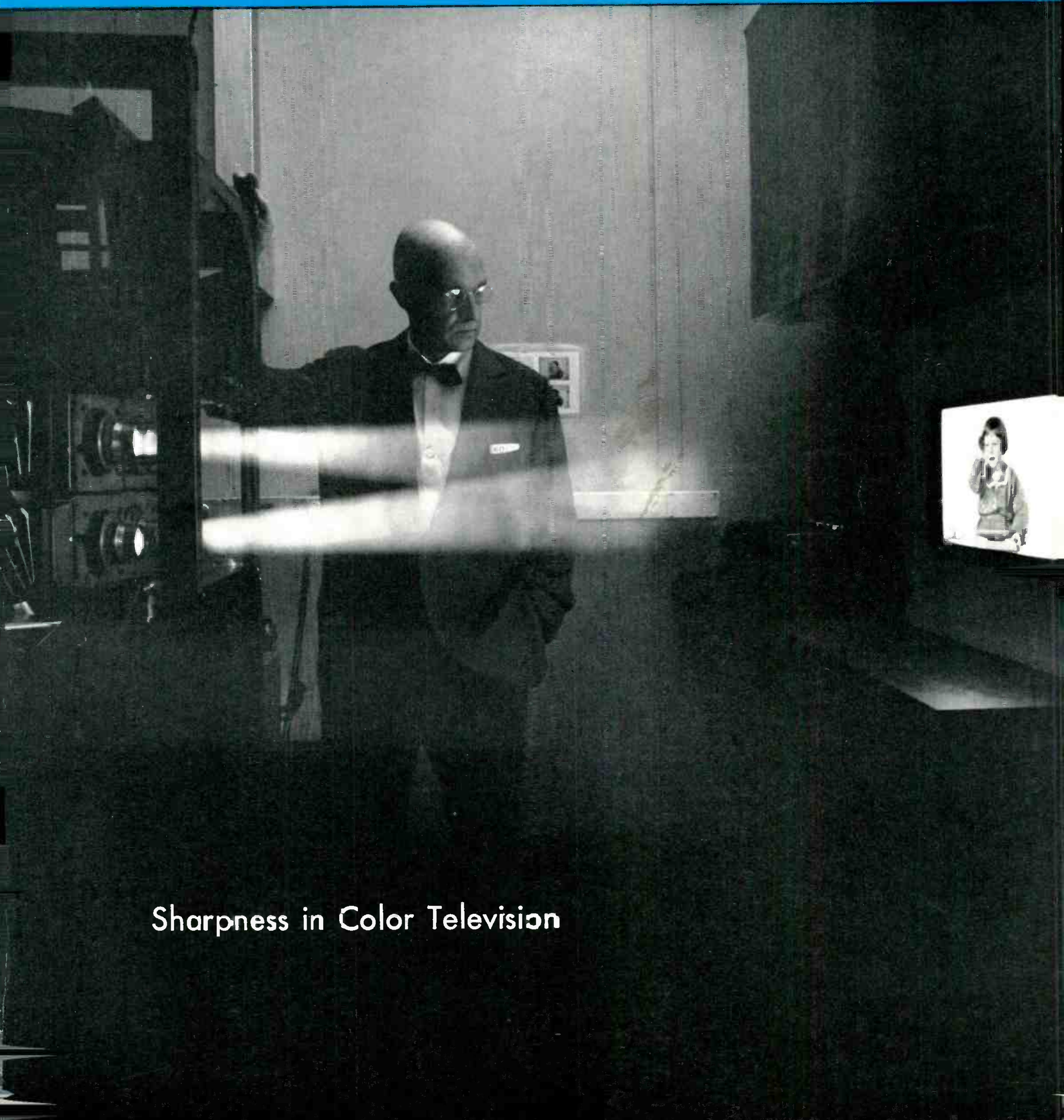
Bell Laboratories

RECORD

Volume XXXV

Number 12

December 1957



Sharpness in Color Television

Bell Laboratories RECORD

CONTENTS

Simulating Sharpness in Color Television. *M. W. Baldwin, Jr.*	481
A Modern Crossbar PBX. *O. H. Williford*	485
The "Twistor" Memory Device	488
Telephone Communications for RAPCON Centers. *G. A. Giddings*	490
Propagation of Millimeter Waves Through the Atmosphere, *A. B. Crawford and D. C. Hogg*	494
Microdeviometer for Evaluating Periodic Structures	498
Cable Splicing Goes Modern, *W. C. Kleinfelder*	499
F. R. Kappel Addresses Independents' Association	502
Automatic Calculation of Transmission Deviations. *R. C. Nance*	503
Welding at Relay Contacts	508
Lightning Protection of TD-2 Stations. *D. W. Bodle*	509
A Printer-Comparer-Scanner for AMA. *Miss M. E. Pilliod*	512

THE COVER: Converging beams of red, blue and green light produce image for Bell Laboratories' study of subjective aspects in color television. (See opposite page.)

The BELL LABORATORIES RECORD is published monthly by Bell Telephone Laboratories, Incorporated, 463 West Street, New York 14, N. Y., M. J. KELLY, President; M. B. LONG, Secretary and Treasurer. Subscriptions: $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.

Simulating Sharpness in
COLOR TELEVISION

Color television bears out well the adage, "beauty is in the eye of the beholder," since only the human eye can measure "sharpness." This purely subjective quality of video depends on the many complex parameters of a television system. Because Bell System transmission facilities are frequently a part of such systems, a color television simulator has been devised at the Laboratories to help answer some of the basic questions about sharpness.

M. W. BALDWIN, JR. *Visual and Acoustics Research*

From time immemorial man has made pictures in color. Before modern times all pictures were made by hand, and any faults in form or color could be attributed to the artist's lack of skill. As the scientific understanding of picture-making increased, this better understanding led to the introduction of new techniques. Complete freedom from hand reproduction became possible about a century ago, with the invention of photography. This revolutionary advance brought with it, of course, new kinds of picture faults that required increased scientific understanding. Photography has progressed rapidly – nowadays we make pictures that move, we make them in full color, and most of us take them quite for granted.

The youngest of the arts of picture-making is color television. This new art has released us from some of the limitations imposed by the dyes and processes used in color photography, but not without cost. The very complexity of television apparatus results in a host of new picture faults to be understood and overcome.

To increase our understanding of some of these faults, the Visual and Acoustics Research Department at Bell Laboratories has for some time used a "defocusing" projector. The chief function of this projector is to make color pictures that are measurably blurred. This unusual research tool can also produce a full color image that looks like the picture one might see on a color television receiver. The blurring that results from out-of-focus projection can then be used to simulate the blurring that results when a color television picture is transmitted over a circuit of limited bandwidth.

In the future, the Bell System may be called upon to transmit television signals which will produce color pictures sharper than those presently broadcast for home entertainment. By being able to simulate such color television pictures right now, it is possible to study some of the factors which influence sharpness.

Color television pictures are produced by a three-color additive process. The picture tube produces a separate and complete image in each of the primary colors – red, green and blue – and these three pictures are superimposed on the screen of the tube. The controlled addition of three colors at every point on the screen can produce whatever color is required at each point to build up a full color image on the viewing screen.

The defocusing projector, shown in Figure 1, also makes color pictures by an additive process.

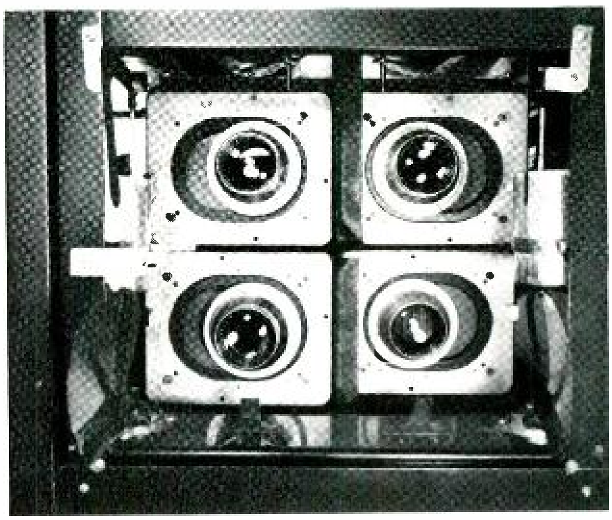


Fig. 1 — Front view of the defocusing projector showing the four individual projector lenses.

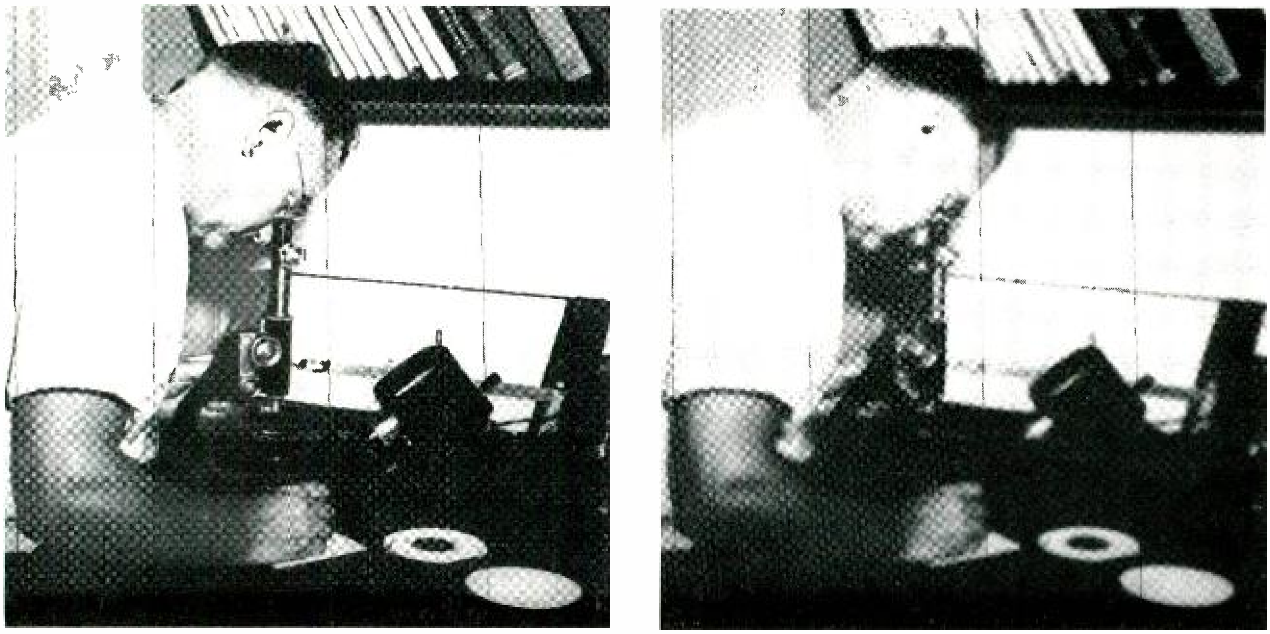


Fig. 2 — The vertical reference lines on the screen show that these two pictures are the same size.

as a proper simulator should. The projector, or more accurately, the projection machine, is actually composed of four projectors, with independent focusing adjustments, directed at a common projection screen. The machine projects separate pictures, one in red light, one in green light and one in blue light onto the screen, where the additive process takes place. The viewer sees only the sum of these three pictures, or a full color image. The fourth projector is available for showing a comparison picture if needed.

A basic requirement, when separate images are projected to make a color picture, is that the separate images remain in good register on the screen. The machine would not be useful for sharpness studies if the effects of focus adjustment were to be contaminated by misregistration. In other words, image size and centering must both remain fixed while the focus changes.

The optical principle used to maintain constant magnification with variable focus is a simple one. Taking an ordinary home slide projector as an example, we know that the picture gets larger as the projector is moved farther from the screen. We also know that the picture goes in and out of focus as the lens is moved back and forth on the projector. Likewise, movement of the lens causes the picture to change size. If one could move the whole projector back and at the same time move the lens forward on the projector by the proper distance, he could keep the picture from changing size. The increase in size due to moving the projector back would cancel out the decrease in size due to moving the lens forward, yet the picture would go out of focus. Figure 2 illustrates projections of the same slide and shows that the two images are exactly the same size, even though the picture on the right is obviously out of focus.

To make possible the precise motions and optical relationships necessary to get a constant-size picture of variable focus, a well-known mechanism

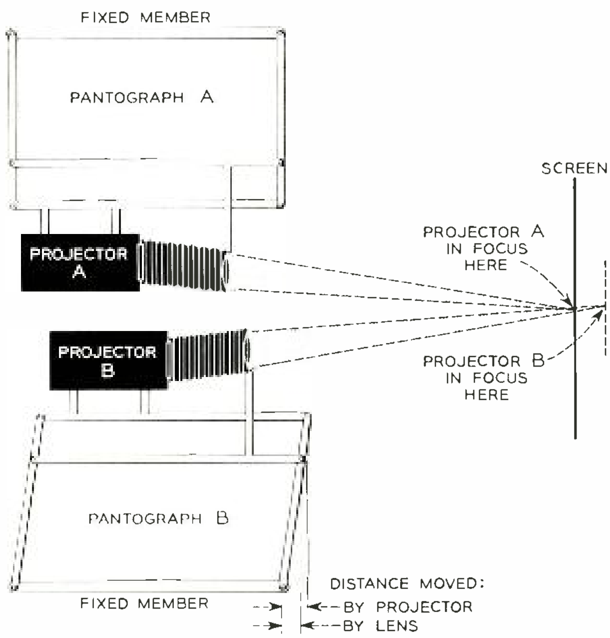


Fig. 3 — Pantograph maintains spacing of projector and lens for in- and out-of-focus projection.

— the pantograph — is used. The pantograph, which is simply a geometric parallelogram with pivots at the corners, provides exactly the motions required. Figure 3 shows how the pantograph was adapted to this use. The pantographs as they appear in the simulator are shown in Figure 5. A bellows, seen between the slide carrier and the lens, accommodates the relative motion of these parts as the projector moves in its focusing and defocusing action. The bellows stretches about ⅜ of an inch when the whole projector moves back two inches. The two projectors on the other side are mounted in the same way.

The four projectors are mounted so that the projection lenses and lantern slides are all squared onto, or held parallel to, the screen. The centers of the lenses are closer together than the centers of the slides. The resulting projection is known

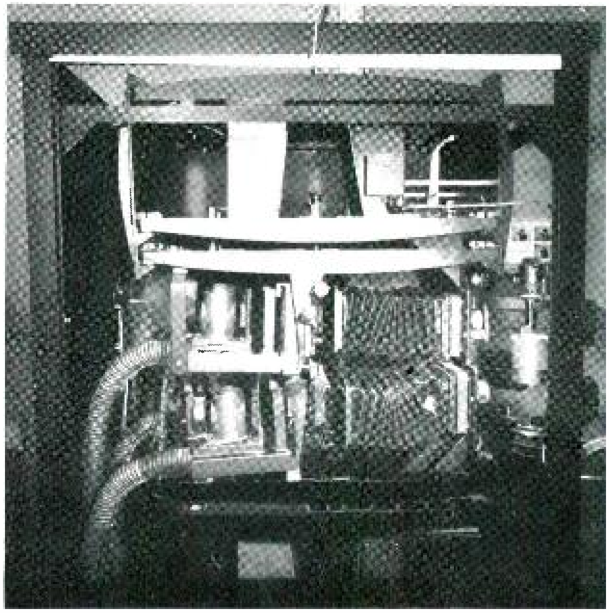


Fig. 5 — Side view shows top pantograph as it actually looks in the projection machine.

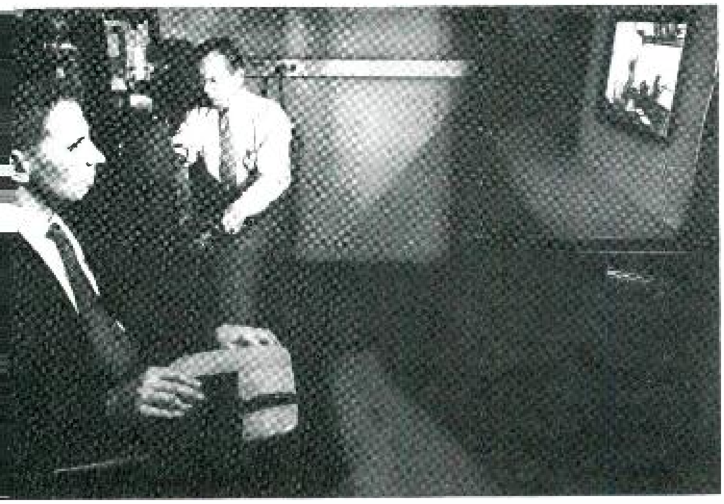


Fig. 4 — The observer, E. Averbach, tells the operator, G. Nielsen, when he thinks the sharpness of this picture matches that of a comparison picture.

as off-axis projection, because the center of the image is a few degrees off the optical axis of each lens. This kind of projection insures perfect registration of the images on the screen at all times and eliminates "keystone" distortion — an image irregularity that would result if the projectors were not squared onto the screen. The keystone effect, to describe it simply, is the tapered shape a rectangular picture assumes when projected at an angle. The slightly tapered keystone shape, which is ordinarily not objectionable, would make image registration impossible. The illuminating systems are "toed-in" so that they all point toward the center of the screen to improve the uniformity of coloring over the field.

This machine performs well because all of its parts have been made and aligned with precision. The lengths of corresponding sides of the pantographs differ by less than one thousandth of an inch. The lantern slides and the lenses are squared onto the screen to better than five minutes of arc. The in-focus magnifications of the four projectors are equalized to better than one part in 2,000. As a result, the separate images on the screen, whether in sharp focus or not, are in register to within the limits of unaided vision.

A most important part of this projection machine is its control system. Each of the four projectors is actuated by small hydraulic controls which move the projectors slowly and smoothly and hold them firmly in position. Small indicating units monitor the individual projector positions and transmit these positions to indicator dials mounted on the control panel.

The indicator dials, in effect, relate the focus condition of individual projectors to the sharpness of the color picture on the screen. The sharpness of a three-color additive picture — a purely subjective quality — can only be judged by an observer. In a typical experiment, the observer examines a picture in the "test condition" (the three projectors out of focus by different amounts) and then examines a picture in the "gauging condition" (the three projectors out of focus by the same amount). The observer then adjusts the gauging condition to be equally as sharp as the test condition. Figure 4 shows the projector as it is used with an observer. The indicator dial readings called for by the observer in making this sharpness match are then recorded by the operators and can be translated into bandwidth information by a straightforward calibration procedure.

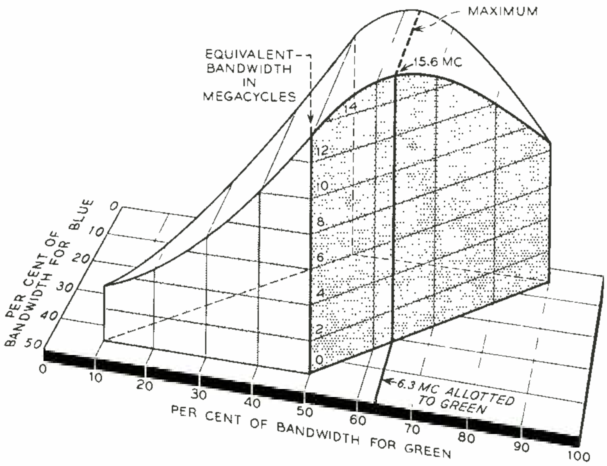


Fig. 6 — Equivalent bandwidths of a 10-mc, three-color picture show the line of maximum sharpness.

A three-dimensional plot of the sharpness-match data from ten observers, statistically analyzed and put into terms of bandwidth, is presented in Figure 6. The percentages of the total band of ten megacycles allotted to blue and green are shown on the base plane. Red would, of course, occupy the remainder of the band. The equivalent bandwidth of the gauging picture (all three projectors focused identically) is plotted vertically. All of the points on the vertical, or equivalent-bandwidth, axis form the top surface of the plot. Wherever the surface lies above ten megacycles, the color picture looks sharper than would the picture transmitted by a ten-megacycle band equally apportioned. The maximum sharpness — equivalent to a 15.6-megacycle picture — occurs when 63 per cent of the total band is allotted to green. In other words, a ten-megacycle test picture (each projector out of focus by a different amount) with 6.3 megacycles devoted to green looks just as sharp as a 15.6-megacycle picture with 5.2 megacycles devoted to each color. It is also interesting to note that the remaining 37 per cent of the total band can be allotted to red and blue in any proportion.

Many experiments of this type have been performed by engineers at the Laboratories and elsewhere, some of them earlier than this one, and they all point toward the same conclusion: television in three colors can be made to look just as sharp as television in monochrome without paying the price of three times the bandwidth. Such information is the foundation of the latest system of color television transmission adopted by the Federal Communications Commission.

In practical terms, television researchers want to know whether the color picture sent by one television system will look sharper than that sent by another. This color television simulator is helping to fit together some of the pieces of this larger puzzle. In addition to increasing our understanding of some of the complex problems involved in the transmission of color television signals, this projection machine has also made some valuable contributions in the field of visual acuity in color.

THE AUTHOR

M. W. BALDWIN, JR., a native of Portland, Maine, received the E.E. degree from Cornell in 1925 and the M.A. degree from Columbia in 1928. He joined Bell Laboratories in 1925, and has been associated with the Research Department since that time. His primary concern has been television research, with particular emphasis on subjective aspects. During the war he was involved in the development of an automatic tracking anti-aircraft radar. He is a member of Eta Kappa Nu and of Tau Beta Pi. He is a Fellow of the I.R.E., and is currently Chairman of its Standards Committee.

A Modern Crossbar PBX

O. H. WILLIFORD
Special Systems Engineering I

Private Branch Exchange (PBX) customers differ widely in their telephone requirements — some have only a few extensions and others have thousands of extensions in hotels, department stores, and large industrial establishments. Most businesses, however, require less than sixty extensions, and demand has been increasing for a modern dial PBX system to serve such customers. The new 756A PBX is a small "packaged" design that matches the decor of modern offices. In addition to the conventional PBX services, the 756A provides a "camp-on" feature to permit automatic connection when a line becomes free.

To most people, a PBX is a telephone switchboard, frequently located in or near the reception room of a business establishment and used for servicing calls over the company's telephone extensions. In a dial PBX, however, the switchboard is only one part of the total equipment; much of the work of interconnecting telephones is done automatically by electromechanical switches. The switchboard in a dial installation might thus be considered as a sort of "control panel," with the relays, switches, and other equipment out of sight.

In small manual PBX systems, much or even all of the "behind-the-scenes" equipment can be mounted within the switchboard itself. On the other hand, even a small dial system requires switching equipment and power equipment mounted in additional cabinets. As a consequence, the installation of present-day systems occasionally offers difficulties because a particular building may have narrow doors, too small an elevator, or insufficient floor bracing. These problems have been solved by the new 756A crossbar dial PBX developed at the Laboratories.

Many telephone customers requiring dial PBX service have between 20 and 60 extension lines and 10 or fewer central-office trunks, and the most economical arrangement for serving this field is to provide only one or two "packaged" systems. The 756A is a small packaged design supplied in capacities of either 40 or 60 lines and equipped for 6 central-office trunks. Four additional central-office trunks can be added as desired. The basic switching components are crossbar switches and wire-spring relays. The 756A is also the first equipment to use the recently-developed "2-in-1" wire-spring relay that provides two relays in the space normally required for one.

Physically, the entire PBX is housed in two modular cabinets of steel and aluminum (Figure 1). The depth and height are similar to those of standard office filing cabinets, and all maintenance is done from the front. Each module contains three small relay racks arranged so that they can be pulled forward out of the module like vertical file drawers. Each rack mounts on ball-bearing telescoping slides. Interlocking latches prevent more than one rack being pulled out at a time and, since each weighs about the same, the combined weight of the other two racks is sufficient to keep the cabinet steady. For this reason there is no need for floor bolts when installing this system.

The PBX cabinets are designed for mounting in regular office space, along with file cabinets or other office furniture. Since an extended rack projects no further than a standard file drawer, the aisles do not need to be widened. The cabinets are of modern styling, finished in a shade of beige-gray that has become popular in office furniture. Sound-absorbing material reduces the noise of the switching equipment. The PBX is connected to the office wiring by plugs and pre-arranged jacks.

A total of three equipment modules are provided, from which the twin-module 40-line or 60-line 756A may be constructed. One module is common to both 40 and 60 lines, and the second contains additional equipment for either the 40-line or the 60-line system. A new modern attendant's console, shown in the illustration at the head of this article, has sufficient capacity to handle all ordinary calls requiring the assistance of an attendant. This console features push-button keys and simplified operation. Since it is assumed that the attendant will have other duties as a secretary or receptionist, the console is small enough for table- or desk-top mounting.

Smaller systems may use a six-button telephone set instead of the console. With some installations a switchboard may be more desirable than either the console or the six-button set. In such cases the

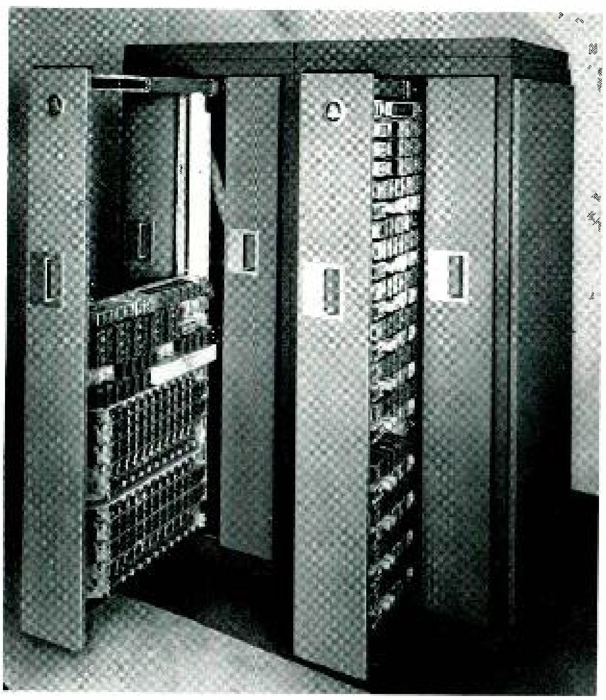


Fig. 1 — The 756A crossbar PBX dial equipment.

60-line system can be used with a switchboard.

The power supply is completely self-contained, and is mounted in the first or basic module. Commercial 115-volt, 60-cycle ac is stepped down in voltage, rectified, and filtered to produce 48 volts dc for use in the PBX. The filter contains a large capacitor that stores sufficient electrical energy to maintain the voltage during momentary interruptions of the commercial supply. Where interruptions are apt to be of appreciable length, an additional modular cabinet can be supplied. This cabinet contains storage batteries as a reserve power source, and a rectifier keeps the batteries charged. Ringing current, signaling tones, and flashing interruptions are generated by equipment in the power-supply unit regularly furnished.

While most present-day dial PBX's use step-by-step switches, the 756A achieves small size and faster operation by using crossbar switches and common-control principles. It operates essentially as a small crossbar office; register circuits connect to calling lines and trunks to supply dial tone and receive called numbers. The called numbers are passed to a marker which determines the busy and idle state of called points, performs an idle-hunting function for grouped lines and trunks, and controls the establishment of talking connections. The crossbar switches establish all connections.

Although only one marker is supplied, it actually contains two independent marker channels, used alternately on successive calls. Should trouble be encountered, the marker "times out" and makes a second trial using the other channel. The two registers are also used alternately unless one is busy. Busy tone is normally supplied by a busy-tone trunk but, should this trunk itself be busy, the marker operates a relay in the appropriate register, and the register supplies busy tone. Troubles are indicated by lamp displays.

All conventional PBX services are available with the 756A. Calls to extensions are placed by dialing two digits; with two to seven as the number in the initial digit. Calls requiring the attendant are placed by dialing zero. Dialing an initial 9 causes connection to an idle central-office trunk and the calling station line receives a second dial tone from the central office. Where certain extensions are restricted from direct outside dialing, users must dial 0 for the attendant and ask her to get the number. If they dial 9, they will be intercepted and transferred to the attendant. Also, certain extensions, while not restricted from dialing local outside calls, will also be intercepted if used to dial the code reserved for long-distance telephone calls.

Inward calls from a central office first cause the attendant to be signaled. She answers a trunk by its key appearance on the console and asks for the desired called party. She then operates a key to summon a register which furnishes dial tone, and then either keys or dials the desired extension number into the PBX equipment. The trunk is connected to the desired station which receives ringing current, and subsequent talking battery from the central office. The attendant may split the connection when desired until after conversation with the called party begins. After the attendant releases her keys, she may be recalled by the called party operating his switch-hook momentarily. Disconnects take place automatically without involving the attendant.

A "camp-on" feature has been included in the 756A for inward calls from a central office. If the called station is busy, the attendant is so notified and can advise the calling party that he may wait if he wishes. After the attendant releases from the call, the trunk will "camp-on" until the line is free. As soon as the first call disconnects, the trunk is automatically cut through to the called line and applies ringing current. No further assistance is required from the attendant. This feature reduces waiting time for inward calls to busy lines and frees the attendant for other duties.

The central office provides talking current for both inward and outward calls, and also provides current to ring the PBX attendant on inward calls. For intra-PBX calls – those between two extensions – ringing and talking current are supplied by the PBX. An additional circuit, called an "intercom"

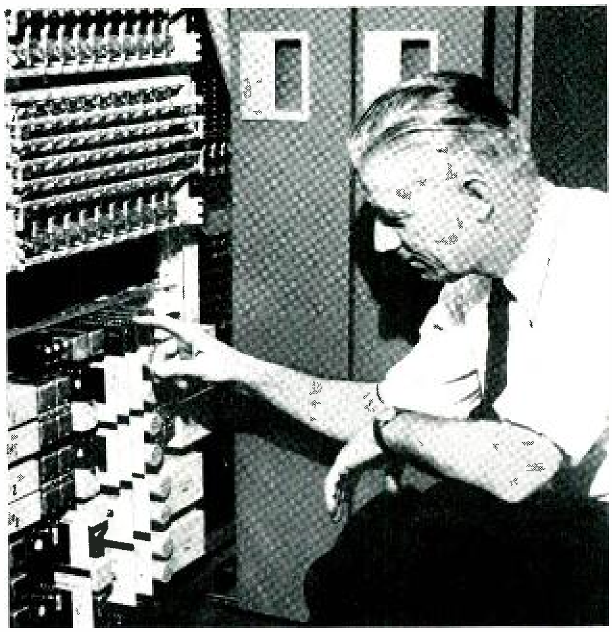


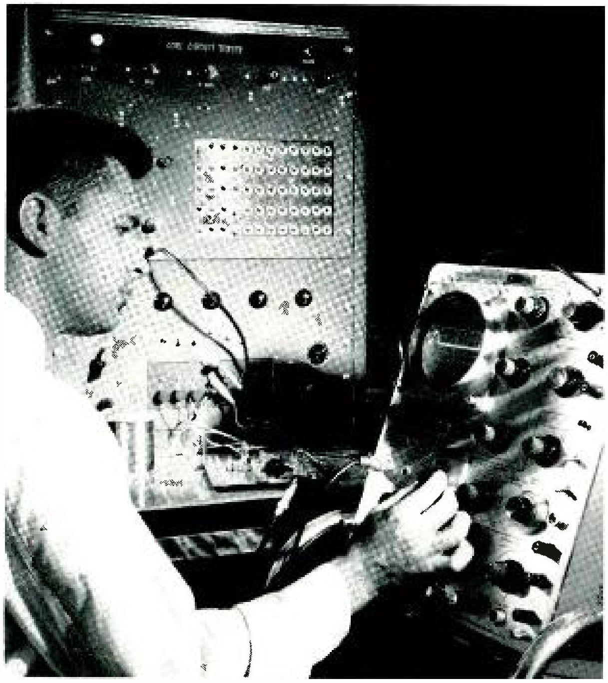
Fig. 2 — The 756A PBX circuitry being inspected at the Cleveland, Ohio, trial installation.

trunk, or junctor, is brought in on this type of call to supply the necessary currents and signals. Outward trunks to other PBX's are reached by dialing 8, and calls over these trunks are handled in the same manner as outgoing calls.

This new PBX, modern in design and appearance, should fill the telephone needs of today's smaller businesses. The ease of installation and maintenance, the adaptability of its size and modular construction to the requirements of modern offices, and the new features offered should make the 756A system attractive both to customers and to the Operating Telephone Companies.

THE AUTHOR

O. H. Williford, whose home town is Greenwood, Miss., joined the Laboratories in 1920 and initially engaged in laboratory and field testing of step-by-step, panel, manual and No. 1 crossbar systems. During World War II, he was associated with various military projects, and at the close of the war he became concerned with the development of the No. 5 crossbar system, particularly in the design of the maintenance facilities. He was an active member of the group representing the Laboratories during the installation and cutover of the first No. 5 system in Media, Pa. Transferring to the Systems Engineering Department, he prepared engineering information on the No. 5 system for the use of Operating Company engineers in planning central offices. He was active in the Englewood DDD trial and thereafter in engineering studies related to the expansion of the customer dialing network. He is now in charge of a Special Systems Engineering group studying requirements for new PBX features and systems.

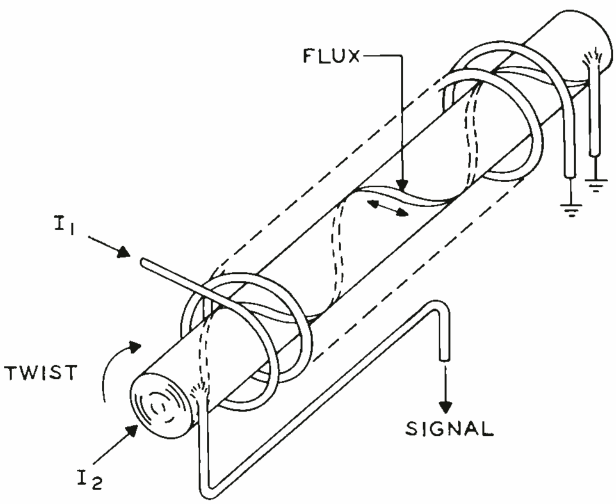


The "Twistor" Memory Device

A. H. Bobeck tests memory characteristics of a "Twistor" device, which incorporates magnetic wires.

A new concept in memory devices has recently been announced at Bell Laboratories. As a result of exploratory work by A. H. Bobeck of the Device Development Department, it may now be possible to design memory systems that are simpler to fabricate and more economical to manufacture than existing systems. The new concept, which has been given the name "Twistor", may find extensive application in computers and electronic switching systems where rapid-access, high-capacity memories are necessary.

With the "Twistor" concept, a memory array could be constructed in the familiar grid-like or coordinate pattern. This is the way present magnetic-core memories are arranged – horizontal and vertical wires are interwoven, with a donut-shaped magnetic core encircling each intersection. A pulse of energy along one wire is chosen to be insufficient for magnetizing a core, but coincident pulses along both a horizontal and a vertical wire will magnetize the core in a circular direction. Pulses of opposite polarity magnetize the core in the reverse direction around the donut. In this way, one "bit" of information is stored at one coordinate point in the array.



Set-up for testing magnetic wire: I_2 supplies circular field and I_1 in solenoid supplies longitudinal field, resulting in helical magnetization of the wire.

Eliminates Cores

A "Twistor" array would be similar in appearance to the magnetic-core memory, but would have no cores. It would be constructed merely by interweaving copper wires with wires made of a magnetic material, much as window screen is woven.

The "Twistor" gets its name from a characteristic of magnetic wire. Normally, such wire can be magnetized most easily in the longitudinal direction (in a straight line along its length). But if a torsional force is applied to the wire, the magnetization will prefer to lie along a helical, rather than longitudinal, path. Torsion may not have to be applied to the magnetic wire in a final device. The preference for helical magnetization may be "frozen" into the wire during processing.

In a "Twistor" memory, the required helical field can be obtained by applying coincident pulses of current through the copper and magnetic wires. Since current causes a circular magnetic field around a conductor, the circular component is readily supplied with a pulse of current through the magnetic wire. The field resulting from current in the copper conductor is also circular, but at an intersection where the copper wire touches the magnetic wire at right angles, this field has a component longitudinal to the magnetic wire. Thus, to "write" information into 10 x 10 array, for example, current could be applied to wire number 7 of 10 vertical magnetic wires, and to wire number 3 of 10 horizontal copper wires. This would produce helical magnetization in the magnetic wire in the immediate vicinity of the (7,3) coordinate point. In this way, a "bit" of information can be stored in the "direction" of the helical magnetization.

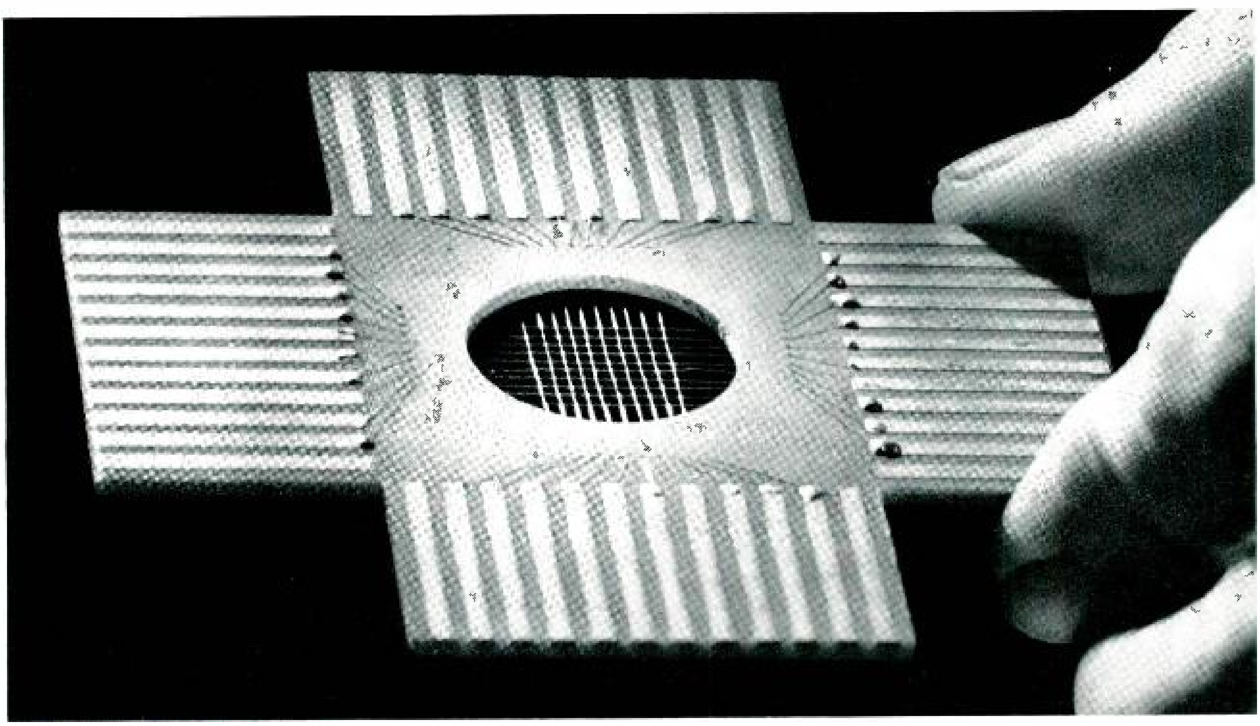
Although two pulses of current are needed to "write" information into a "Twistor" memory, only a single pulse is required for "readout". The current is applied to one of the copper wires so that it will overdrive the longitudinal field in the reverse direction at any intersection where a bit is stored. A "readout" pulse of voltage will then be induced in the associated magnetic wire. Because the lines of magnetic flux along the helical path "wrap" the magnetic wire many times, a favorable increase in output signal is obtained. Thus, the magnetic wire is used both as the storage medium and as the sensing element.

Ten Bits per Inch

Investigations are now under way to determine optimum size and composition for the magnetic wires. It appears that a conductor plated with magnetic material will be most useful. Diameters as small as one thousandth of an inch appear to be usable. At least 10 bits per inch may be stored along such a magnetic wire without adverse interaction.

In conventional magnetic-core memory devices, conductors must be threaded through the cores to make up a suitable matrix. When a ferrite sheet is used, either a threading or a plating operation is necessary for suitably locating the conductors. However, with the "Twistor", the ferrite material is completely eliminated and no threading or plating is necessary. Speed of operation and output are comparable to those of ferrite systems.

Present indications are that the drive circuits for a "Twistor" array can be readily transistorized. Thus, a memory system using the "Twistor" concept will retain all of the advantages of ferrite-core or sheet systems, and will be much simpler and more economical to fabricate.



An experimental version of the "Twistor" memory: information-storage section in center consists only of horizontal magnetic wires and vertical copper wires. Magnetic wire serves for both storage and sensing.

Telephone Communications for RAPCON *Centers*

G. A. GIDDINGS
Station Apparatus Development

To handle air traffic in the vicinity of air bases, the Air Force is installing a number of Radar Approach Control (RAPCON) Centers. These Centers, which maintain high safety standards of aircraft control, require highly specialized communications service, both internally and with other control points. A modified version of the Bell System's 102A key equipment is being installed to provide safer, more efficient air-traffic service of this type.

Since World War II the United States Air Force has greatly extended the use of radar for controlling military air traffic. Personnel operating a radar-control system are given a graphic display of the location, direction of travel and speed of all aircraft within the range of the radar set. To use the advantages of radar methods, Radar Approach Control (RAPCON) Centers have been installed at many Air Force Bases. These centers use radar for departure and landing control of all traffic within the traffic pattern of the air base, and extend this control from the visual limit of an airport control tower to about 50 miles from the base.

The chief purpose of air-traffic control is to provide safe separation of aircraft in the control area, especially those under instrument flight rules. Modern aircraft compound the safety problem by virtue of the complexity of operation. The time element has become increasingly important because many jet planes now fly over 600 miles per hour. At this speed, the aircraft is traveling one mile every six seconds, or ten miles per minute. Another important consideration is that the fuel consumption of jet aircraft is very high, particularly below 20,000 feet. Positive and definite landing preparations are therefore necessary, since even a lapse of a few seconds in traffic-control procedures could mean the difference between safety and disaster.

The success with which RAPCON Centers control these high speed aircraft depends to a large degree on a rapid and efficient voice-communication system. RAPCON Centers are furnished with the No. 102A key equipment system. With this system, several attendants, or controllers, can establish direct communication with any one of many internal and external lines. This key equipment was originally designed for the Civil Aeronautics Administration to control civilian air traffic without the use of radar. Certain features have been added for the switching and other arrangements necessary to meet the operational procedures required by the RAPCON Center method of air-traffic control.

No. 102A key equipment was originally arranged for one attendant at an operating position who had access to telephone lines only. Two controllers – a duty controller and an assistant – are normally required at each RAPCON Center position, and they have a relatively large number of direct air-ground radio contacts. Thus the two attendants must be able to share the telephone facilities and to integrate closely the telephone and radio equipment. They can independently use either the same or separate telephone and key circuits, and either the same or separate radio equipment at the console. Each attendant has a transfer key so that the same telephone headset may be used on either telephone lines or Air Force-owned radio equipment; rapid transfer is possible from one to the other. The convenience and savings in time gained by this arrangement are of great value in the over-all operations. The transfer keys, line key units, and attendant's telephone-set jacks are mounted in the Air Force-owned consoles as shown in the illustration on page 490.

Rapid and positive intercommunication between the operating personnel in a RAPCON Center is imperative. For example, when the controller in charge of departures (departure controller) finds that an aircraft has been inadvertently taxied onto an active runway, he must immediately contact the controller in charge of incoming traffic (final controller) to warn him of the existing hazardous condition. The final controller can then direct any aircraft on final approach to a temporary holding point to avoid a collision. An "override" feature permits this fast and positive intercommunication between operating personnel. It is arranged so that any attendant may have immediate communication with an attendant at any other position in the RAPCON Center, even though the called attendant may be talking on a radio channel or a telephone line.

Figure 2 is a schematic diagram of the intercommunicating circuits between two positions. Either the duty or assistant controller, who share the equipment at position No. 1, can override the assistant controller at position No. 2 by operating the associated line key. This key connects the controller's telephone circuit at position No. 1 – through an induction coil and an operated relay – directly to the telephone circuit of the assistant controller at position No. 2. Operation of the key also lights the line lamp at the overridden position to inform the controller that he has been overridden by position No. 1.

When the assistant controller's transfer key at position 2 is in the telephone position, a two-way talking circuit is immediately established between the controllers, whether or not the controller at position 2 is connected to a telephone line. When the key is operated for radio transmission, a relay opens the transmitting circuit from the controller at position 2 so that a one-way talking circuit is established from the controller at position 1 to the headset receiver of the controller at position 2. This circuit is not connected to the input of the radio transmitter because the message may be misunderstood by the pilot and confuse him. If the controller at position 2 wishes to talk to position 1 over this circuit, he operates the key to the telephone-lines position. The calling controller may interrupt any conversation in progress. (Both sides of the called controller's conversation, either radio or wire, are heard by the overriding controller through the sidetone circuit.) Similarly, either the duty or assistant controller at position 2 can override the assistant controller at position 1.

The override feature is normally arranged so that override calls can be made to only one (assistant controller) of the two attendants at a position. During light-load periods, however, the position may be operated by only one attendant (duty controller). For this case, the assistant controller has a third position of his transfer key, as shown in Figure 2. This position is called "single operator." When the duty controller is alone at the position, the assistant controller's transfer key is operated

Fig. 1 — G. A. Giddings examines arrangement of modified 102A key unit for RAPCON operation.

to this single-operator position. This connects the assistant controller's receiver circuit to the duty controller's receiver circuit and extends the override features to the duty controller.

It is very important to record the conversations of the attendants, especially when they talk to pilots. A recorder jack panel is provided so that any one of the Air Force-owned continuously-running tape recorders may be connected to record all the radio and telephone conversations concerning aircraft control.

All radio transmitters use a push-to-talk arrangement and, to permit hands-free operation, this is usually done with a footswitch at the position. However, this footswitch may be bypassed by operating a footswitch-shorting key in the front of the console. When this is done, the radio transmitter is actually keyed with the locking or nonlocking push-to-talk

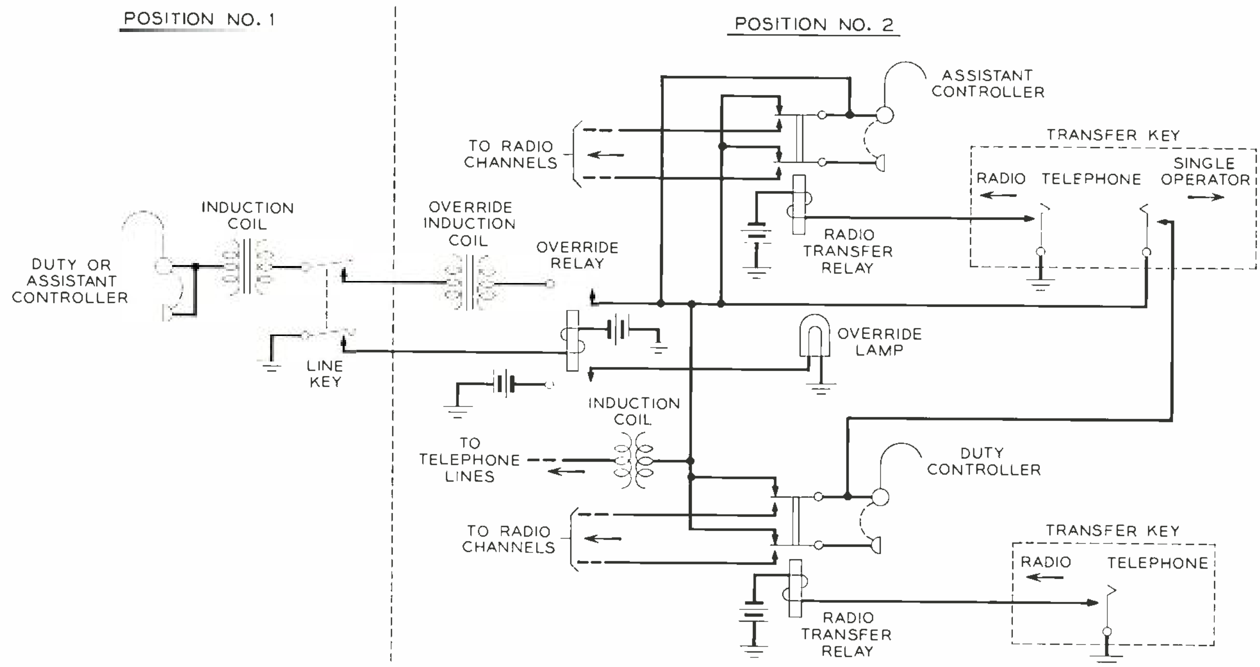


Fig. 2 — The override feature provides rapid communication between controllers in emergencies.

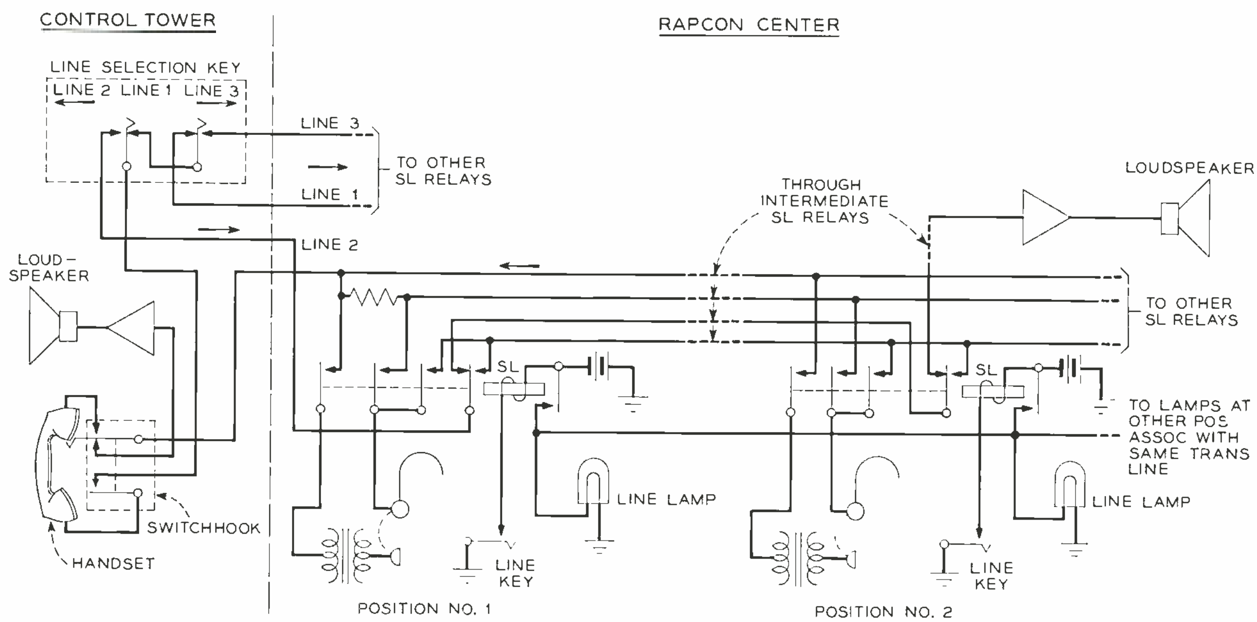


Fig. 3 — During periods of heavy traffic or in an emergency, the "hot line" arrangement makes possible direct communication between the RAPCON Center and the airport control tower.

switch in the cord of the telephone headset. The 53-type headsets used have a 12-foot retractile cord, which permits the attendant to move from his position and still talk on radio channels.

One-way "hot" lines (lines continuously open for transmission) are installed in the system to provide fast, direct and positive communication between a RAPCON Center and the associated airport control tower. This arrangement is needed in periods of very heavy traffic, and especially so in case of an emergency. Normally one hot line runs from RAPCON to the tower and either two or three from the tower to RAPCON. Figure 3 shows the special termination arrangement for these hot lines. The tower controller can talk immediately to a position in the center by lifting his telephone handset and operating a line-selection key to the line associated with the called position. The switchhook contacts in the handset transfer the "receive" line from the loudspeaker to the handset receiver and connect the talking battery to the handset transmitter. The controller at position 1 in the RAPCON center can talk immediately to the tower by operating a line key which activates a relay associated with that position. The relay performs four functions. (1) It lights the line lamps associated with the transmit line at that and all other positions to indicate that the line is in use. (2) It transfers the receive line at that position from the loudspeaker to both the head telephone set of the controller's receiver and a bus circuit in the receive line to other relays associated with the same receive line. (3) It connects the controller's head telephone set transmitter to the transmit line. And (4) it connects two resistors between the transmit line and the controller's receiver circuit to provide sidetone to the controller. In a similar manner, the controllers at other positions can talk to the control tower by operating the line key associated with the transmit line.

Both controllers at a position in the RAPCON Center have individual loudspeakers in the console for monitoring radio channels when their headsets are connected to the telephone lines. When a controller's headset is connected to radio channels, he may operate a switch in the console to cut off the loudspeaker and to permit him to listen with his headset receiver only. However, the key equipment is arranged so that if the loudspeaker-cutoff switch is left on when the attendant returns to telephone-line operation, the loud-speaker is automatically connected to the output of the radio receiver. This ensures that the radio channels will always be monitored.

The Air Force plans to use RAPCON Centers at overseas locations as well as in the Continental United States. At all U. S. installations, Operating Telephone Companies install and maintain the RAPCON telephone equipment. Key equipment for the overseas Centers, however, is pre-assembled and packaged in kit form by the Western Electric Company and is sold directly to the Air Force. It is installed and maintained, therefore, by the Air Force.

These additions to No. 102A key equipment, for use at both United States and overseas RAPCON installations, speed the control and promote the safety of handling the high-speed military aircraft of today. They comprise another step in a series of measures being taken to keep communications in pace with the continually growing traffic control problem of the Air Force.

THE AUTHOR

G. A. GIDDINGS, a native of Pontiac, Mich., received a B.S. degree in Electrical Engineering from Michigan State University in 1941. He immediately joined the Michigan Bell Telephone Company, and worked in their Plant Department for twelve years, except for three years during World War II when he was on loan to the Laboratories for work on war contracts. In 1953, he transferred to the Laboratories and was concerned with the development of station systems for military applications. Mr. Giddings recently transferred to the O. & E. Department of the A.T.&T. Company.

For the large information-carrying capacities required of future communications systems, it is necessary to go to shorter wavelengths and greater bandwidths. Theory and experiment have shown, however, that millimeter waves are sometimes severely attenuated by rain and by certain gases in the air. To get precise information on this point, a very accurate method has been devised for measuring such losses over a broad band of frequencies.

Propagation of Millimeter Waves Through the Atmosphere

A. B. CRAWFORD and D. C. HOGG *Radio Research*

Most long-distance telephone and television traffic in the Bell System is handled by coaxial cable and microwave radio-relay systems. Coaxial cable, because of its shielding and underground installation, is relatively immune to atmospheric disturbances, but radio services must always be designed with careful consideration of the effect of the atmosphere on the propagation of radio waves.

Microwave radio-relay systems — TD-2, TH (now under development) and TJ — use the atmosphere as a low-loss medium through which the radio energy is propagated. This may give the impression that the atmosphere is transparent to all radio frequencies; actually, however, as the frequency increases, attenuation is severe in certain bands.

Transmission losses encountered by radio waves in the atmosphere can be divided into two general categories: those due to precipitation — rain, snow, fog — and those due to certain gases of the air — principally oxygen and water vapor. At 4,000 megacycles, the frequency of the TD-2 radio-relay system, such losses are so small that they can be neglected for most practical purposes. But when the operating frequency is increased to about 10,000 mc, the frequency of the TJ system,* attenuation by rain becomes an important consideration. This type of loss increases rapidly as one proceeds to still higher frequencies, and at 60,000 mc it has a value of 20 decibels per mile for a moderately heavy rain. Fortunately, fog causes much less attenuation, principally because there is a lesser amount of precipitate per unit volume of air. Likewise, because of its crystalline structure, snow attenuates radio waves much less than rain.

At the higher frequencies, the second category of atmospheric loss is also important. Even if it is not raining or snowing, the oxygen and water vapor that constitute part of our atmosphere attenuate radio waves appreciably in the region of millimeter waves (frequencies between 30,000 and 300,000 mc). The oxygen molecules in the air become resonant to the frequencies of mm waves and absorb much of the propagated energy. As shown in Figure 1, absorption occurs chiefly in the band from 50,000 to 70,000 mc, with an attenuation of more than 20 db per mile at 60,000 mc. At this frequency, therefore, oxygen attenuation of mm waves is about the same as that from a moderately heavy rain. Also, during rain, the two attenuations are additive, so that transmission in the region of 60,000 mc would be very difficult.

These considerations do not necessarily mean

* RECORD, *April*, 1957, *page* 153.

that frequencies higher than those employed in present microwave systems are impracticable, but losses may limit the use of mm waves in the atmosphere to very short ranges. Also, transmission losses can be avoided through the use of waveguide systems, and the Laboratories is now concentrating on this type of system in which the "atmosphere" or propagation medium within the waveguide can be controlled.*

Any research into possible mm-wave systems, however, depends upon an accurate knowledge of the transmission losses. Described here is a precise method devised for making an accurate determination of atmospheric loss. It has proved to be reliable for studies of attenuation over a broad range of frequencies in the mm-wave region. The method is demonstrated by experiments that determine absorption by the oxygen in the air. In these experiments, mm waves are propagated through the atmosphere toward two reflectors located at different distances from the transmitter, so that the difference in the energies of the two reflected waves is a measure of the absorption.

In principle, attenuation by the atmosphere can be determined simply by radiating a mm wave from a transmitting antenna to a receiving antenna. If the gains of the antennas are known accurately, and if the antenna beams are narrow enough to preclude reflections from the ground and from objects along the path of propagation, one can calculate the power that would be received provided the atmosphere had no loss (often called the free-space power). Thus, the calculated power minus the observed power provides a measure of the atmospheric attenuation between the transmitter and receiver.

* RECORD, *March*, 1955, *page* 113.

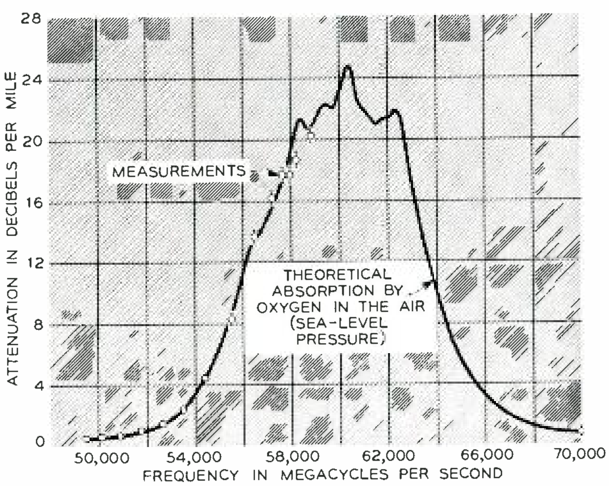


Fig. 1 — Measured datum points for oxygen absorption and calculated curve, showing close agreement between theory and test results.

Fig. 2 — R. A. Desmond inspecting polyethylene lens on conical horn antenna. Antenna served for both transmitting and receiving the test signals.

Unfortunately, the accuracy of this one-way transmission method is seriously affected by slight instabilities at the transmitting and receiving terminals. Moreover, if one wishes to measure a number of frequencies, the method is time-consuming, since oscillators at both the transmitter and receiver must be adjusted for each measurement.

A more accurate and more convenient experimental procedure is indicated in Figure 3. This is the two-way transmission method presently used at the Holmdel Laboratory. The mm waves at various frequencies are generated by a mm-wave oscillator and are directed by an antenna toward two corner reflectors R_1 and R_2. These reflectors are of the tri-hedral type investigated at the Laboratories.* They have the configuration of an inside corner of a cube, and they direct the incident beam back upon itself. Reflectors of this type were used because they are less sensitive than flat reflectors to minor misalignments in position.

The transmitting antenna also receives the reflected signals. First, the two reflectors are placed side by side facing the antenna, and their relative reflecting properties are determined by comparing the reflected power when the reflectors are covered alternately with a highly absorbent, non-reflecting material. This calibration is carried out at all frequencies of interest.

The reflectors are then separated as shown in Figure 3. Knowing the relative reflecting properties

* B.S.T.J., **26**, *October*, 1947, *page* 852.

and the distances d_1 and d_2 from the antenna to the two reflectors, one can readily calculate the ratio of the powers that would be reflected from R_1 and R_2 if there were no loss in the atmosphere. The difference between the measured and calculated ratios then represents the attenuation of that portion of the atmosphere between R_1 and R_2. Since the measurement is in terms of ratios rather than absolute values, it is independent of the gain of the antenna and of the absolute operating levels of the measuring set.

The method of measuring the reflected signals is illustrated in Figure 4. The transmitted mm-wave signal is frequency modulated in a "sawtooth" manner, and the modulating frequencies have a small total excursion, F. The transmitted signal – solid-line sawtooth curve in Figure 4(a) – is radiated from the antenna to the near corner reflector, R_1. Upon being received, the reflected signal is delayed with respect to the transmitted signal by a time, t_1, equal to twice the distance to the reflector divided by the velocity of light. This delayed signal is indicated by the dashed-line sawtooth curve. During a portion of each cycle, T_1-t_1, the transmitted and received signals differ in frequency by a constant value, f. Power at this difference or "beat" frequency is amplified in a narrow-band amplifier centered on f. Because during time t_1 there is a much larger value of beat frequency, the amplifier will have no output for this period. The result, therefore, is a series of pulses at frequency f, each of length T_1-t_1, and with a repetition rate $1/T_1$.

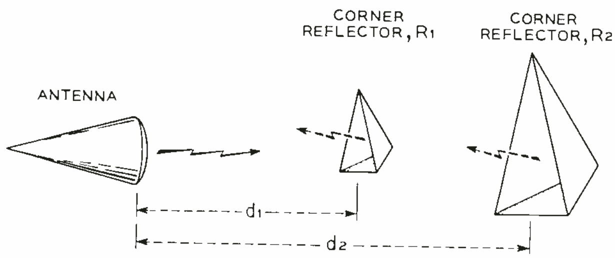


Fig. 3 — The two-way transmission method: reflectors are first placed side-by-side and then spaced at distances d_1 and d_2 from the antenna.

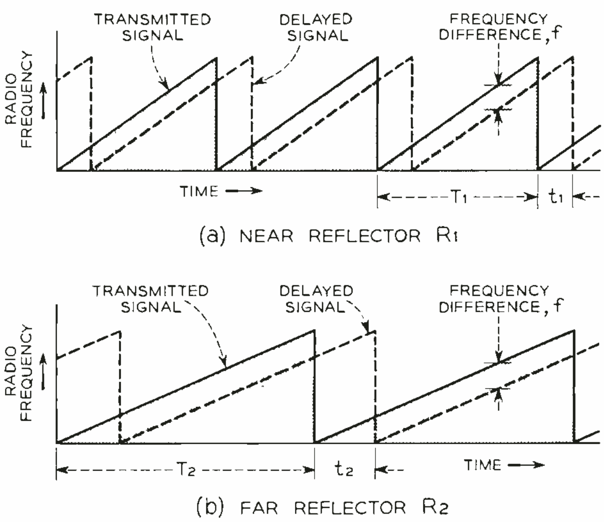


Fig. 4 — Transmitted and reflected signals for (a) near reflector R_1 and (b) far reflector R_2.

Fig. 5 — D. C. Hogg, left, and A. B. Crawford adjusting waveguide assembly used in experiments.

For the far corner reflector, R_2, the period of the sawtooth modulation is increased in proportion to the increase in distance, as indicated in Figure 4(b). Consequently, the difference frequency, f, is identical to that obtained with the near reflector. Also, the frequency excursion, F, is held constant, which means that the average power output of the transmitter remains unchanged. Thus, the same amplifier can be used for both the near and far reflectors, and a single meter can be used to compare the difference between the received powers. Actually, the signals are adjusted to give identical meter readings for the two cases, and the power difference is read from a precision attenuator.

A block diagram of the electronic apparatus is shown in Figure 6. In brief, the sawtooth generator in the upper left of this illustration modulates the mm-wave oscillator at the lower left, and power is fed to the antenna at the lower right. Part of this power, however, is delivered through a 6-db coupler to a balanced converter. The reflected signal is received by the antenna and is also delivered to the converter, via the 3-db coupler. This balanced converter, which uses two wafer-type millimeter rectifier units, mixes the transmitted and delayed signals to produce the difference or intermediate frequency, f. (The wafer-type rectifiers, of a special design developed at the Laboratories, will be described in a subsequent RECORD article.) As indicated in the rest of the diagram, the IF signal then passes through the precision attenuator and amplifier, and thence to an oscilloscope for viewing the pulses, and to a detector and meter or recorder for the taking of data.

The RF source used for most of these measurements was a low-voltage reflex klystron developed by E. D. Reed of the Laboratories.* It has an average power output of about 12 milliwatts over the 50,000 to 60,000 mc range. The IF amplifier is centered on a frequency, f, of 750 kc and has a bandwidth of 300 kc. This bandwidth is narrow enough to give a good signal-to-noise advantage and is wide enough to take care of any non-linearity in the sawtooth modulation. Backward-wave oscillators† are also used as sources of mm-wave power for this type of measurement.

The measurements shown by the points in Figure 1 were made with this equipment. They were taken during winter days when the air was dry enough to eliminate effects due to water vapor. The solid curve in the illustration represents a theoretical calculation based on absorption by oxygen. Because of the good agreement between the measured and calculated values, attenuation by dry air in the measured band of frequencies is believed to be due mainly to absorption caused by resonance of the oxygen molecules. In this band, water vapor attenuates radio waves much less than oxygen. Even in conditions of relatively high humidity, water vapor increases the attenuation only about one-half decibel per mile.

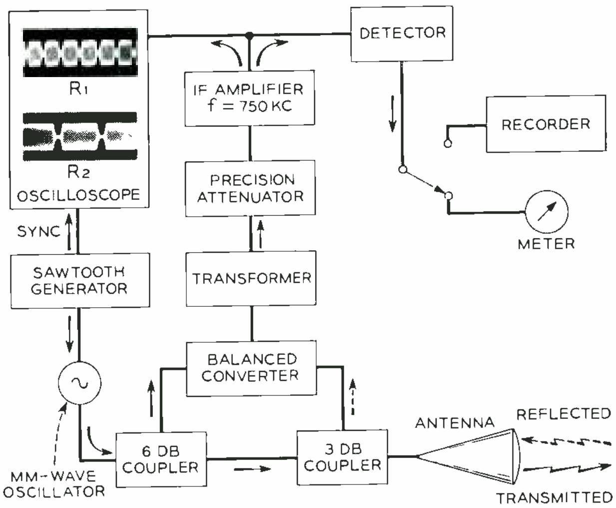


Fig. 6 — Transmitted and reflected signals are mixed in a balanced converter, amplified, and delivered to an oscilloscope and meter or recorder.

* RECORD, *May*, 1955, *page* 173. † RECORD, *July*, 1957, *page* 242.

THE AUTHORS

A. B. CRAWFORD was born in Graysville, Ohio. He received the B.S. degree in Electrical Engineering at Ohio State University in 1928 and joined the Radio Research Department of the Bell Telephone Laboratories the same year. For a number of years he was concerned with ultra-short wave measuring techniques and propagation studies. During the war years he worked on various microwave components for radar systems. In recent years he has headed a subdepartment in Radio Research at the Holmdel Laboratories working on microwave antennas, line-of-sight and beyond-the-horizon radio propagation and point-contact rectifiers. He is a Fellow of the Institute of Radio Engineers and a member of Sigma Xi.

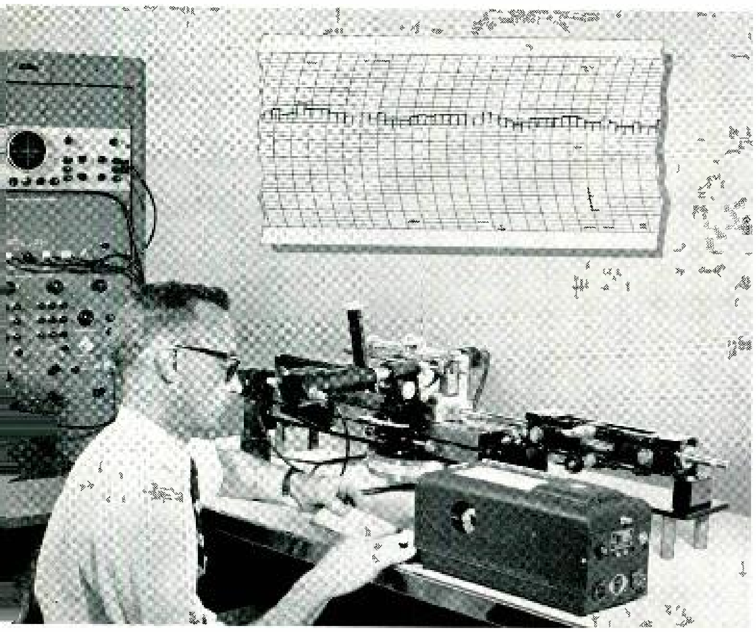
D. C. HOGG, a native of Saskatchewan, Canada, spent five years with the Canadian Army during World War II in radar and telecommunications work in Britain and Europe. After the war, he received the B.Sc. degree from the University of Western Ontario, London, Canada, in 1949, and the M.Sc. and Ph.D. from McGill University, Montreal, in 1953. At McGill University, his research was centered upon microwave diffraction. Mr. Hogg joined Bell Laboratories in 1953. He has been concerned with research on over-the-horizon microwave radio propagation and with atmospheric attenuation of millimeter waves.

Microdeviometer for Evaluating Periodic Structures

An automatic instrument has been developed at Bell Laboratories for rapidly measuring and recording very small imperfections in pitch uniformity of repetitive structures. The instrument, termed a "microdeviometer," is presently being used for evaluating the helices of traveling-wave tubes, but it can be used equally well for measuring the pitch uniformity of other periodic structures such as precision screws and the grids of electron tubes.

In a traveling-wave tube, the wave to be amplified is launched on one end of a helix, which is wound in such a manner that the wave is effectively slowed down along the axial direction of the helix. When the axial velocity of the wave equals the velocity of an electron beam focused through the center of the helix, amplification results. Thus, the helix must be very precisely dimensioned if the tube is to meet design requirements.

In the microdeviometer, the output is a pen recording which tells at a glance the deviation of each successive relevant part of the periodic structure from the ideal, the ideal structure being one in which the length of each repeated section is exactly the same as every other. Longitudinal displacements are indicated to an accuracy of one micron (1/1000 mm). A traveling-wave tube helix can be completely evaluated in less than 5 minutes, compared to more than two man-days necessary by previously available techniques.



H. T. Closson examines record of precision measurements of pitch uniformity obtained with the new microdeviometer.

Incorporates Electronic Computer

The apparatus incorporates a combination of optical, electronic and mechanical technology. Essential features include: (1) an optical grating which provides a very accurate distance scale, (2) an optical system for ascertaining the position of the part to be measured with respect to the chosen scale, and (3) an electronic method of analyzing this information and recording it on a strip chart.

The part to be measured is rigidly mounted on a moving platform on which is also mounted the precision optical grating. This grating moves past a similar fixed grating, so that a beam of light is interrupted when the rulings on the two gratings are superimposed. The light beam falls on a photocell, where the interruptions produce electrical pulses representing accurate distance increments of one micron. Another combination of a fixed beam of light and a photocell produces an output pulse when an element of the periodic structure passes a fixed reference point. In other words, pulses from the helix are obtained for comparison with the very accurate pulses from the precision gratings.

The pulses are fed to an electronic computer which evaluates the deviation from the ideal. This information is then recorded on a chart in such a manner as to provide a direct reading of the actual deviation of each element.

In the accompanying photograph, the mechanical-optical section of the microdeviometer is in the center, and the specially designed electronic computer is at the left. The pen-recording strip chart is obtained from the unit seen at the lower right. The inset view shows a typical record, where the positions of the horizontal bars represent helix-turn deviations from the ideal.

Cable Splicing Goes Modern

W. C. KLEINFELDER
Outside Plant Development

Since outside plant makes up about 37 per cent of the total Bell System plant investment, Laboratories' development effort directed toward the improvement of outside plant facilities and techniques pays large dividends. The "punched-sleeve" method of cable splicing is a good example of this type of development. The new method results in the splicer's making better joints more rapidly and efficiently than by the traditional method.

Each year the Operating Companies of the Bell System add about 50,000 sheath miles of telephone cable to their outside plant. These cables vary in size from the smallest aerial distribution types containing 6 pairs of wire to the big feeder cables containing as many as 2,100 pairs, running in underground conduit systems. The cables are installed in lengths that range from less than 200 feet at one extreme to 2,000 feet and more at the other. A work force of more than 14,000 cable splicers must make more than 300 million conductor joints each year in splicing together several hundred thousand sections of cable.

Although many construction and maintenance operations of the outside plant forces have been modernized, and although some have been highly mechanized, the techniques for joining cable conductors have remained virtually unchanged since the beginning of the telephone business. The time-honored method of joining two or more paper or pulp-insulated cable conductors is simple and requires a minimum of equipment. The cable splicer, or his helper, slips a cotton sleeve over one of the conductors before the joint is made. He then brings the conductors together, cuts them to proper length, removes a few inches of insulation, twists the bare conductors together, cuts them to final length, and slips the cotton sleeve over the joint for insulation to replace that previously removed.

The mechanical and electrical stability of joints produced by this method is generally satisfactory for today's exchange distribution plant which is subjected to ac ringing voltages and sizeable transmitter currents. Because high-resistance joints do occasionally develop, however, the twisted conduc-

Fig. 1 — Pneumatic presser and sleeve used in punched-sleeve cable splicing. The sleeve assembly consists of a tube made of the same metal as the conductors to be joined (aluminum or copper) with a jacket of plastic that is closed at one end.

F. R. Kappel Addresses Independents' Association

The telephone industry must show the commissions and the public that the only way to telephone progress is through telephone prosperity, A. T. & T. President Frederick R. Kappel said in a talk before the United States Independent Telephone Association in Chicago on October 14.

"Telephone service has been a low-earning enterprise now for a long time. It ought not to be," Mr. Kappel told the annual convention. He said a large segment of the public and "too many" commissions seem to think that low earnings mean low rates and good earnings mean high rates; whereas the fact is that good earnings, in the long run, mean quality service at lower cost to the user.

"Is it asking too much of regulatory commissions," he continued, "to exercise in fullest measure their practical judgment, their imagination and their political courage?

"I am sure it is not. And I am especially sure of this when I reflect that the problems which confront the regulator when a business is successful . . . are as nothing compared with the problems which confront him when a business doesn't have the money to do what ought to be done."

Employment and Service

Mr. Kappel said he "cannot believe" that many states expect to attract other industry and raise employment and prosperity "as they regulate telephone expansion and employment down.

"It is our job to demonstrate that every state needs our financial good health, not only for what this means in direct telephone employment and wages, but equally or even more for what we can do to help make the state attractive to others.

Turning to the field of labor relations, Mr. Kappel said that what telephone employees really know and believe about their company depends on how diligent the company is in giving employees the facts and demonstrating its sincerity.

"I saw a union editorial the other day that had the Bell System waxing rich and practically choking on fat profits," he said. "This kind of thing is so absurd you may wonder why I even mention it. The reason is that the problems which unions and managements are concerned with are so important that there just isn't room for careless or misleading talk.

"You and I know that the telephone companies are bound to provide wages and working conditions that compare favorably with other industry and offer attractive opportunity for willing and industrious men and women.

"Frivolous and unconsidered statements can only cause harm—the more so if by silence we seem to give them our consent. What we need is to get such a steady stream of truth flowing that there's no room in the river for anything else."

Mr. Kappel referred also to competition in providing communication services. "It seems there are quite a few non-communication companies today that would like to provide a considerable part of their communications themselves, without depending on the common carriers," he said.

"Of course, this goes against the basic principles and experience which have shown that the public interest depends on common carrier service. Indiscriminate licensing of non-common carriers to build their own systems would not only sacrifice the most efficient use of the radio spectrum; it could very seriously interfere with the ability of the telephone companies to serve the public at reasonable prices.

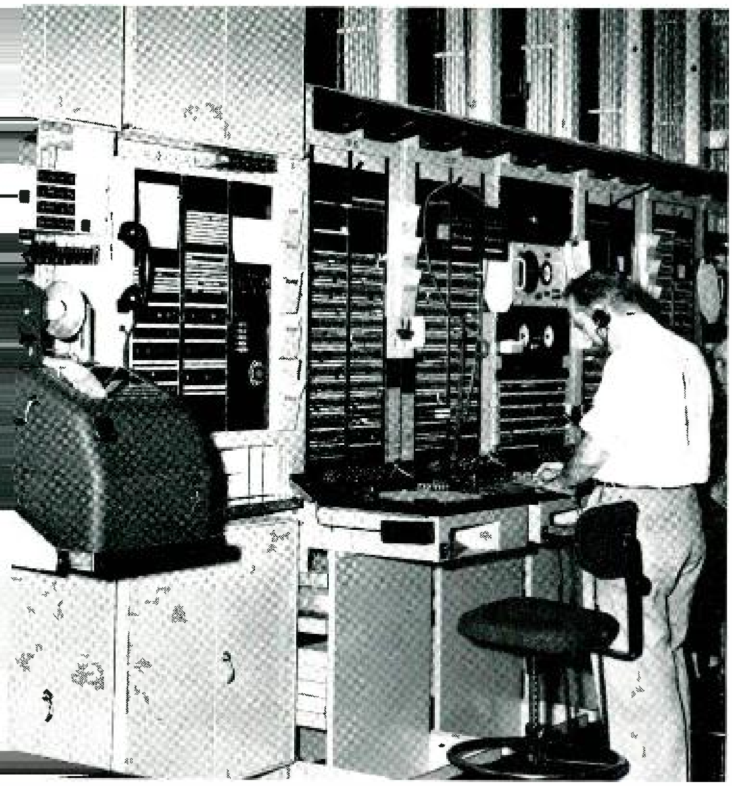
"We are sure," he continued, "that common carrier-service results in lower costs to the public. We are confident it also makes possible much more efficient use of the radio spectrum. We know a strong common-carrier network is a much greater asset in time of emergency or war than a fragmentized hodge-podge of private systems could ever be."

Future Management

Building future telephone management, Mr. Kappel said, "is the responsibility of every boss in the business. . . . The great essential is to have the kind of working atmosphere that gives people air and room and freedom and incentive to grow. We'll do the best job, I'm sure, when—and only when—every boss acts on the understanding that an indispensable part of his assignment is to . . . encourage the growth of his subordinates."

Mr. Kappel congratulated the USITA on its 60 years of progress and its vital part in the total accomplishment of the industry. "The way things are nowadays, none of us have much time to be looking back. The future isn't waiting for us. It's rushing right at us," he said.

"We in the telephone business must meet these changes together, for ours is one single industry and our service is indivisible. Far more than in other types of business, the progress we make depends on how effectively we combine our efforts."



With the expansion of direct distance dialing and automatic alternate routing, transmission maintenance requirements for long-distance trunks are more exacting. To assist the maintenance forces in gathering transmission data more efficiently, new circuits, including a computer unit, have been incorporated into the intertoll trunk-test equipment. This equipment speeds the analysis of transmission performance and thus expedites maintenance of trunks.

Automatic Calculation of Transmission Deviations

R. C. NANCE *Switching Systems Development*

Long-distance telephone channels, called intertoll trunks, must be maintained at high transmission efficiency if service is not to be interrupted or impaired. This is and always has been a general requirement for long-distance facilities, but it is even more important now that completely automatic and highly versatile switching systems are enabling more and more people to dial their own long-distance calls without operator assistance.

A long-distance communication path may require several separate transmission links connected in tandem (seven links is the usual maximum), and with fully automatic alternate routing, the path itself will be only one out of several possible alternatives. When operators were involved in all long-distance calls, they could frequently detect any degradation of transmission quality and report it as an aid to the maintenance forces. Now that telephoning is becoming more completely automatic, however, the discovery and measurement of transmission deviations must also become more automatic. To insure that necessary adjustments are promptly made, the maintenance force must more closely observe intertoll trunk performance. This is true both of the operational aspects of trunks – the many switching and regulating actions that take place in setting up the trunk connection – and of transmission performance – whether voice and signals are transmitted over the trunk without excessive deviation from design values.

To aid maintenance, several types of testing and measuring circuits have been developed. As shown in simplified form in Figure 2(a), tests can be performed from a toll test board at an originating ("near-end") office, by making connection to an automatic transmission-measuring and noise-checking circuit at the terminating or "far-end" office. However, because personnel at the near-end office set up the tests and record the data, this arrangement is not fully automatic. Consequently, addi-

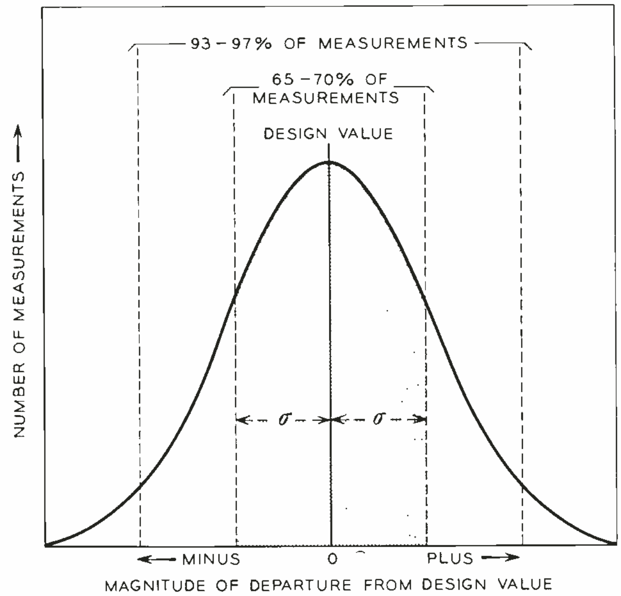


Fig. 1 — Normal distribution curve for random variation of transmission values about design value.

tional equipment was developed for use at near-end offices. As described in an earlier RECORD article,* an automatic circuit is available for testing the operational functions of intertoll trunks outgoing from No. 4 toll crossbar offices. This is the equipment labeled "AOIT" (automatic outgoing intertoll trunk-test circuit) in Figure 2(b). It is able to test large numbers of trunks rapidly with few manual functions, thereby substituting in part for the lack of operator supervision.

The automatic transmission test and control circuit and the recording teletypewriter printer circuit in Figure 2(b) have also been added to the near-end test equipment. These circuits, in conjunction with the AOIT, perform fully automatic two-way transmission-loss measurements and noise checks, and also provide a printed record of the operational or transmission-test results.

With this test gear, however, a large amount of data-plotting is still required, and more recently a computer-type circuit has been added to the test facilities to simplify the presentation of data in usable form. But before describing this circuit, it is well to review the sort of data-gathering operation required in the transmission-testing of trunks.

Transmission performance of intertoll trunks is measured in terms of how much a given trunk deviates from a specified or design loss. For example, over a certain trunk the transmitted energy may decrease in power by 6 db when it is desired that the actual loss should be only 5 db. Transmission performance is then described by saying that this trunk has a transmission deviation of +1 db. However, trunk use becomes, to a considerable extent, a matter of chance selection, and for this reason, performance is considered by statistical analysis of a large number of trunks or by groups of trunks, rather than on an individual trunk basis.

Experience has shown that when a sufficiently large number of transmission measurements are made, the variations, taken as a whole, will follow a normal distribution curve as shown in Figure 1. Most of the trunks in a group will be fairly close to

* RECORD, *December*, 1954, *page* 467.

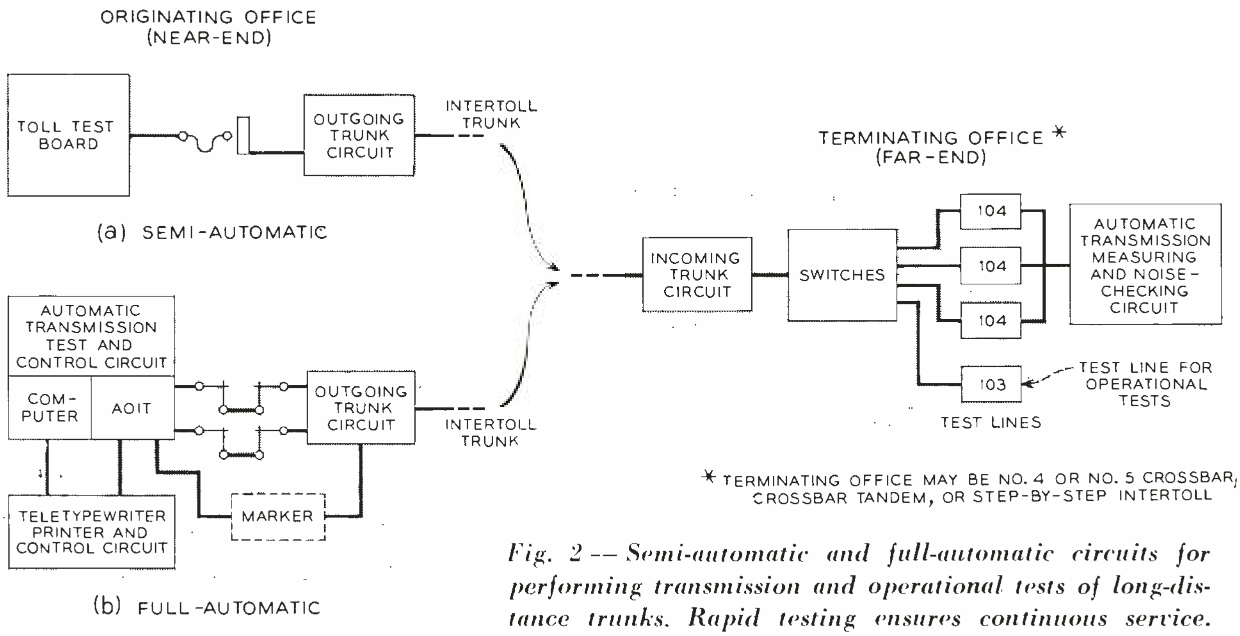


Fig. 2 — Semi-automatic and full-automatic circuits for performing transmission and operational tests of long-distance trunks. Rapid testing ensures continuous service.

their specified loss values, while some trunks may deviate 2 or 3 db or more. In the illustration, this fact is reflected by the peak seen in the curve at zero deviation with gradually decreasing numbers of measurements on either side. However, because the specified losses are not necessarily the same for each trunk in a large group, the distribution of deviations usually will not be symmetrical about zero, but will center on an algebraic average of all deviations. The displacement from the normal is known as "bias" and indicates the general trend of deviations in the group.

Statistical analysis of all deviations, both above and below the specified values, provides the "standard deviation" (σ). As indicated in Figure 1, the standard deviation is the cross-hatched area under the curve. With normal deviation, about 65 to 70 per cent of all deviations will occur in this region, and in transmission parlance it is called the "distribution grade." If the distribution grade is low, the group of trunks is good, with most trunks near their assigned values. If it is high, some of the trunks need readjustment.

Although the trunks are thus considered as a group, the data for the curves must be obtained from separate measurements on each trunk. When transmission grade is calculated manually, the procedure of recording a large number of measurements is somewhat simplified by using a special data sheet. Part of one of these sheets can be seen in Figure 4. The procedure consists first of subtracting the specified loss from the actual measured loss of the trunk. For each of the resulting deviation values, a "stroke" or mark is then placed on the data sheet. For example, suppose the first deviation value measured fell between –1.25 and –1.75 db. On the horizontal line representing this band, a stroke would be placed just to the left of the vertical line for tally number one. All successive values in this same –1.25 to –1.75 db range would later be stroked in the later tally positions along the horizontal line, and all other deviation values would be stroked along the other horizontal lines in the same manner. This is continued until all the deviations have been calculated and recorded, so that the total number of strokes as observed from the tally position of the last stroke on each line is the total number of measurements within each of the one-half db deviation bands. It will be seen that an envelope enclosing these strokes is similar to the distribution curves of Figure 1, except that here the graph is oriented horizontally. The data sheets also give visual clues to areas where maintenance effort

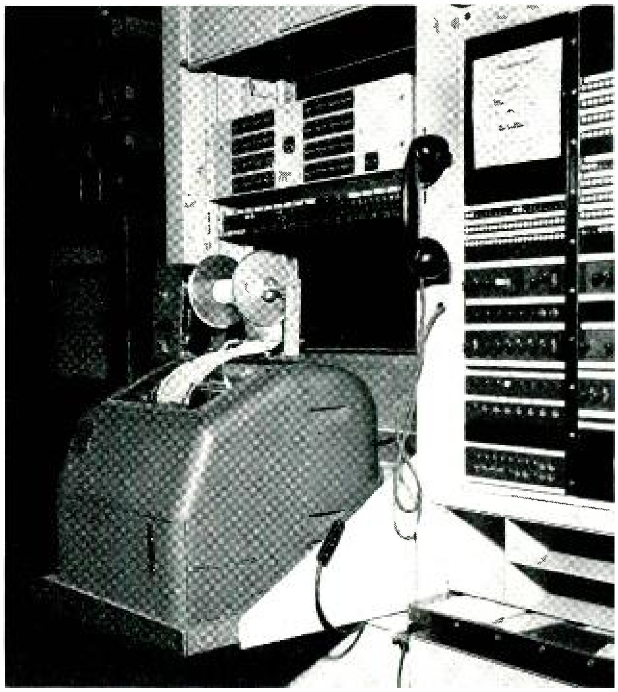


Fig. 3 — Registers which score number of deviations in various decibel-bands, seen above teletypewriter which records results of tests.

should be placed to ensure reliable operation.

There are a number of other operations performed with the data sheet before the information is brought to its final form, but from this description it is obvious that when large numbers of deviations are involved, manual subtraction and totalization of the data can become prohibitively time-consuming. The new computer included in the near-end testing equipment greatly reduces the amount of manual work required. This circuit automatically calculates all the individual deviations and totalizes them in one-half db ranges according to sign. That is, the operations of subtracting the specified from the actual values, and of adding by strokes, are performed automatically. The maintenance people merely read the total number of strokes for each one-half db band from message registers. Only the final stroke in each range is placed on the data sheet, after which the sheet is handled in the customary manner.

In addition, the associated recording teletypewriter provides a record of each test. A portion of such a record is shown in Figure 5; it gives maintenance personnel a number identifying the trunk that was tested, the specified loss, and the deviation from this specified loss in each direction of transmission (in and out of the office). For example, the specified loss for trunk number 1,378 is 7.5 db. The test results indicate transmission deviations of −5.2 db in the far-to-near direction and +0.7 db in the near-to-far direction. For simplicity, the decimal point between the tenths and units digits for specified loss and deviation entries is not recorded by the

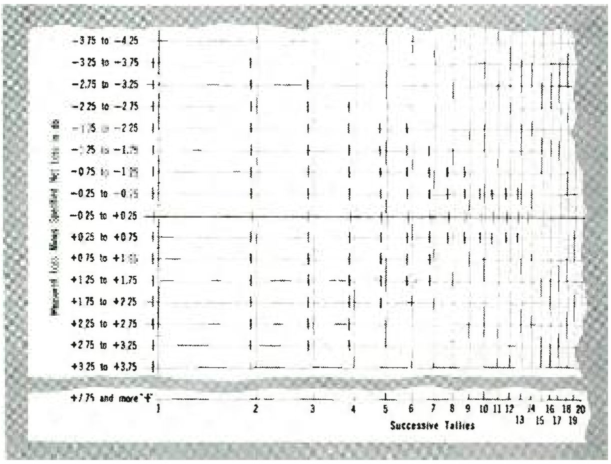


Fig. 4 — Portion of special data sheet used in recording of transmission deviations.

printer. In addition, for an entry of less than 10 db. the tens digit is omitted, again for simplicity.

The record also gives a symbol to indicate when measurements exceed transmission or noise limits, or when circuit failures occur to prevent satisfactory completion of the test. For instance, on trunk numbered 1,377, the noise exceeded limits in the far-to-near direction, as indicated by the symbol N. On trunk numbered 1,378 the deviation exceeded wide deviation limits in the far-to-near direction, as indicated by the U in the appropriate column. The record for trunk numbered 1,267 indicates, by the symbol Y, that far-end equipment failure prevented completion of the test. In Figure 5, the character B on the test record indicates that the trunk was busy at the time a test was attempted, and A indicates that the test call did not successfully complete to the terminating office.

Basically, the computer duplicates the operations described above for the manual determination of transmission deviations and their proper sign (+ or −). This information is passed to the teletypewriter for recording. A "class" relay associated with each trunk supplies the specified loss value, and this is subtracted from the measured loss value. The measured loss values are stored in relay memory circuits that have registered the test results. The values are in decimal form — between zero and 19.9 db — and before being fed into the computer, they are translated into their biquinary equivalents. The biquinary system is a method of encoding any digit from 0 to 9 in such a way that it can be registered by operating two out of seven relays. Five of these relays (the "quinary" part) represent *either* 0, 1, 2, 3, 4, *or* 5, 6, 7, 8, 9, depending on which of the remaining two relays (the "bi" part) is operated. Since two and only two relays must be operated for each digit, the computer can be made self-checking to the extent that if more or fewer than two relays operate, or if two relays operate in an invalid combination, an error is automatically detected. After a subtraction is completed in the computer, the information is passed to the teletypewriter in a form suitable for its operation.

In the design of the computer, it was decided that it would be convenient to have a circuit that would only add and that would perform the required subtraction by the "nines complement" method. It may be recalled from arithmetic studies that a "nines" method is sometimes used to check a subtraction by adding the complements. The computer uses a version of this device to perform subtraction by addition of the complements.

For example, a trunk might have a specified loss of 7.2 db; this quantity would appear in the computer as 99.9 minus 07.2 or 92.7. Suppose now that the actual loss of this trunk is 9.1 db. The computer *adds* 09.1 to the 92.7 to get a sum 101.8. Or, suppose the actual loss of the trunk is 5.2 db, in which case the arithmetic is 92.7 plus 05.2 equals 97.9 db. It will be noticed that the sum is greater or less than 100.0, depending on whether the actual loss is

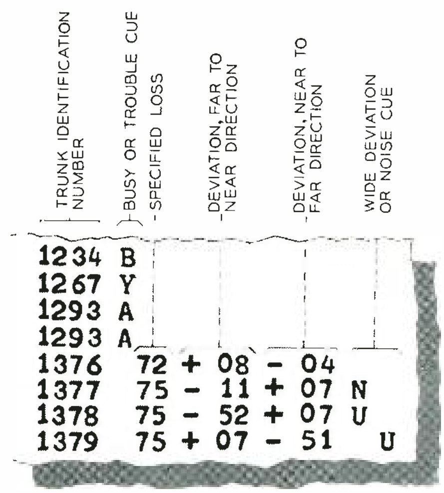


Fig. 5 — Teletypewriter record of computer-analyzed results of transmission tests. Data are used for rapid maintenance of trunks.

greater or less than the specified loss. The mathematical expression is $(99.9 - S) + M = D$, where S is the specified loss, M is the actual measured loss, and D is the "deviation."

This "deviation," however, does not represent the true sum, which must be the actual deviation from the specified loss. With a number over 100 like the 101.8, the first digit "1" is dropped and 0.1 is added, to result in the true deviation of *plus* 01.9 db. With a number below 100 like the 97.9, the nines complement of the *sum* (99.9 minus 97.9) yields the true result of *minus* 2.0 db. In this manner, the computer is able to give an indication of the correct sign of the result, and all values are recorded by the teletypewriter with their appropriate + or – signs. Several entries of this type can be seen in the teletypewriter record shown as Figure 5.

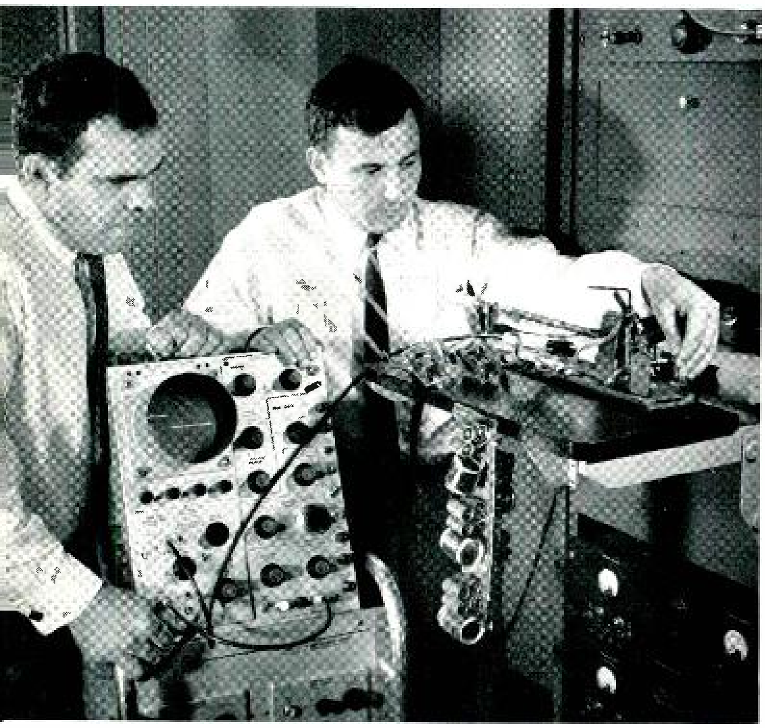
Thirty-three message registers at the near end totalize the individual transmission deviations for each 0.5 db increment from +8 db to –8 db according to sign. This is done so that the values will agree with the increments on the special data sheet used for transmission analysis. An additional message register totalizes the number of individual one-way measurements, and its reading should be equal to the total of the readings on the thirty-three deviation registers. Each register, equipped with a manual reset key, is reset to zero prior to the start of a test cycle and is read immediately on completion of the test cycle.

During normal operation of the test circuit, two-way measurements and a noise check are made on each trunk. The computer first calculates the deviation and scores the proper register for the far-to-near measurement. When the printer completes this entry, the computer is restored to normal so as to service the near-to-far measurement in a similar manner. Should the printer not be functioning, the control circuit will automatically recycle the computer for the near-to-far calculations. At the end of a test cycle, the deviation register readings can be transcribed as the final tally on the data sheet.

Prior to standardization, successful field trials of the near-end equipment were conducted in the Washington, D. C. No. 4A toll switching office, in conjunction with far-end equipment trials in several other cities throughout the United States. This equipment is now in production by the Western Electric Company, and it will greatly aid maintenance forces in the analysis of transmission performance of long-distance trunks and will expedite corrective action by maintenance forces.

THE AUTHOR

R. C. NANCE, a resident of Wood-Ridge, N. J., joined the Laboratories in 1936, and became a draftsman before taking military leave from 1941 to 1945 to serve in the Signal Corps in the Pacific Theater. Shortly after his return to the Laboratories he did design work on switchboard trunk circuits and toll crossbar trunk circuits. In 1953 he became a Member of Technical Staff, concerned with the design of automatic trunk test frames and associated recording printer circuits for No. 4 and crossbar tandem offices. More recently his work has involved design of sender test frames for CAMA toll crossbar installations. Mr. Nance attended evening classes at Newark College of Engineering to receive the Associate E.E. degree in 1940.



Welding at Relay Contacts

J. L. Smith (left) and W. S. Boyle studying welding at relay contacts. The coil and capacitor combinations in the center of the picture are simulated lengths of transmission wire used in the studies.

At Bell Laboratories, continuing studies are directed at one of the oldest and most fundamental problems of the communications industry – the action of a pair of contacts in an electromechanical relay or switch as these contacts make or break an electrical circuit. Thousands of contact operations may be involved in a single telephone call.

Of special interest has been the phenomenon of arcing – the discharge of electrical energy when two contacts are close together. Frequently, arcs cause welding of the contacts. According to recent research studies at the Laboratories, it has been found that welding at relay contacts takes place the instant the arc is extinguished. This work, by J. L. Smith and W. S. Boyle, sheds new light on the mechanism of the welding process.

The process was studied by short-circuiting various short lengths of charged transmission line through an arc formed by closure of a pair of clean relay contacts. It was found that the contacts tend to weld at the time when the line has just been completely discharged. Since the arc is known to produce a small pool of molten metal on the contact surface, this suggests that molten metal is drawn across the contact gap by the redistributed field after the arc is extinguished, resulting in a weld.

For longer transmission lines or more complex circuitry, welding is most probable at the instant the arc is terminated. In such cases, however, termination is due to a fundamental instablity in the arc itself. This arises because the diameter of the molten pool of metal increases as the cube root of the energy which has been dissipated in the arc, while the heat losses from the pool increase linearly with its diameter. In the constant-current arc, therefore, there occurs a critical time after which it can no longer be maintained because of the heat losses.

This time of extinction can be computed from the physical constants of the contact metal and the current and voltage of the arc. The extinction times thus computed for several contact materials at various voltages and currents agree with the observed times to weld with a maximum deviation of about 30 per cent.

Prior to these studies, it had been generally believed that since the volume of molten metal increases with time, welding occurred only after dissipation of a critical amount of energy and hence for a critical volume of melt. These studies have now shown that welding occurs both for much greater and much smaller energies. Welding time bears no direct relationship to power dissipated in the arc, but it is very well correlated with the time of extinction of the arc.

Lightning Protection of TD-2 Stations

D. W. BODLE *Outside Plant Development*

In addition to providing fast, efficient and economical communications, two fundamental requirements in the Bell System are safety for telephone users and employees and uninterrupted service. This applies of course, to the vast TD-2 microwave radio-relay networks throughout the nation. TD-2 carries a large percentage of the country's telephone and television transmission traffic, and antenna sites must be protected from damage by lightning. Such careful attention has been given to this problem that there has not been a single injury or service interruption from lightning strokes.

To obtain the height required for line-of-sight transmission, TD-2 radio-relay stations are located on hilltops or on tall supporting structures — and for this reason they are prime targets for lightning. With about 600 such installations in a microwave network of some 21,000 route miles, the likelihood of a thunderstorm occurring over some part of this vast network is very great. The probable lightning-stroke incidence for these 600 structures is estimated at over 500 per year, which, without adequate protective measures, would constitute a considerable hazard to personnel, equipment and service continuity.

A structure hit by a stroke of lightning becomes part of the path over which the current passes between cloud and earth. The magnitude of the stroke current is principally a function of meteorological conditions and is not significantly affected by the impedance of the structure. The crest values of current in lightning strokes vary over a wide range, as shown by the distribution curve in Figure 1. It may be noted from this illustration that the average value is about 16,000 amperes, but that strokes may occasionally reach magnitudes of current exceeding 200,000 crest amperes. On the average, stroke currents rise to peak value in 1 to 2 microseconds and decay to half value in 40 to 50 microseconds. Because of the rapid rate of rise of the surge front and because of the high currents involved, inductive potentials of many thousands of volts can develop, even in structures with negligible resistance.

Such inductive potentials could cause arcing to adjacent conducting objects and thus introduce fire and safety hazards. Where appreciable resistance is present in the surge path — as might occur at joints

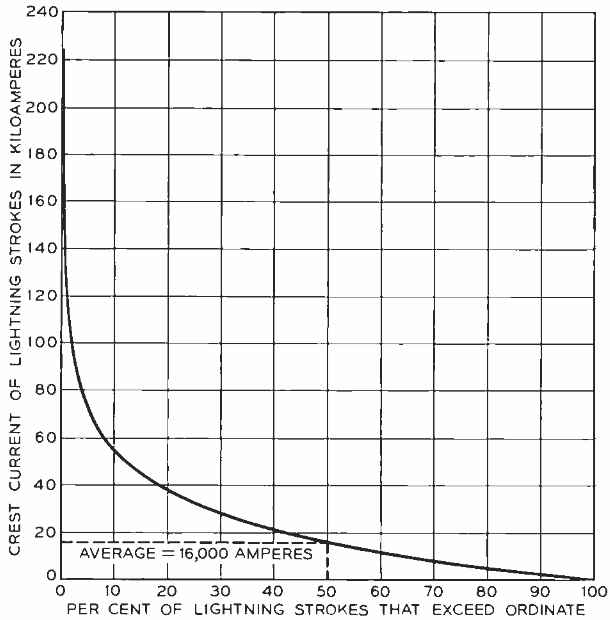


Fig. 1 — Distribution of lightning-stroke currents; average is about 16,000 amperes, but some strokes may exceed 200,000 amperes.

and connection points — another fire hazard could exist from arcing produced by stroke currents of large magnitude. It is therefore necessary to provide, between the stroke point and earth, paths having sufficiently low inductance to limit the build-up of inductive potentials, and also having adequate current-carrying capacity to prevent arcing effects.

Fortunately, the antenna towers commonly used in the TD-2 system are metallic structures having waveguides and wiring conduits for tower lights in good electrical contact with the tower at frequent intervals. These parallel paths provide a good low-impedance path for the lightning currents.

Considerable metal is also present in the equipment buildings in the form of structural members, reinforcing bars, additional wiring conduits, and equipment racks. These may be interconnected to some extent in the normal course of construction, but more adequate interconnection must be assured by specific bonding connections. Connections are established not only between the various conducting components, but also between them and the area-grounding structure. The basic approach has been to simulate as far as economically possible a type of protective structure known as a "Faraday Cage." This is accomplished by means of many conducting paths and frequent bonding connections.

In the absence of electrical arcing, a surprisingly small wire (No. 10 AWG copper) will carry most lightning surges without fusing. It is customary, however, to use No. 6 copper conductors for assured-carrying ability. Sometimes, for purposes of mechanical strength, No. 2 copper is employed. To reduce potential drops due to the impedance of such conductors, it is preferable to provide multiple paths to ground for stroke currents, especially with respect to those parts of an installation housing equipment and personnel. These factors have been well recognized in the design of protection for microwave installations.

The antenna horns employed in the TD-2 system are of heavy metal construction capable of withstanding the fusing effects of a lightning stroke. When the horn assembly is supported on a steel tower, which is the most common arrangement, there is no problem of the electrical conductivity to earth. Some supporting structures are of concrete construction, however, in which case particular care is taken to provide adequate electrical conductivity through the reinforcing bars and other steel members.

The circuits required for aircraft-warning lights are enclosed in metal conduits supported on the structural steel of the tower. The topmost fixture is provided with an "air terminal" in the form of a 5-foot vertical stainless steel rod to shield the fixture against direct strokes.

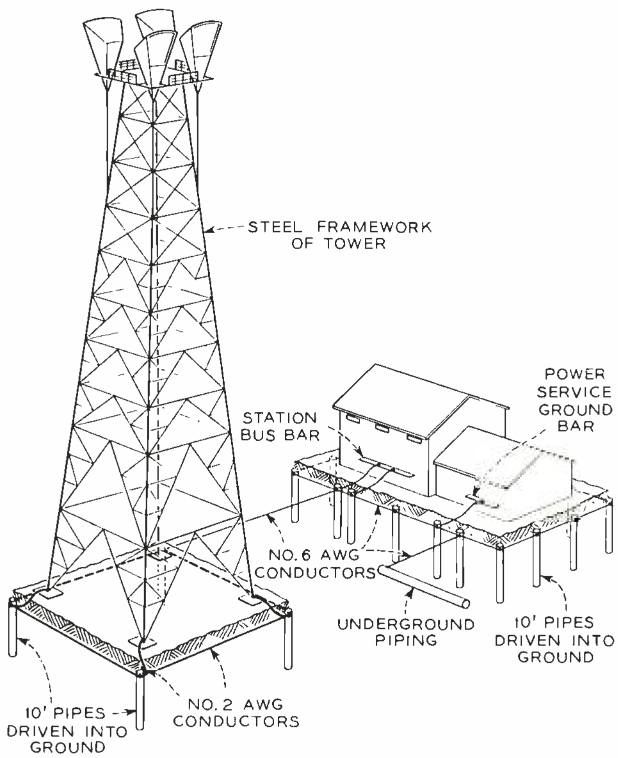


Fig. 2 — Representation of buried-ground network to protect TD-2 sites from lightning damage.

In a typical installation, the transmitting and receiving equipment is housed in a building near the base of the tower. The waveguides from the horns are electrically bonded at intervals to the steel tower, and between the tower and the building such waveguides are supported on a steel rack. The rack provides additional conductivity in parallel with the waveguides between the tower and the building ground.

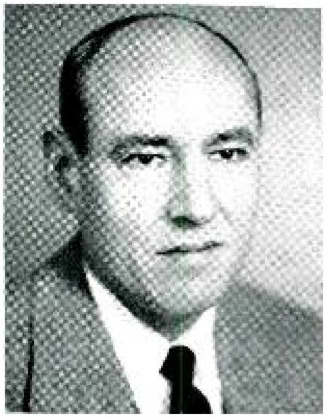
The grounding arrangement for a microwave installation is solely for protection purposes, since it is not required for microwave transmission. Usually, a buried metallic piping system, such as a water system, is not available, so it is necessary to construct a "made" ground. Because of adverse grounding conditions at many microwave sites, however, it is uneconomical to attempt the construction of a very low-resistance ground. Rather than specify a resistance value, Bell System practices require a buried network dimensioned in relation to the size of the installation. A general idea of such buried-ground networks is given in Figure 2.

This grounding network — supplemented by bonding connections to the tower footing ground, fuel tank and other buried metallic objects — effectively eliminates potential differences around the tower and equipment building. For high stroke currents, the area adjacent to the station will attain a high potential with respect to remote earth, but will not endanger personnel or equipment within the station area. Power and local communication lines feeding the station will, however, be subjected to this rise in station potential and will thus require special protection measures in the form of arresters on the power conductors and protectors on all communication circuits. The grounding terminals of these arresters and protectors are all connected to the station ground ring. Additional protection may also be provided at intervals on these facilities to equalize potentials and to provide an adequate path to remote ground for a sizeable proportion of the stroke current.

Fig. 3 — J. B. Hays, left, and author discuss results of Laboratories study of electrical protection.

A final but very important link in this chain of protective measures is the extensive grounding and bonding of conduits and equipment racks in the station to eliminate potential differences in the area occupied by personnel.

All of the protection measures described are essential to provide personnel safety and service reliability. Considerable attention during construction is given to these protection details to insure that none is overlooked, and as a result, there has been no case of electric shock to personnel or failure of microwave service or equipment due to lightning.



THE AUTHOR

D. W. BODLE, a native of Huguenot, N. Y., entered the Development and Research Department of the A.T.&T. Co. in December, 1929, where he studied inductive coordination and joint-use problems. He became a member of the Laboratories in 1934. Mr. Bodle's experience has been chiefly in the field of protection of equipment against foreign potentials and the protection of personnel from electric shock, and he has engaged in several field investigations of the characteristics of natural lightning. During World War II he was concerned with the design of cathode-ray indicators for airborne radar. Mr. Bodle received a B.S. degree in Electrical Engineering from New York University. He is a licensed professional engineer and a member of the A.I.E.E. and of the I.R.E.

A Printer-Comparer-Scanner for AMA

MISS M. E. PILLIOD

Telegraph, Signaling and Special Systems Development

In the Automatic Message Accounting system, the two functions of printing and comparing paper tapes formerly required separate machines. Now, these two functions are performed by a single AMA unit, which in addition can automatically scan tapes for special information. The newly developed AMA printer-comparer-scanner thus increases the efficiency of message accounting procedures and also simplifies the tasks of operating personnel.

The Automatic Message Accounting System, now installed in numerous localities throughout the country, performs many long-distance traffic accounting functions. As the volume of long-distance traffic continues to grow, efforts are being directed toward simplifying and combining the services of AMA. The development described here concerns the combining of several functions so that they can be performed more efficiently by a single machine.

The new development resulted from the need for a simpler means of transcribing AMA perforator tape information into printed form. During the early stages of the design it became apparent that at very little additional cost the machine could also be made to perform functions of the AMA tape comparer as well as provide a new requirement of tape scanning. The AMA printer-comparer-scanner combines these functions in a single machine. The machine, shown in Figure 1, consists of one bay of relays, one printer cabinet and two reader cabinets.

The work performed by the printer-comparer-scanner can best be understood in terms of what the AMA system has been designed to do. Included among the many AMA processing steps are provisions for printing data,* for comparing paper tapes,† and now, scanning paper tapes. The printing function is necessary in some instances so that information which appears as punched holes in a paper tape can be recorded in a form readable by accounting personnel. The comparing function is used in test procedures whereby an AMA paper tape is compared with a known or standard tape to check that the equipment is functioning properly. The new function of scanning provides a method whereby a tape containing call information may be inspected to observe irregularities, answer questions raised by customers, aid maintenance, or compile data for the few cases where bills are made out on irregular dates.

In the initial stages of AMA development, toll-call rating (calculation of charges for long-distance calls) was handled manually. AMA call records, perforated on tape at the central office at the time

* RECORD, *September*, 1952, *page* 368. † RECORD, *September*, 1952, *page* 349.

the call was made, were processed through various AMA machines, and the information necessary to calculate the charges on each call was assembled as a single entry on a tape. The AMA printer then translated the numerical information on the tape into printed letters and numbers and prepared individual toll slips which were used by accounting personnel to prepare customers' statements. The tremendous growth of long-distance traffic handled by AMA (approximately 32 million toll messages per month) has made manual methods impractical. A present step towards the automation of toll rating is the use of punched card methods. This change in method of handling toll calls removes the necessity for the complex AMA printer.

The only call records which must be printed under the present method of AMA operation are the "straddle" records. This term is significant because when calls are in process at the time the central office tape is cut, the records will straddle the cutting point. The assembler-computer will process the records on each side of the cutting point at different times and therefore will be unable to perform the necessary computations. The assembler-computer perforates the straddle call records on a separate tape. Also included on this tape are records of calls which exceed the capacity of the assembler-computer for calculating conversation time or message-unit charges. The tape is printed and IBM cards are punched manually from the printed record. The calls are then merged with the rest of the records for automatic processing. An example of a straddle record, depicted in Figure 2, shows no translation of either the calling or called customer's office code. The information is printed in the same numerical form used by the switching equipment.

Another use of the printer is in obtaining message-unit summary information for customers who change or disconnect their lines during the billing month. In the normal billing procedure, summaries of the message-unit usage of each customer are made several times a month and the record is kept in tape form. A summary tape is prepared for each central office code. For each customer who has made any message-unit calls during the period of time covered by the tape, an entry is made giving the total message-unit charges which he has accumulated. The entries are arranged in ascending order of customer line number. These summaries are accumulated through the billing month and at the billing date an IBM card is punched from the tape for each customer, showing his total usage for the month. This card, together with the cards for toll messages made by the customer during the month, is used in making the final bill.

When a customer is to be billed prior to the regular billing date, however, it is necessary to determine his usage before the cards are punched. As a normal procedure, a printed record is made of the intermediate summary tapes which are prepared during the month. The records are available when they are needed for billing a particular customer without preparing cards for all the customers in the office.

As a further application of the printer function, it may be necessary, for maintenance reasons, to print a verbatim record of an AMA tape. The printer-comparer-scanner can do this in either of two ways. Figure 3 shows a portion of central office tape printed in the two forms. The form to the left shows each line printed as it appears on the AMA tape. The form to the right shows each entry printed across a single line of the page. When the "in line" form is used, the zeros, which are always

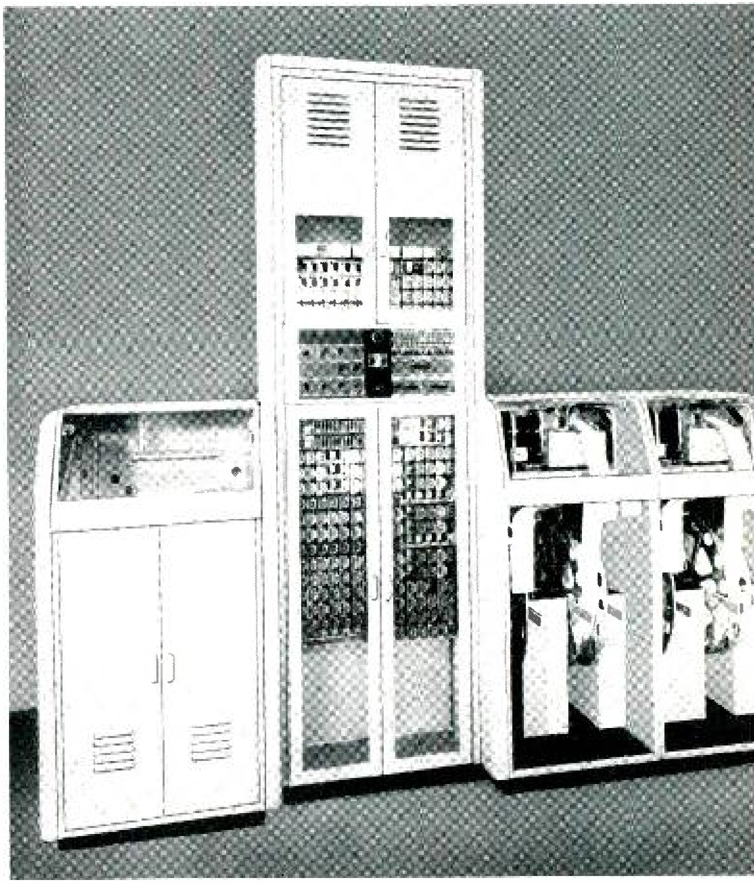


Fig. 1 — The printer-comparer-scanner unit includes a printer cabinet, left, a bay of relays, center, and two reader cabinets. Several functions are combined in the machine.

the first digits of a supplementary line, are omitted from the printed copy. This form is essentially the same as that used to print straddle records.

The second function of the printer-comparer-scanner — tape comparing — is used in testing AMA machines. Since those machines pass intelligence from one to another in the form of punched paper tapes, the machines are best tested by means of known test input tapes which will produce known output tapes. The test output tape can then be checked against a master tape. The printer-comparer-scanner checks the two tapes, line by line, for identity of the perforation. This function was previously performed by the AMA tape comparer.

The third function of the new AMA unit — scanning — fills a need long felt in the field for a means of obtaining special information from AMA tape rapidly and accurately. The alternatives to an automatic tape scanning device are: using a hand reader, or printing the entire tape and then scanning the result by eye. Both of these methods are time consuming and susceptible to human error. When the printer-comparer-scanner is used, instructions required to locate the desired information are set into the machine on switches and keys located on

DAY HOUR	MINUTE TRUNK NO.	CALLING LINE OFFICE NUMBER		CALLED LINE AREA	OFFICE	NUMBER
100109	00044	01050	00900	00001	01484	00140
210109	54757					
100109	00057	00100	00100			
100109	00011	03300	00100			
100109	00034	06122	00100			
100109	00026	00961	00900	00003	21454	21390
100109	00025	01500	00100			
303503						
220007						

Fig. 2 — A typical straddle record with key to identify each numerical group in the various entries.

110470
239070
040818
001878
012120
109871
109780
211080
006432
106162
104862
211062
002900
281023
154871
239071
040615
001532
031110

110470			
239070	40818	01878	12120
109871			
109780			
211080	06432		
106162			
104862			
211062	02900		
281023			
154871			
239071	40615	01532	31110

Fig. 3 — A verbatim record of a central office AMA tape can be printed in either of these two forms — vertical or "in line."

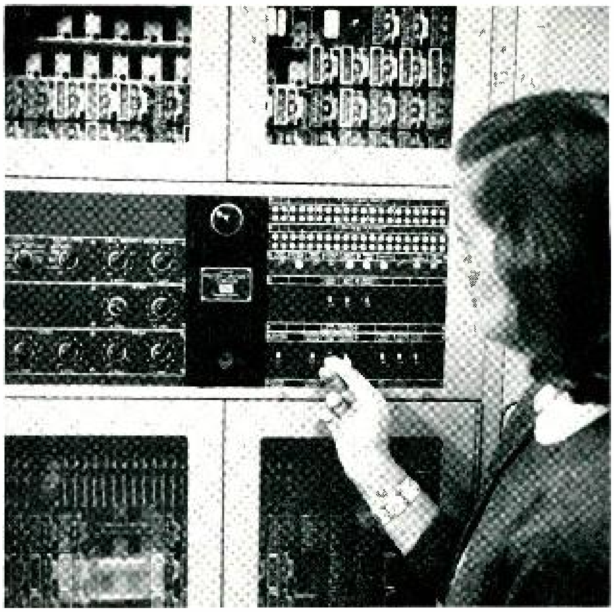


Fig. 4 — The author introduces into the control panel information which will initiate the scanning feature of the printer-comparer-scanner.

the control panel (see Figure 4). When the tape is inserted, the machine starts scanning the tape a line at a time until the desired information is found. The tape moves along at the rate of about eight feet per minute. When the desired information is encountered, the machine blocks and sounds an alarm to attract the attention of the attendant. At this point, the attendant operates a key to obtain a printed record of the information.

One possible use of the scanning function provides an alternative to the printing of the intermediate summary tapes which was discussed earlier. When message-unit summary information is required for billing a particular customer, the four switches, shown in the lower left row of Figure 4, are set to correspond to his line number. The tape containing his record is inserted and the machine starts scanning at its usual rate of eight feet per minute. The machine will continue scanning until

Fig. 5 — A printed record of the scanned tape. Customers' line numbers appear in left column and message unit charges appear in right column.

2706	0011
3219	0301
3807	1000
3807	0323
4404	0099
5667	0184
6321	0724
7487	0190
8804	0323
9917	0253

it encounters either the desired line number or a higher line number. This feature makes it unnecessary to scan the entire tape if there is no entry corresponding to the desired line number.

As an example, suppose that information on line number 3953 is desired. All numbers from 0000 to 3952 will be passed over and the machine will stop on 3953 or, if 3953 is missing, on 3954 or the next number higher than 3953 which it encounters. Lamp indications inform the attendant whether the machine has stopped because the desired number has been found or because a higher number has been encountered. Under key control, the customer's line number and his message units are printed. The machine can then be reset to scan for some higher number. A tape containing message-unit summary information for 10,000 customers can be scanned in less than half an hour, whereas four hours would be required to print the complete information. The printed record is shown in Figure 5. The information is arranged in two columns with the customers' line numbers appearing in numerical order in the left hand column and the associated message unit charges in the right hand column.

Many other scanning functions can be performed, and in every case the procedure is the same. The required data are set into the machine and the tape is scanned until the information is found. The machine can be set to step a message register, instead of stopping when it encounters the desired information, and to continue scanning for subsequent appearances of the same information. A possible use of this feature might be to determine the amount of traffic handled by a given trunk in a central office. New applications of the printer-comparer-scanner are continuously being studied.

THE AUTHOR

Mary E. Pilliod, a native of New York City, joined the Laboratories in 1945 after receiving her A.B. degree from Vassar College. She has been mainly concerned with AMA development, primarily circuit design and laboratory testing of the accounting center machines used in this system. She participated in accuracy tests in 1948 at Philadelphia where the first No. 5 crossbar installation with AMA was made, and a year later in similar tests when No. 1 crossbar and AMA were used together for the first time. She also participated in pre-cutover tests of nationwide customer dialing at Newark and Englewood in 1951. After a short period devoted to design of crossbar tandem circuits for use with AMA, she returned to accounting center circuit design work to develop the Printer-Comparer-Scanner. From 1955 until she left the Laboratories recently, she was engaged in designing circuits for the Common User Group, part of the air-ground communication system for SAGE.

"Our Mr. Sun" to Be Telecast on NBC

The widely acclaimed Bell System Science Series program, "Our Mr. Sun", will be telecast in color over the NBC television network on Sunday, December 15, at 5:30 P.M., EST (4:30 P.M., CST; 3:30 P.M., MST; and 5:30 P.M., PST). Starring Dr. Frank Baxter as "Dr. Research" and Eddie Albert as "Fiction Writer", the program dramatizes many facts about the sun and shows scientists at work on solar studies throughout the world.

First telecast in November, 1956, "Our Mr. Sun" will be the second in a series of four Bell System Science programs over NBC-TV for 1957-58. "The Strange Case of the Cosmic Rays" was seen on October 25, and "The Unchained Goddess," a new program about weather, will be seen on Wednesday, February 12. "Hemo the Magnificent", about the blood and its circulation, will be seen for the second time on Sunday, March 16. All four of these programs were produced and directed by Academy Award Winner Frank Capra. In addition to their use on television, these films have been shown to about six million students in classrooms during 1957.

W. O. Baker Receives Honorary Degree

W. O. Baker, Vice-President in charge of research at Bell Laboratories, received the honorary degree of Doctor of Science from Washington College on October 20. The degree was awarded in Chestertown, Maryland, at a convocation marking the 175th anniversary of the College, of which George Washington was the first benefactor.

Dr. Daniel Z. Gibson, right, President of Washington College, presenting honorary Doctor of Science degree to W. O. Baker.

College President Daniel Z. Gibson made the presentation and cited Dr. Baker as "one of the most distinguished young scientists of the United States." The citation continued by recognizing Dr. Baker as "an authority on the chemistry of high polymers and in the development of synthetic rubber. . . . He has served as visiting lecturer at Princeton, Northwestern, Western Reserve and Brooklyn Polytechnic Institute, is a consultant for the Office of Naval Research and the Army Quartermaster Corps, and is a member of the Visiting Committee in Chemistry at Princeton University, and the Science Advisory Committee of the Executive Office of the President. We are proud to welcome home a native son and to recognize his distinguished achievements."

Dr. Baker was graduated from Washington College in 1935 and continued study at Princeton, where he received the Ph.D.

J. R. Townsend Receives A.S.A. Gold Medal

J. R. Townsend, formerly of the Laboratories and now special assistant to the Assistant Secretary of Defense for Research and Engineering, received one of the highest awards of the American Standards Association on November 14. He was awarded the gold Standards Medal at the Association's Annual Award Dinner during the Eighth National Conference on Standards held in San Francisco. This Medal is awarded for leadership in the actual development and application of standards.

With the Bell System for more than 38 years, Mr. Townsend is a nationally known materials expert who has been called on frequently to render service to the highest levels of government. On leave from Bell Laboratories since 1952, he served as Director of Materials Application Engineering for the Sandia Corporation until his recent appointment to the government post. At the Laboratories, Mr. Townsend was active in the initiation and promotion of the materials testing laboratories as well as the x-ray, optical, welding and metallurgical laboratories. Among his many official positions, he has served as President of the American Society for Testing Materials and as a member of the A.S.A. Board of Directors.

Contents of the September, 1957, Bell System Technical Journal

The September, 1957, issue of The Bell System Technical Journal contains the following articles:

Oceanographic Information for Engineering Submarine Cable Systems by C. H. Elmendorf and B. C. Heezen.

Resistance of Organic Materials and Cable Structures to Marine Biological Attack by L. R. Snoke.

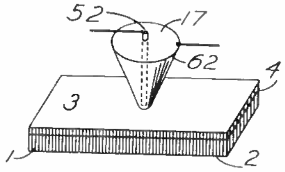
Dynamics and Kinematics of the Laying and Recovery of Submarine Cable by E. E. Zajac.

Theory of Curved Circular Waveguide Containing an Inhomogeneous Dielectric by S. P. Morgan.

Circular Electric Wave Transmission in the Dielectric Coated Waveguide by H. G. Unger.

Circular Electric Wave Transmission Through Serpentine Bends by H. G. Unger.

Normal Mode Bends for Circular Electric Waves by H. G. Unger.



Patents Issued to Members of Bell Telephone Laboratories During September

Albersheim, W. J. – *Automatic Distortion Correction* – 2,805,398.

Brown, J. T. L., and Pollard, C. E., Jr. – *Relay Adjusting Set* – 2,806,186.

Carbrey, R. L. – *Circulating Pulse Decoder* – 2,806,950.

Carbrey, R. L. – *Circulating Pulse Coders* – 2,806,997.

Cioffi, P. P. – *Traveling Wave Tube Apparatus Including Magnetic Structures* – 2,807,743.

Crowley, J. C. – *H-Plane Hinge Joint* – 2,805,401.

Edwards, C. F. – *Impedance Matching Devices for Wave-Guide Hybrid Junctions* – 2,806,210.

Germanton, C. E. – *Register Circuit* – 2,807,796.

Haynes, J. R., and Hornbeck, J. A. – *Semiconductive Devices* – 2,805,347.

Hopper, A. L. – *Wave Guide Frequency Converter* – 2,806,138.

Hornbeck, J. A., see Haynes, J. R.

Joel, A. E., Jr. – *Communication System* – 2,806,088.

Ketchledge, R. W. – *Ambient Temperature Compensation of Thermistors* – 2,806,200.

Krom, M. E., and Posin, M. – *Line Concentrator Service Observing Circuit* – 2,807,668.

Lewis, B. F. – *Multiparty Identification System* – 2,806,091.

Pollard, C. E., Jr., see Brown, J. T. L.

Posin, M., see Krom, M. E.

Reck, F. – *Tool for Unwrapping Wrapped Wire Connections* – 2,804,887.

Robertson, G. H., and Walsh, E. J. – *Electron Discharge Devices* – 2,806,169.

Ross, I. M. – *Semiconductor Signal Translating Devices* – 2,805,397.

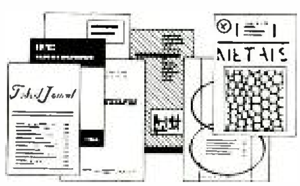
Smith, K. D. – *Electronic Systems* – 2,807,712.

Wallace, R. L., Jr. – *Magnetic Register* – 2,805,407.

Walsh, E. J., see Robertson, G. H.

Weibel, E. S. – *Electronic Analogue Multiplier* – 2,805,021.

Wilson, D. K. – *Alloyed Connections to Semiconductors* – 2,805,370.



Papers by Members of the Laboratories

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

Archer, R. J., *Optical Measurement of Film Growth on Silicon and Germanium Surfaces in Room Air,* J. Electrochem., Soc., **104**, pp. 619-622, Oct., 1957.

Arnold, S. M., see Treuting, R. G.

Baker, A. N., and Webber, D. S., *Hydrogen Vibration Spectra of Rochelle Salt,* J. Chem. Phys., **27**, pp. 689-692, Sept., 1957.

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

Breidt, P., Jr., see Hobstetter, J. N.

Burns, F. P., and Fleischer, A. A., *Piezoresistive Effect in Indium Antimonide,* Phys. Rev., **107**, pp. 1281-1282, Sept. 1, 1957.

Chynoweth, A. G., *The Pyroelectric Behavior of Colemanite,* Acta Crystallographica, **10**, pp. 511-514, Aug., 1957.

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

Dunn, H. K., and Young, R. W., *On the Interpretation of Certain Sound Spectra of Musical Instruments,* J. Acous. Soc. Amer., **29**, pp. 1070-1073, Oct., 1957.

Ellis, W. C., Williams, H. J., and Sherwood, R. C., *Evidence for Subgrains in MnBi Crystals from Bitter Patterns,* J. Appl. Phys., Letter to the Editor, **28**, pp. 1215-1216, Oct., 1957.

Feher, G., Fuller, C. S. and Gere, E. A., *Spin and Magnetic Moment of P^{31} by the Electron Nuclear Double-Resonance Technique,* Phys. Rev., Letter to the Editor, **107**, pp. 1462-1464, Sept. 1, 1957.

Feinstein, J., and Kino, G. S., *The Large-Signal Behavior of Crossed-Field Traveling-Wave Devices,* Proc. I.R.E., **45**, pp. 1364-1373, Oct., 1957.

Fleischer, A. A., see Burns, F. P.

Foster, F. G., see Williams, H. J.

Fuller, C. S., see Feher, G.

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

Geller, S., and Gilleo, M. A., *The Crystal Structure and Ferrimagnetism of Yttrium-Iron Garnet, $Y_3Fe_2(FeO_4)_3$,* J. Phys. and Chem. Solids, **3**, (Nos. 1-2), pp. 30-36, 1957.

Gilleo, M. A., see Geller, S.

Gordon, J. P., and White, L. D., *Experimental Determination of the Noise Figure of an Ammonia Maser,* Phys. Rev., Letter to the Editor, **107**, pp. 1728-1729, Sept. 15, 1957.

Hobstetter, J. N., and Breidt, P., Jr., *Detection of Both Vacancies and Interstitials in Deformed Germanium,* J. Appl. Phys., Letter to the Editor, **28**, pp. 1214-1215, Oct., 1957.

Kelley, E. M., see Williams, H. J.

Kino, G. S., see Feinstein, J.

Kisliuk, P., *The Sticking Probabilities of Gases Chemisorbed on the Surfaces of Solids,* J. Phys. and Chem. Solids, **3**, Nos. 1-2), pp. 95-101, 1957.

Lax, M., *Frequency Dependence of the AC Resistance of Thin Semiconducting Films,* Phys. Rev., **107**, pp. 650-655, Aug. 1, 1957.

Matthias, B. T., and Corenzwit, E., *Superconducting Alkaline Earth Compounds,* Phys. Rev., **107**, pp. 1558-1559, Sept. 15, 1957.

Papers by Members of the Laboratories, Continued

Matthias, B. T., and Remeika, J. P., *Ferroelectricity of Dicalcium Strontium Propionate*, Phys. Rev., Letter to the Editor, **107**, p. 1727, Sept. 15, 1957.

Mertz, P., *Information Theory Impact on Modern Communications*, Comm. and Electronics, **32**, pp. 431-437, Sept., 1957.

Pfann, W. G., *Techniques of Zone Melting and Crystal Growing*, Solid State Physics, Vol. IV, Academic Press, New York, 1957.

Remeika, J. P., see Matthias, B. T.

Romanow, W. J., *Crystallographic Angles for Manganese Bismuthide*, J. Metals, **209**, p. 1284, Oct., 1957.

Schwartz, J., *Spin Echo Apparatus*, Rev. Sci. Instr., **28**, pp. 780-789, Oct., 1957.

Sherwood, R. C., see Williams, H. J.

Sherwood, R. C., see Ellis, W. C.

Treuting, R. G., and Arnold, S. M., *Orientation Habits of Metal Whiskers*, Acta Metallurgica, **5**, p. 598, Oct., 1957.

Wernick, J. H., *Effects of Crystal Orientation, Temperature and Molten Zone Thickness in Temperature Gradient Zone Melting*, J. Metals, **9**, pp. 1169-1173, Oct., 1957.

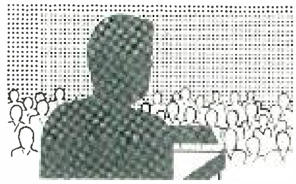
Wernick, J. H., and Benson, K. E., *New Semiconducting Ternary Compounds*, J. Phys. Chem. Solids, Letter to the Editor, **3**, (Nos. 1-2), pp. 157-159, 1957.

White, L. D., see Gordon, J. P.

Williams, H. J., see Ellis, W. C.

Williams, H. J., Sherwood, R. C., Foster, F. G., and Kelley, E. M., *Magnetic Writing on Thin Films of MnBi*, J. Appl. Phys., **28**, pp. 1181-1184, Oct., 1957.

Wooley, M. C., *Passive Components for Submarine Cable Telephone Repeaters*, I.R.E., Trans. on Reliability and Quality Control, pp. 14-24, Nov., 1957.



Talks by Members of the Laboratories

Following is a list of talks given before professional and educational groups by Laboratories people during October.

I.R.E.-PG Conference on Electronic Devices, Washington, D. C.

Amron, I., Corby, W. J., Craft, W. H., Koontz, D. E., and Pondy, P. R., *A Method of Wide Applicability for Cleaning and Etching Electronic Materials*.

Burcham, N. P., and Miller, L. E., *Stabilization of Germanium Alloy Junction Transistor Characteristics Through Surface Treatment*.

Closson, H. T., Danielson, W. E., and Nielsen, R. J., *Automatic Measurement of Micro-Deviations in Periodic Structures*.

Corby, W. J., see Amron, I.

Craft, W. H., see Amron, I.

Craft, W. H., see Feder, D. O.

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

Early, J. M., and Knowles, C. H., *High Frequency Junction Transistors*.

Early, J. M., and Sevick, J., *Characteristics and Structure of a Diffused-Base Germanium High Frequency Amplifier Transistor*.

Feder, D. O., Craft, W. H. and Koontz, D. E., *Simple Techniques for Storing Ultraclean Electron Tube Components*.

Knowles, C. H., see Early, J. M.

Koontz, D. E., see Amron, I.

Koontz, D. E., see Feder, D. O.

Miller, L. E., see Burcham, N. P.

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

Pondy, P. R., see Amron, I.

Scovil, H. E. D., *Solid State Masers*.

Sevick, J., see Early, J. M.

Wahl, A. J., *An Analysis of Transistor Base Spreading Resistance and Associated Effects*.

54th Meeting of Acoustical Society of America, Ann Arbor, Mich.

Bommel, H., see Mason, W. P.

David, E. E., Jr., Guttman, N., and van Bergeijk, W. A., *Some Factors Governing the Lateralization of High Frequency Complex Waveforms*, (Presented by W. A. van Bergeijk).

Flanagan, J. L., *Pitch Discrimination for Synthetic Vowels*.

Guttman, N., see David, E. E., Jr.

Mason, W. P., and Bommel, H., *Frequency and Temperature Dependance of Internal Friction in Pure Copper*.

McSkimin, H. J., *Measurement of Dynamic Shear Impedance of Liquids at High Ultrasonic Frequencies*.

Pierce, J. R., *Explanation of Limens of Loudness*.

Schroeder, M. R., *On the Steady State Transmission in Rooms*.

van Bergeijk, W. A., see David, E. E., Jr.

Weinreich, G., *Acoustoelectric Effect in Germanium*.

Electrochemical Society, Buffalo, N. Y.

Bemski, G., and Struthers, J. D., *Gold in Silicon*.

Forster, J. H., and Veloric, H. S., *The Effect of Variations in Surface Potential on Junction Characteristics*.

Howard, B. T., *Phosphorus Diffusion in Silicon*.

Singleton, J. B., and Silverman, S. J., *Techniques for Preserving Lifetime in Diffused Silicon*, (Presented by S. J. Silverman).

Silverman, S. J., see Singleton, J. B.

Smith, K. D., *Semiconductor Materials and Processes*.

Struthers, J. D., see Bemski, G.

Veloric, H. S., see Forster, J. H.

National Electronics Conference, Chicago, Ill.

Abraham, R. P., see Kirkpatrick, R. J.

Blecher, F. H., *Transistor Feedback Amplifiers.*

Hewitt, W. H., and von Aulock, W. H., *A Reciprocal Ferrite Phase Shifter for X-Band.*

Kirkpatrick, R. J., and Abraham, R. P., *Transistor Characterization at VHF.*

von Aulock, W. H., see Hewitt, W. H.

A.I.E.E. Fall Meeting, Chicago, Ill.

Egan, T. F., see Hermance, H. W.

Hermance, H. W., and Egan, T. F., *The Examination of Electrical Contacts by the Plastic Replica Method,* (Presented by T. F. Egan).

Hoth, D. F., *A Study of Negative Impedance Loading.*

McDavitt, M. B., *6,000 Mc/Sec Radio Relay System for Broad-Band, Long Haul Service in the Bell System.*

Scheinman, A. H., *A Numerical-Graphical Method for Synthesizing Switching Circuits.*

Other Talks

Baker, A. N., *Recent Developments in Semiconductors,* New York Telephone Company, White Plains, N. Y.

Bashkow, T. R., and Desoer, C. A., *Digital Computers and Network Theory,* I.R.E.-PG Conference on Circuit Theory, Syracuse, N. Y.

Benson, R. J., *Wear Studies of Fine-Pitch Gear Materials,* Semi-annual Meeting, American Gear Manufacturers Association, Chicago, Ill.

Birdsall, H. A., see McMahon, W.

Blecher, F. H., *Properties of Junction Transistors,* Chicago Section of I.R.E., Chicago, Ill.

Bleicher, E., *Life Testing of Electronic Components,* The American Society for Quality Control, Bridgeport, Conn.

Bradley, W. W., *The Sea Bottom as an Environment for Metals,* National Association of Corrosion Engineers, San Diego, Calif.

Camilli, C. T., see McMahon, W.

Chapin, D. M., *Solar Energy and the Bell Solar Battery,* American Society of Mechanical Engineers, New London, Conn.

Compton, K. G., *Sources of Underground Corrosion Potentials,* S. E. Regional Meeting, National Association of Corrosion Engineers, Birmingham, Ala.

Desoer, C. A., see Bashkow, T. R.

Dickieson, A. C., *Trends in Transmission Systems Development at Bell Telephone Laboratories,* Tokyo Section of I.R.E., Tokyo, Japan.

Ferrell, E. B., *The Control Chart – Modifications and Extensions,* Metropolitan Section of American Society for Quality Control, Newark, N. J.

Fisher, C. E., *Quality Assurance,* Waco Section, American Society for Quality Control, Waco, Texas; San Antonio Section, San Antonio, Texas; Dallas-Ft. Worth Section, Ft. Worth, Texas, and South Texas Section, Houston, Texas.

Fox, A. G., *Masers and Mavars,* Baltimore Section of I.R.E., Baltimore, Md.

Galt, J. K., *Cyclotron Absorption in Bismuth and Graphite,* Rutgers University, New Brunswick, N. J.

Ganse, G. R., *The Quality Survey – An Essential Part of an Overall Quality Program,* Montreal Section of American Society for Quality Control, Montreal, Canada.

Geils, J. W., *Research and Development in Industry Today,* Newark College of Engineering, Newark, N. J.

Graham, R. E., *Review of Paris Symposium on Physical Problems of Color Television,* Society of Motion Picture and Television Engineers Convention, Philadelphia, Pa.

Hamming, R. W., *Numerical Methods of Computation for Digital Computers,* Western Electric Company, New York City.

Harmon, L. D., *Computer Simulation of Pattern Recognition,* Symposium on Pattern Recognition, University of Michigan, Ann Arbor, Mich.

Harvey, F. K., *The Physics of Hearing and Music,* New Jersey Division of New York Section, A.I.E.E., Allenhurst, N. J.

Hawkins, W. L., *The Behavior of Antioxidants in Autoxidation,* Chemical Symposium, Stevens Institute, Hoboken, N. J.

Hebel, L. C., Jr., *Nuclear Spin Relaxation in Superconductors,* I.B.M. Watson Laboratory, New York City and Physics Colloquium, Princeton University, Princeton, N. J.

Helm, H. A., *The Analysis of Digital Control Systems,* Conference on Computers in Control, A.I.E.E., Atlantic City, N. J.

Herbst, R. T., *Computer Programing Techniques,* 2nd Annual Symposium, Piedmont Subsection, I.R.E., Greensboro, N. C.

Hornbeck, J. A., *Device Research at Bell Telephone Laboratories,* Joint Session, Tokyo Section I.R.E.-Institute Electrical Communications Engineers of Japan, Tokyo, Japan.

Ingram, S. B., *Graduate Training for the Young Engineer at Bell Telephone Laboratories,* 4th General Assembly, Joint Meeting of the Engineers Council for Professional Development and the Engineers Joint Council, New York City.

Ingram, S. B., *The Utilization and Training of Engineers in Industry,* Management Division, Cleveland Engineering Society, Cleveland, Ohio.

Johnson, G. R., see McMahon, W.

Katz, D., *Magnetic Regulated Power Supplies,* Northern New Jersey Section, I.R.E., Montclair, N. J.

Laudise, R. A., *Hydrothermal Growth of Oxide Crystals,* Conference on Growth and Evaluation of Single Crystals of Ferrimagnetic Ceramics, Air Force Cambridge Research Center, Bedford, Mass.

Lawson, C. C., *Buried Distribution of Telephone Circuits,* Annual Convention of the Wire Association, Chicago, Ill.

Legg, V. E., *Basic Magnetic Components,* Northern New Jersey Section, I.R.E., Montclair, N. J.

Loar, H. H., *Semiconductor Devices,* New York Telephone Company, Nyack, N. Y.

Lundberg, J. L., *Pyrolyses and Photocyses in the Flash Illumination of Polymers,* Chemistry Department Seminar, New York University, New York City.

MacNair, W. A., *Industrial Research and Development,* U.S. Army Signal School, Ft. Monmouth, N. J.

McClure, B. T., *Total Ionization by Low Energy Electrons in Neon,* Gaseous Electronics Conference, Cambridge, Mass.

Talks by Members of the Laboratories, Continued

McMahon, W., Birdsall, H. A., Johnson, G. R., and Camilli, C. T., *Degradation Studies of Mylar*, Conference on Electrical Insulation, Pocono Manor, Pa.

Mayo, J. S., *Analysis of an On-Off Digital Control System*, Symposium on Feedback Control, A.I.E.E., Atlantic City, N. J.

Miller, L. E., *The Bell Solar Battery*, A.I.E.E., Allentown, Pa.

Moore, E. F., *A General Introductory Survey of Automata*, Informal Seminar on Automatic Computers and their Capabilities, University of Pennsylvania, Philadelphia, Pa.

Moore, G. E., *Physics in Industrial Laboratories*, Physics Club, Fordham University, New York City.

Morrison, J., *Gas Collection and Analysis System Employed in Vacuum Tube Problems*, 1957 4th National Vacuum Symposium, Boston, Mass.

Nielsen, J. W., *The Use of Molten Lead Oxide as a Solvent for Magnetic Crystals*, Symposium on Crystal Growth, Air Force Cambridge Research Center, Bedford, Mass.

Pierce, J. R., *Fancies and Fallacies of Space Travel*, Joint I.R.E., A.I.E.E. and American Rocket Society, New York Section, New York City; Griffiss Air Force Base Club, Rome Air Development Center, Rome, N. Y.

Pierce, J. R., *The Challenging Field of Engineering Writing and Speech*, 1st National Symposium, I.R.E.-PG on Engineering Writing and Speech, New York City (Presented by H. S. Black).

Pfann, W. G., *New Methods of Purifying Solid Materials*, Stuyvesant High School, New York City.

Pollak, H. O., *The Problem of Minimal Connecting Networks*. Computation Laboratory, National Bureau of Standards, Washington, D. C.

Schawlow, A. L., *The Intermediate State of Superconductors*, Physics Colloquium, Johns Hopkins University, Baltimore, Md.

Schroeder, M. R., *Artificial Stereophony Using Single Input*, 1957 Convention of the Audio Engineering Society, New York City.

Scovil, H. E. D., *The Solid State Maser*, PGMTT, PGED and Northern New Jersey Section, I.R.E., Murray Hill, New Jersey.

Sharpe, L. H., *Electrolytic Regeneration of Cupric Chloride Etching Solutions*, Joint Bell Telephone Laboratories-Western Electric Company, Printed Wiring Symposium, Greensboro, N. C.

Sobel, M., *On a Nonparametric Definition of the Representativeness of a Sample with Tables for Applications*, Columbia University, New York City.

Stephens, Miss S. J., *Preparation and Properties of Clean High-Area Metal and Alloy Evaporated Films for Use in Surface Studies*, 4th National Vacuum Symposium, Boston, Mass.

Warthman, K. L., *Bell Telephone Laboratories Optical Tracking System for NIKE Radar*, Society of Motion Picture and Television Engineers, Philadelphia, Pa.

Weinreich, G., *Acoustoelectric Effect in Germanium*, Physics Colloquium, Yale University, New Haven, Conn.; University of Minnesota, Minneapolis, Minn.

Wenk, H. A., *Trips to DEW Line and White Alice*, Mountain Lakes School, Mountain Lakes, N. J.

Wilkinson, R. I., *Some Engineering Applications of Queueing Theory*, Administrations Applications Conference, American Society for Quality Control, Columbia University, New York City.

Wintringham, W. T., *Tailoring a Facsimile System to Its Application*, Savings Bank Research Group, New York City.

Wright, S. B., *Life Along the DEW Line, Circa 1957*, St. Cloud Presbyterian Couples Club, West Orange, N. J. (Presented by R. C. Newhouse.)

Younker, E. L., *Storage Devices: Characteristics and Techniques*, 2nd Annual Symposium, Piedmont Subsection, I.R.E., Greensboro, N. C.