9 JAN '61

NAVY ELECTRONICS LIBRARY LABORATORY

December 1960

Bell Laboratories RECORD

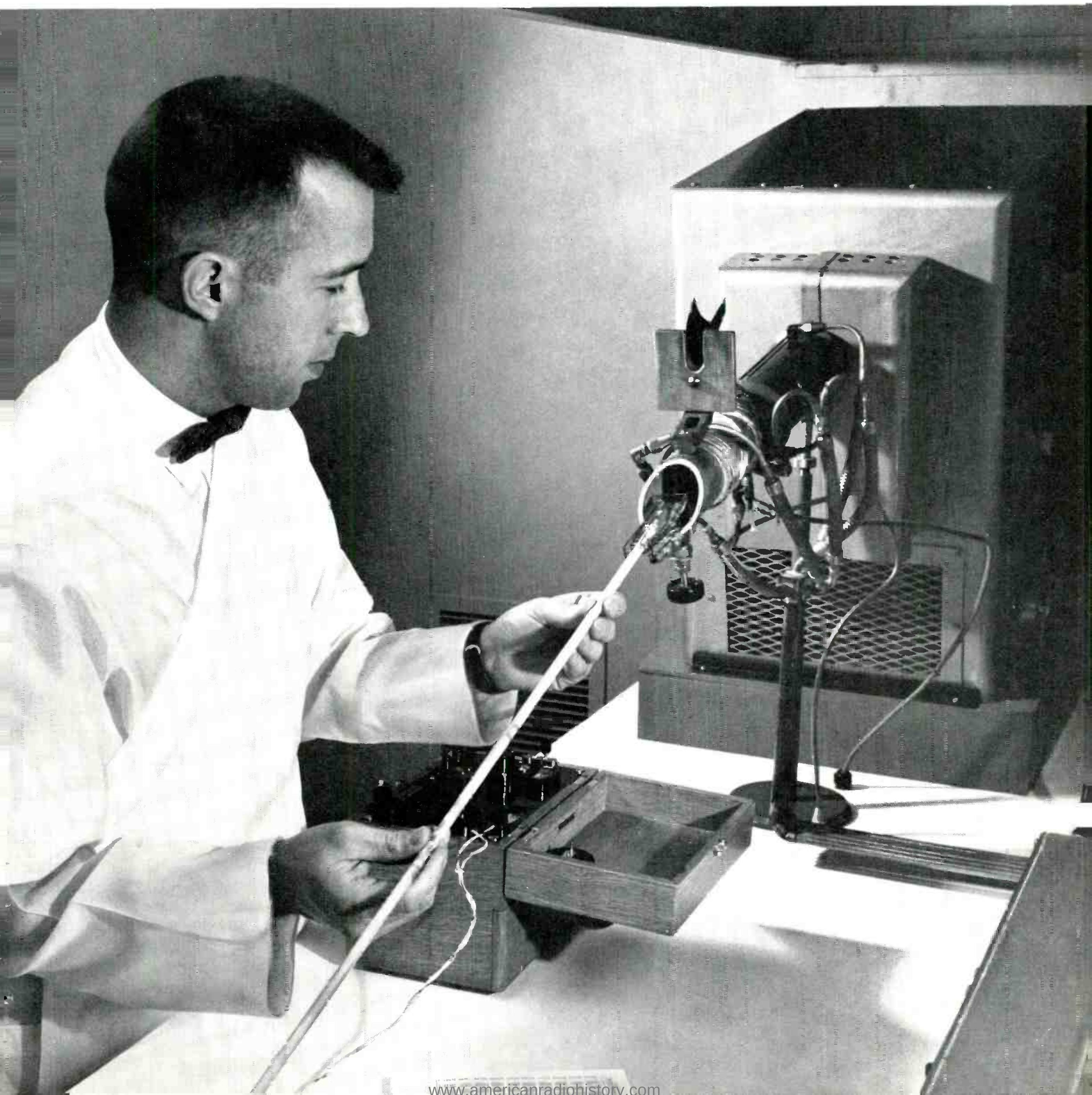
ECO Trial Begins

A New Group-Alerting System

Research on Oxide-Coated Cathodes

Magnetic-Latching Crossbar Switches

Components for Canaveral Repeaters



www.americanradiohistory.com

Editorial Board

F. J. Singer, *Chairman*
W. M. Bacon
J. A. Burton
J. W. Fitzwilliam
E. T. Mottram
R. J. Nossaman
W. E. Reichle

Editorial Staff

W. W. Mines, *Editor*
A. G. Tressler, *Assistant Editor, Murray Hill*
J. N. Kessler, *Assistant Editor*
M. W. Nabut, *Assistant Editor*
R. F. Dear, *Production Editor*
T. N. Pope, *Circulation Manager*

THE BELL LABORATORIES RECORD is published monthly by Bell Telephone Laboratories, Incorporated, 463 West Street, New York 14, N. Y., J. B. FISK, President; K. PRINCE, Secretary; and T. J. MONTIGEL, Treasurer. Subscription: $2.00 per year; Foreign, $2.60 per year. Checks should be made payable to Bell Laboratories Record and addressed to the Circulation Manager. Printed in U. S. A. © Bell Telephone Laboratories, Incorporated, 1960.

www.americanradiohistory.com

Bell Laboratories **RECORD**

Volume 38 • Number 12 • December 1960

Contents

PAGE

443 ECO Trial Begins

446 A New Group-Alerting System *J. Orost and W. H. Seckler*

451 Research on Oxide-Coated Cathodes *H. E. Kern*

457 Magnetic-Latching Crossbar Switches *F. A. Zupa*

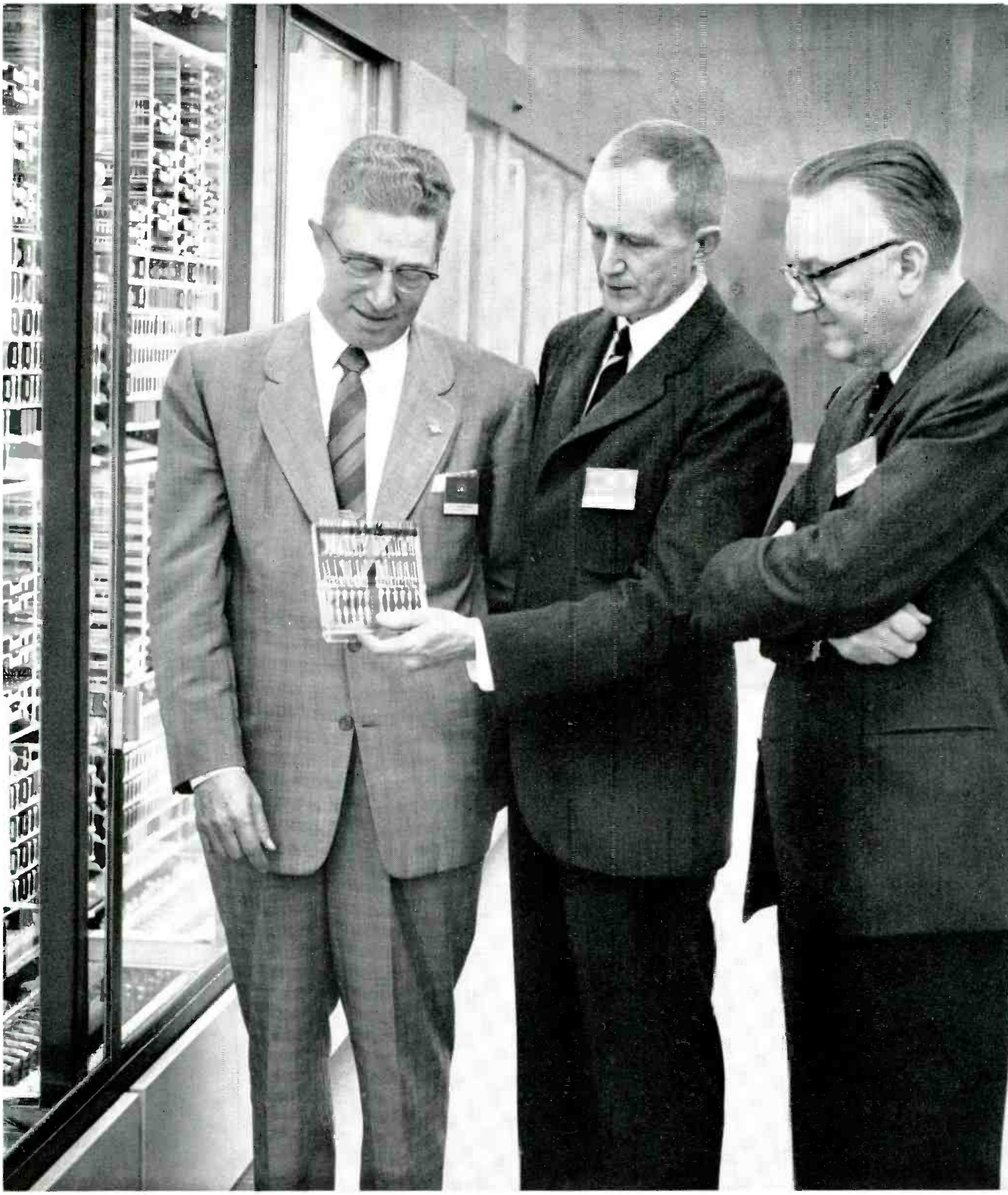
463 Canaveral Test Range: Filters and Equalizers for Unattended Repeaters *F. R. Bies*

467 The "B" Canvas Tray

468 Nike Zeus Test Center at Kwajalein

Cover *E. T. Graney inserts tiny parts for electron tubes in furnace with precisely controlled atmosphere and temperature. These tubes, used for fundamental studies of cathode characteristics, are fabricated under super-clean conditions.* *(See page 451.)*

www.americanradiohistory.com



From the left, William V. Kahler, President of Illinois Bell, James B. Fisk, President of Bell Laboratories, and Eugene J. McNeely, Executive Vice President of A.T.&T., shown in the Morris office, examine one of the small gas-tube units that make up the switching network of ECO.

www.americanradiohistory.com

". . . we asked the question, looking years ahead, can we take advantage of the high speed inherent in electronic, computer-like technology and all the rest we have learned over the years and produce a switching system which is more economical, more reliable and easier to maintain, which uses less space, which is more flexible and adaptable to customer needs, which, in short, will open new dimensions in communications service?" — J. B. Fisk

ECO Trial Begins

A customer trial of the world's first electronic telephone central office was started in Morris, Illinois, last month by Bell Laboratories and Illinois Bell. Developed by the Laboratories, it is the first system that performs electronically all the functions in the handling of telephone calls. It was described by Laboratories President James B. Fisk as ". . . a totally new system making possible a variety of new services which will double the flexibility and hence the potential value of each customer's telephone."

The electronic central office (ECO) is a product of one of the most massive research and development projects ever sponsored by a commercial enterprise. It represents hundreds of man-years of effort on the part of Bell Laboratories engineers and scientists. It also represents a major Bell System effort, with A. T. & T. and Western Electric playing big roles.

For years, communication scientists have thought it possible to use electronic switching as a way to provide better, more economical telephone service. Research was started at Bell Laboratories in the late 1930's to outline the eventual needs and possibilities of an electronic switching system. Much of the theory was developed during this period, but the components needed to make such a system economically feasible were lacking.

By 1954, the development of components like small gas tubes, electronic memories, and highly reliable transistors made an electronic central office appear feasible. Intensive work on the project was started at this time by the Switching Systems Development Department.

On November 17, fifty customers of the Illinois Company—the first of 300 who will take part in the customer trial—were officially cut over to ECO service. To mark the occasion, 200 guests—business, educational and civic leaders and members of the press—gathered in Morris for a special ceremony and to hear an address by Dr. J. B. Fisk and an explanation and demonstration of the system by R. W. Ketchledge, Director of Switching Systems Development IV. Illinois Bell President William V. Kahler was host, and Eugene J. McNeely, Executive Vice President of the A. T. & T. Company and Rosel H. Hyde, Federal Communications Commissioner, also took part in the ceremony.

The ECO brings to the trial customers at Morris a whole new range of customer services. Through the use of a switching network made up of tiny gas tubes, unique new memory systems and a control system made up of thousands of

www.americanradiohistory.com

transistors and other solid-state devices, which operate in millionths of a second, ECO will permit its trial users to:

- Use home extension telephones as intercoms, simply by dialing two digits.
- Reach frequently called numbers by dialing only two digits instead of seven.
- Have incoming calls routed to another phone when the original called line is busy.
- Dial a code which causes all subsequent incoming calls to be automatically transferred to any other local number. (For example, to a friend's home during an evening visit, or to an answering service.)

These are some of the things ECO can do. Other new services expected to be introduced after the trial is underway will permit customers to:

- Call a third person into an existing telephone conversation ("conferencing").
- Have an immediate connection to a busy line as soon as it becomes available ("camp on").

A great many things will be learned from the Morris trial. It will of course tell how the ECO performs. In addition, it will give an insight into which of the new service features telephone users prefer. Bell Laboratories engineers are already at work investigating ways to provide some of these features through present switching systems, should they prove popular.

The trial also presents an opportunity to study the kinds of activity and the number of people needed to operate and maintain the new exchange. During the trial, the Morris ECO will be operated jointly by Illinois Bell and Bell Laboratories.

In appearance, the ECO has little in common with present telephone switching systems. The long, high racks of equipment and the noisy chatter of relays are gone. Instead, there are several rows of neat gray cabinets filled with thousands of plug-in packages of electronic components (RECORD, *May*, 1960). The switching network—23,000 tiny, neon-filled tubes (RECORD, *December*, 1958)—goes about its work quietly, with only a bright glow to show which tubes are operating.

Another important difference is that ECO uses stored-program control to perform its job—that is, each action of the machine is determined by instructions stored in its memory. The difference between ECO's stored-program control and present systems can be simply illustrated by the two different approaches to a square-root problem. One way is by a series of logical steps—pointing off two places, finding a trial divisor, and the rest of it. The other way is by looking up the answer in a book of square-root tables.

Existing electromechanical exchanges, even those with "common control"—use the first method to work out the detailed logic of each telephone call. The ECO, on the other hand, solves many of its problems by "looking up the answer in the book." In this case, the "book" is information stored on photographic plates in the machine's memory. This program of instructions tells it what to do in any situation.

Because ECO is extremely flexible, it is capable of offering many new and different services. Each switching function is accomplished by dozens of high-speed, elementary actions taking place a thousand times more quickly than they do in present electromechanical systems. These simple steps are programmed into complex operations.

How ECO Completes a Call

Briefly, here's how the Morris ECO works in completing a call: A scanner (RECORD, *May*, 1959) checks the condition of every line ten times a second. When a customer picks up his telephone to make a call, the scanner detects the action and reports it to the "brain" of the system—central control (RECORD, *February*, 1960). A temporary, or "scratch-pad" memory—the barrier-grid store (RECORD, *December*, 1959) shows that this is a new call, because its record shows that a tenth of a second ago the telephone was on-hook. The temporary memory also reports that it has no record of anyone trying to reach this line, so central control decides that the customer wants to dial.

The ECO sends dial tone to the customer, letting him know that the system is ready to handle his call. At the same time, space is reserved in the barrier-grid store for the digits to be dialed. The scanner now starts looking at this customer's line 100 times a second so it won't miss any of the 20-per-second dial pulses. Since each operation of the ECO takes only a few millionths of a second, the system goes ahead and does millions of other jobs while the customer is dialing.

Suppose this customer has "abbreviated dialing," which allows him to reach several of his frequently called numbers by dialing just two digits instead of seven. When he requested this service, the directory number for each telephone he wanted to have represented by a two-digit code was listed in the flying-spot store—ECO's semipermanent memory (RECORD, *October*, 1959).

When this customer dials two digits, the ECO first checks to see if he has abbreviated-dialing service. It finds that he does, and recognizes, for example, the dialed code as shorthand for his brother's telephone number. The central control then commands the memory to report the com-

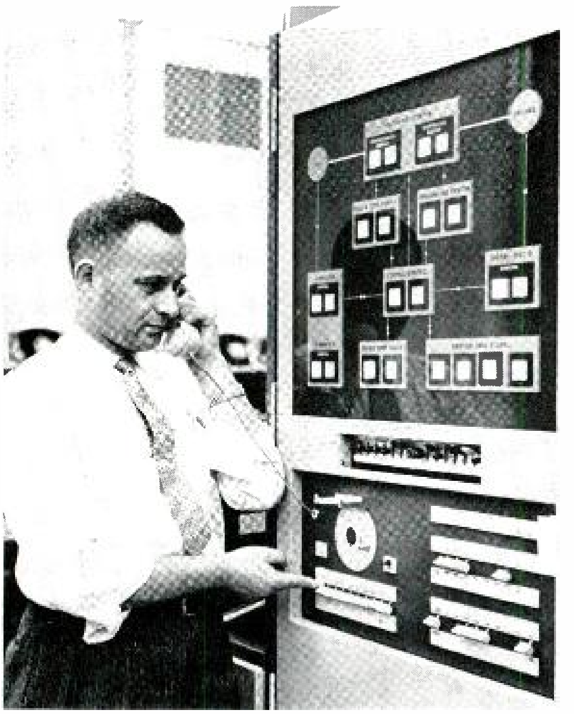
www.americanradiohistory.com

plete directory number. It also sends a command to the switching network to set up a ringing circuit to the brother's telephone and sends the calling customer ringing tone.

Someone at the brother's home picks up the phone. The scanner detects this within a tenth of a second. Common control orders the switching network to connect a talking circuit and drop the ringing circuit. This is all done before the person answering gets the phone to his ear.

A complex automatic telephone switching system, such as ECO, simulates the human brain in the twin functions of "logic"—solving problems—and "memory"—the storage of information. Early switching systems had "distributed" memory and logic—in the progressive-control systems like step-by-step and panel. The No. 1 and No. 5 crossbar systems provided memory and logic more efficiently. Separate relay units were provided expressly for temporary memory functions, such as recording numbers as they are dialed, and other relays are used solely for logic operations. This was called "common control."

ECO does not simply substitute electronic devices for relays; it solves call-handling problems in a completely new way. The solutions to these problems—in the form of specific instructions—are stored in the photographic memory. These "answers" are found a thousand times faster



Administration center of ECO in Morris, Ill. Dan Danielsen of Laboratories speaks on test phone.

than with older systems, and can be easily changed to meet the varying needs of a specific situation.

In the search for a memory system having megabit capacity and almost instantaneous access, Laboratories engineers seized the idea of storing information on photographic plates in a "flying-spot store." Here a cathode-ray tube produces a small spot of light which can be positioned to read out stored information from the plate. For each position of the spot of light, 67 different items of information can be read out. All the $2\frac{1}{4}$ million bits can be read in one-ninth of a second.

The temporary memory in ECO—the barrier grid tube—is a special type of electron tube. It is somewhat like a TV picture tube, except that the target is not a phosphor screen but a piece of mica. A beam of electrons is shot at the mica target, and where the beam strikes, an electrical charge is placed. A charge (or lack of charge) in any particular place on the mica represents an item of information. The item can be read quickly and then erased, leaving the space ready for new information.

With this complex electronic "brain", central control directs the closing of switches to connect one telephone with another. Switches in the Morris ECO are neon gas tubes. When a connection is made the tubes "fire," showing an orange light. Light from blue fluorescent lamps shining on the tubes insures quick firing. These neon tubes are carefully temperature-controlled for reliable operation.

ECO's speed of operation also has another important benefit. Because it performs its various tasks in microseconds, it has enough "spare" time to check its own circuits continually. When it discovers a fault, it locates and diagnoses the trouble and, in some cases, even makes the necessary corrections. If the fault can't be corrected by the machine, it writes out in detail, on a teletypewriter, what the trouble is, adding the month, day, hour and minute of the malfunction. Then the repairs are made by the ECO staff.

Morris represents the first step toward a whole new telephone future. Although the first step has just been taken, engineers at the Laboratories are already working on the next step—a production model suitable for volume manufacture by the Western Electric Co. Many components in the production model will differ from those used at Morris, but the over-all operating principles of the two systems will be similar. The first production model is scheduled for operation by mid-1965 and from that time on ECO will be gradually introduced into the Bell System to meet the needs of telephone growth and progress.

www.americanradiohistory.com

In case of fire, seconds may mean the difference between life and death. Thus, the communication link between a firehouse and its volunteer firefighters is vitally important. Now a new Bell System telephone service provides a fast and reliable way to alert a fire company.

J. Orost and W. H. Seckler

A New Group-Alerting System

For many years, fire departments serving suburban and farm communities have alerted their firemen with outdoor sirens or horns. Such communities generally rely on volunteer firefighters who are usually at nearby places of business or at home when a fire breaks out. When they hear an alarm, they go either to the firehouse where they are directed to the fire, or they go directly to the area as instructed by coded horn signals.

If a fireman must first go to the firehouse, valuable time is lost. A fire may break out only one block away, but unaware of its location, the fireman may cross town just to be told that the fire is in his own neighborhood. Fire gathers momentum rapidly. A child may be trapped by a wall of flame because a volunteer fireman is caught in downtown traffic.

Often, firemen are impeded by people who have become familiar with the horn signals. Furthermore, in recent years, communities have grown to a point where the siren alarms of neighboring towns sometimes overlap, and it becomes hard to distinguish one from another. Also, better insulated homes make it increasingly difficult to hear and identify such signals indoors. For these and lesser reasons, it became apparent that fire departments needed an improved method of alerting their volunteer firemen.

Recognizing that the telephone could provide an efficient method of alerting firemen, a number of fire-department officials inquired about such arrangements. As a result of these inquiries, the Laboratories were requested by the A.T.&T. Company to make studies to determine the most satisfactory way of providing an alerting service which could be associated with all types of central offices. Carried out with the cooperation of A.T.&T. and the telephone companies, these studies resulted in the development of the central-office group-alerting system.

This alerting arrangement is superimposed on the regular local telephone system serving the community in which the firemen reside. It uses the fireman's regular line and telephone set to inform him of an emergency. Special central-office equipment connects the fireman's line with the alerting system. A dispatcher at a central location controls the operation of this equipment over a special line to the central office. The dispatcher may be stationed at any point such as fire headquarters, or police headquarters. From there, through a special telephone, the dispatcher an-

www.americanradiohistory.com

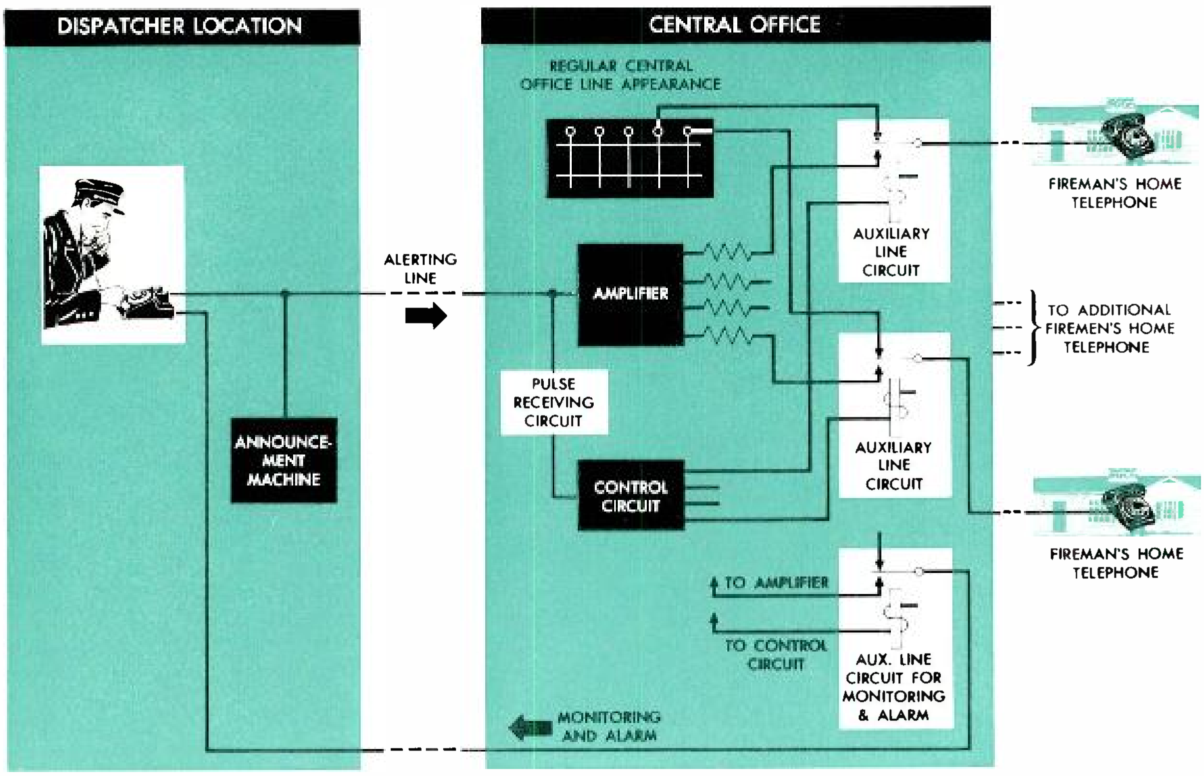
nounces the location and nature of a fire, or any emergency, and his message is automatically repeated over the line to one or several specified groups.

In addition to alerting volunteer firemen, the system can be used to alert other groups such as civilian-defense personnel. Also, large industrial concerns can add this system to their PBX installations for "in plant" alerting. Economies in cost, maintenance, and operation have been effected by using standard equipment and by minimizing the amount of equipment in the central office for each fireman's line.

The system's operation is simple and reliable. At the control location, the dispatcher dials a digit on his special telephone. This indicates to the central-office equipment that the dispatcher is to be connected to the telephones of certain volunteer firemen. The firemen's telephones ring in a distinctive manner, and as the dispatcher announces the alert, the message is simultaneously recorded on a small announcing machine connected to the system. The dispatcher then presses a button on his telephone set that causes the recorded message to be repeated over the line until the end of the alert.

A fire alert does not interrupt a busy line, but such lines are "camped on" by the central-office circuitry for the duration of the alert. This makes certain that the next call on the busy line will be the fire alert. As soon as a fireman is alerted and he hangs up his telephone, his line is immediately re-connected to regular telephone apparatus for conventional calls. When the alert is over, all unanswered lines are restored to normal, the central office timer is re-set, and the system is ready for the next alert.

Reliability, the most important requirement of a fire-alerting system, is insured through design features such as (1) continuous test on the control line from the dispatcher to the central office, (2) dependence on only the central-office 48-volt battery for basic operation, and (3) duplication of equipment at critical points in the control circuit. In the event of trouble on critical circuits, a system of alarms immediately notifies both the dispatcher and the central office. Besides these safeguards, the dispatcher can check on the over-all operation of the system by monitoring the output from the central office to the firemen at any time during an alert. As an added safeguard, there are provisions for including an alternate line between the dispatcher's location and the central office. To prevent possible confusion dur-



Alerts go out from the dispatcher's location through the central office to the firemen. The duplication of equipment at critical points and other safety features assure system reliability.

www.americanradiohistory.com

A fire dispatcher demonstrates the procedures for alerting a group of volunteer firefighters.

ing an alert, the system is arranged so that the firemen cannot talk to the dispatcher or to each other over the network.

The central-office group alerting system is highly flexible in application and can be tailored to the needs of a wide range of communities served by almost any kind of central office. For example, a very few or as many as 480 lines can be included in the system. As a community grows, firemen's lines can be readily added or changed. Those communities desiring to alert their firemen from more than one central location can have as many as three dispatching points—all connected to the same central-office control equipment.

For full coverage to areas served by more than one central office, the system can be extended from the central office associated with the dispatcher's position to one or more distant central offices. If large fire departments wish to alert specific groups of firemen, on either a geographical or functional basis, this too can be done. There are arrangements which permit the dispatcher to selectively alert as many as eight groups by dialing a separate digit for each group.

The design of the system provides not only for operation on single-party lines, but also on two and four-party full-selective and eight-party semiselective lines. For efficient operation, however, there should be no more than one fireman on any multiparty line associated with the group-alerting system.

A key reason for the system's economy is that all control of the individual fireman's line and telephone is exercised from the dispatcher and central-office locations. No special lines, equipment, telephone sets, or ringing devices are needed in the firemen's homes. In fact, it is not even necessary for a telephone company representative to visit a fireman's home when arranging his line for operation with the group-alerting system. All connections are made at the central office.

To illustrate the operation of this new system. let's trace the steps involved in sending an alert and discuss some of the features brought into play during such an emergency. It should be pointed out first that the only equipment the dispatcher uses is a dial telephone set with illuminated buttons for controlling the automatic announcement equipment.

As soon as the dispatcher receives information describing the extent and location of a fire, he picks up the handset of the special telephone on his desk, checks to see that the DIAL button lights, and dials the digit associated with the group of firemen he wishes to alert. The CHECK button then flashes, indicating that ringing current is connected to the firemen's lines. Pressing down the RECORD button on his telephone set, he prepares to record the alert. When the RECORD button lights, the announcement machine is ready to record and he announces the alert.

This initial message is recorded at the same

www.americanradiohistory.com

time as it goes out on the line "live." Then, the dispatcher releases the RECORD button and presses the automatic announce (AUTO ANN) button to put the recorded message on the line. If he wants to monitor his announcement, he simply presses the CHECK button. His original message can be modified at any time by going through the recording procedure again. This automatically erases the original message.

At the other end of the line, the firemen's telephones ring in a distinctive manner—½ second on 1½ seconds off—to indicate an alert, instead of the usual 2-seconds on and 4-seconds off. When a fireman picks up his phone, he is given all the information concerning the nature and whereabouts of the fire. When he hangs up, his line is immediately re-connected to the regular central-office equipment for normal operation.

System Reliability

To terminate the alert, the dispatcher presses the DIAL button and dials ZERO. This restores all unanswered lines to the regular central-office equipment and resets the system for the next alert. There is also an automatic timer at the central office that terminates alerts after 4 or 8 minutes, depending on how it is set.

Sometimes a fire department is divided into a number of separate hook-and-ladder or hose companies. If, after sending the first alert, an additional group is needed to aid in putting out the fire, the dispatcher presses the DIAL button and dials the digits corresponding to that particular fire company. He must then press his AUTO ANN button again to put the recorded announcement back on the line. The central-office time-out circuit is reset to start anew after each digit is dialed. This give each added group the advantage of a full 4 or 8 minutes of recorded announcement, depending on how the central-office timer is set.

These procedures illustrate the operation of the group-alerting system under normal conditions. Now let's consider operation under an emergency condition following an alert.

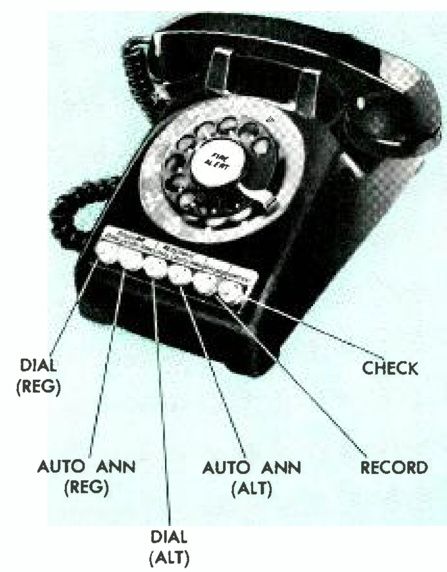
If the dispatcher's line to the central office fails, for example, a major alarm is sounded at the central office, and the CHECK button flashes on the dispatcher's set. In addition, a steady high tone transmitted over the monitor line is heard when the dispatcher picks up the handset and presses the CHECK button. If the dispatcher dials the alerting digit and the digit-memory circuit in the central-office fails to operate, this failure is also immediately indicated to central-office personnel and the dispatcher by various alarms. If such trouble occurs during an alert, and the system has an alternate line to the central office, the dispatcher presses the alternate (ALT) key to switch to that line, and he then proceeds in the normal manner.

If there is a commercial power failure at the dispatching point, the DIAL button does not light when the handset is picked up. In this situation, the dispatcher dials the alerting code in the usual way but he must repeat the message continuously because the announcing set will not record without ac power. Thus, for basic operation, the group-alerting system is independent of commercial power.

The announcement-checking feature discussed earlier may also be used to check the functioning of the system at any time. By dialing a specially assigned digit—2—an alert is sent out only over the auxiliary monitor-line circuit and causes the CHECK button on the dispatcher's telephone to flash. The dispatcher then records a message, puts it on the line, and checks it by listening at the receiver in the same manner as on a regular alert.

If an installation of the group-alerting system has two or possibly three dispatching locations, a preference circuit in the central-office control unit recognizes an alert code from the first operating location and provides a busy tone to the other locations. After the alert, the other locations immediately have access to the system.

The announcement machine used with the group-alerting system has a maximum message



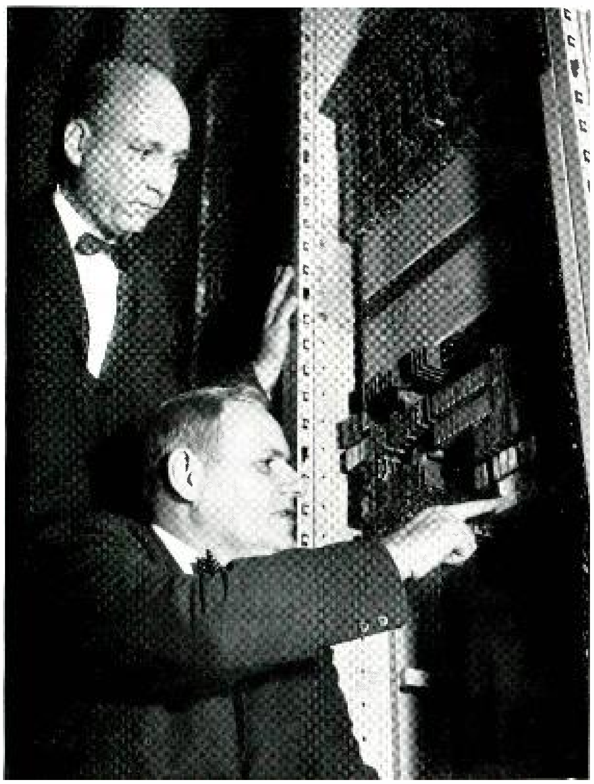
By dialing a digit on this special telephone, a fire dispatcher can alert one or several groups of volunteer firefighters. A recorder built into this new system repeats the alert over the line.

www.americanradiohistory.com

duration of 120 seconds per message. Most alerting messages, however, are brief—usually no more than 10 seconds. The design of the machine permits it to be automatically recycled over only that portion of the recording drum used for a particular message. Thus, the only time during an alert when an announcement is not on the line is the few seconds it takes for the announcement machine to recycle.

In this discussion, we have assumed that the community was of such size that the dispatcher had an announcement machine as well as the equipment for alerting a number of different groups. In the case of smaller communities that wish to keep costs to a minimum, there is a standard arrangement available for alerting only a single group of firemen without an announcement machine.

Since December, 1958, when the first group-alerting system went into service for the fire department in Garden City, Long Island, many telephone companies have acquainted municipal groups in their areas with this new system. Today, there are many group-alerting systems in operation, and all report highly satisfactory performance. Because it is fast, reliable, and economical, a sizable future demand is anticipated.



Authors J. Orost, left, and W. H. Seckler inspect register relays at Freeport, N. Y., central office.

Bell System to Build and Launch Active Satellite

News of Space Research

Bell Laboratories will develop and build an active communications satellite that is slated to be placed in orbit within a year. This new satellite, four feet in diameter and weighing 150 pounds, will contain electronic devices to receive, amplify, and send signals back to earth. A system of such satellites will make possible the experimental transmission of telephone calls, television, and data between the United States and Europe.

In an application to the Federal Communications Commission for experimental frequency allocations, the Long Lines Department of A.T.&T. Co. said that the Company is prepared to contract for the launching of the necessary satellite and to proceed with the construction of transmitting and receiving stations on the ground.

Plans call for a system that would make use of satellites with solar-powered repeaters orbiting at an altitude of 2000 to 5000 miles. Because the satellite will be mutually visible to the ground stations for a limited time, the initial experimental system will transmit up to about 35 minutes some three or four times a day. The first U.S. ground station will be at the Laboratories Holmdel, New Jersey, installation, where current Bell System space communications work is going on.

The new project is a further step in the Bell System's research program for fundamental space communications. An earlier phase of this program was Bell System work on the National Aeronautics and Space Administration's Project Echo, which employs a passive, or reflecting, satellite. Data from this experiment has substantiated predictions that broadband communications between continents is now practicable by using satellite relay stations in space.

In addition to requesting experimental frequencies for the satellite experiment, the A.T.&T. Co. also asked the FCC for rule changes which would make feasible establishment of satellite communications on a commercial basis.

www.americanradiohistory.com

Broadband telephone repeaters deep in the ocean (or deep in space) depend on complex reactions at the cathode of an electron tube to produce the electrons vital to amplification. New research on these complicated reactions has shown that minute impurities in the nickel base of oxide coated cathodes contribute significantly to both tube life and efficiency.

H. E. Kern

Research on Oxide-Coated Cathodes

Ever since 1908, the year Lee de Forest invented the "audion," progress in long-distance communication has been tied to advances in electron-tube development. As transmission systems grow in range and information-handling capacity, the electron tubes that transmit, amplify and receive their signals must perform to increasingly higher standards. Outstanding examples of transmission media that require high performance from electron tubes are the various Bell System submarine cable systems. Here, dependable tube performance over a long life span is essential.

In an electron tube, the cathode element generates, or emits, the free electrons that make possible "electronic action." This element, made of selected nickel coated with alkaline-earth oxides, is a vital component in the electron tube because its ability to emit a sustained stream of electrons is directly related to the performance and life of the tube.

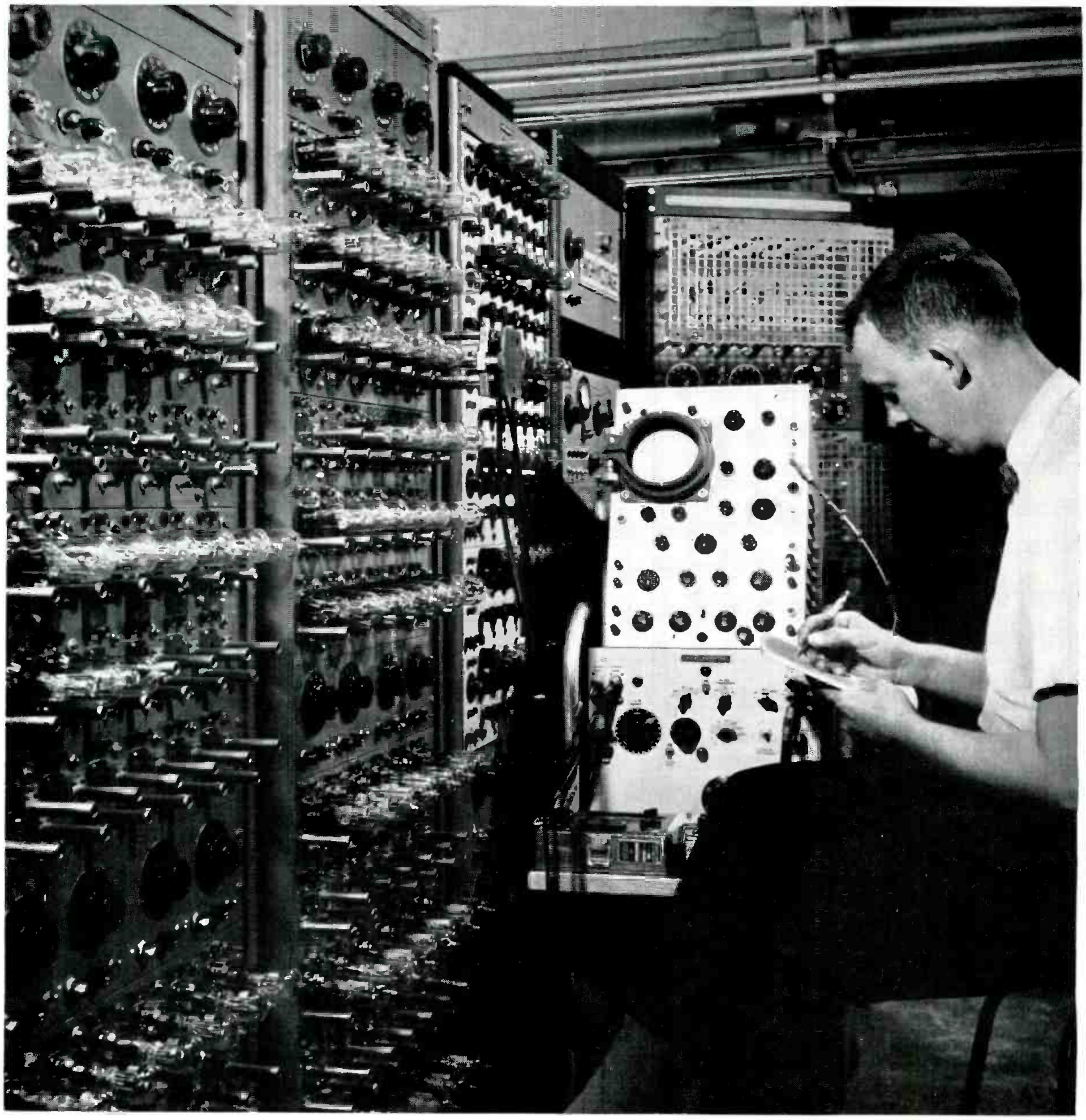
Thus, performance and life are directly related to understanding the fundamental physics and chemistry of how (both *how much* and *how long*) oxide-coated cathodes generate electrons in an operating tube. This article describes studies at Bell Laboratories directed toward achieving such an understanding.

During the past several years, these studies have been greatly stimulated and enhanced by the development of nickel alloys of extremely high-purity for use as cathodes. These nickels were developed at the Laboratories by K. M. Olsen of the Metallurgical Research Department (RECORD, *February*, 1960). Through rigid control of their high purity, these nickel alloys have helped scientists at the Laboratories to extend our knowledge of the important physical and chemical relationships that exist in the oxide-cathode system.

The oxide-cathode system consists of a nickel base coated with a mixture of barium-strontium oxide (BaSr)O, or barium-strontium-calcium oxide (BaSrCa)O, hereinafter designated simply BaO. To yield usable levels of emitted electrons, the oxide-coated cathode must be heated at temperatures from 650 to 800 degrees C.

Pure BaO itself is a poor emitter. However, the

www.americanradiohistory.com



The special diodes made to check various tube materials and characteristics are tested on these racks. Here, C. W. Caldwell, Jr. records data read from the oscilloscope and meter scales.

introduction of as little as 0.001 to 0.01 per cent (by weight) of "free" barium atoms in the relatively inactive BaO coating produces an active thermionic emitter. During emission, the BaO coating acts as an n-type, excess-impurity semiconductor, with Ba or Sr as the impurity donor. Theoretically, a cathode life of over 50 years would be possible if the level of Ba donor atoms in the BaO coating could be maintained. But some loss results from evaporation and chemical reaction with gases and ions in the tube. Even with a vacuum as high as 10^{-9} millimeters of mercury, attained in some tubes, there still remains about one hundred billion molecules of gas available for chemical reaction in the tube envelope.

The continuing replacement of these lost donors is essential to prevent decline of emission and subsequent failure of the tube. Fortunately, this replacement is achieved by the production of Ba atoms as a result of chemical reaction between the BaO coating and certain impurities in the base nickel. The effective impurities are referred

www.americanradiohistory.com

to as "reducing impurities," since they "reduce" the BaO molecules to Ba atoms.

Briefly, this is the way the coated cathode produces a continuing supply of Ba donors: The reducing impurity, (R) reacts with the BaO to form an impurity oxide, RO, and free Ba atoms. The impurity oxide is produced at the interface between the nickel base and the coating. Free Ba atoms formed by this reaction diffuse into the BaO coating to maintain the desired donor level. When the BaO coating becomes saturated with Ba atoms, the optimum donor level is theoretically reached. If more Ba atoms are produced than those required for saturation, they will evaporate from the coating. This vaporized Ba may cause "grid emission," or electrical leakage.

After the BaO is saturated with Ba, the ideal situation appears to be a rate of formation of Ba donors that would always remain infinitesimally greater than the rate of donor loss. In commercial vacuum tubes, however, the donor-production rate is usually adjusted to exceed greatly the donor-loss rate. This insures rapid "initial" activation, or start of emission. Unfortunately, this practice can seriously shorten tube life by rapidly depleting both reducing impurities and BaO. It also can produce grid emission and electrical leakage.

The oxide cathode, then, is part of a highly dynamic chemical system. And a quantitative knowledge of both the donor-production rate and the donor-loss rate *throughout life* is essential for the design of high-performance, long-life oxide cathodes. Of the two rates, donor loss is more difficult to study, because it can result from reaction with gases evolved from any piece-part in the tube. This gas evolution varies with materials, processing schedules, tube geometry, cathode-current density, and electrode potentials. In addition, foreign materials deposited on the anode during tube processing may be decomposed or ionized by electron bombardment and returned to the cathode to deactivate the coating.

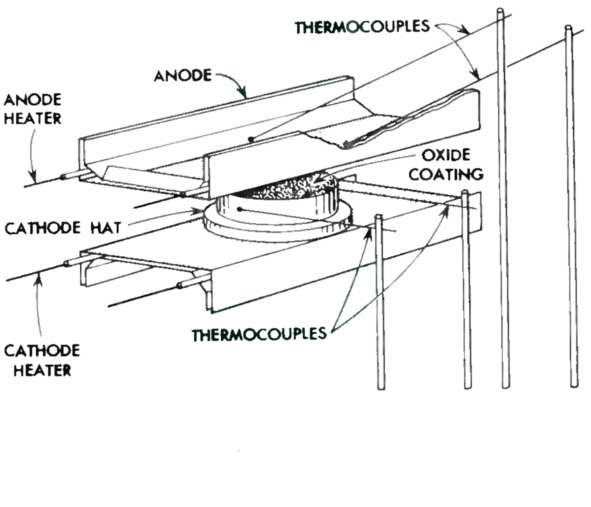


Diagram of the planar diode used in the cathode studies. Thermocouples control tube temperatures.

It is not unusual, therefore, for different tube types to present drastically different chemical environments to identical cathode systems. In microwave tubes, for example, the trend toward higher frequencies has magnified the donor-loss problem. Pin-point-sized cathodes are now associated with internal structures that have relatively large gas-emitting areas. The ratio of structural-surface area to cathode-coating area has in some cases actually increased to a million to one. Factors like this make obtaining quantitative information on donor-loss rates a very complicated matter.

Donor Production Studies

Studying the *donor-production rate* is somewhat simpler, because this rate is principally related to the physical and chemical properties of the nickel-alloy base. In contrast with the alloys used in the studies described here, commercial cathode-nickel alloys contain varying amounts of the reducing agents aluminum, carbon, magnesium, manganese, silicon, titanium, tungsten and zirconium, either as impurities or additives. Concentrations of these elements usually range from 0.01 to 0.2 per cent by weight, except for tungsten, which is added in concentrations of 2 to 4 per cent. Fundamental studies of donor-production rates cannot be conducted with nickel-cathode materials containing such a large number of reducing impurities.

For the cathode research described here, a variety of high-purity nickel alloys were prepared by the Metallurgical Research Department. Each alloy contains a desired concentration of a single reducing agent, and in some cases, two reducing elements. All other impurities were held below 50 parts-per-million (ppm) and in many cases below 10 ppm. With these alloys, it has been possible to obtain a more precise estimate of the Ba-donor production rate necessary for optimum emission, because the reaction that produces donors can be related to the presence of only a single, well defined reducing agent. In addition to their usefulness for fundamental studies, it appears that one or more of these controlled-additive alloys may have direct application in the development of future Bell System tubes.

www.americanradiohistory.com

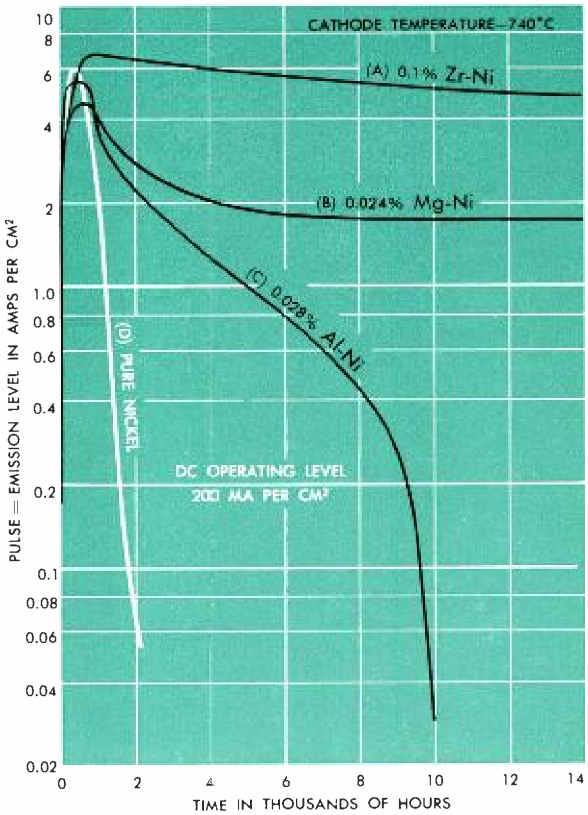
Let us consider now the factors that affect the Ba production rate in a BaO coating on a high-purity nickel alloy containing a single additive. Initially, the atoms of the reducing impurity (R) are distributed uniformly throughout the pure nickel. When the cathode is heated, the reducing-impurity atoms react with the BaO at the interface of the coating and the nickel to form the impurity oxide and free barium, as mentioned earlier. The removal of impurity atoms from the coated surface layer of the nickel creates a concentration gradient. At the elevated temperatures of the cathode, this gradient induces diffusion of impurity atoms toward the depleted surface layer. In this way, a new supply of reducing atoms is continuously arriving at the interface to react with the BaO coating. The production of Ba donors ceases when all reducing-impurity atoms have diffused to and reacted with the BaO coating.

In cathodes using heavy-gauge nickel (0.030-inch to over 0.050-inch thick), the total number of reducing-impurity atoms may readily exceed the total number of BaO coating molecules on the nickel cathode. If this condition exists, tube life will terminate when a sufficient number of the reducing atoms in the nickel have diffused to the coating to react with all of the BaO molecules. Termination of life in this way implies that the reaction product (RO) mentioned earlier will not form a complete blocking layer at the interface between the nickel and the BaO coating.

For many of the additives used in cathode alloys, the reaction that produces Ba will be limited by the rate at which reducing atoms diffuse through the nickel rather than by the intrinsic chemical-reaction rate between BaO and the reducing atoms. A knowledge of these diffusion rates is therefore essential for determining Ba-donor production rates. Diffusion studies on single-additive nickel alloys were therefore combined with thermionic-emission studies of the same alloys to determine fundamental relationships involved in Ba-donor production rates.

Emission Studies

For the first phase of research on these relationships—emission studies—a diode rather than a multi-element tube was used. The planar diode is shown on page 453. To minimize gaseous migration to the cathode from other parts, all metal structures except the heater, the getter, and several special thermocouples were made of ultrapure nickel. The thermocouples make it possible to control and reproduce temperatures to within 2 to 3 degrees C. This special diode made it possible to decrease donor losses from environmental reactions and to achieve a degree of reproducibility of results never before attained.



Curves showing emission and life characteristics of three significant cathode alloys and pure nickel.

For the emission studies, tests were conducted on 0.050-inch-thick nickel cathodes at a temperature of 740 degrees C. The test current density for space-charge limited emission was 200 ma/cm^2, dc. Temperature-limited emission was measured by microsecond-pulse techniques without interrupting the dc emission. In this technique, the pulse current, expressed in amperes/cm^2, is a measure of the total thermionic emission that can be obtained.

Many alloys were tested in these studies. Some of the cathodes that exhibited outstanding total-emission characteristics are plotted on the graph above. All of these cathode materials activate initially at about the same rate, and all attain their peak emission levels in 500 to 700 hours. However, the total emission for the pure-nickel cathodes (curve D) falls rapidly to well below the desired dc operating current, and these tubes fail. They fail because the concentration of reducing impurities in the nickel is too low to maintain an adequate donor-production rate in opposition to donor losses to the environment.

www.americanradiohistory.com

For the alloys containing higher concentrations of reducing additives, both the 0.1 per cent Zr-Ni (curve A) and the 0.024 per cent Mg-Ni (curve B) cathodes exhibit sustained emission levels well above the dc operating current, although initially the Zr-Ni seems better able to resist environmental poisoning than the Mg-Ni, as indicated by the drop in emission at 700 hours. At 14,000 hours, both of these nickel alloys show promise of continued useful life.

The 0.028 per cent Al-Ni alloy (curve C), although activating to about the same peak values as the other alloys, cannot sustain its emission. This decline in emission is associated with the development of a high resistance at the interface between the oxide coating and the nickel base, which is related to gradual loss of adherence (peeling) of the BaO coating to the base nickel. Neither the Zr-Ni nor the Mg-Ni alloys has shown any indication of developing interface impedance or coating peeling.

Of the alloys tested so far, Zr-Ni shows the highest sustained total emission, under the test diode operating conditions. This favorable property, in combination with other superior characteristics, such as freedom from interface impedance, low sublimation rate, and high tensile strength, indicates that 0.1 per cent Zr-Ni is extremely attractive for oxide-cathode bases.

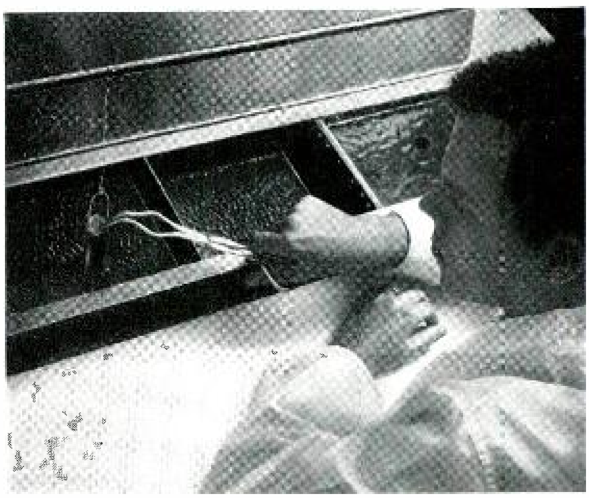
As pointed out in the earlier discussion of tube life, producing Ba donor atoms by reduction of the BaO coating involves a continuous depletion of both the BaO and the additive in the nickel base. To prevent too rapid a depletion of these reactants, and to avoid electrical leakage through vaporized excess Ba atoms, the donor atoms of Ba should be formed at the minimum rate necessary to sustain thermionic emission. Donor-production rates depend on the diffusion constant and the concentration of the additive used in the nickel and the thickness of the cathode.

Diffusion constants for the various reducing additives in high-purity nickel, obtained by H. W. Allison of the Semiconductor Research Department, are shown in the table at the top of page 456. The table also shows the times required to deplete 50 per cent of the original reducing additive concentration for 0.050-inch thick nickel cathodes at 740 degrees C. These results show that carbon is the most rapid diffuser, followed by zirconium, magnesium and aluminum, in that order.

From these diffusion data, donor-production rates associated with each reducing additive were then calculated. The manner in which these rates change with time is shown in the series of curves on the next page.

Since the initial rates of production of Ba atoms for these alloys differ by almost two orders of magnitude, some differences might have been expected in the time required to reach the maximum emission levels. *(See page 454.)* However, no significant differences were observed in the diode test data. In fact, a pure nickel, containing only 0.001 per cent carbon, less than 0.001 per cent Mg, and less than 0.001 per cent Si as reducing impurities, activated just as rapidly, as other nickels containing single additives. This behavior is due to the presence of carbon, found as an impurity in all alloys, in quantities of from 0.001 to 0.002 per cent. Carbon, with its very high diffusion constant, even in concentrations of only 0.001 per cent, becomes the principal initial activator. As the curves on the following page show, carbon is capable of producing Ba donors during the first 500 hours of life at a rate slightly higher than that produced by 0.024 per cent Mg. The rapid initial activation of nickel containing Al, Mg and Zr is also possibly due to the presence of minute amounts of carbon. This reaction of carbon is an excellent indication of the extreme sensitivity of the oxide cathode to very minute amounts of reducing impurities.

The action of carbon as the principal initial activator suggested another promising concept: controlled addition of double or multiple reducing elements to the high-purity nickel base. If the additives are chosen on the basis of their diffusion rates in nickel, they may offer both rapid initial activation and long life. Nickel cathode materials containing combinations of additives are now beng evaluated, with encouraging results.



To prevent extraneous reactions in the test diodes, the parts must be ultra clean. Here, R. F. Franklin removes parts from ultrasonically agitated bath.

www.americanradiohistory.com

Though it is important to initial activation, the carbon impurity has little bearing on long life. After about 500 hours, the rate at which carbon produces Ba donors becomes too low to offset donor losses to the environment. Thereafter, as curve D on the graph on page 454 shows, pure nickel, with no additives to help it, suffers a rapid decline in emission. Loss of carbon from the Mg-Ni (curve B) and the Al-Ni (curve C) alloys also causes a decline in emission. After the carbon has been depleted from their respective alloys, neither Mg nor Al can prevent a slump in emission.

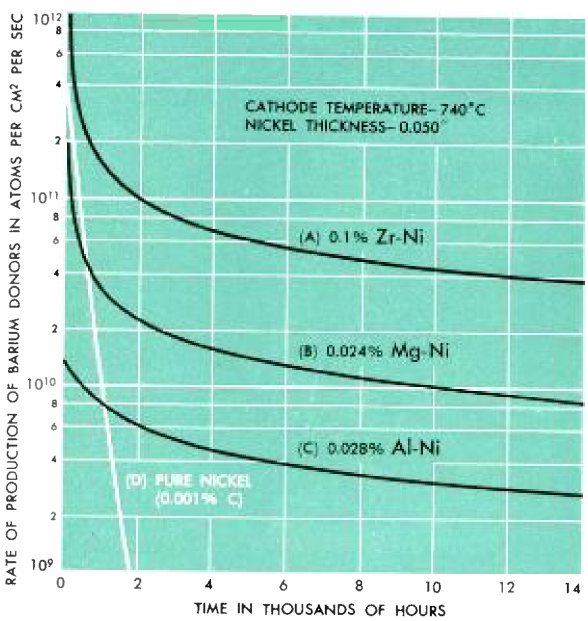
Mg-Ni recovers after 7000-8000 hours, however, indicating that the donor-loss rate eventually falls below the rate at which Mg produces Ba donors. This may not be the case for Al-Ni, however. Here, the emission decreases continuously until dc failure at about 9000 hours. Since Al-Ni was the only alloy that developed interface impedance with "coating peel," it is probable that the drop in total emission is related to this factor.

The 0.1 per cent Zr-Ni alloy, which produces Ba at the fastest rate, is not influenced to any extent by the loss of its 0.001 per cent carbon impurity. No sharp peak in the emission curve occurs initially as it did for the other alloys. After about 1000 hours, donor production continues to exceed donor loss by an amount sufficient to sustain high emission over thousands of hours.

By combining the emission data and the donor-rate data for these alloys, chemists at the Laboratories can establish quantitative limits of donor-production rates that make possible both high thermionic emission and long life. To be specific, in an operating environment and dc current density similar to that of the test diode, a tube should perform satisfactorily if the Ba-donor production rate were within the range of 10^{10} to 10^{11} Ba atoms per cm^2 per second. For the lower production rate, a cathode life of about 60 years is possible before all the BaO coating is lost by reaction with diffused reducing atoms.

DIFFUSION CONSTANTS

Reducing Additive	Diffusion Constant at 740°C (cm^2/sec)	Time to Deplete 50 Per Cent of Reducing Additive from 0.050 inch Thick Nickel (Hours)
Carbon	5.4×10^{-9}	160
Zirconium	1.7×10^{-11}	51,000
Magnesium	4.2×10^{-12}	207,000
Aluminum	1.6×10^{-13}	5,440,000



Donor-production rates vs. *time for the three alloys and nickel shown in emission curves. Curves were plotted from diffusion data in table above. Alloys are same as in curves on page 454.*

Another important part of this research was a study of the sensitivity of the BaO coating to controlled amounts of oxidizing impurity in a pure-nickel base. Pure nickels with six different oxygen contents, ranging from 0.0003 per cent to 0.078 per cent by weight, were used for this study. Without exception, the rate of activation of the BaO coating responds *inversely* to the oxygen content of the nickel. Oxygen contributes to the donor-loss rate by diffusing through the nickel base to the BaO coating and reacting with it to tie up the Ba donors. In the absence of reducing impurities in the nickel cathode, a concentration of oxygen exceeding about 0.002 per cent was sufficient to prevent activation of the coating.

The development of ultrapure alloys for cathode bases made it possible to extend our fundamental knowledge of oxide-coated cathodes. Most importantly, basic studies with these alloys have demonstrated the extreme sensitivity of the oxide cathode to faint traces of impurities. And for the first time in the history of the oxide cathode, quantitative limits have been established for the rate of production of Ba donors for a specific test structure. Within these limits both high emission and long life should be possible. An article in next month's RECORD will describe how this fundamental knowledge has been used in designing experimental cathodes for future Bell System tubes.

www.americanradiohistory.com

New magnetic-latching hold magnets make it possible for the economical, time-tested crossbar switch to be used in switching systems where low power is a factor. With a single, low-power pulse, the many hold magnets involved in a switching path can be locked up, magnetically, for the duration of a telephone call.

F. A. Zupa

MAGNETIC-LATCHING CROSSBAR SWITCHES

Electromagnetic switching devices are the most essential and most widely used of all the components that make up today's telephone switching systems. These devices—principally crossbar switches and relays—form the communication paths through switching networks and perform the important logic and memory operations that control these networks.

At present, such devices usually require a continuous flow of operating current to hold their electromagnets in the operated position. This often presents serious power-supply problems, particularly in new applications of crossbar switches. The electromagnets of these switches require appreciable current, and in a crossbar system as many as twelve crossbar-switch hold magnets are required to establish and maintain the talking path for one interoffice telephone conversation.

Switching engineers at Bell Laboratories are therefore very much interested in electromagnets that can be used effectively in switching devices, yet consume less power than present magnets. This article describes the design and development of a low-power-consumption electromagnet for crossbar switches. This new electromagnet consumes little power because it has the important properties of pulse operation and "magnetic latching."

Magnetic latching is achieved by a specially designed magnet core that makes it possible to maintain a substantial magnetic force of attraction *after* termination of the electrical pulse that energizes the core. There are no mechanical catches associated with the design. The open-circuit latching force holds the elements in the electromagnetic circuit in the operated position solely by "residual" magnetic induction produced by the prior application of a short pulse of operating current. To restore these magnetic elements to their nonoperated position, it is only necessary to energize the magnet coil with another short pulse whose current strength is lower and whose polarity is opposite to that of the operate pulse.

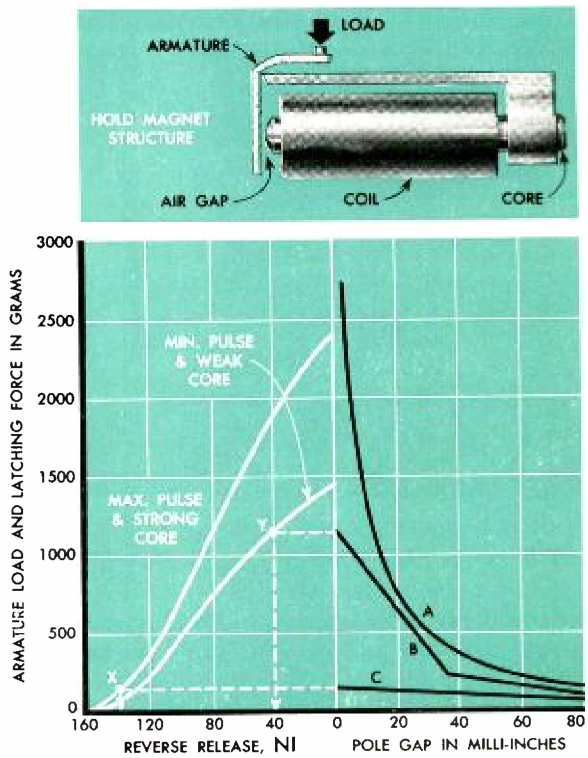
Magnetic latching offers a variety of simple and proven switching arrangements which have considerable functional and economic advantages.

www.americanradiohistory.com

that the open-circuit latching force is at least several hundred grams greater than the maximum spring-load value. When this requirement is met, the electromagnet will be capable of holding in the latched position under the shocks and vibrations encountered in actual service.

From a careful consideration of these functional operating and latching characteristics, it was apparent that, under the magnetizing force of the operate pulse, the magnet core should be capable of assuming properties similar to those of a hard permanent magnet. However, the core should also be magnetically soft to the extent that it will readily permit release of the armature on application of the reverse pulse. In addition, transition from a strongly magnetized state to a partially demagnetized state must be accomplished within the limits of the strength of the available electrical release pulses.

After considering the modern permanent-magnet alloys and discarding them, primarily because they require excessive amounts of applied current to operate, it appeared that a type of permanent-magnet steel in use over 50 years ago might be processed to have the magnetic properties of saturation and residual induction approaching those of a soft magnet steel, and at the same time retain a value of coercive force approaching that of a permanent-magnet type of steel. Since the magnetic properties of steel are largely determined by its carbon content and its physical hardness, a critical study of the relation between these properties could disclose the particular iron-carbon alloy and heat-treating process required to produce the desired magnetic properties in the hold-magnet core. This study led to the development of workable, magnetic-latching cores made of high-carbon steel.



Design objectives: right, hold-magnet load range and its magnetic-pull characteristics, and, left, range of magnetic-latching forces for the same magnet core. Above, the hold-magnet structure.

Design of the Magnet Core

The high-carbon steel selected for study as a possible core material is a common tool steel. Parts made of this steel can be hardened easily to any degree of hardness, ranging from a soft temper to a very hard and brittle temper. Hardening this type of steel, in general, consists of quickly quenching the fabricated part in water or in oil, immediately after heating it at a temperature of about 1475°F for a suitable time. The part is then reheated at a lower temperature, the value of which determines its final hardness, and cooled slowly in air at room temperature.

The quenching and reheating temperatures and associated time cycles used in the heat-treatment process have an important effect on the resulting chemical and physical changes that take place in the steel cores. These physical changes are of prime importance, because they determine the magnetic properties of the steel core. Therefore, the hardening heat treatment that would produce the combination of magnetic properties necessary to meet the operate, latching and release requirements was both explored and verified by careful laboratory experiments.

In planning and conducting such experiments, consideration was given to certain well known factors that determine the force of attraction between the core and armature of an electromagnet. These factors apply whether the armature is in the nonoperated or the operated position. The first is the total number of magnetic flux lines (in maxwells) between the polefaces of the core and the armature *(see hold-magnet structure above)*. Second is the *effective* poleface area of the core and armature. (This area on the core, for practical purposes, is considered equal to that on the armature.) The third factor is a constant, the value of which corrects for the portion of the magnetic flux that is not perpendicular to the poleface areas. This constant is slightly less than unity when the armature is in the operated posi-

www.americanradiohistory.com

tion (against the core), and it is much less than unity when there is a large airgap between the polefaces.

Since the force of attraction between the core and the armature in general varies directly as the square of the total number of flux lines traversing the airgap and inversely as the area of the polefaces, this area is an important factor in the performances of the magnet. Also, for each airgap there is an optimum poleface area. Taken together, these design factors mean that within certain operating limits of the electromagnet, the greater the poleface area, the greater the magnetic force of attraction on the armature at the larger open gaps. But when the poleface area is made smaller, the force of attraction starts to become greater as the armature passes through a certain critical airgap and touches the core.

From such factors, and data obtained by careful experimentation, it was determined that a poleface area no larger than the cross-sectional area of the core itself favored the latching force without seriously reducing the magnetic forces at certain critical load points in the open gaps. Another important design consideration dealt with the shape of the core poleface. Since flat, or plane, poleface surfaces that align perfectly are difficult to realize in practice, it was determined that the shape of the core poleface should be spherical with a large radius. Such a shape has the lowest magnetic reluctance in practice and yields the greatest concentration of working magnetic flux when the mating poleface surfaces are in the operated position.

The sketch below compares the relative effects of misalignment for a spherical poleface (*left*) and for a plane poleface design. With both cores misaligned by the same amount as shown, the effective airgap between the plane polefaces is much greater than the corresponding airgap between the plane and spherical polefaces. This means that the resulting latching flux at the spherical surface will be greater in value for a uniformly stronger latching force.

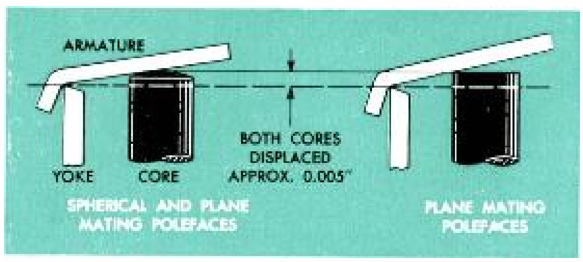
Some of the results of the heat-treatment experiments, using core shapes based on the factors just discussed, are shown on the left in the illustration on page 462. These curves show the latching force of the magnet and the reverse-polarity ampere turns required for release when the physical structure of the steel core is very hard, of a particular value of intermediate hardness, and relatively soft. Each of these physical states, as noted before can be obtained by regulating the reheating temperature used in the heat-treating process.

The very hard core (H-1) was given the heat treatment commonly used to produce a permanent magnet. With the core material in the very hard state, the magnet requires a release pulse of about 250 ampere turns to reduce the latching force to zero. However, the open-circuit latching force is sufficient to hold a load of only 800 grams. The 250-ampere-turns pulse required to demagnetize the core represents a high coercive force in the steel core, but the 800-gram latching force represents a low value of residual magnetic flux.

The soft core (H-3) was obtained by the commonly used high-temperature annealing, or normallizing, process. With the core material in this physical state, the open-circuit latching force (920 grams) is slightly greater than that of the very hard core. Its ability to retain residual magnetic induction, however, is comparatively low, since it needs only about 75 ampere turns to reduce it to zero.

In the middle (H-2), shown in white, is a curve that represents a core heat-treated to produce a particular intermediate degree of hardness. With this heat treatment, the core material has magnetic-latching properties that are outstanding compared to those of the very hard and the soft cores. In fact, the results of this study disclosed that there is an optimum physical hardness state, above and below which the resulting magnetic latching force diminishes. This optimum hardness state of the magnet cores, as measured on the Rockwell hardness-testing instrument, was found to center at number 60 on the 30-N scale. The corresponding hardness numbers for the H-1 and H-3 cores are 31 and 35, respectively. As this plot shows, the latching force (1800 grams) of the particular medium-hard core is more than twice that obtained with the permanent-magnet-type heat treatment (very hard core). Yet it requires only 150 ampere-turns to reduce this latching force to zero.

To sum up briefly, the heat-treatment experiments showed that the new combination of magnetic properties developed by the particular intermediate-hardness core is very high compared



The importance of poleface shape showing effect of misalignment on closed polegap reluctance.

www.americanradiohistory.com

to the corresponding values in the harder and softer cores. Since the greatest contact-spring load on the magnet armature is 1150 grams, the latching force of 1800 grams produced by the intermediate hardness core provides considerable working margin to resist the shocks and vibrations that may be encountered by a latched hold magnet in service.

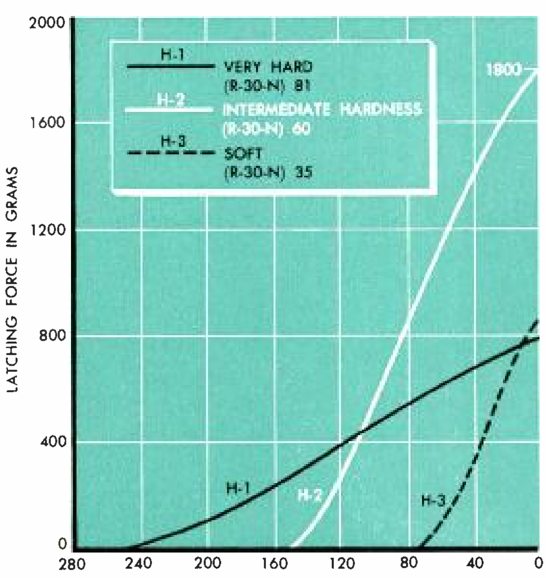
The remaining important criterion for judging the functional value of such a steel core is the ampere turns required by the magnet to actuate the armature under maximum contact-spring load. The ampere-turn values needed to just operate the magnet for cores with each of the three different states of physical hardness represented below disclose that the H-1 core requires about twice as much as that with the H-2 core. The H-3 core is still better in this one respect. The reason is that the maximum permeability of the H-2 and H-3 cores are about three and four times, respectively, as good as that of the H-1 core.

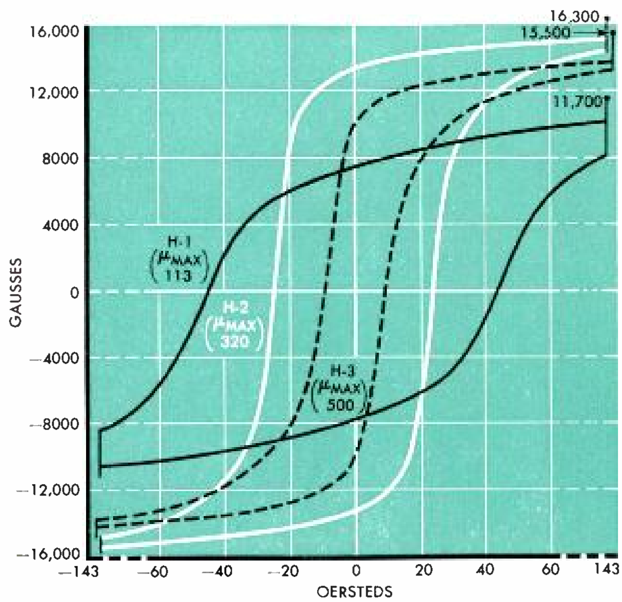
Interestingly, too, these data are in agreement with the established fact that the magnetic properties of ferrous materials are very much dependent upon the heat treatment of the material. Also, heat-treating processes to obtain useful physical hardness in tool steels is an old art. In the development of the magnetic-latching hold magnet, these well known arts were used to find a very useful combination of magnetic properties existing in high-carbon tool steel and to emphasize these properties to the desired degree. Basically, this was done by associating physical hardness directly with magnetic properties. This optimum combination of magnetic values is indicated by the magnetic hysteresis loops shown on the right in the illustration above. The (H-1), (H-2), and (H-3) physical-hardness states of the cores represented by these hysteresis loops correspond to those on the adjacent curves.

Principles Now in Use

A number of 100- and 200-crosspoint crossbar switches with these newly designed magnetic-latching hold magnets have been built both at the Laboratories and the Western Electric Company. The cores in the hold magnets of these switches have the magnetic properties of the intermediate-hardness (H-2) cores as shown above. Operating test results on these switches have shown the new magnets capable of meeting the operating and latching requirements originally established for them. These are the requirements summarized in the load and latching-force curves on page 460, with the addition of satisfactory working margins.

In the light of these operating test results, crossbar switches with magnetic-latching hold magnets are being used in new equipments, such as line concentrators, where the supply of operating power is much smaller than that normally available in a central office. Magnetic-latching hold magnets are therefore expected to extend the use of the crossbar switch as a low-cost electromagnetic switching device. The same principles of magnetic-latching design and processing are currently being applied to smaller electromagnetic switching devices, such as relays.





Curves at left show latching force vs. *reverse-release ampere turns for cores of three widely different hardness values. Hysteresis loops on right show magnetic properties of same cores.*

www.americanradiohistory.com

Myriad problems arise in transmitting communications over long distances and through mediums carrying several types of signals. For communications at the Cape Canaveral test range, Bell Laboratories engineers have met and solved certain of these problems with two cleverly applied electronic devices.

F. R. Bies

CANAVERAL TEST RANGE

Filters and Equalizers for Unattended Repeaters

Two common problems are inherent in a modern communications system. One involves keeping the signals within their assigned frequency space, and the other involves keeping the distortions of the system to a minimum. To deal with these problems, engineers have two electronic weapons at their disposal—filters and equalizers.

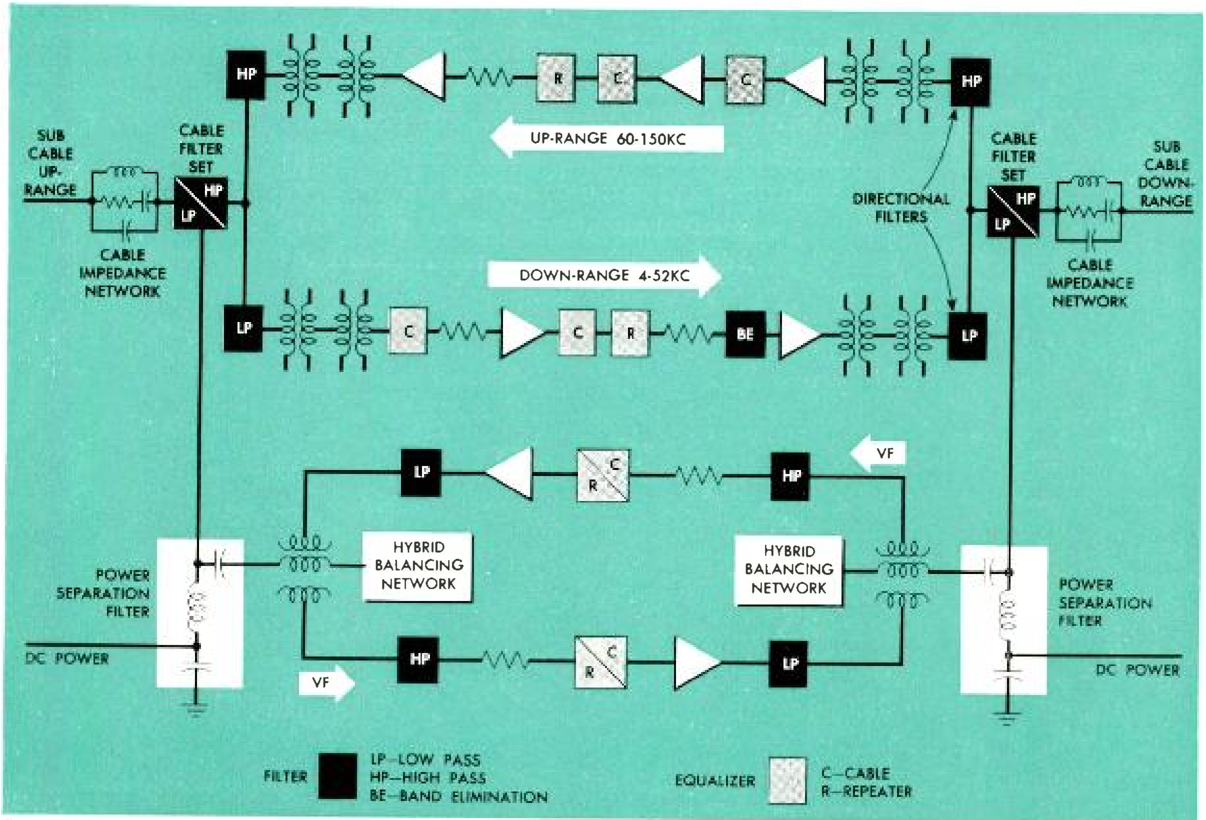
The communications system for the U. S. Air Force Missile Test Center at Cape Canaveral, Florida (RECORD, *September*, 1957) furnishes a good example of how these weapons are applied. This system, designed at Bell Laboratories, uses a number of highly selective filters and equalizers at unattended repeaters along the route of the submarine coaxial cable. Their purpose is to separate the signals being sent up and down the range, so they may be amplified, equalized, and recombined, with minimum distortion, for further transmission over the cable.

The Test Center's communications system provides telephone, data-message and telemetering channels over the 1250 nautical miles from Cape Canaveral, down range over many islands, to Puerto Rico. The system uses a single coaxial cable, having a solid insulator, with land-based repeaters, and spans a frequency range from 0 to 150 kc. Nine attended and fourteen unattended repeaters are located along the route. The cable itself is similar to that of the transatlantic submarine cable (RECORD, *February*, 1957). Design engineers chose this communications system because of its reliability and stability during the inclement weather and electrical storms common to the Caribbean area.

The major reason the Canaveral cable needs specially designed filters and equalizers is directly related to the way it is used as a transmission medium; it is a single submarine cable with land-based repeaters unequally spaced along the route. For example, to energize unattended repeaters, direct current is sent to them from an attended station over the cable. This current must be separated from the communications channels. Special devices are also needed to separate the message channels from the voice-frequency channel used by maintenance personnel to communicate between attended stations and unattended repeaters during maintenance or "lineup" checks. This voice channel occupies a range from 300 to 2750 cps.

Particularly, the special filters involve separating the down-range services from those of the up range for amplification and equalization. In the

www.americanradiohistory.com



Special devices at an unattended repeater on Air Force cable serve to separate power current from signals, carrier-frequency channel from the voice channel, and carrier frequencies from rest of band.

down-range direction, for example, the system handles either twelve telephone-message channels, ten telephone-message channels and a program channel, or ten telephone-message channels and a telemetering channel. All together, these channels cover a frequency band from 4 to 52 kc. In the up-range direction, the system handles either twelve telephone-message channels, ten telephone-message channels and a program channel, or nine telephone-message channels and a broadband telemetering channel. The latter can handle ten separate telemetering sub-channels whose bandwidths total 46 kc. These up-range facilities cover a frequency range from 60 to 150 kc.

The most obvious reason for equalizers is related to the distances between repeaters. They are not equally spaced but vary in distance from one another from 19 to 92.5 nautical miles. This non-uniformity in spacing of repeaters required the development of a "family" of equalizers to balance signal losses between repeaters despite the differences in length of portions of the cable, and despite the fact that these signals travel over several different frequency bands.

An examination of the simplified schematic diagram of an unattended repeater seen above will show how all the special filters and equalizers are used. For example, the dc power that energizes the electron tubes of the unattended repeater is sent from an attended repeater over the center core of the cable. This dc passes through the cable's impedance-matching network and filter set, and into a "separation" filter where it is removed from a resonant arm connected in shunt across the circuit. This resonant arm is part of a high pass filter with a peak of attenuation at 125 cps, well below the 300-cycle edge of the voice-frequency channel used for circuit maintenance.

The direct current passes through the inductor of the shunt arm, but it is blocked from ground via a capacitor. Thus it can be used for power in the repeater, provided the impedance of the power supply is kept fairly high over the maintenance circuit. This is done by passing the dc signal through a high-impedance choke coil after it is picked off the shunt arm. The power is put on the cable at attended stations the same way it is removed from the cable at unattended stations. This handling of direct current in the cable reduces noise and interference in the carrier frequencies.

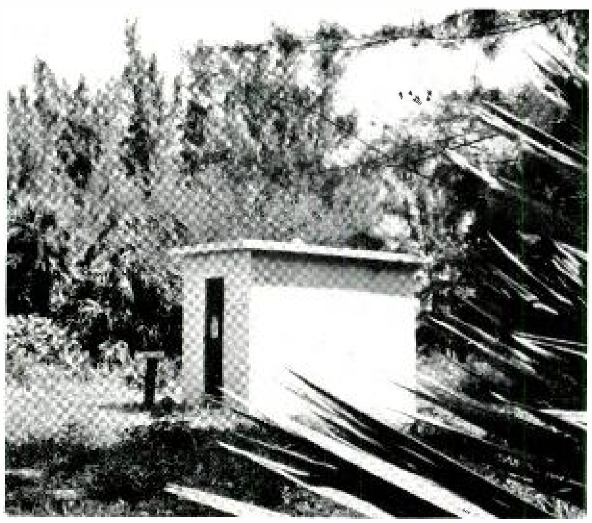
The cable filter through which the dc power passes is both a low- and a high-pass filter. It

www.americanradiohistory.com

separates the voice-frequency channel, whose top frequency is 2750 cps, from the carrier channels, which range from 4 kc to 150 kc. The low-pass portion of the filter handles the high direct current at a high voltage and deliberately maintains a high signal loss to 150 kc. This loss, plus that in the maintenance channel, prevents the carrier frequencies from "feeding" about a repeater, causing it to oscillate, or "sing." The high-pass portion of the filter, however, must pass the carrier frequency signals and, at the same time, prevent the direct current and voice frequencies from interfering with the carrier channels.

A further restriction on the low-and high-pass section is that it must not produce any interfering modulation products. These could be caused in the filter by high-level carrier signals, transmitted in one direction, modulating together in one of the components of the filter. The result would produce tones that could be stronger than the low-level signals being received from the opposite direction of transmission.

Another special filter in the chain is the "directional" filter which separates the range of carrier frequencies from the rest of the band. This is another low- and high-pass filter set. The low-pass filter section passes the frequency range from 4 to 52 kc and the high-pass section passes 60 to 150 kc. Because a large amount of amplification is needed in the carrier signal to make up for losses in the submarine cable between islands, the directional filter has to maintain more than 90 db discrimination to prevent oscillation around the carrier-frequency loop. This filter also must meet stringent modulation requirements because at its "parallel" side there is a large difference between the strength of the carrier signals being transmitted and those received. The filter precludes modulation which would appear as false tones.



One of the unattended huts that house the electronic equipment to filter and equalize signals.

This same type of filtering is required at each end of a repeater. However, filters at each end of the repeater, or at each repeater station, may have different requirements because they each may receive different levels of signal. To simplify developing, manufacturing, stocking, and maintenance, Laboratories engineers analyzed the system and developed filters to meet the most severe requirements. As a result, there is only one design of the filter, permitting over-all savings in manufacture and administration of the system.

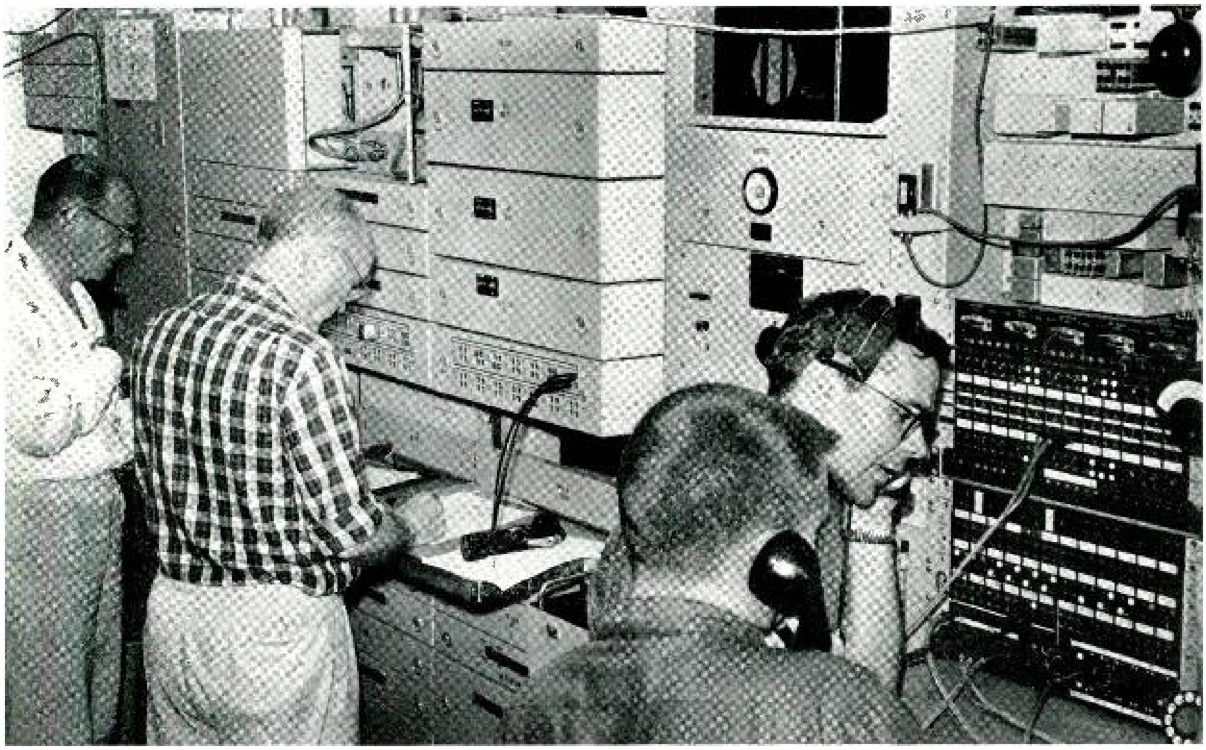
Maintenance Channel

Before turning to the problems of equalization of the system, we should discuss some of the problems connected with the maintenance channel. As shown in the lower portion of the block diagram, the maintenance channel is a "two-wire" system between repeaters, and as such can have arrangements for equalizing and amplifying in only one direction of transmission. Therefore, at a repeater, the two-wire system must be transposed to a "four-wire" system by a hybrid coil to permit equalizing and amplifying the voice frequency in both directions. A four-wire arrangement is also required to permit telephone transmitters and receivers to be inserted in the circuit.

It is also necessary to maintain a signal balance of at least 37 db across this hybrid coil over the frequency range controlled by the high and low-pass filter. This prevents oscillation about the loop, and furthermore, keeps the voice signal in one direction from affecting the one in the opposite direction. The balance is achieved by a special network on one side of the coil whose impedance matches that of the filters, networks, and the submarine cable on the other side. This balancing network must simulate the actual impedances very closely. Thus the configuration and some of the components of the balancing network duplicate those of the filters and other electrical components. In addition, the engineers designed a two-terminal network to simulate the submarine cable impedance very closely over the voice-frequency range.

Besides special filters, an unattended repeater must have an impedance that simulates the impedance of the submarine cable. This minimizes amplitude distortion with a change in frequency caused by a "mismatch" of impedances at the junction of the cable and a repeater. The matching is done by inserting a cable-impedance network be-

www.americanradiohistory.com



Terminal equipment at repeater station along route of Canaveral Test Range communications system.

tween the cable and the unattended repeater. This network makes the repeater, whose impedance is practically a pure resistance over the entire frequency range, increase its resistance over the low-frequency portion of the range. Furthermore, it has a negative reactance, similar to the impedance of the submarine cable, over the range of low frequencies.

Filters make it possible to restrict each frequency range, thereby affording a way to equalize and amplify each independently. Therefore, equalization of the unattended repeater had to be flexible so that the unequal spacing of the repeaters could be handled properly. This is done in two ways. First, an equalizer is placed in each range to correct only for the distortion which the filters and other components introduce near or about the edges of the frequency band. Second, a "family" of equalizers is established for each frequency range to correct for the loss in the cable. Since this loss varies with the length of the cable, engineers developed four "constant resistance" equalizers for the two carrier-frequency ranges. These are connected in tandem for the correct mileage. Each constant resistance equalizer has "taps," giving it some aspects of a potentiometer and permitting the cable to equalize to the nearest one third of a mile.

Such an elaborate system of equalization was not needed for the maintenance channel since its attenuation is much lower and some distortion can be tolerated at each repeater. So, for this channel, the engineers merely computed the over-all distortion, divided it equally among all the repeaters, and designed an equalizer to correct for this amount at each repeater. This means that at some repeaters the system is over-corrected and at others it is under-corrected. However, this has a negligible effect on over-all performance of the maintenance channel.

The method of equalization used for the carrier-frequency range has worked very well and in some cases where the actual length of cable is different from that computed, a change in one or two of the equalizers has quickly corrected the difference. Some cases required a large amount of equalization because of the long length of cable to be equalized. Here, the equalizers were inserted between successive stages of gain, thereby permitting the system to be arranged for the best possible signal-to-noise ratio and reducing the effects of low-frequency noise and vibration.

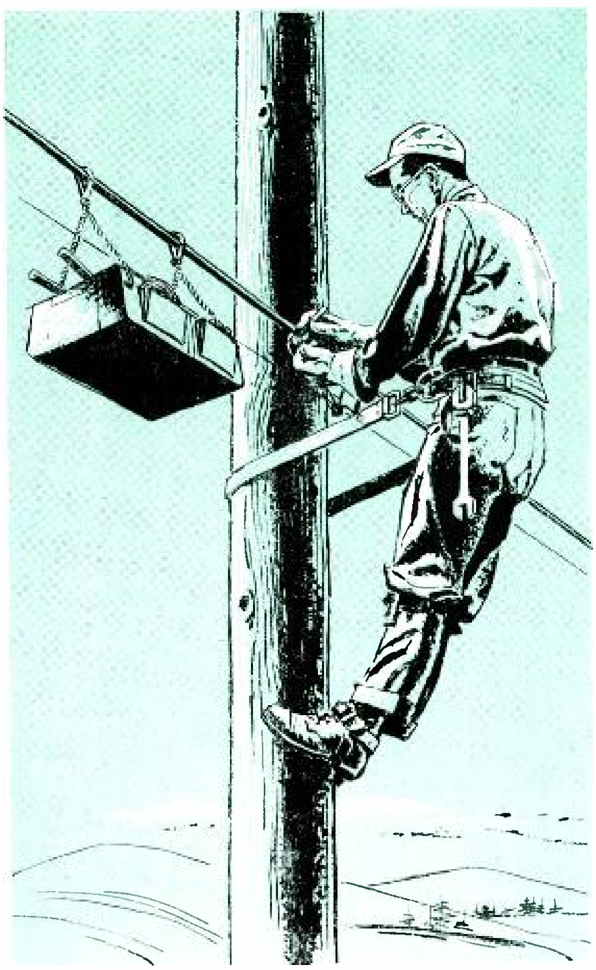
The Canaveral system has been in operation since 1955. It has performed very satisfactorily and has provided the U. S. Air Force with communications usable under any weather conditions.

www.americanradiohistory.com

No item that enhances the safety of Bell System crews is too insignificant for Laboratories attention. A canvas tray, recently designed, allows one-man crews working on telephone poles to keep their tools in safe reaching distance.

THE "B" CANVAS TRAY

With the trend toward one-man crews, a definite need has arisen for an improved tool and material holder which will ensure that these items are readily available to the craftsman while performing his work. The canvas bucket previously used for this general purpose is not entirely suitable; it does not provide enough space for tools and materials currently used, and is not well adapted to selection of the appropriate item.



In cable joining, for example, a variety of tools is frequently used and must be close at hand if the job is to be done efficiently. These include such tools as a hammer, chipping knife, six-foot rule, scissors, shave hook, carding brush, five-inch screwdriver, dial test set, and cutting and diagonal pliers. In addition the splicer must have readily available an assortment of such materials as muslin, cotton sleeving or houseline for ties, stearine, prepared sleeves, desiccant, cable terminal or splice case parts, lashed cable supports, and various types of tape.

The "B" Canvas Tray is designed to meet conditions brought about by the newer cable joining techniques and one-man operation. It is a collapsible rectangular compartment measuring 12 inches wide, 18 inches long and 6 inches deep. It has two 5-inch wide pockets on the outside surface of one side and a 10-inch wide pocket on the opposite side. In addition to providing more room, a tray of this size and shape offers several advantages over the canvas bucket. Tools lie flat and are more readily available for repetitive operations. Also, it is more convenient—and safer—for the splicer to reach for tools and materials in the relatively shallow tray.

The tray, shown in the accompanying drawing, is made of medium-weight, green, cotton duck with a covered masonite floor. It is arranged with two ¼-inch manila rope loops, each with a galvanized swivel eyesnap. The tray can hold tools and materials required for the various work operations and be suspended from the strand in the work area.

H. G. Geetlein
OUTSIDE PLANT DEVELOPMENT

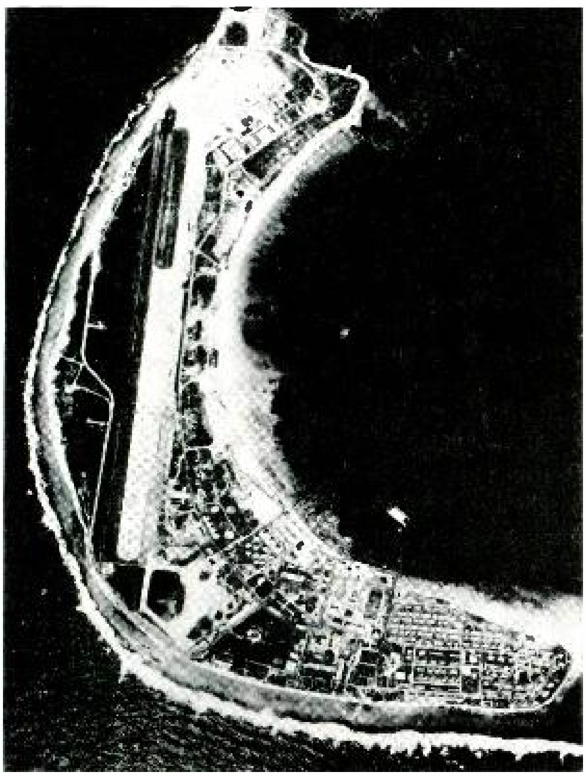
www.americanradiohistory.com

Nike Zeus Test Center at Kwajalein

More than sixteen years ago, a Pacific atoll called Kwajalein made headlines when American troops fought their way ashore as part of the costly plan to put down an aggressor nation. Now, this largest atoll of the Marshall Island group is about to resume its role as a battleground for peace and freedom. But the character of this program differs from that in early 1944. Today Kwajalein is serving as a base for deterring the enemies of freedom, hopefully at less cost, before they can disrupt the peace.

News of Military Development

The island of Kwajalein will become the site of the eighteenth branch of Bell Laboratories early next year when it begins to operate as a testing ground for the Nike Zeus anti-missile missile system. When completed, this installation will become the fifth test center for Nike Zeus, behind White Sands, Ascension Island, Point Mugu, California and, of course, the Whippany Laboratories.



Largest atoll in the world, Kwajalein measures approximately three and one-half miles long by one-half mile wide. Its size as well as its geographical position aid in use as a Zeus test base.

The primary purpose of the Kwajalein Laboratories will be to "prove" the results of tests conducted at the other four test sites, concentrating on the radar capabilities of Nike Zeus. Basically, the test plan is designed to find the margins of the Zeus defense zone, and to demonstrate the effectiveness of the weapon system.

The anti-missile missile system called Nike Zeus has been conceived and developed as a joint effort of Bell Laboratories, the Western Electric Company, the Douglas Aircraft Company, and many other sub-contracting industrial organizations. The Zeus mission is to intercept and destroy attacking ballistic missiles traveling through space at speeds of up to 15,000 miles per hour. These missiles may come from the other side of the earth, or from off-shore submarines.

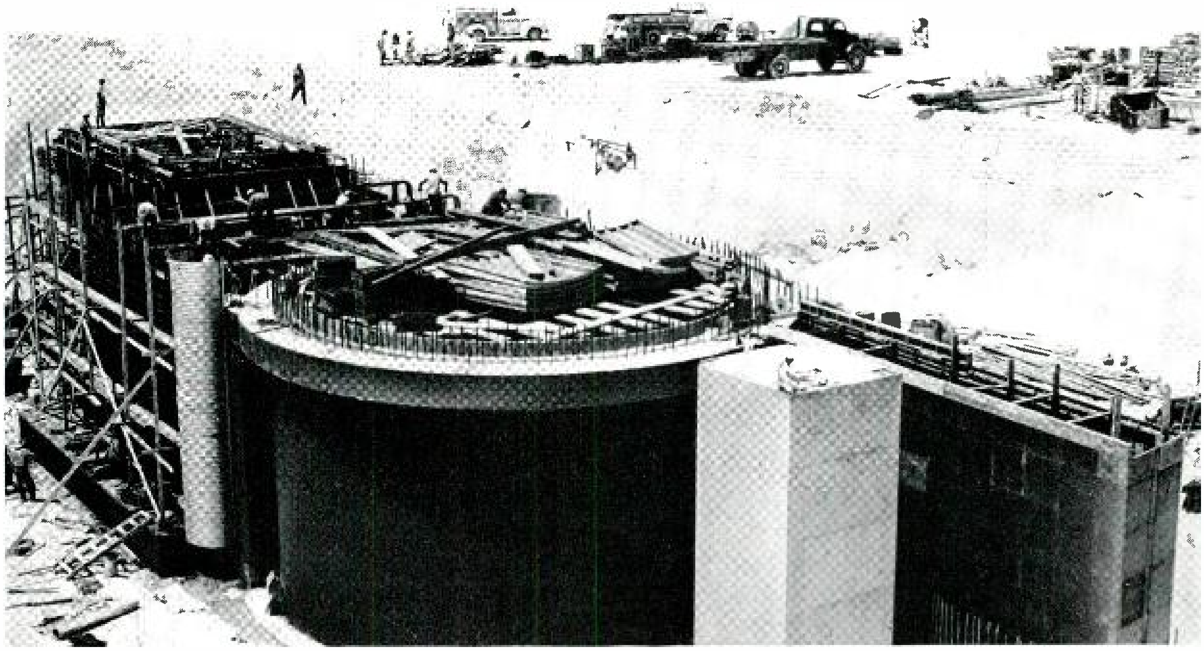
Broadly, the Nike Zeus system consists of an acquisition radar and a weapons battery. This battery has target- and missile-tracking radars, a discrimination radar, a computer, and the missiles and their launch cells. The acquisition radar detects and tracks enemy missiles at very long range in any direction. The battery equipment permits tracking of both targets and missiles and commands the Zeus missiles to intercept targets at the best defensive point.

The effectiveness of this equipment will be tested against intercontinental ballistic missiles launched from Vandenberg Air Force Base in California, 4900 miles away, and guided downrange toward the Kwajalein area.

Center of the test operation on Kwajalein will be a joint technical operations building with office space and technical service areas for both military and civilian personnel attached to the project. From here will be directed the activities of the main Zeus hardware. This will include storage and assembly areas, tracking radars and a boresight tower for their use, and target-tracking radars with their pressurized radomes.

One acquisition radar will serve the test site. A transmitter building will be topped by an 80-foot wide triangular transmitter surrounded by a 660-foot diameter fence. The receiver will be located in a segment of a 300-foot radius ground

www.americanradiohistory.com



Foundation for the Nike Zeus acquisition receiver antenna at Kwajalein. Immense power of the acquisition radar requires the transmitter and the receiver to be located quite far apart.

plane, oriented to cover the interception "zone."

Western Electric is the prime contractor for the Nike Zeus program, and Bell Laboratories is responsible for the research and development program. For this reason, the Laboratories directs the activities of all the subcontracting firms involved in the test program at Kwajalein.

Thus it will be necessary to have a permanent staff of Bell Laboratories personnel assigned to the Kwajalein Island "Field Station." Present plans call for establishing Laboratories technical and staff personnel as the nucleus of a department under L. W. Morrison, Director of Guided Missile Development. R. W. Benfer, former Director of the White Sands Laboratory, has recently been appointed Director of the Kwajalein Island Field Station. In this position he will be responsible for the test program of the Nike Zeus System at Kwajalein. C. A. Warren, Director of Missile Systems Development, is the project engineer.

In addition to the Laboratories personnel at Kwajalein, there will be Western Electric Company technical and staff-support personnel, as well as representatives of the sub-contracting companies. In addition, a number of Laboratories people will be on "transient" duty for periods of a few months as they are needed.

Living facilities on this tropical atoll are surprisingly similar to those near any Stateside location of the Laboratories. For permanent civilian residents there are 100 houses assigned for Zeus contractor personnel, and the U. S. Army Corps of Engineers is now building a "bachelor officers' quarters" that can hold 425 people. The island has an elementary school. All buildings are owned by the United States Government, including those housing recreational facilities, such as tennis courts, swimming pool, movie theatre, and an 8500-volume library.

Air transportation by chartered plane from the United States to Kwajalein is available on a regular schedule. Planes travel between Los Angeles, California, and Kwajalein via Honolulu. Thus, although this test center is over 7000 miles from the "birthplace" of Nike Zeus—the Whippany Laboratories—key personnel can closely watch the progress of the field tests.

Perhaps the most significant thing about the Kwajalein branch laboratory is that it points out the vast areas of the earth needed for testing the tools of modern warfare. The nature of vehicles such as Nike Zeus make it imperative that they be directed away from populated areas. Moreover, they must engage in operations spreading over thousands of miles. And because Bell Laboratories plays such an important part in developing these systems, it is not only logical but essential to establish this island laboratory.

www.americanradiohistory.com

All-Number Calling Being Introduced In Bell System

All-Number Calling (ANC) was recently introduced in Omaha, Nebraska, by Northwestern Bell and is currently being introduced in many other areas of the Bell System. Like many Bell System innovations, ANC had its beginnings at Bell Laboratories. In 1954, a team headed by John E. Karlin of the human-factors engineering group began a series of experiments to determine how easy it would be for customers to remember numbers and whether they would like telephone numbers without letters (RECORD, *August*, 1958).

News of the Bell System

Mr. Karlin began his investigation with Laboratories employees. They dialed seven-digit, letter-number calls in controlled situations, and then made all-number calls. Later, they were tested to see how well they remembered both kinds of telephone numbers. From these early experiments, the study group concluded that: it was easier to dial numbers only; number-dialing was quicker and more accurate than letter and number dialing; for short periods it was just as easy to remember numbers only; but for long periods, numbers only were slightly harder to remember.

Next, 73 employees tested ANC on their telephones at home in New York and suburban New Jersey. Notwithstanding conditions of use unfavorable to ANC, the conclusions were about the same, with a majority favoring the ANC method after using it for a while, and very few experiencing difficulty with ANC.

In 1958, all-number calling was field-tested in Wichita Falls, Texas. Where dialing error in the average cutover to two-letter, five-number dialing normally rises 112 per cent, the figure rose only 58 per cent at Wichita Falls. Further study conducted at Bell Laboratories since these tests has reinforced the view that ANC is a better dialing system.

Although these early studies were not specifically directed at the problem, the fact is that the Bell System is running out of letter codes. This is an especially acute problem with the advent of direct distance dialing, in which the United States and Canada are divided into geographical areas called number-plan areas and assigned three-digit area codes. There can be no two telephone numbers alike in any area. With the old system—two-letter, five-digit numbers—there are 540 central-office codes potentially available in any area. This stems from the fact that certain combinations of letters on the dial are difficult to fit with central-office names. For instance, the dial pulls 5-5, 5-7, 9-5 lack any suitable names. Another limitation arises from confusion of the letter "O" with the numeral "0". This was so great that the numeral zero has generally been eliminated from use as a central-office code.

When the area-code plan was instituted—three digits assigned to each geographical area—there were 152 three-digit combinations for area-code use. Eighty-six of these codes were used when operator toll-dialing was installed in 1947. The remaining 66 were expected to last for many years. But the System has grown so rapidly that 31 of the codes have been used and the remaining 35 area codes are expected to be exhausted by 1975. The limitation of 540 central offices in any one area forces the use of a new code each time this maximum figure per area has been reached.

ANC meets this problem head-on with a seven-digit number. This provides the greatest possible number of central-office codes, since there is no name-assignment problem nor is there any number-letter confusion. ANC increases the number of central-office codes from 540 to 800, thus slowing down the assignment of new area codes and postponing the day when ten-digit numbers with area codes will have to be used rather than seven-digit numbers. Besides meeting problems of growth, there are other major customer advantages of ANC:

(1) A greater proportion of calls will continue to require only seven digits. (2) The door is closed on confusion between the numeral *1* and the letter *I* and the numeral *0*, and the letter *O*, which caused up to 50 per cent of all dialing errors. (3) Difficulties in spelling and pronunciation of central-office names are ended. (4) Dials are easier to read, particularly in dark areas or for older people, because of the larger numerals. (5) Telephone instruments will be easier to miniaturize with letters gone. (6) The Bell System will be able to offer new services, such as in-dialing to PBX stations and direct dialing to mobile stations. (7) Occasional public reaction to the changing of central-office names will be precluded.

www.americanradiohistory.com

news in brief

Lloyd S. Miller Elected A.T.&T. Vice President

Lloyd S. Miller has been elected a vice president of the American Telephone and Telegraph Company. He continues as director of the Washington, D. C., office, a post he has held since 1958.

Mr. Miller, an alumnus of Kansas State College and the Washburn School of Law at Topeka, joined Southwestern Bell in 1936 as an attorney. In 1954, he became general solicitor in St. Louis. The following year he was elected vice president — revenue requirements, a position he held until he was appointed director of A.T.&T.'s Washington office in March, 1958.

L. S. Miller

During World War II, Mr. Miller served in the Army Air Force as a lieutenant colonel. He is a director of the Armed Forces Communications and Electronics Association and also a member of the Kansas, the Missouri, and the American Bar Associations.

Robert D. Lilley Elected W.E. Vice President

Robert D. Lilley, formerly personnel director of Western Electric, has been elected vice president, Personnel and Public Relations Division, effective November 1.

R. D. Lilley

Mr. Lilley succeeds Arthur P. Clow, who resigned from the Western Electric Company to become director and vice president in charge of operations of the Chesapeake and Potomac Telephone Company in the District of Columbia and adjacent metropolitan territory.

Mr. Lilley had assumed the position of personnel director on August 1, 1960, after having been assistant works manager at Baltimore since May, 1957. He joined the Bell System in 1937 as an engineer at the Kearny Works.

Echo I Used as Space Mail Carrier

Speed Mail, the Postal Department's electronic system for sending mail great distances within seconds, entered the space age last month, when a letter was transmitted from Washington, D. C., to Newark, N. J., via the Echo I satellite balloon. The letter was sent first over telephone lines from Washington to a transmitting facility of the U.S. Naval Research Laboratory at Stump Neck, Md., and from there, bounced off Echo to Bell Laboratories spare communications center in Holmdel, N. J. The mail traveled from Holmdel to the Newark Post Office over regular telephone circuits.

"Mr. and Mrs. America, c/o Postmaster, Everywhere, U.S.A.," was the address of the letter from Postmaster General Arthur B. Summerfield. Mr. Summerfield said this was the "first such letter to be processed through outer space."

Mr. Summerfield's letter was fed into machines for scanning and reading and sent from Washington as an electronic facsimile to the Newark Post Office, where it was converted into a duplicate of the original. Since only machines actually "saw" the letter —the original was destroyed automatically after transmission— the sanctity of the mail was assured.

Echo had already passed similar tests before the Speed Mail experiment. On September 22, 1960, photographs were transmitted from Stump Neck to Holmdel, using Echo to relay the facsimile signals (RECORD, *October*, 1960).

Echo Balloon Still Useful

These facsimile mail experiments were carried out despite wrinkles on Echo's aluminum-coated surface, which cause heavy signal fading.

Although the 100-foot diameter sphere circles the earth six times each day, Project Echo engineers at Holmdel, N. J., say it is visible only three times now during early morning hours. The earth's shadow prohibits visibility during evening hours.

The balloon's wrinkles, which are causing a reduction in the intensity of the received signal, result from three factors: (1) loss of gas pressure inside the sphere; (2) Echo's path in-and-out of the earth's shadow where temperature variation is extreme; and (3) effects of air drag.

Engineers say that Echo, zooming across the sky at 16,000 miles-per-hour, has a life expectancy of about one year. A satellite's life span is determined by solar radiation pressure and air drag.

www.americanradiohistory.com

Echo tours the earth every 118 minutes. Presently, its closest distance to the earth is 720 miles, while its farthest is 1,250 miles.

Experiments are being run only once a week at Holmdel. Primarily, they involve receiving carrier signals transmitted from the U. S. Naval Research Laboratory at Stump Neck.

Bell System Telephones Reach 60 Million

Somewhere in the United States the 60 millionth Bell System telephone was recently installed. The milestone phone was one of about 55,000 installed throughout the system every day. Another 46,000 are removed daily for a net gain of about 9,000 telephones.

Actually, America's telephone "population" is now more than 73 million. The additional 13 million instruments are operated by some 3,500 non-Bell telephone companies.

The 50 millionth Bell System phone was added only three years ago. In the last ten years, the System has gained more than 24 million telephones.

Meanwhile, as Americans have been getting more telephones, they've been using them more. In 1950, the average person in this country placed fewer than 400 calls per year; today he places more than 500.

ASQC Honors George D. Edwards

The American Society for Quality Control has established a new award, the Edwards Medal, named in honor of George D. Edwards, formerly Director of Quality Assurance at the Laboratories.

The Edwards Medal is awarded for "outstanding leadership in the practice of quality control."

Mr. C. E. Fisher, past president of the ASQC and Central Office Quality Engineer at the Laboratories, presented the first medal to Mr. Edwards at the society's banquet earlier this year.

Home Interphone Service To Be Available Throughout the Bell System In 1961

Three phone units are available with the Home Interphone. A separate speaker unit, shown at the lower left, goes with each phone.

Bell Laboratories has designed and developed a new home communication system that will be available from all the Telephone Operating Companies early in 1961. The new service features intra-home communication from any telephone in the house.

Called the "Home Interphone," the system combines, for the first time, home telephones with a wide range of intercommunication services that include door-answering, paging by voice throughout the house, hands-free response to an interphone call. A person can even pick up the handset and listen to children at play inside or even outside the house.

All of these features are now built into versions of the standard home telephones. Each unit in the system is a master station, which means that all functions can be performed from all phones. The unit includes a 500 set, a wall phone, or a Princess telephone, and a separately mounted speaker unit.

Heart of the system is the transistorized central control unit. About the size of a wall phone, it is coupled with a small transformer and can be installed in an out-of-sight location such as the basement.

In the base of each phone is a tiny microphone, and on the wall near each phone is a small speaker. These are the two major items which enable each phone to serve as an intercommunicator. Controls consist of a two-position switch used to select an outside line on the interphone. By lifting a plunger on the phone, one can hold outside calls and use the intercom part of the system at the same time. Pressing a line button connects a person to the combination speaker-microphone mounted outside of the house near the door.

www.americanradiohistory.com

One Million Princess Phones

In recognition of the millionth Princess phone connected in the United States, John D. Dodd, New York Telephone Company vice president, presented a Princess to Ralph R. Miller, director of the Museum of the City of New York.

In making the presentation, Mr. Dodd pointed out that the Princess, designed and developed at Bell Laboratories, is the sixth major innovation in the home telephone since its invention in 1876. The five predecessors are also on permanent display at the museum's communications collection.

The Princess, the lightweight and compact telephone marketed in any of five colors with dial nightlight, was recently introduced by the Bell System.

John D. Dodd of New York Company, right, presents Princess to Ralph R. Miller of the Museum of the City of New York.

Bell System Telecast on Science of Genetics

The latest one-hour program in the Bell System Science Series, "The Thread of Life," will be telecast Friday, December 9 at 9 P.M. over the NBC network.

Dr. Frank C. Baxter, who has been featured in previous Bell System science programs, uses films showing chromosomes dividing in the process of mitosis, animated drawings, charts, and models to explain some of the important mechanisms of heredity discovered in the past 100 years. One of Dr. Baxter's most interesting models is a portion of a molecule of DNA, or Deoxyribonucleic acid, which scientists think may be the chemical basis of the gene itself and therefore the "thread of life."

The "Thread of Life" was produced under the supervision of a board of ten leading scientists.

Dr. Andrzej Bajer (right) and his wife, Dr. Jadwiga Jole-Bajer, show Dr. Frank C. Baxter how they take motion pictures of mitosis.

Nation's Largest Data-Phone Network Installed

The largest data-communications network using new Data-Phone equipment, a result of Bell Laboratories research and development, is being installed by Hardware Mutuals—Sentry Life insurance group.

Utilizing the Data-Phone, which permits business machines to "talk" to each other, the nation's largest mutual property-casualty insurance group is linking its headquarters in Stevens Point, Wisconsin, with 32 branch offices throughout the country.

This new system cuts the time normally required by the industry to provide complete customer service from "as long as two weeks to less than two days," according to James P. Jacobs, president of the Hardware Mutuals—Sentry Life group.

The new arrangements for transmitting and processing insurance data will greatly speed policyholder service, reduce operation costs by more than a million dollars, and effect an important increase in the income of the company's investors.

www.americanradiohistory.com

PAPERS

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

Bartholomew, C. Y., *Impurities Introduced into Kovar-Envelope Electron Tubes by Atmospheric Corrosion*, Trans. I.R.E., 7, pp. 185-186, July, 1960.

Bilaniuk, O. M., see Hensel, J. C.

Blumberg, W. E., *Spin Relaxation of F-Center Electrons*, Phys. Rev., 119, pp. 1842-1850, Sept. 1960.

Blumberg, W. E., see Teaney, D. T.

Bond, W. L., see Collins, R. J.

Bond, W. L., see Garrett, C. G. B.

Bozorth, R. M., Davis, D. D., and Williams, A. J., *Properties of some Magnetic Superconductors*, Phys. Rev., 119, pp. 1570-1576, Sept. 1, 1960.

Broyer, A. P., see Chevalier, J. G.

Bulloch, W. D., *Communications of Tomorrow*, Proc. Sixth Annual Ind. Management Conf., pp. 9-12, May 6, 1960.

Burrus, C. A., see Trambarulo, R.

Carbrey, R. L., *An Introduction to PCM Terminal and Repeater Methods*, Electronics Design, 8; No. 12, pp. 52-57, June 8, 1960; No. 13, pp. 66-69, June 22, 1960; No. 14, pp. 98-103, July 6, 1960.

Carbrey, R. L., *Video Transmission Over Telephone Cable Pairs by Pulse Code Modulation*, Proc. I.R.E., 48, pp. 1546-1561, Sept., 1960.

Chevalier, J. G., and Broyer, A. P., *Surface Flashover Between Printed Wiring Conductors*, Elec. Mfg., 66, pp. 10-12, Oct., 1960.

Christensen, H., see Theuerer, H. C.

Collins, R. J., Nelson, D. F., Schawlow, A. L., Bond, W. L., Garrett, C. G. B., and Kaiser, W., *Coherence, Narrowing, Directionality and Relaxation Oscillations in the Light Emission from Ruby*, Phys. Rev. Letters, 5, pp. 303-305, Oct. 1, 1960.

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

Deutsch, M., *The Pathetic Fallacy: An Observer Error in Social Perception*, J. Personality, 28, pp. 317-332, Sept., 1960.

Dimock, P. V., *Data Transmission Performance on Long-Haul Telephone Facilities*, Proc. National Electronics Conf., 16, pp. 29-36, Oct. 10, 1960.

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

Feher, G., Hensel, J. C., and Gere, E. A., *Paramagnetic Resonance Absorption from Acceptors in Silicon*, Phys. Rev. Letters, 5, pp. 309-311, Oct. 1, 1960.

Feher, G., see Hensel, J. C.

Frisch, H. L., see Morrison, J. A.

Galt, J. K., see Kunzler, J. E.

Garret, G. C. B., see Collins, R. J.

Geller, S., *The Crystal Structure of B-GA$_2$O$_3$*, J. Chem. Phys., 33 pp. 676-684, Sept. 1960.

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

Germer, L. H., Scheibner, E. J., and Hartman, C. D., *Study of Adsorbed Gas Films by Electron Diffraction*, Phil. Mag., 5, pp. 222-236, March, 1960.

Gilbert, E. N., *Random Graphs*, Annals Math. Stat. 30, pp. 1141-1144, Dec., 1959.

Gilbert, E. N., *Synchronization of Binary Messages*, Trans. PGIT, 6, pp. 470-477, Sept., 1960.

Glarum, S. H., *The Dielectric Relaxation of Isoamyl Bromide*, J. Chem. Phys., 33, pp. 639-643, Sept., 1960.

Gupta, S. S., *Order Statistics from the Gamma Distribution*, Techometrics, 2, pp. 243-262, May, 1960.

Hanscom, F. E., see Jonas, L. A.

Hartman, C. D., see Germer, L. H.

Helfand, E., *Transport Coefficients from Dissipation in a Canonical Ensemble*, Phys. Rev., 119, pp. 1-9, July 1, 1960.

Hensel, J. C., and Bilaniuk, O. M., *The B^{10} (d,p) B^{11} Reaction and the Configurations of B^{11}*, Phys. Rev., 120, pp. 211-223, Oct. 1, 1960.

Hensel, J. C., and Feher, G., *Valance Band Parameters in Silicon from Cyclotron Resonance in Crystals Subjected to Uniaxial Stress*, Phys. Rev. Letters, 5, pp. 307-309, Oct. 1, 1960.

Hensel, J. C., see Feher, G.

Hogg, D. C., *Problems in Low Noise Reception of Microwaves*, Trans. National Symposium Space Electronics & Telemetry, p. 8-2, Sept. 1960.

Hopper, A. L., *An Improved Method of Gain Control for Transistor I.F. Amplifiers*, Proc. National Electronics Conf., 16, pp. 152-156, Oct. 10, 1960.

Jaccodine, R. J., *Crystal Growth in Paraffin*, Nature, 187, pp. 498-499, Aug. 6, 1960.

Joel, A. E., Quirk, W. B., *Field Trial of an Experimental Electronic Telephone Switching System*, A.I.E.E. Conf. Paper, pp. 1-1 - 1-11, Oct. 12, 1960.

Jonas, L. A., and Hanscom, F. E., *High Voltage Static Eliminators for Teletypewriters*, Elec. Eng., 79, pp. 823-826, Oct., 1960.

Kaiser, W., see Collins, R. J.

Kaminsky, G., see Lee, C. A.

Kennaugh, E. M., see Morgan, S. P.

Kleimack, J. J., see Theuerer, H. C.

Kunzler, J. E., Walker, L. R., and Galt, J. K., *Adiabatic Demagnetization and Specific Heat in Ferrimagnets*, Phys. Rev., 119, pp. 1604-1614, Sept. 1, 1960.

Lee, C. A., and Kaminsky, G.,

www.americanradiohistory.com

Anomalous Barrier Capacitance in p-n Junctions of InSb, J. Appl. Phys., 31, pp. 1717-1719, Oct., 1960.

Linares, R. C., *The Growth of Barium Titanate Single Crystals from Molten Barium Fluoride*, J. Phys. Chem., 64, pp. 941-942, July, 1960.

Loar, H. H., see Theuerer, H. C.

Lumsden, G. O., *Fortified Wood Preservative for Southern Pine Poles*, Forest Products J., X., pp. 456-462, Sept., 1960.

Matthias, B. T., and Merz, W. J., *Seignette Elektrizitat*, Helvetica Physica Acta, V., pp. 41-49, 1960.

McCall, D. W., and Douglass, D. C., *Nuclear Magnetic Resonance in Solid Adamantane*, J. Chem. Phys., 33, pp. 777-778, Sept., 1960.

Merz, W. J., see Matthias, B. T.

Miller, R. C., see Savage, A.

Morgan, S. P., Weil, H., Kennaugh, E. M., *Scattering by a Spherical Satellite*, Proc. I.R.E., 48, p. 1781, Oct., 1960.

Morrison, J. A., *Bounds on the Nonlinear Diffusion Controlled Growth Rate of Spherical Precipitates*, Am. Math. Soc. Notices, 4, pp. 502-503, Aug. 1960.

Morrison, J. A., and Frisch, H. L., *Bounds on the Nonlinear Diffusion Controlled Growth Rate of Spherical Precipitates*, J. Appl. Phys., 31, pp. 1621-1627, Sept., 1960.

Nelson, D. F., see Collins, R. J.

Portis, A. M., see Teaney, D. T.

Quirk, W. B., see Joel, A. E.

Savage, A., and Miller, R. C., *Temperature Dependence of the Velocity of Sidewise 180° Domain-Wall Motion in $BaTiO_3$*, J. Appl. Phys., 31, pp. 1546-1549, Sept., 1960.

Schawlow, A. L., see Collins, R. J.

Scheibner, E. J., see Germer, L. H.

Schulz-DuBois, E. O., *The Three-Level Solid-State Maser*, Progress in Cryogenics, II, pp. 175-231, 1960.

Sinden, F. W., *On the Replacement and Expansion of Durable Equipment*, J. Soc. Ind. & Appl. Math., 8, pp. 466-480, Sept., 1960.

Smith, D. H., *Power Distribution, Conversion & Control for an Electronic Telephone Switching System*, A.I.E.E. Conf. Paper, Oct. 12, 1960.

Sperling, G., *The Information Available in Brief Visual Presentations*, Psychological Monographs, 74, pp. 1-29, 1960.

Teaney, D. T., Blumberg, W. E., and Portis, A. M., *Measurement of F-Center Concentration and Relaxation Time by Microwave Faraday Rotation*, Phys. Rev., 119, pp. 1851-1853, Sept. 15, 1960.

Theuerer, H. C., Loar, H. H., Kleimack, J. J., and Christensen, H., *Epitaxial Diffused Transistors*, Proc. I.R.E., 48, pp. 1642-1643, Sept., 1960.

Trambarulo, R., and Burrus, C. A., *Esaki Diode Oscillators from 3 to 40 KMC*, Proc. I.R.E., 48, pp. 1776-1777, Oct., 1960.

Ulrich, W., *Maintenance and Administration Methods in an Electronic Switching System*, Trans. A.I.E.E., pp. 7-1 - 7-28, Oct. 12, 1960.

Wagner, R. S., *On the Growth of Germanium Dendrites*, Acta Met., 8, pp. 57-60, Jan., 1960.

Walker, L. R., see Kunzler, J. E.

Walfrafen, G. E., *A Cube-Root Law for the Activity Coefficient Quotient of the Dissociation of HSO_4-Ion*, J. Chem. Phys., 33, pp. 947-948, Sept., 1960.

Weil, H., see Morgan, S. P.

Williams, A. J., see Bozorth, R. M.

Wood, E. A., *The Unit Cell and Space Group of Gallium Iron Oxide a Piezoelectric Ferromagnetic Crystal*, Acta Crys., 13, p. 682, 1960.

PATENTS

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

Anderson, P. W.—*Non-Linear Reactance Amplification*—2,958,045.

Ashkin, A., Cook, J. S., Louisell, W. H., and Quate, C. F.—*Parametric Amplifier*—2,958,001.

Bode, H. W., and McSkimin, H. J.—*Selective Paging System*—2,955,279.

Bowers, F. K.—*Pulse Code Transmission System*—2,957,947.

Budlong, W. A., Drew, G. G., and Harr, J. A.—*Electronic Telephone Switching System*—2,955,165.

Collins, R. W.—*Combined Direct Dispatch Telephone Exchange Mobile Radio System*—2,957,048.

Cook, J. S., see Ashkin, A.

Courtney-Pratt, J. S.—*Improvements in or Relating to Electronic Image Forming Tubes*—841,200.*

*Listed with the British Patent Office.

Crawford, A. B.—*Electromagnetic Wave Transmission*—2,956,277.

Cutler, C. C.—*Heterodyne Systems Employing Trains of Pulses*—2,956,128.

Davey, J. R.—*Angle Difference Translator*—2,954,928.

DeMonte, R. W.—*Impedance-Matching Network*—2,957,944.

Dempsey, J. L., and McAlpine, R. K.—*Diode Gate Translator*—2,957,168.

Drew, G. G., see Budlong, W. A.

PATENTS (CONTINUED)

Edson, J. O.—*Frequency Band Compression*—2,957,948.

Elder, H. E., and McDowell, H. L. *Traveling-Wave Tubes*—2,956,-198.

Friis, H. T.—*Diversity System*—2,956,276.

Graham, R. E.—*Multilevel Quantizer*—2,956,157.

Greenidge, R. M. C., and Ranges, J. E.—*Plugging of Plastic Insulated Cable*—2,957,038.

Hagelbarger, D. W.—*Continuous Digital Error-Correcting System*—2,956,124.

Harding, P. A.—*Measurement and Elimination of Flutter Associated with Periodic Pulses*—2,958,043.

Harr, J. A., see Budlong, W. A.

Hefele, J. R.—*Facsimile Transmission System with Modification of Intermediate Time Signal*—2,956,115.

Holman, E. W., and Schmidt, W. C.—*Transistor Selective Ringing Circuit*—2,957,950.

Jaeger, R. P.—*Code Generator*—2,957,952.

James, D. B.—*Pulse Shift Monitoring Circuit*—2,956,180.

James, D. B., Johannesen, J. D., Karnaugh, M., and Malthaner, W. A.—*PCM Time Division Telephone Switching System*—2,957,949.

Johannesen, J. D., see James, D. B.

Karnaugh, M., see James D. B.

Kolding, A. R., and Packard, G. N.—*Speech Interpolation System*—2,957,946.

Kompfner, R., and Quate, C. F.—*Traveling-Wave Tube*—2,955,-223.

Larisch, R. W.—*Electrical Control Circuits*—2,957,088.

Long, T. R., and Wolfe, R. M.—*Ferroelectric Storage Device*—2,957,164.

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

Malthaner, W. A., see James, D. B.

Mallery, P.—*Magnetic Control Circuits*—2,955,212.

Mason, W. P.—*Electromechanical Torsional Band Pass Wave Filter*—2,955,267.

May, J. E., Jr.—*Ultrasonic Delay Line*—2,957,142.

McAlpine, R. K., see Dempsey, J. L.

McDowell, H. L., see Elder, H. E.

McSkimin, H. J., see Bode, H. W.

Mitchell, M. E.—*Phase Shift Voltage Comparator*—2,957,981.

Nielsen, J. W.—*Method of Making Single Crystal Garnets*—2,957,827.

Pace, F. P.—*Transistor Ring Counter with Bistable Stages*—2,957,091.

Packard, G. N.—*Timing Circuit*—2,957,945.

Packard, G. N., see Kolding, A. R.

Perry, A. D., Jr.—*Rapid Lock-In Flywheel Synchronizing System*—2,957,045.

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

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

Rack, A. J.—*A Pulse Code Device*—2,957,943.

Ranges, J. E., see Greenidge, R. M. C.

Rowen, J. H.—*Nonreciprocal Wave Transmission*—2,958,055.

Schmidt, W. C., see Holman, E. W.

Schwenzfeger, E. E.—*Translator*—2,956,265.

Sharpless, W. M.—*Millimeter Wave Crystal Rectifier*—2,956,-160.

Smythe, E. H.—*Object Location System*—2,956,274.

Vitalo, A. E.—*Testing System*—2,957,055.

Wennemer, G. P.—*Automatic Telephone System*—2,957,047.

Wolfe, R. M., see Long, T. R.

Ziegler, A. W.—*High Pressure Compression Seal Terminal*—2,957,041.

TALKS

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

AMERICAN CHEMICAL SOCIETY MEETING, New York, N. Y.

Dewald, J. F., *On the Activity Coefficient of Electrons in Zinc Oxide as Deduced from Double Layer Measurements.*

Frisch, H. L., and Wasserman, E., *Topological Chemistry of Closed Ring Systems: Catenanes, Knots and other Topological Varieties.*

Garrett, C. G. B., *Catalysis at a Semiconductor Surface.*

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

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

Lebowitz, J. L., see Helfand, E.

Nelson, L. S., *Kinetic Spectroscopy of Methane Pyrolyzed on Flash-Heated Grids.*

Reiss, H., see Helfand, E.

Snyder, L. C., *Huckel M. O. Computations to Describe the Benzidine Rearrangement.*

Story, P. R., *7-Substituted Norbornadienes.*

Trozzolo, A. M., *Charge-Transfer Complexes. Unusual Phase Equilibria.*

Wasserman, E., *The Preparation of Interlocking Rings.*

Wasserman, E., see Frisch, H. L.

Whelan, J. M., *Purification of Arsenic.*

Worthington, M. A., and Hawkins, W. L., *Synergistic Antioxidant Combinations. I. Diphenoquinones and Sulfur Compounds and Synergistic Antioxidant Combinations. II. Hydrocarbons and Sulfur Compounds.*

www.americanradiohistory.com

FERMI SURFACE CONFERENCE, Cooperstown, N. Y.

Hsu, F. S. L., see Kunzler, J. E.

Klauder, J. R., and Kunzler, J. E., *Higher Order Open Orbits and the Interpretation of Magnetoresistance and Hall-Effect Data for Copper.*

Kunzler, J. E., and Hsu, F. S. L., *Magnetothermal Oscillations and the Fermi Surface.*

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

FIFTH NATIONAL TUBE TECHNIQUES CONFERENCE, New York, N. Y.

Caldwell, C. W., *Carbon Diffusion vs. Thermionic Emission in Nickel Based Oxide Cathodes.*

Graney, E. T., *A Comparison of Oxide Cathode Emitters in Corning's 7052 and 7056 Glasses.*

Pfahnl, A., *Aging of Electronic Phosphors in Cathode Ray Tubes.*

INTERNATIONAL CONFERENCE ON SEMICONDUCTOR PHYSICS, Prague, Czechoslovakia

Ditzenberger, J. A., see Whelan, J. M.

Feher, G., *Electron Spin Resonance Experiments on Shallow Donors in Germanium and Silicon.*

Flood, W. F., see Haynes, J. R.

Garrett, C. G. B., read by Hannay, N. B., *Organic Semiconductors.*

Hannay, N. B., see Garrett, C. G. B.

Hannay, N. B., see Whelan, J. M.

Haynes, J. R., Lax, M., and Flood, W. F., *The Role of Excitons in Recombination Radiation from Silicon.*

Haszko, S. E., see Wolfe, R.

Hopfield, J. J., and Thomas, D. G. *Magneto-Optic Absorption Spectrum of CdS.*

Kaiser, W., *Electrical and Optical Properties of Oxygen in Silicon and Germanium.*

Lax, M., see Haynes, J. R.

Morin, F. J., *Halides, Oxides, and Sulfides of the Transition Metals.*

Struthers, J. D., see Whelan, J. M.

Thomas, D. G., see Hopfield, J. J.

Wernick, J. H., see Wolfe, R.

Whelan, J. M., Struthers, J. D., Ditzenberger, J. A., read by Hannay, N. B., *Effect of Silicon in Gallium Arsenide.*

Wolfe, R., Wernick, J. H., and Haszko, S. E., *The Properties of Silver Antimony Telluride.*

INTERNATIONAL LOW TEMPERATURE PHYSICS CONFERENCE, Toronto, Canada

Brennert, G. F., see Kunzler, J. E.

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

Klauder, J. R., and Kunzler, J. E., *Open Orbits and the Fermi Surface of Copper from Magnetoresistance and Hall-Effect Data.*

Kunzler, J. E., Klauder, J. R., and Brennert, G. F., *Anisotropy in the Hall Effect and Magnetoresistance of Single Crystals of High Purity Copper.*

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

INTERNATIONAL SYMPOSIUM ON DATA TRANSMISSION, Delft, Netherlands

Bennett, W. R., and Froehlich, F. E., *Effectiveness of Error Control Procedures in Digital Data Transmission.*

Bennett, W. R., and Froehlich, F. E., *Techniques for Comparing Modulation Methods for Data Transmission over Telephone Channels.*

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

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

OTHER TALKS

Allen, F. G., *Field Emission Microscope Studies of Silicon and Germanium Surfaces*, Linfield Research Institute, McMinnville, Ore.

Andrews, F. T., Jr., *Standard Data Transmission Tests*, A.I.E.E. Fall General Meeting, Chicago, Ill.

Christensen, H., see Theuerer, H. C.

Coutless, K. G., *A Liquid Displacement Test Method for Determining the Anisotropic Dielectric Properties of Printed Wiring Boards*, NRC Conf. on Electrical Insulation, Washington, D. C.

Darnell, P. S., *Electronic Components and the Future*, Am. Ord. Assoc., Electronics Division, Pacific Missile Range. Point Mugu, Calif.

Dimock, P. V., *Data Transmission Performance on Long-Haul Telephone Facilities*, National Electronics Conf., Chicago, Ill.

Felsberg, A. T., *Holmdel Laboratory*, Freehold Rotary Club, Freehold, N. J.

Frost, J. J., see Mason, W. P.

Gambrill, L. M., *The Unicom Systems-Engineering Plan*, National Symposium on Global Communications, Washington, D. C.

Garn, P. D., *An Evaluation of Past and New Techniques in Thermal Analysis*, Perkin-Elmer Corp., Norwalk, Conn.

Garrett, C. G. B., *Catalysis at a Semiconductor Surface*, Gordon Research Conf. on Semiconductors, N. H.

Grubbs, W. J., Jr., *Hall-Effect Devices*, I.R.E., Winston-Salem, N. C.

Gupta, S. S., *Gamma Distribution as a Model for Life and Acceptance Sampling in Life Tests*, Am. Statistical Assoc., Stanford University, Stanford, Calif.

Gupta, S. S., *On the Distribution of the Ratio of the Largest of Several Chi-Squares to an Independent Chi-Square*, Am. Statistical Assoc., Stanford University, Stanford, Calif.

Hannay, H. B., *Mass Spectroscopy of Solids*, Appl. Spectroscopy Soc., Cleveland, Ohio.

Harmon, L. D., *Machine Reading of Cursive Script*, Fourth Lon-

www.americanradiohistory.com

don Symposium on Information Theory, London, England.

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

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

Haynes, J. R., *The Role of Excitons in Recombination Radiation from Silicon*, Royal Radar Establishment, Worcestershire, England; University of Moscow, Moscow, U.S.R.R.

Hogg, D. C., *Problems in Low Noise Reception of Microwaves*, National Symposium on Space Electronics and Telemetry, Washington, D. C.

Hopkins, I. L., *Stress-Strain Relations in Cross-Linked Polyethylene*, A.S.M.E. Rubber & Plastics Conf., Erie, Pa.

Hopper, A. L., *An Improved Method of Gain Control for Transistor I.F. Amplifiers*, National Electronics Conf., Chicago, Ill.

Jakes, W. C., Jr., *Bell Laboratories Participation in Project Echo*, Monmouth County Subsection I.R.E., Little Silver, N. J.

Jenkins, H. M., *The Role of Partial Reinforcement in Discrimination Learning*, MIT, Lincoln Laboratory, Lexington, Mass.

Kreer, J. G., Jr., *Elementary Information Theory, Its Early History*, West Virginia University E.E. Graduate Seminar, Morgantown, W. Va.

Kreer, J. G., Jr., *Standards Activities of the A.I.E.E./I.R.E.* Student Section, West Virginia University, Morgantown, W. Va.

Kunzler, J. E., *Some Solid-State Physics Investigations Involving the Measurement of Very Small Amounts of Energy*, Calorimetry, Conf., Gatlinburg, Tenn.

Logan, B. F., see Schroeder, M. R.

Lowry, W. K., *Systems Engineering Approach to Documentation Problems*, Advisory Gp. for Aeronautical Research and Development, Istanbul, Turkey.

Mason, W. P., Forst, J. J., and Tornillo, L. M., *Recent Developments in Semiconductor Strain Transducers*, Instrument Soc. of Am., N.Y.C.

McAfee, K. B., Jr., *Diffusion-Separation of Helium Through Glass Barriers*, Am. Inst. Chem. Engineers Forty-third Meeting, Tulsa, Okla.

McDonald, H. S., *A Note on the Use of Glow Modulator Lamps for Studies of Vision*, Optical Soc., Boston, Mass.

McMillan, B., *A Calculus of Information*, Stanford University, Stanford, Calif.

Mendizza, A., *Corrosion Problems in the Bell System*, Am. Electroplaters Soc., Chicago, Ill.

Morrison, J. A., *Bounds on the Nonlinear Diffusion Controlled Growth Rate of Spherical Precipitates*, Am. Math. Soc., East Lansing, Mich.

Peek, R. L., Jr., *Magnetization and Pull Characteristics of Mating Magnetic Reeds*, A.I.E.E. Fall General Meeting, Chi., Ill.

Pierce, J. R., *Military Communications, 1970 and Beyond*, Sixth National Communications Symposium, Rome-Utica Section of I.R.E., Utica, N. Y.

Pierce, J. R., *Satellite Communication*, Detroit Engineering Soc., Detroit, Mich.

Pierce, J. R., *Science and Progress in Space*, Sixth National Communications Symposium, Rome-Utica Section of I.R.E., Utica, N. Y.

Pierce, J. R., *Some Technical Aspects of Satellite Communication*, XIII General Assembly of International Scientific Radio Union, London, England.

Pollak, H. O., *The Role of Industrial Members in the Mathematical Association of America*, Math. Assoc. of Am. Section Officers, Lansing, Mich.

Quirk, W. B., *Field Trial of an Experimental Electronic Telephone Switching System*, A.I.E.E. General Fall Meeting, Communication Switching Session, Morris, Ill.

Rand, M. J., *Moisture Gettering with Porous Vycor*, Electrochem. Soc., Houston, Tex.

Saunders, R. L., Jr., *Graphic Arts Applications in the Records Management Field*, Assoc. of Record Executives and Administrators, N.Y.C.

Schroeder, M. R., and Logan, B. F., *"Colorless" Artificial Reverberation*, Audio Engineering Soc., N.Y.C.

Simpkins, E. G., *Work Simplification*, Special Libraries Assoc., N. J. Chapter, Mt. Bethel, N. J.

Sperling, G., *Short Term Storage of Information in Vision*, Fourth London Symposium on Information Theory, London, England.

Sperling, G., *Visual Information Storage*, Sixteenth International Congress for Psychology, Bonn, Germany.

Steinberg, P. L., *Resistance of Organic Materials to Marine Bacterial Attack*, Soc. Ind. Microbiology Annual Meeting, Oklahoma State University, Stillwater, Okla.

Theuerer, H. C., and Christensen, H., *Epitaxial Films of Silicon and Germanium by Halide Reduction*, Electrochem. Soc., Houston, Tex.

Thomas, U. B., *Battery Considerations for a Communications Satellite*, Am. Rocket Soc. Space Power Systems Conf., Santa Monica, Calif.

Tornillo, L. M., see Mason, W. P.

Trumbore, F. A., *Heavily Doped Materials for Esaki-Tunnel Diodes*, A.I.M.E. Meeting, Boston, Mass.

www.americanradiohistory.com

Turner, D. R., *A Simple Method for Monitoring the Chemical Etching Rate of Germanium and Silicon*, Electrochem Soc. Meeting, Houston, Tex.

van Bergeijk, W. A., and Harmon, L. D., *What Good Are Artificial Neurons?* Bionics Conf., Dayton, Ohio.

Van Wynen, K. G., *Technical Developments and Implications for Personnel*, Personnel Relations Conf., Mich. Bell Tel. & Tel. Co., Detroit, Mich.

Wagner, R. S., *On the growth of Germanium Dendrites*, A.I.M.E., Inst. of Metals Division, N.Y.C.

Weber, L. A., *An Experimental Four Phase Modem*, A.I.E.E. Fall General Meeting, Chicago, Ill.

Weick, W. W., *Current-Carrying Capacity of Printed Circuits*, Printed Circuit Symposium, Greensboro, N. C.

Westover, R. F., *Effect of Hydrostatic Pressure on Polyethylene Melt Rheology*, Soc. Plastics Engineers Tech. Conf., Chicago, Ill.

Whelan, J. M., *Interaction of Holes, Electrons and Electrically Active Impurities in Gallium Arsenide*, Gordon Conf., N. H.

Worthington, M. A., and Hawkins, W. L., *Novel Thermal Antioxidants Formed by the Interaction of Sulfur Compounds with Synergistic Agents*, Tenth Canadian High Polymer Forum, Montreal, Canada.

THE AUTHORS

W. H. Seckler

W. H. Seckler, a resident of Williston Park, Long Island, joined the Laboratories in 1935. His early work was concerned with the development of various kinds of electron tubes. After transferring to the Systems Engineering Department in 1949, Mr. Seckler participated in studies of various AMA projects. Later, he was involved with special signaling and alerting systems used by the Telephone Operating Company's civilian and military customers. In this capacity, he participated in the engineering of alerting and communication networks for the Strategic Air Command, for the Joint Chiefs of Staff and other military applications. Mr. Seckler attended Brooklyn Polytechnic Institute. He is co-author of "A New Group-Alerting System," in this issue.

J. Orost, a resident of Elberon, N. J., joined the Laboratories in 1951. At that time he was responsible for the design and development of service-observing circuits for the military. This work led him into the broader aspects of announcement systems. Later, he was concerned with the expanded recorded announcement facilities associated with the Weather Bureau and time-of-day. Recently, Mr. Orost developed the 8A and 9A Announcement Systems used for commercial services, such as sponsored weather and news. In developing the central-office group-alerting system he adopted the telephone to meet the needs of volunteer firemen and other groups requiring emergency alerting systems. Mr. Orost is co-author of "A New Group-Alerting System," in this issue.

J. Orost

F. A. Zupa

Frank A. Zupa, after about six years on apparatus and materials testing in the former Physical Laboratory, has been engaged in design and development work on practically all of the armature-type relays and magnets used in Bell System switching circuits. The most notable of this work—relays which are still in large production—are the Y type (slow-release relay), the UA type (heavy- and medium-duty sensitive relays), the modernized EA type (line and cut-off relays) and the B type (supervisory relays). In military engineering work during World War II, he was responsible for the packaging and production design of an optical proximity fuse. Mr. Zupa, a native of New York City, obtained his early technical training by attending evening sessions at the Col-

www.americanradiohistory.com

lege of the City of New York and received the degree of B.S. in E.E. from Cooper Union in 1922. In this issue he is the author of "Magnetic - Latching Crossbar Switches."

H. E. Kern, author of the article, "Research on Oxide-Coated Cathodes," is a native New Jerseyite. He received his B.S. degree in Physical Sciences from the Polytechnic Institute of Brooklyn in 1949. During World War II he was engaged in work on the Manhattan Project at the Laboratories, after which he entered his present field of study—oxide-coated cathodes. As a member of the Semiconductor Research Department his efforts have been directed toward a more complete understanding of the perverse physio-chemical nature of the oxide-coated cathode. He has also contributed to the development of cathodes for specific tube types, such as the W.E.-416 microwave triode, submarine-cable tubes, magnetrons, traveling-wave tubes and klystrons. Mr. Kern is a member of the American Vacuum Society, the American Society for Testing Materials and Phi Lambda Upsilon.


F. R. Bies

F. R. Bies, born in Brooklyn, N. Y., joined Bell Laboratories in 1925. He graduated from Cooper Union in 1930 with a B.S. degree in Electrical Engineering. As a member of the transmission network group at the Laboratories, he has worked on the development of quartz crystals and electrical filters for long- and short-haul carriers systems. In 1956 Mr. Beis transferred to the Merrimack Valley Location of the Laboratories and at present is concerned with the development of filters and equalizers for the broadband carrier terminal. He is the author of the article "Canaveral Test Range: Filters and Equalizers for Unattended Repeaters."


H. E. Kern

www.americanradiohistory.com