by the new power supply. In addition, metering networks are supplied on the dc outputs to monitor important voltages and currents.

There are only four electron tubes in the entire power supply. These are long-life types, applied conservatively within their ratings. The shortest expected life is about five years.

Among the examples of new design techniques used in these power supplies is the extensive use of solid-state devices. The main regulator is a magnetic amplifier and all the rectifying devices are silicon junction diodes. The magnetic amplifier and silicon diodes regulate and rectify with higher efficiency than comparable electron-tube units. The TJ power supply is the first production power supply to use silicon rectifiers for high-voltage rectification.

Rectifier circuits produce a pulsating dc voltage that always possesses the same polarity. But this voltage isn't as useful as a dc supply for electron tubes because it causes pulsations in amplitude, or "ripple," of the output voltage. These pulsations must be smoothed out by filter networks made up of inductor coils and capac-



*Author shown testing the TJ power supply unit. Approximately 160 pounds of components and wiring are packed into 21 by 19 by 10⅛ inches.*

itors. The supply was designed to take advantage of the constant-current nature of the loads, and the averaging characteristics of the filters.

As long as the current from a rectifier is kept flowing by the series input choke of the ripple filter, the dc of the output follows the half-cyclic average value of the ac input. Thus one needs only monitor the output of one of the supplies —400V) and regulate the ac input.

This method of regulating the outputs is shown in the accompanying block diagram. Because the load is constant, the feedback regulator maintains the half-cyclic average of the ac voltage at a constant value, and all the dc output voltages are maintained constant. The feedback amplifier controls the magnetic amplifier, and thereby regulates the power to the rectifiers.

The 3A magnetic amplifier regulates ac voltage by absorbing area (volt-seconds) from the ac wave presented to it. For a given combination of bias and control currents, a magnetic core absorbs a given amount of the ac wave; indicated by area A in the diagram on page 264. Then the core saturates, and the magnetic amplifier presents a very low impedance to current flow. Volt-time area B is then applied to the rest of the circuit. On the next half-cycle of voltage, the other core absorbs area C and passes area D. The resulting waveform looks rather chopped up, and requires somewhat more filtering than a wave from a conventional full-wave rectifier.

Variations in ac line voltage are regulated by varying the volt-time area absorbed in the magnetic amplifier cores. This is done by changing the bias and control currents. The bias current is supplied from the unregulated ac and applied through a network to the bias winding of the magnetic amplifier. An increase in the unregulated voltage increases the bias current and tends to correct the regulated output.

Finally, an electron-tube circuit in the feedback amplifier adjusts the control current to maintain the –400 volt output exactly at –400 volts. In the process of maintaining the –400 volt output constant, the average ac voltage to all the other outputs is also maintained constant. The wave diagram shows how, by varying the total area absorbed (A+C), the average output passed (areas B+D) is kept constant.

When the input line voltage varies, and the average value of the regulated voltage is maintained constant, the parameters of the waveform vary, however. The peak voltage is the same as the input peak voltage, because the magnetic amplifier in this circuit always begins to conduct before the peak occurs. But the root-mean-square (rms) voltage, which is pertinent when heating effects are considered, does vary with line voltage. In the range of operation of the TJ power supply, a 10 per cent variation in line voltage, with a constant regulated voltage, produces 5 per cent variation in rms voltage.

For the separate filament supplies, the regulated ac voltage is stepped down by a filament transformer and supplied to the three filament outputs. The filaments of various tubes in the TJ system are heated by the rms or "effective" voltage applied to them, and thus these supplies are regulated within about ±5 per cent.

Several features were included in the TJ power supply to assure safety for all personnel involved in operation and maintenance. In the first place, electrical circuits are covered when the equipment is in the operating position. The cover, which has a recessed control panel, forms the front of the power supply. Pin jacks are available for making pertinent measurements, but the circuitry can be reached only by a thin probe. It also has current-limiting resistors in series with all pin jacks more than 150 volts off ground. When the equipment must be opened for access during maintenance, an interlock circuit removes power from the circuit. The few parts of the circuit not de-energized by the interlock are covered by transparent plastic covers and sleeving to avoid contact by maintenance personnel.

Long-term reliability involves working well under normal conditions; it also involves the ability to withstand many kinds of abnormal conditions and the ability to work well when conditions return to normal. TJ equipment is protected against external short circuits and overloads by a circuit breaker and fuses within each power supply. The circuit breaker, besides acting as an on-off switch, will also trip and turn off the input power in the event of an internal short circuit.

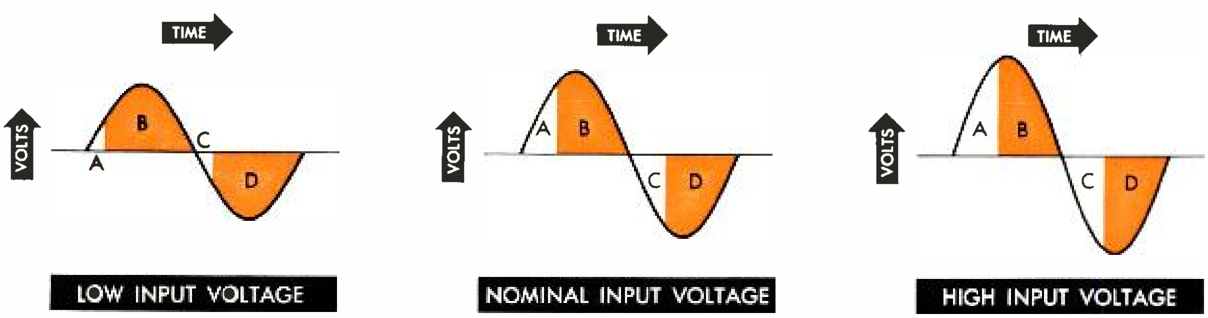
The silicon rectifying elements are very sensitive to excess inverse voltages. During a field trial, Laboratories engineers traced failures of diodes to lightning-voltage surges. Customary lightning protection for power service consists of diodes and carbon blocks that can limit surge voltages at the equipment to less than 1000 volts. However, for this supply such protection is not sufficient. The TJ power supply is designed to operate from a 117-volt power line, and the maximum peak voltage from this — even with a line voltage 10 per cent higher — is only 183 volts. A safety factor of about 4½ times normal on all the rectifiers would be expensive, so the designers incorporated a lightning-voltage limiter in the production models. This limiter consists simply of two rectifiers and two capacitors.

During normal operation, the capacitors charge to the peak ac voltage of the input line. When a lightning surge tries to raise the voltage beyond the recurrent peak of the ac, the rectifier takes energy from the surge and charges the capacitor. For a 1000-volt surge, the capacitor, typically, may charge about 20 volts above its normal peak voltage of 165. Thus, the 1000-volt surge is held to 185 volts.

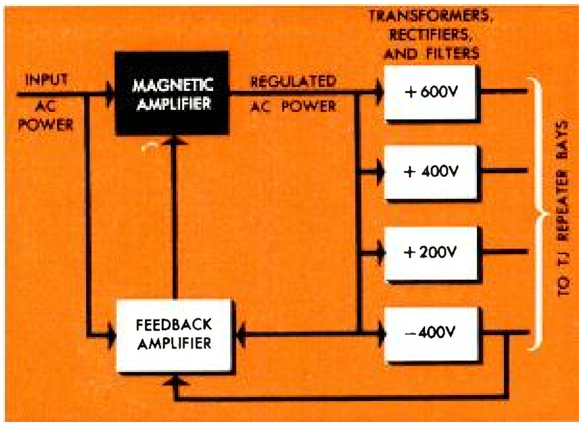
### Voltage Surge Protection

Lightning is infrequent, and a light bleeder current easily discharges the excess voltage before another surge occurs. A model was tried with this surge protector, and was hit with repeated 1000-volt surges from a lightning-surge simulator. After 50 simulated lightning hits, the power supply continued to operate.

This new power supply also includes a sensitive relay to protect the klystrons (which generate microwaves in the transmitter and receiver) from the application of "resonator" voltage before "repeller" bias voltage is available. Briefly, the resonator voltage in a klystron accelerates its electron beam. If the repeller unit has no bias, the accelerated electrons from the resonator can stream into the repeller at full speed, melting it in a matter of milliseconds. The sensitive relay operates only when voltage is present on the –400V output (repeller supply); the positive voltages (including resonator volt-




*The 3A magnetic amplifier regulates ac voltage by absorbing area (volt-seconds) from the ac wave presented to it. Two magnetic cores absorb areas (A or C) from alternate half cycles. Areas B and D, constant with varying input, go to the rectifiers and their waveforms are filtered.*




*Block diagram of the operation of the power supply circuit showing how outputs are regulated.*

age) are applied only when this relay is operated.

The power supply for TJ radio is an example of good packaging for maximum economical use of space. It weighs 160 pounds, mounts on a 19-inch-wide relay rack, and is 21-inches high. Full accessibility is required, although the TJ bay must be mounted against a wall so that only the front is available for such access.

One part of the answer to full accessibility is to use the full depth allowed. Components are mounted on both sides of the backplate and on the inside of the cover. All wiring is placed on the front of the backplate and the inside of the cover. The cover has a hinge at the bottom and, when released by two twistlock fasteners, swings open to expose all the wires and connections This is sufficient for adjustments, trouble shooting and replacement of most components. The backplate divides into two parts, with the upper part also hinged to swing forward. This permits access to the back of the backplate so that even the filter capacitors, transformers and other coils can be replaced from the front of the power supply. The general arrangements made for front access can be seen in the accompanying photograph.

The cover presents a smooth, attractive appearance and serves its utilitarian functions of supporting components and protecting personnel from contact with live electrical parts. A recessed panel holds the necessary controls and test jacks in a convenient position with no protruding parts to catch clothing or to break off accidentally. When the cover is opened, its weight is counterbalanced by sash pulleys—one on each side—which allow easy movement. The sash pulleys—visible in the photograph in the upper corners of the open power supply—hold the cover open in a horizontal position.

The photograph also shows the arrangement of circuits in the supply. Mounted inside the cover are: (in addition to the front-panel controls) the directly regulated −400 volt supply; the auxiliary plate-voltage supply; and, on the shelf in the corner, the voltage-reference tube and feedback amplifier. The magnetic amplifier is mounted on the upper-left corner of the backplate, which is vertical in the photograph. Positive supplies are lined up vertically on the upper section of the backplate, and the filament supply, relays and external connections are in the lower section.

Because this power supply is the first in the Bell System to use silicon diodes in a high-voltage rectifier application, the rectifier-bridge circuits have been changed several times to keep pace with advances in the state of the art. For example, the tool-made sample shown in the photograph had more than one hundred 200-volt diodes mounted on card assemblies. Successive improvements in the diode section of the supply include: omission of bridging resistors, reduction to five 400-volt diodes in the production sample, and now that 2000-volt units are available, reduction to a single 2000-volt diode per arm. When only four 2000-volt diodes are needed for a rectifier bridge, they can be mounted on tall standoffs (directly from the back panel) to save the equipment and assembly expense of the rectifier-bridge card assemblies used initially.

### Use of Connectors

One final feature of the TJ power supply is that all 42 connections to transmitter, receiver, IF amplifiers, metering panels, AFC and blower motors — the whole TJ repeater bay — are made through connectors, which merely plug into the power supply.

The use of connectors facilitates installation and helps to assure that everything necessary is plugged in before the power-supply interlock circuit is closed. Also a connector takes less room for a given number of leads than a terminal strip, and once wired correctly assures the right connections throughout the long life of the equipment.

TJ Radio is an increasingly popular source of microwave transmission for telephone circuits. The new power supply described in this article promises long-term reliability at low over-all cost for TJ transmission. Rugged long-lived silicon diodes and magnetic amplifiers guarantee that this new power supply shall continue to enjoy many of the benefits which solid-state electronics confer.

*Customer dialing of toll calls will take a major step forward with the application of Centralized Automatic Message Accounting (CAMA) to the 4A and 4M Toll Systems. These changes have brought about a need for new considerations in the routing of nationwide toll calls.*

E. Jacobitti

# 4A and 4M CAMA

## Routing Arrangements

For nationwide customer dialing, the dialing instructions must be uniform for all central offices in clearly recognizable numbering plan areas. In telephone language, a numbering plan area consists of a particular geographical territory in the United States and Canada. Each numbering plan area is represented by a distinctive 3-digit code, with either a 1 or 0 as a middle digit. Each such area will generally contain some 500 or fewer local central offices, each of which will be assigned a distinctive 3-digit office code.

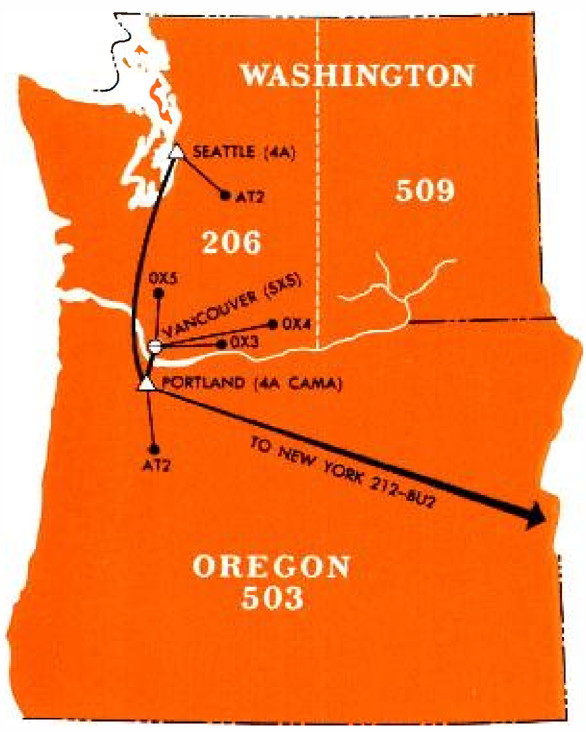
Thus, each telephone will have, for distance-dialing purposes, a unique identity — a 3-digit area code, an office code of three digits that may include one or two letters, and a station number of four digits. Under this plan a customer will dial seven digits to reach another customer in the same numbering area, and ten digits to reach a customer in a different numbering area. (In addition to the 7- or 10-digit codes, a directing code will be necessary in some instances.)

With the introduction of centralized automatic message accounting (CAMA) facilities for the No. 4A and 4M toll crossbar systems, direct distance dialing (DDD) will be available to many customers for the first time. To further implement direct distance dialing, the No. 4-type systems are also arranged to furnish CAMA facilities for customers in two areas adjacent to the area in which the No. 4 CAMA office is located.

The map opposite illustrates a geographical location where the 4A CAMA office serves customers in area 206 and its home area 503. Suppose a customer from OXford 3 in Vancouver calls a customer in ATwater 2, Seattle, and his call is routed via the Portland 4A CAMA toll office. OXford 3 and ATwater 2 are in area 206, and therefore the customer will dial the 7-digit AT2 number 282-XXXX. There is also a 282 (ATlantic 2) office in Portland, so to be able to route this call back to the originating area — even though the area code 206 is not received — the 4A CAMA office in Portland must know the area from which the call originated. This is done by using an area of origin mark from the trunk circuit to generate the correct area code, which is then prefixed to the dialed code to make possible the correct translation.

The area of origin of the incoming trunk used on a customer-dialed call is indicated by the trunk class translator frame (RECORD, *June*, 1960). When the call originates in the home area, the area of origin mark "zero" is received. Area of origin marks "A1" or "A2" are received for calls originating from the two adjacent areas. In the case of the call from a customer in OXford 3, (*see map*) to a customer in ATwater 2, the area mark "A1" will indicate that the call is originating from area 206. However, before action can be taken by the decoder with this mark, it must know whether an area code was dialed.

This is determined by the CAMA sender, which indicates by a 7D mark that seven digits were received. With these two marks — the area mark "A1" from the trunk class translator and the "7D" mark from the sender — the decoder proceeds to steer the call to the proper card translator, prefixes the area code 206 in the first 3-digit position of the code leads, and transfers the received office code 282 to the second 3-digit position of the code leads. This simulating of a dialed area code and shifting of the code leads permit the 6-digit card (code 206-282) to be selected in the right card translator. The translator in turn gives proper routing instructions for call completion.



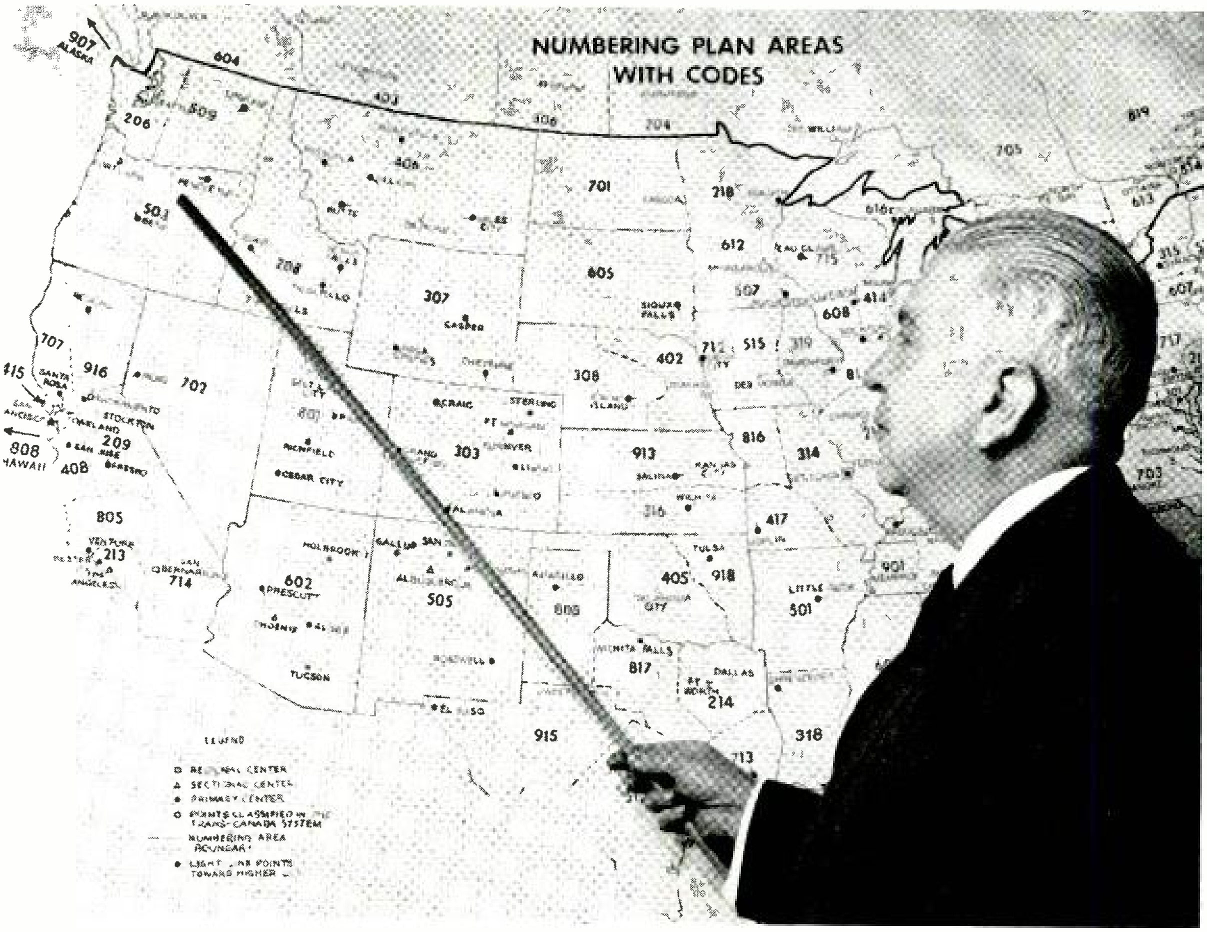

*Area code numbers in Northwestern United States. Western Washington code is 206; Oregon code is 503. Middle digits of all codes are "zero" or "one".*

A slightly different situation exists on a call from OXford 3 to the ATlantic 2 office in Portland. Here the area mark "A1" received by the decoder from the trunk class translator again indicates that the call originates from area 206. The CAMA sender associated with this call reveals to the decoder that it has received ten digits 503-282 XXXX. The home area code is "recognized" by the decoder which proceeds to delete it and then shifts the office code to the A, B and C digit positions. The decoder goes on to complete the call by selecting the ATlantic 2 card 282 in the home translator.

If the Oxford customer had dialed a call for BUckminster 2 in New York City, instead of ATlantic 2 in Portland, the decoder would again have examined the area code and determined now that it is not the home area but some distant area 212. With this information, the decoder will proceed to select the New York area code card (212) in the home translator and complete the call in the regular manner — that is, without code shifting or deletions.

Customers served by 4A CAMA may unintentionally dial calls using codes which are irregular or unauthorized, such as the use of two area codes, or special "operator only" codes. These calls, which require detection and special routing arrangements, all involve the digits "zero" or "one" in the D or E positions. The sender, upon recognizing this condition, stops the progress of the call, and signals the decoder to set this call up so that the customer reaches a special operator or a particular trunk group which gives a machine announcement suggesting that he consult the directory for correct dialing information.

The decoder, in conjunction with the routing card in the 4A system, continues the screening process on those codes which the CAMA sender cannot detect. For example, codes such as 121-XXXX must be screened by the decoder because CAMA customers may inadvertently call an inward operator (code 121). To detect routings of this nature, the 121 route card will indicate "UCR" (Unauthorized for CAMA Routing). This indication causes the decoder to route the call to a machine announcement instead of the regular 121 inward operator. The machine announcement will suggest that the customer consult his directory to avoid subsequent incorrect dialing. If




*Author points out 503 area on nationwide dialing map. Other three-digit numbers are also area codes.*

this same 121 code is used by an operator on a non-CAMA call, the "UCR" indication is disregarded and the connection to the 121 inward operator is permitted in the regular manner. The "UCR" indication can therefore permit discrimination on any code route in the 4A system. For example, all arbitrary codes used by operators on non-CAMA calls, or unauthorized area codes, will have the "UCR" indication to prevent their use by CAMA customers.

Furthermore, by using the "UCR" indication, customers would be prevented from unintentionally dialing any route involving 6-digit translation. To safeguard this arrangement, all permissible routings for both CAMA and non-CAMA customers will be coded "ACR" (Authorized Code Routing). The 4A CAMA system checks each routing for one or the other ("UCR" or "ACR") indication, and warns if neither or both occur on any call.

Customers, after becoming acquainted with CAMA dialing facilities, may attempt to route local calls through the 4A toll system after they have tried and failed to complete them through the regular local telephone plant. For example, if a customer in the OXford 4 office (*see page 267*) is unsuccessful in completing a call to a customer in OXford 5 office, he may try to complete the same call by first dialing a directing code which routes the call to the 4A CAMA office. Then, following this code he would dial OX5 plus four digits. If these calls were allowed to be completed through the toll system, the trunk group between Vancouver and Portland would be overtaxed unnecessarily. All misrouted calls of this type are screened by the CAMA equipment and routed to a machine announcement.

Facilities are available at the 4A system maintenance center for initiating calls with all possible code routings so that these new features may be tested for proper operation. In this manner, satisfactory performance of the CAMA features in the 4A and 4M toll switching system will be verified.

*Piezoelectric materials have many important applications in communications. Two very strongly piezoelectric materials have recently been demonstrated, by doping them with lithium to neutralize their excess conductivity.*

# New Piezoelectric Compounds Exhibit Large Coupling Constant

News of Semiconductor Research

The discovery that zinc oxide and cadmium sulfide are strongly piezoelectric was recently revealed by A. R. Hutson of the Semiconductor Research Department. He reported his finding in the May issue of *Physical Review Letters*, a publication of the American Physical Society.

In piezoelectric materials, the application of a mechanical stress generates an electrostatic charge. Conversely, an electrical field applied to such a crystal changes the crystal's physical shape according to the way it is cut. An electrical signal at a radio frequency can thus be applied to a piezoelectric crystal to generate mechanical vibrations at the same frequency as the signal. This property is known as electromechanical coupling. The best electromechanical transducers of this type are made from materials which are strongly piezoelectric, and such materials exhibit a large electromechanical-coupling constant.

To demonstrate the piezoelectricity in zinc oxide, it first had to be "doped" with lithium to neutralize the excess conductivity. The degree of piezoelectricity exhibited by doped zinc oxide is about four times as great as that of quartz; cadmium sulfide is twice as great. Mr. Hutson made confirming measurements on single crystals of zinc oxide grown both by vapor techniques and from a flux, or molten salt. The cadmium-sulfide crystals were grown by the vapor technique only.

Both zinc oxide and cadmium sulfide are recognized as "n-type" semiconductors. For example, zinc oxide usually shows a room temperature resistivity less than $10^3$ ohm-cm—a figure denoting a good semiconductor, This relatively low resistivity has heretofore effectively hidden all direct experimental evidence of piezoelectricity. Mr. Hutson decided to investigate the piezoelectric constants of these materials while studying some of their unusual conductivity properties. A large piezoelectric constant seemed to explain these anomalies theoretically, but it had never been observed experimentally.

The conductivity of the zinc oxide was "quenched" by diffusing lithium atoms into the material. These acted to "neutralize" the excess electrons which were contributing to the conductivity. When this was done, the resistivity of the material was raised from $10^3$ to $10^{12}$ ohm-cm at room temperature.

Both electrical and mechanical measurements were made on vapor-grown needles and flux-grown platelets of zinc oxide, and on the vapor-grown cadmium sulfide. With dielectric constants of 8.2 and 9 for zinc oxide and cadmium sulfide, respectively, Mr. Hutson calculated the electromechanical coupling constants to be approximately 0.4 for zinc oxide and 0.2 for cadmium sulfide, compared with 0.095 for quartz.

# Hearing Effect Reproduced Electronically

A psychoacoustic phenomenon called the "Cocktail-Party Effect" has recently been duplicated electronically by a group of investigators at Bell Laboratories. The name of this phenomenon comes from the fact that the human listener can concentrate his attention on a specific voice in which he is interested, and thereby "enhance" it from the surrounding babble of voices or other noise. This is true even though the voice of interest may be no louder than the surrounding noise.

News of Acoustics Research

The binaural, or two-eared, listener can enhance the effective intensity of the desired voice by 5 to 15 decibels by "suppressing" the level of background noise. A scheme for reproducing this feat electronically was described recently by E. E. David, Jr. and J. F. Kaiser, of the Visual and Acoustics Research Department, to the Acoustical Society of America.

The cocktail-party effect depends on the fact that in normal hearing the two ears, because of their spatial separation, pick up slightly different sound patterns. A single ear, with only one sample of the sound field, cannot pick out specific voices or sounds from a surrounding babble as easily. Similarly, a remote listener auditing with a telephone transmitter, or any single microphone, is unable to suppress spurious noises in the originating environment. Thus, background noise interferes much more with a transmitted voice than the same noise would if the two-eared listener were standing in the same room with the talker.

The advantage achieved by the ear and brain in the cocktail party effect is more than would be expected through linear addition of the two aural inputs. Therefore, the investigators used nonlinear techniques in the attempts to duplicate the effect electronically. In one technique, the output of two microphones are compared automatically to generate a gating wave, which controls the volume of the combined output of the two microphones. This gating raises the intensity of the combined signal only when energy from the desired voice arrives simultaneously at the microphones. Otherwise, the gate suppresses the combined signal. Noise or interfering speech signals will pass through the gate only if they occur simultaneously with the desired speech signals. However, this simultaneity is rare, and the pattern, or continuity, of the undesired signal is disrupted, greatly reducing its interfering qualities.

In subjective tests, enhancements of 9 db in effective signal level were achieved against a background of one interfering talker and 5 db was found with two extra talkers. While the data reported are preliminary, they suggest that human-attention mechanisms may be simulated.

*J. F. Kaiser, left, and E. E. David with equipment used to duplicate electronically a hearing phenomenon. Effect studied is one permitting listener to pick out one conversation from a cacophonous background.*

# Nike Hercules Destroys Corporal Missile in Test

The Army demonstrated early last month how an improved version of its Nike Hercules can meet short-range ballistic missile threats when a Hercules missile destroyed a Corporal missile at White Sands Missile Range, New Mexico. The spectacular engagement between the two missiles was carried out many miles above the desert and miles from the defended area.

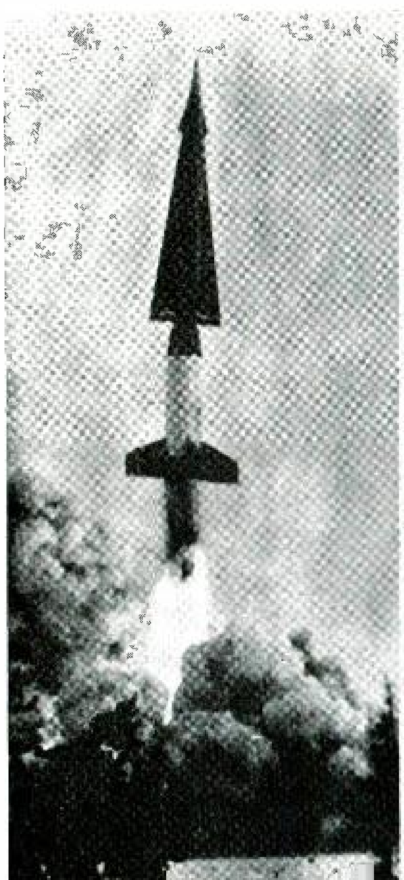
The photographs below show Nike Hercules, left, which is a surface-to-air guided missile and Corporal, right, the U.S. first operational ballistic missile. Center sequence shows, top to bottom, the actual missile intercept and the complete destruction of the Corporal target. Hercules is on top with Corporal directly below.

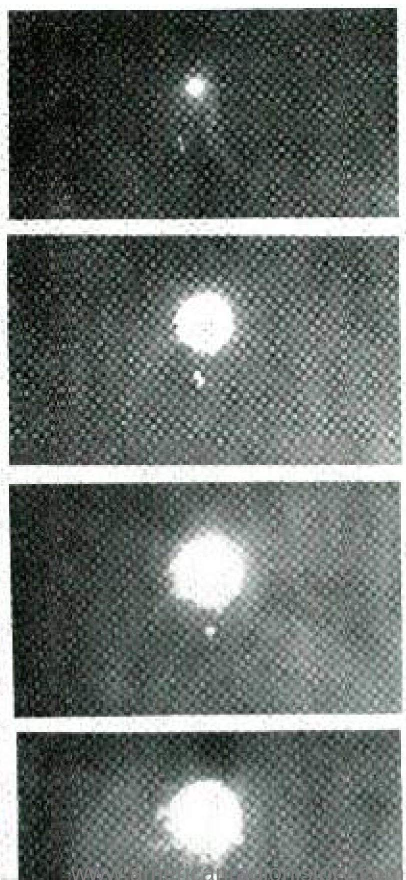
In the test, an operational Army Corporal with a warhead was fired at a target near the Nike Hercules site. As soon as the Corporal emerged above the intervening mountains it was detected, tracked and destroyed considerably short of its target by the Hercules missile. The firing was carried out by Army personnel and Bell Laboratories and Douglas Aircraft Company engineers.

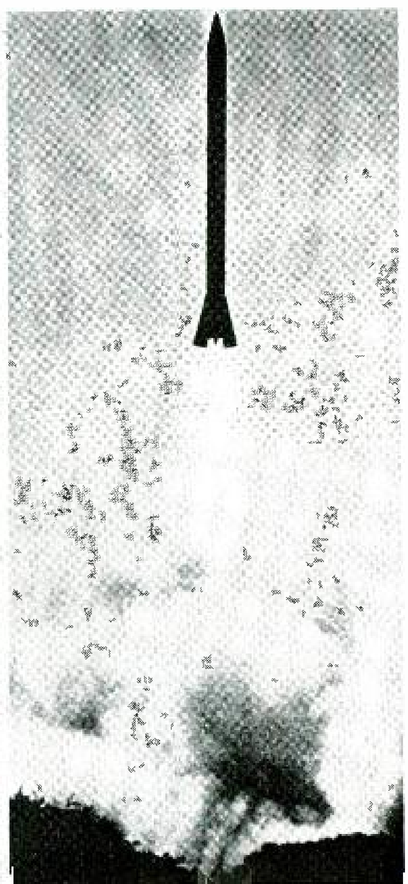
Nike Hercules, now extensively deployed in defense of the U. S. and vital overseas installations, has previously demonstrated its ability to engage and destroy supersonic, high-performance aircraft, which pose a threat today. The inherent growth potential of the system has permitted Bell Laboratories to design an improved version by modifying already deployed Nike Hercules systems. This modified system is designated the Improved Nike Hercules. These field modifications are supplied by the Western Electric Company, prime contractor for the Nike Hercules system, and one of its principal subcontractors, the General Electric Company.

The Improved Nike Hercules has a defense capability against ballistic missiles of the field artillery type, such as the Corporal and also against air-to-ground missiles. In addition, advanced radar designs insure high performance despite attempts at sophisticated electronic jamming that could be a threat to our defense during the forthcoming decade. The improved Nike Hercules system can use both Ajax and Hercules missiles. No modifications to Nike Hercules launching areas are required.

Under direction of U. S. Army Rocket and Guided Missile Agency, Hercules was designed by Bell Laboratories and Douglas Aircraft Company. The same Army-Industry team responsible for Nike Hercules is also working on Nike Zeus, America's only system now under development to defend against the threat of intercontinental ballistic missiles.







*Extremely rapid reaction to an input signal is one of the great advantages of solid state electronics. In the pursuit of speed, researchers must frequently devise new test instruments geared to the fantastically fast operation of their experimental devices.*

# Electrical Stroboscope Measures Extremely Short Pulses

A new high-speed electrical stroboscope, or sampling oscilloscope, was described last month by W. M. Goodall and A. F. Dietrich, of the Radio Research Department, in a paper presented to the IRE Professional Group on Microwave Theory and Transmission. The new instrument has an effective bandwidth of 5,500 megacycles, and a "rise" time that is only a fraction of a millimicrosecond.

**News of Electronics Research**

In high-speed, short-pulse studies, engineers can obtain a great deal of information by using oscilloscopes to observe repetitive pulse patterns. However, several new devices, such as the microwave transistor recently announced by Bell Laboratories (RECORD, *April*, 1960) and Esaki diodes (RECORD, *March*, 1960), operate too rapidly for conventional oscilloscopes to follow. Standard practice with typical broadband amplifier oscilloscopes is to "trade" sensitivity for fast rise time. In other words, fast rise time and high sensitivity are usually mutually exclusive in these instruments.

This restriction does not apply to an electrical stroboscope, however. Here, the rise time is primarily a function of the bandwidth of the sampling circuits, and sensitivity depends only on the gain of the amplifier in the low-frequency portion of the oscilloscope. But a penalty is paid for these advantages in the time required for integration. The principle involved in the operation of an electrical stroboscope is similar to that of a light stroboscope, which appears to slow down, or "freeze," motion in a moving part by illuminating that part with short recurrent flashes of light.

The instrument described by Messrs. Goodall and Dietrich, uses a gallium-arsenide crystal as a gate, opened briefly by pulses from a high-speed pulse generator to observe short samples of the signal pulse. The final signal seen on the display tube is the result of integrating a large number of these samples. Integration takes place in a manner somewhat similar to the fusion of samples in an observer's eye when he is watching a light stroboscope.

In the electrical device, when the signal pulse and the strobe pulse occur at the same rate, the stroboscope continues to look at the same part of the electrical signal, comparable in a sense to a light stroboscope freezing the motion of a rotating shaft. If the two frequencies differ slightly, the signal interval is scanned repetitively. Here, the analogy to the light stroboscope is the way that a moving part appears to move slowly when the light frequency differs slightly from rotational frequency.

The designers are using the new instrument, which has a sensitivity of 2 mv/cm, in studies of binary pulses in the range of 1,000 megabits, or a billion bits per second. They have produced oscillograms of 160-mc square waves, and of 640 million pulses per second, with a rise time for the wave forms of as fast as $2 \times 10^{-10}$ seconds. Further tests conducted at the Laboratories indicate that rise times at least as short as $10^{-10}$ seconds can be displayed satisfactorily.

# Epitaxial Film Technique Brings Major Improvements In Diffused-Base Transistor

**News of Transistor Development**

Research at Bell Laboratories has recently brought about major improvements in the diffused-base transistor through use of the epitaxial film technique. The improvements include large reductions both in switching time and in the resistance of the collector region of the transistor. The achievement was recently revealed in a paper authored by H. H. Loar, H. Christensen and J. J. Kliemac of the Transistor Development Department and H. C. Theurer of the Metallurgical Research Department.

Epitaxial films are those formed on the surface of a crystal which are identical to the crystal in structure of the lattice. These films have made possible silicon transistors whose switching times are less than a tenth of those made previously, and which have a comparable reduction in the collector resistance. The development is expected to have far-reaching implications in both the fabrication and application of semiconductor devices.

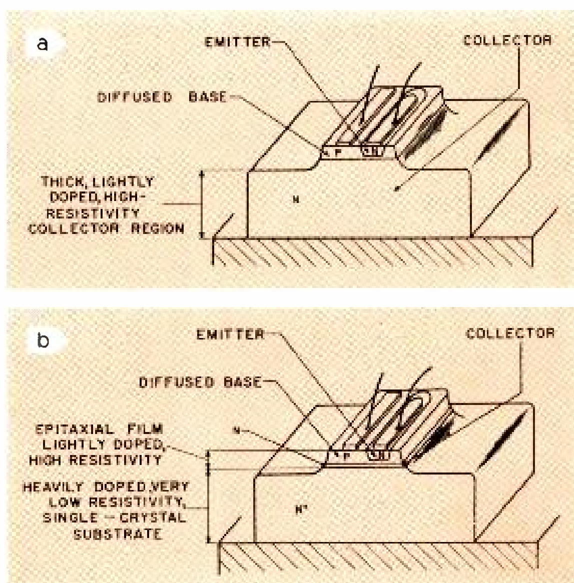
Diffused-base transistors require a collector region with relatively high resistivity to attain low capacitance and high voltage breakdown. Heretofore, for ease of fabrication, this region has been much thicker than required electrically. The excess thickness increases the collector resistance and, through storage of the electrical carriers, the switching time.

Ideally, the thickness of the collector region, lightly doped with impurities, should be in the neighborhood of 0.1 mil, which is about one thirtieth as thin as normally used. Semiconductor wafers prepared by conventional methods become extremely difficult, if not impossible, to handle as they approach this desired thinness. Now, this problem can be solved with the epitaxial film techniques. In this method, lightly doped, high-resistivity, epitaxial films are grown on and supported by a heavily doped, low-resistivity "substrate," giving the desired combination of electrical properties and mechanical strength.

The Laboratories has made diffused-base transistors on epitaxial layers of both germanium and silicon which have exhibited the improvements predicted theoretically. For example, in two similar silicon transistor structures, one conventional and the other using the epitaxial material, switching time in a typical circuit has been reduced from 200 to 20 millimicroseconds. Furthermore, the series resistance of the collector in the epitaxial transistor was reduced by a factor of more than 10 and was comparable to the resistance of conventional devices 15 times larger. Experiments with germanium indicate that epitaxial layers will extend the frequency response of such transistors well beyond that of a 2-kmc device recently announced at the Laboratories.

The new technique involves modification of the "starting" material. The device can then be made by existing production facilities for diffused-base devices. In the process, single-crystal wafers of heavily doped material are first cut and polished. A lightly doped thin film (about 0.1 mil) of the same type of conductivity is then deposited epitaxially on the wafer surface (*see accompanying illustration*). This film provides the desired thin, lightly doped, collector region. From this point on, manufacturers will use standard diffused-base techniques.

Epitaxial material in diffused-base transistors not only results in major improvements in switching time and collector resistance, but also simplifies the design and understanding of transistor devices and brings them closer to ideal forms. Furthermore, the addition of the epitaxial film technique to the well established diffusion technology gives the device engineer an extra degree of freedom in design which should result in new devices, formerly difficult or impossible to achieve.




*Essential differences between conventional and epitaxially grown transistors. Thickness of collector region in (a) results in high resistance. Epitaxial construction of region in (b) permits it to be thinner, hence have less resistance.*

# news in brief

## A.T.&T. Names Three To New Posts

G. N. Thayer

Three men—Gordon N. Thayer, vice president, S. Whitney Landon, assistant to president and secretary of the Company, and Prescott C. Mabon, assistant to the president were involved in recent organization changes at the A.T.&T. Company.

S. W. Landon

Mr. Landon and Mr. Mabon were elected vice presidents of the Company, and Mr. Thayer, since last October vice president in charge of the marketing department, was appointed operations vice president. Mr. Landon will continue as secretary of the Company, a post he has held since 1952. Mr. Mabon has been assistant to the president since 1949.

Mr. Thayer, who joined the technical staff of Bell Laboratories in 1930, was named transmission development engineer in 1948. The following year he became assistant director of transmission development and in 1951 he was named director of transmission development.

Mr. Thayer was elected vice president of the Laboratories in 1952 and was in charge of the Laboratories military development program. Later, for about two years, he was in charge of engineering and development work for the Bell System.

P. C. Mabon

In 1955, Mr. Thayer joined A.T.&T. as chief engineer. Two years later he was elected operations vice president of the Ohio Bell Telephone Company. He returned to A.T.&T. in October, 1959, when he was elected vice president in charge of marketing.

Mr. Landon joined the American Telephone and Telegraph Company in 1934 as an attorney. Three years later he became general attorney in charge of the legal department of the Long Lines Department. He was named assistant vice president and assistant secretary, Secretary's Department, in 1951. The next year he was elected secretary of the Company and appointed assistant to president.

Mr. Mabon joined the General Information Department of the Southern New England Telephone Company in 1934. In 1939 he joined the A.T.&T. Information Department. He was appointed information manager the next year, in 1944 was named assistant vice president, and in 1949 became assistant to the president.

## Dr. Fisk Receives Honorary Degree

At its 206th Commencement Exercises held on June 1, Columbia University awarded Dr. J. B. Fisk the honorary Doctorate of Science.

Others who received honorary degrees from Columbia at the same ceremonies were: Vice Admiral Hyman G. Rickover, chief of the Navy Bureau of Ships and authority on nuclear-powered submarines; Albert J. McConnell, Provost of Trinity College, Dublin, Eire; Lawrence M. Gould, President of Carleton College, Northfield, Minnesota; Bishop Horace W. B. Donegan, Episcopal Diocese of New York; Allan Nevins, Professor Emeritus of American History at Columbia; Mark Van Doren, Columbia Professor Emeritus of English; Frank Pace, Jr., Board Chairman of General Dynamics Corp.; U.S. Comptroller-General Joseph Campbell; U.S. Senator Lister Hill (D-Ala.); and Henry Cabot Lodge, Jr., U.S. Ambassador to the United Nations.

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

## AMERICAN PHYSICAL SOCIETY MEETING, Washington, D. C.

Dillon, J. F., Jr., and Nielsen, J. W., *Resonance in Terbium Doped Yttrium Iron Garnet (YIG) at Low Temperatures.*

Donovan, P. F., Foreman, B. M., Jr., and Miller, G. L., *Nuclear Radiation Spectrometry Using Semiconductor Detectors.*

Feher, G., Gere, E. A., and Wilson, D. K., *Anisotropy of the Direct Phonon Relaxation Process of Donor Electrons in Silicon.*

Foreman, B. M., Jr., see Donovan, P. F.

Frisch, H. L., and Lebowitz, J. L., *Local Equilibrium Distribution Functions.*

Frisch, H. L., Helfand, E., Lebowitz, J. L., and Reiss, H., *Scaled Particle Theory of Fluids.*

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

Geschwind, S., and Nielsen, J. W., *Paramagnetic Resonance of $Cr^{3+}$ in Yttrium Gallium Garnet.*

Helfand, E., see Frisch, H. L.

Lebowitz, J. L., see Frisch, H. L.

LeCraw, R. C., *Spin-Lattice Relaxation of Low k-Number Spin Waves in Yttrium Iron Garnet: Part I Frequency Dependence.*

Miller, G. L., see Donovan, P. F.

Nielsen, J. W., see Dillon, J. F.

Nielsen, J. W., see Geschwind, S.

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

Spencer, E. G., *Spin-Lattice Relaxation of Low k-Number Spin Waves in Yttrium Iron Garnet: Part II Temperature Dependence.*

Stillinger, F. H., *Approximations in the Theory of Dense Fluids.*

Suhl, H., *A "Second" Random Phase Approximation.*

Wilson, D. K., see Feher, G.

## ELECTROCHEMICAL SOCIETY MEETING, Chicago, Ill.

Berry, R. W., Gresh, M., Schwartz, N., and Urban, M. J., *A Selective Electrochemical Etching Procedure to Improve DC Characteristics of Oxide Film Capacitors.*

Bittmann, C. A., Kleimack, J. J., and Reutlinger, G. W., *Semiconductor Thin Wafer Techniques.*

Blakeslee, A. E., *Open Tube Diffusion of Antimony into Germanium.*

Cooper, H. W., Doucette, E. I., and Mehnert, R. A., *Oxidation-Induced Diffusion in Silicon.*

Doucette, E. I., see Cooper, H. W.

D'Stefan, D. J., and Klein, D. L., *Silicon Etching in the $HNO_3$-Rich Phase.*

Fisher, J. S., *A Mathematical Model for the Porous Type Tantalum Anode Capacitor.*

Fuller, C. S., Kaiser, W., and Thurmond, C. D., *Reactions of Oxygen in Ge.*

Gresh, M., Karlik, S., and Schwartz, N., *Niobium Solid Electrolytic Capacitors.*

Gresh, M., see Berry, R. W.

Guldner, W. G., and Houtz, C. C., *The Measurement of the Specific Surface Area of Tantalum Powders and Sintered Anodes.*

Houtz, C. C. *Volume Resistivity of Ammonium Ethylene Glycoborate Electrolytes.*

Houtz, C. C., see Guldner, W. G.

Kaiser, W., see Fuller, C. S.

Karlik, S., see Gresh, M.

Kleimack, J. J., see Bittmann, C. A.

Klein, D. L., see D'Stefan, D. J.

Mackintosh, I. M., *The Diffusion of Phosphorus in Silicon.*

McGahan, T. E., and Spector, C. J., *Precision Lapping, Damage and Diffusion.*

Mehnert, R. A., see Cooper, H. W.

Milner, P. C., *The Interpretation of Measurements of Potential Decay on Open Circuit.*

Reutlinger, G. W., see Bittmann, C. A.

Schwartz, N., see Berry, R. W.

Schwartz, N, see Gresh, M.

Spector, C. J., see McGahan, T. E.

Thurmond, C. D., see Fuller, C. S.

Trumbore, F. A., *Effect of p-Type Germanium Arsenide Occlusions on the Resistivity of Heavily Doped n-Type Germanium.*

Turner, D. R., *On the Mechanism of Chemically Etching Germanium and Silicon.*

Urban, M. J., see Berry, R. W.

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Geller, S., *Crystal Chemistry of and Magnetic Interactions in the Garnets*, Point Gp. Seminar, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. C.

Gerard, H. B., *Fear and Social Comparison*, N. Y. State Psychological Association, N. Y. C.

Germer, L. H., *Studies of Adsorption by Means of Low Energy Electron Diffraction*, Brown University, Providence, R. I.

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Pollak, H. O., *Content and Philosophy of the SMSG Elementary Algebra Curriculum*, Hotel Statler, Buffalo, N. Y.

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Yocom, W. H., see Cook, J. S.

Younker, E. L.—*High Speed Switching Circuits Employing Slow Acting Components*—2,-936,117.

## THE AUTHORS

*H. W. Augustadt* received the B.S.E.E. degree from the University of North Dakota in 1928 and the M.S. degree in Physics from Columbia University in 1941. He joined Bell Laboratories in July, 1928. During his first four years with the Laboratories Mr. Augustadt engaged in network development and design. From 1932 until 1940 he engaged in the development of a variety of sound reproduction systems including sound picture apparatus, public address, speech input and Navy battle announcement systems for battleships, cruisers and aircraft carriers. During World War II he worked on Navy fire control systems and designed the automatic radar ranging and angle tracking systems used in the Mark 12 and Mark 25 radars. In 1955 he was assigned responsibility for the Mark 65 program for the Navy, the subject of his article in this issue of the RECORD. Subsequently he supervised the development of the Navy's current series of guided-missile, weapon-direction equipments for cruisers and frigates.

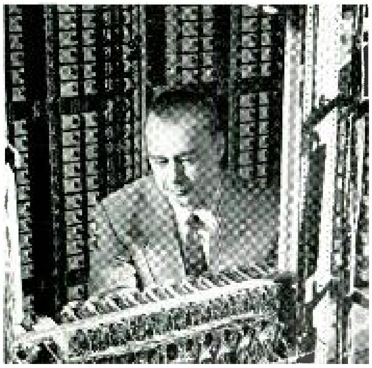
H. W. Augustadt

*Rexford S. Tucker* was born in Jamestown, N. Y., and received an A.B. degree from Harvard College in 1918 and an S.B. from Harvard Engineering School in 1922. He joined the Development and Research Department of the A.T.&T. Company in 1923 and transferred with that group to the Laboratories in 1934. His early work was on noise and cross-talk prevention. During World War II he was engaged in various military projects and was co-editor of the Signal Corps Technical Manual on Electrical Communications Systems Engineering. After the war he worked on mobile-radio systems engineering and is presently engaged in similar work on transoceanic cables. Mr. Tucker is a member of I.R.E., the Acoustical Society of America, A.I.E.E., the Harvard Engineering Society, and Phi Beta Kappa. He is the author of "Sixteen-Channel Banks for Submarine Cables," in this issue.

R. S. Tucker

L. G. Schimpf

*L. G. Schimpf* ("Transistorized Carrier System for TV") was born in New Washington, Ohio, and received a B.E.E. degree from Ohio State University in 1937. He joined the research department of the Bell Laboratories the same year and began work on the application of electronic devices to switching functions. With the outbreak of World War II, he turned his attention to research and development work on military projects. After the war, he specialized in transmission research studies of local subscriber station circuits. Since 1952, he has been engaged in transistor circuit research. His chief interest in this area has been the application of transistors to wideband and high-frequency transmission circuits. Mr. Schimpf, who holds several patents in the field of electronic switching, is a member of the Institute of Radio Engineers, the Acoustical Society of America, Eta Kappa Nu, and Tau Beta Pi.



F. M. Pearsall, Jr.

*F. M. Pearsall, Jr.*, a native of Brooklyn, joined the Laboratories in 1929. He conducted fundamental pulsing studies for step-by-step and worked on the No. 4 crossbar system. During World War II, he designed test circuits for electrical gun directors and operational flight trainers for the Navy. Subsequently, he tested the performance and outlined requirements for the trouble recorder and card translator. After working on the Nike project, Mr. Pearsall did some preliminary investigation of the flying-spot store for the semi-permanent memory for ECO and designed the translator-shift register circuit for the magnetic-drum sender. Most recently, he has been concerned with the development of CAMA trunks and the design of the emergency reporting system. He received a B.E.E. degree from Brooklyn Polytechnic Institute in 1943 and is a member of Eta Kappa Nu, A.I.E.E., and the New York State Society of Professional Engineers. He is the author of "The Direct-Line Emergency Reporting System."

*R. H. Small* was raised in Michigan and received his B.S. degree at Michigan State College (now Michigan State University). He joined the technical staff of Bell Laboratories in 1953. Upon completion of the Communications Development Training program, he attended Newark College of Engineering, receiving his M.S. degree in Electrical Engineering in 1958. In 1957, Mr. Small became a member of the Power Development Department, where he was engaged in the development of unregulated and regulated rectifiers. He resigned from the Laboratories in August, 1959. Mr. Small wrote, "Power Supply for TJ Repeaters."

R. H. Small

*Edward Jacobitti*, author of the article on 4A CAMA routing arrangements, is a native of Newark, N. J. He joined the Engineering Department of the Western Electric Co. in 1919, serving that organization and its successor, Bell Laboratories, ever since. In his early years, Mr. Jacobitti designed local panel and local No. 1 crossbar systems. During the second World War, he did the fundamental and practical design for relay digital computers and other military projects. Following the war, he designed decoders, markers, and translators used in the nationwide dialing toll-switching system project. More recently he has been concerned with the design of the SC2 Supervisory Control system for private-service use and with the application of centralized automatic message accounting (CAMA) to the 4A and 4M toll systems.

E. Jacobitti