Transistorized Rural Carrier System

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The new P1 rural carrier system is another step along the road toward better telephone service. For the first time, extensive carrier operation will be used between a central office and the telephone customer instead of between offices as in the past. To make such an arrangement economically feasible, P1 carrier is fully transistorized and utilizes miniature components that lend themselves to mechanization in manufacture. Future RECORD articles will describe the various components of the system.

During recent years, the increased demand for telephone service in rural areas has focused the attention of the Bell System on new and improved ways of providing this type of service. Rural routes seldom contain very many circuits, and this restricts the use of large-capacity facilities such as cable to the few routes where they are economically feasible. With rural customers scattered over fairly large areas, both technical and economic problems associated with developing improved service are difficult to solve.

Except for a relatively small amount of M1 power line carrier,* rural telephone service has been limited to voice-frequency lines. Most rural lines are complex both in geographical layout and in actual construction; usually they consist of a main route with numerous smaller branches to the more remote customers. Lines may extend as far as 15 to 20 miles from the central office, but the great majority are under 10 miles in length. At the office end, the lines are usually aerial cable; the average cable length is about 3 miles, with about 25 per cent over 5 miles long. The average rural line includes about 2.5 miles of open wire, but in recent years about 20 per cent has exceeded 5 miles in length.

Broad studies made by the Laboratories on new methods of furnishing rural service at reasonable cost indicated that improved service should be approached along two paths – the development of less costly voice-frequency outside plant facilities and the application of carrier-frequency techniques to existing and new rural lines.

Development work on the less costly outside plant facilities produced a new light weight, open-wire construction,† B rural wire,‡ and 6 open-wire pairs per crossarm instead of the conventional 5 pairs where an extra pair is needed.

In applying carrier frequency transmission to rural lines, the major obstacle is that of the cost of terminals, one of which is required at each end of the circuit. For relatively short lines, such as those in rural areas, the cost of the terminals becomes disproportionately large, resulting in a high cost per circuit mile. Obviously, therefore, the solution to the problem of adapting carrier techniques lay in reducing the cost of the terminals by using new devices, improved circuitry, and more efficient manufacturing techniques.

Completely new designs were evolved, using transistors, silicon-aluminum diodes, ferrite-core inductors, and new voice-frequency and carrier-frequency transformers, most of which were developed specifically for this application. New filter designs, signaling techniques, and power supply arrange-

* RECORD, *October*, 1947, *page* 363. † RECORD, *April*, 1954, *page* 121. ‡ RECORD, *May*, 1954, *page* 167.

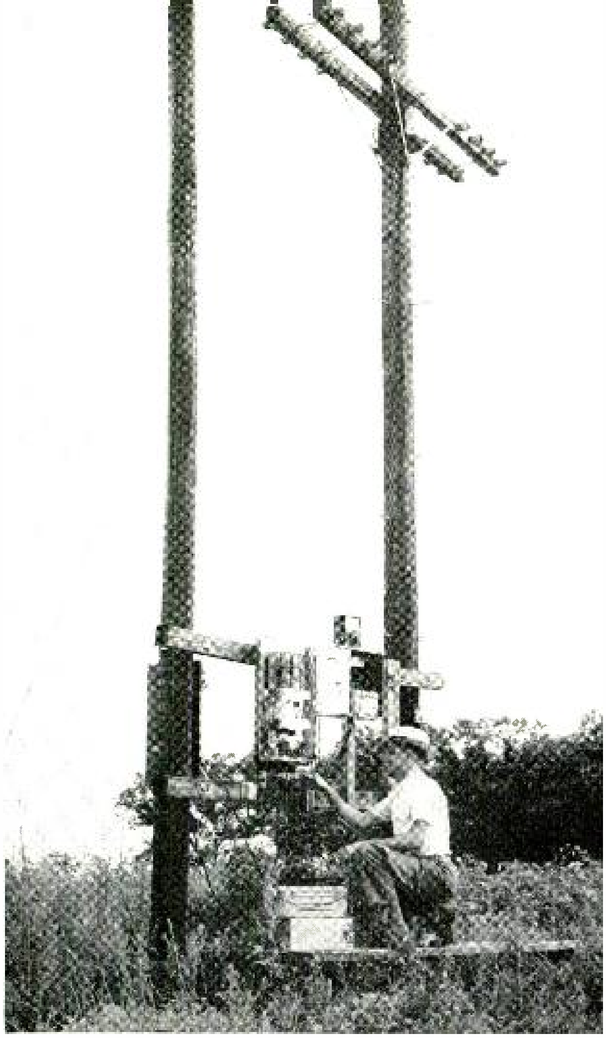


Fig. 1 — R. C. Boyd checks experimental equipment in the field trial in Georgia.

ments were also developed. Equipment assemblies were designed to use printed wiring, which lends itself to mechanical assembly, and it was decided that they should be completely tested and evaluated under actual service conditions before they were standardized for the Bell System.

An exploratory field trial was conducted in Americus, Georgia, a town of about 12,000 population in an agricultural area 115 miles south of Atlanta. The Americus exchange is served by an attended dial office with about 2,400 lines. This general area, and Americus in particular, was chosen to take advantage of the relatively intense summer static conditions and because two of the rural routes satisfied the layout requirements desired for the trial. The primary objectives of the trial were to obtain information relating to (1) transmission, noise and crosstalk performance of rural lines at carrier frequencies, (2) over-all performance of the new carrier system including speech transmission and signaling, (3) adequacy of proposed installation, operating, and engineering procedures, and (4) installed carrier system costs.

Over a period of approximately two years, eight complete experimental and prototype channels were systematically tested in the field trial. Some of the experimental equipment is shown in Figure 1. These tests aided in refining the carrier designs into the new P1 carrier system.

Objectives for the carrier system were that: (1) it should be applicable to the common types of rural plant including both cable and open wire; (2) it should consist of three or four independent two-way carrier channels per system, applicable to a pair of wires in increments of one to four channels to provide flexibility for varying growth rates, and should permit the operation of more than one system per pole line; (3) it should provide for both manual and dial operation and should include ringing arrangements for 4-party selective service and for 8-party semi-selective or divided-code service; (4) it should embody simplicity, flexibility of application, adaptability to low growth rates, low power consumption, and ease in engineering, installation and main-

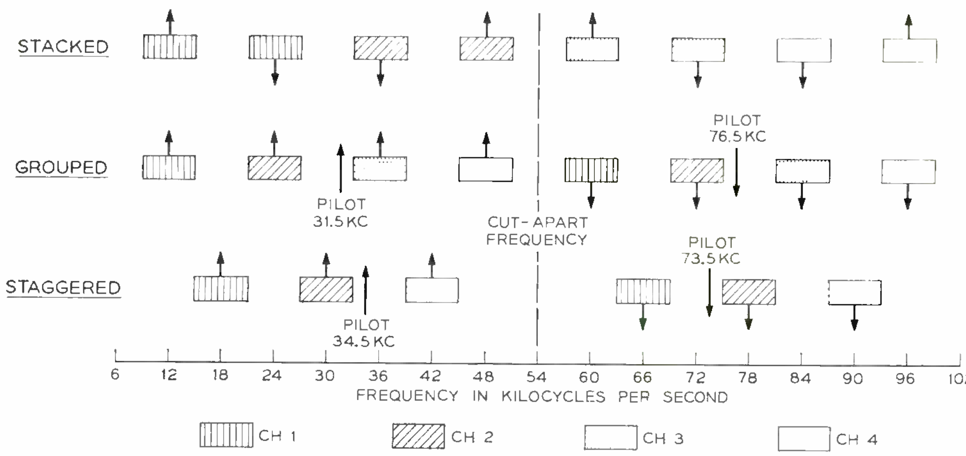


Fig. 2 — Frequency allocations of the channels for the three possible arrangements.

tenance; and finally, (5) equipment packaging should provide for outdoor mounting of repeaters, outlying terminals, and associated power supplies without sacrificing ruggedness, easy accessibility, electrical stability, and small size.

The P1 carrier system that has been developed provides up to four 2-way channels for simultaneous operation on a single pair of wires "above" a voice-frequency circuit. Each channel uses a transmitted carrier and double-sideband transmission for each direction. The carriers are spaced at 12-kc intervals, providing adequate channel separation, and are arranged in the frequency band between 12 and 96 kc as shown in Figure 2.

Three frequency plans provide stacked, grouped, and staggered channel arrangements. *Stacked* channels employ pairs of adjacent oppositely directed carriers. This plan may be used where it is desirable to cover the greatest possible distance without repeaters by using the low-frequency channels for the longer distances and the higher frequencies for the shorter distances. Repeatered systems require the use of *grouped* frequency allocations in which the 8 carriers are divided into 2 groups of 4 carriers each (low and high groups) for transmission in the two directions. To improve the crosstalk performance between two repeatered carrier systems assigned to pairs with high crosstalk, a three channel *staggered* grouped arrangement can be used with carriers inter-leaved 6 kc from the normal grouped arrangement.

Each channel requires a terminal at the central-office end of the line and a pole-mounted outlying or "remote" terminal, Figure 4, near the customers to be served. The system is flexible to the extent that several variations of the general scheme are possible. In Figure 3, the voice-frequency circuit "under" the carrier channels is distributed to customers nearest the office by normal wire facilities. Each voice-frequency branch from the carrier line is served through a carrier-blocking (low-pass) filter that suppresses carrier frequencies from the branch and reduces the carrier-frequency bridging loss of the branch. Channel 1 of the carrier system serves the most remote customers and ends the carrier line. Channel 2 is bridged onto the carrier line to serve customers at intermediate distances.

The derived voice-frequency circuit of channel 1 serves its customers by conventional wire distribution. If customers served by intermediate channels are not near the main line, wire distribution is also used. If they are along the main line, the derived voice-frequency circuits of intermediate channels may be arranged in two ways. Wire distribution can be used but, depending on local conditions, it may be more economical to feed the voice circuit

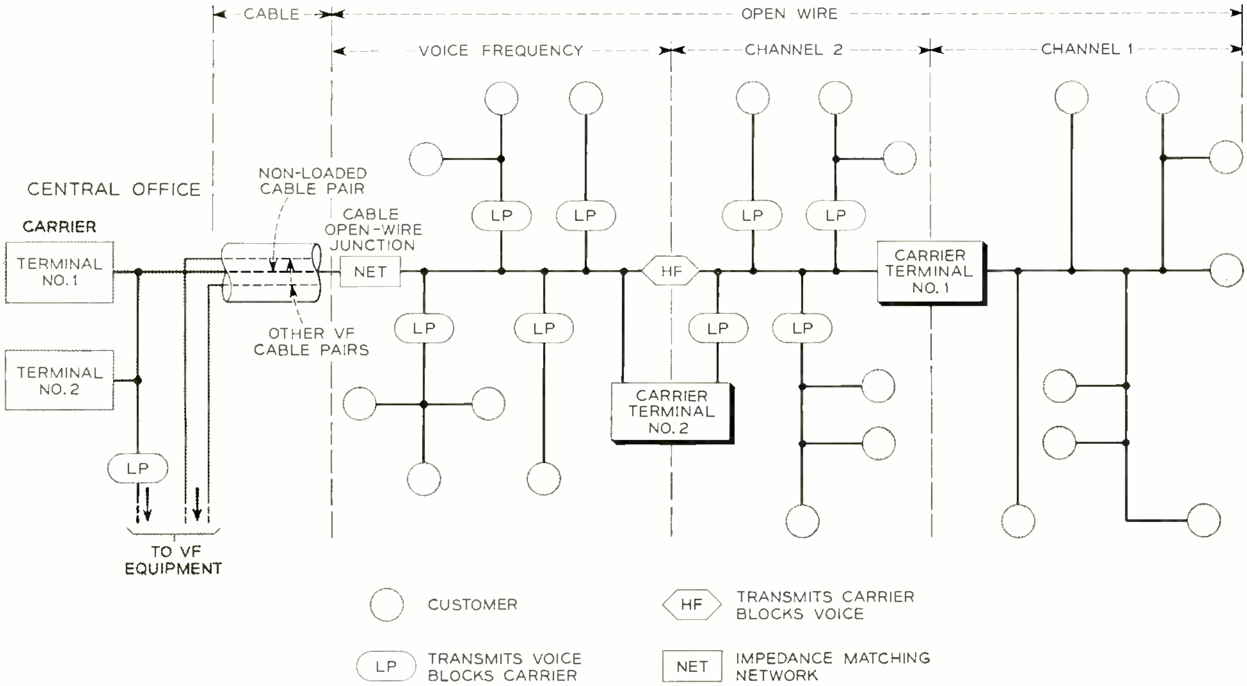


Fig. 3 — A typical arrangement for two channels on a voice-frequency line. Up to 24 parties (8 per channel) can be accommodated. The system is flexible in that several variations are possible.

gram form, the essential components of this arrangement. For large cities, or where the number of lines is large, cable plant can be saved by employing concentrating equipment as shown in Figure 2. The direct-line arrangement is now in service and the concentrator arrangement is under development and will be available in the near future. In the concentrator arrangement, instead of all lines going directly to the Fire Department headquarters, reporting stations "home" on the nearest central office. A large number of lines are then concentrated onto a group of a few trunks to the emergency headquarters. There the individual line originating a call is visually identified.

The new outdoor telephone set is distinctive in design and pleasing in appearance. It may be used with either the direct-line system or the concentrator arrangement. Figure 3 shows a box as installed in Indianapolis, one of the cities where direct-line service is furnished. The weatherproof case is of cast aluminum and as obtained from Western Electric has a red enamel finish. Early models had red enamel doors with the rest blue. The words "telephone" at the top and "pull" on the handle at the left are raised and unpainted. Other signs are put on locally as required by the city.

The left-hand door of the outer case is unlocked but self-closing. When the door is open, the handset is readily accessible. The right-hand door is bolted shut. In this section are the subset and ringer, and space to mount a fuseless protector if required. The telephone set employs 500-type components to give good transmission, since the set might be used on long loops and in noisy locations.

The new switchboard is modern, fast, and simple-to-operate. It is of modular design so that it can be furnished in the proper size to meet the needs of the customer. Figure 5 shows the switchboard as installed in Omaha, Nebraska, where the first installation of the direct-line system is now in service. For emergency reporting, the switchboard is arranged to terminate all reporting lines, central-office fire trunks over which fire calls from regular telephones are received, and tie lines from "zero" and information operators. These last are used to immediately complete fire calls that have reached an operator.

Commercial voice recording equipment can be connected to the system to automatically record all conversations as required by some cities. Certain dispatching features may also be incorporated in the switchboard to meet specific requirements. Voice paging lines to fire or police stations, for example, may be selected individually or in combinations. Automatic and manual status indicators may be included to give the dispatcher a ready reference as to the status of all available equipment. Direct telephone lines to fire houses, police stations, hospitals, civil defense headquarters, or other places can appear on the switchboard.

The direct-line system as installed in Omaha is

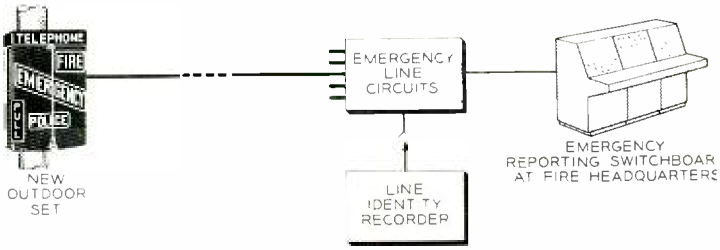


Fig. 1 — The direct-line telephone reporting system.

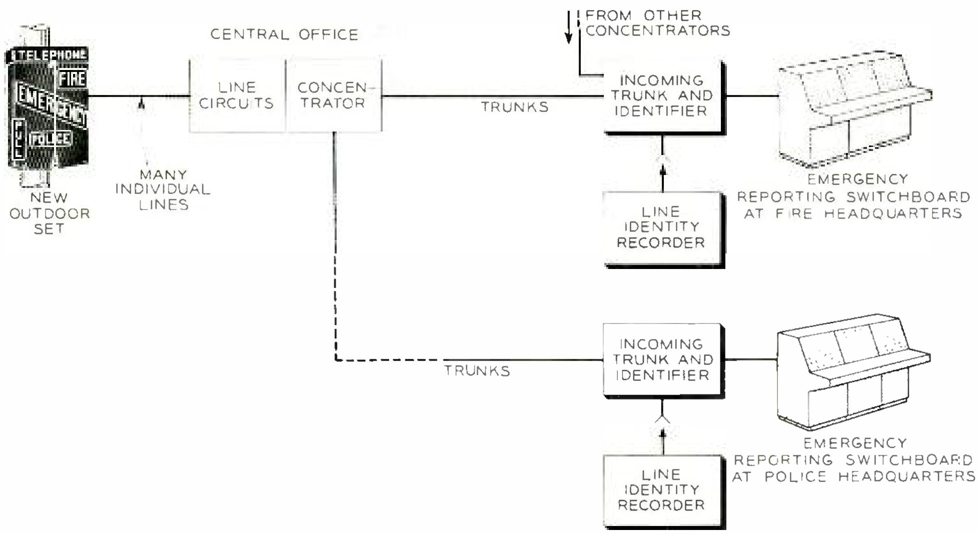


Fig. 2 — The system using concentrating equipment, with optional duplication of facilities for Fire and Police Departments.

Fig. 3 — The new outdoor telephone set as used in Indianapolis.

essentially a single-office manual system with certain features to make it especially reliable. In the interests of reliability, no multi-station loop arrangements are used; each station line is carried directly to fire headquarters over an individual pair of wires. The over-all circuit is under continuous electrical test. Should the circuit fail or the handset be taken away, an alarm indication will appear at the switchboard at fire headquarters and can also be extended to the test center of the Telephone Company. This also applies to power failure alarms. Each line has two appearances in the switchboard, one key-ended for fast, simple operation and the other jack ended. Each appearance has an associated line lamp and designation strip, so the effect of line lamp failures becomes negligible. The jack appearance also permits answering by a second operator and permits extending calls over tie lines to other places such as police headquarters or hospitals.

Although the switchboard is arranged for two-man operation, one man can handle the entire board and usually does. The lines are split into two groups, one on each side of the console, Figure 4, but the jacks associated with each group are placed alongside the keys of the opposite group. Thus, jacks giving access to the same lines as the keys at the left are in the right side of the jack field, and vice versa. An operator at either position can answer half the lines with keys and the other half with jacks.

To place a call over this system, a person need only open the door of the outdoor telephone set and remove the handset from the switchhook. No dialing or other signaling is necessary. The call is indicated at the switchboard by an audible signal and a flashing line lamp. Once the call is originated it is locked-in and the lamp continues to flash until the operator answers, even if the originating

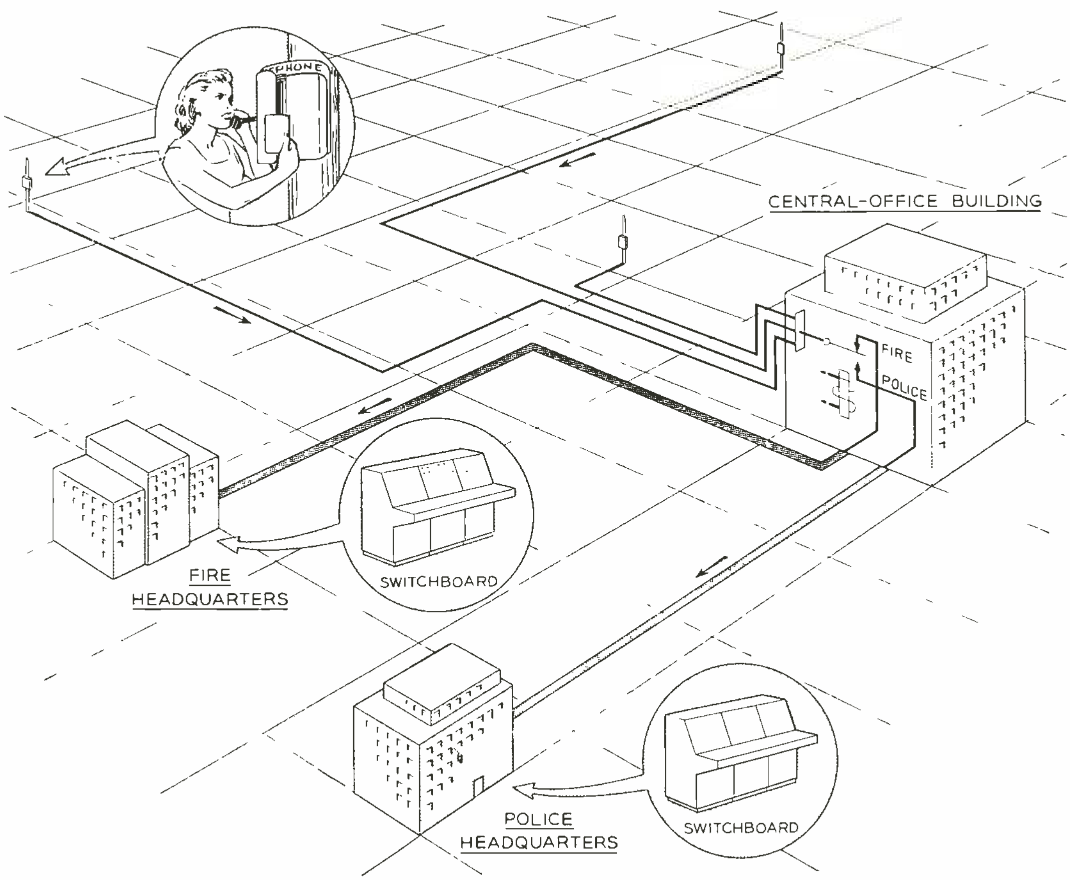


Fig. 4 — Sketch of the system in Indianapolis. Special switching arrangements permit the system to be used for regular police reporting.

party hangs up. The call is answered by the operator momentarily actuating a non-locking push-button key; the lamp then lights steadily. At the conclusion of the call, the operator merely presses a non-locking position-release button to restore the circuits to normal.

Figure 4 is a perspective view of the system as installed in Indianapolis. Basically, the operation of this system is the same as that in Omaha. The same type of outdoor telephone sets and line circuits and a similar switchboard are used. However, a selective routing feature permits calls to be routed either to fire or police headquarters merely by the operation of a push-button. This feature operates in this manner: if a person wishes to report a fire, he merely picks up the handset in the call box and is immediately connected with fire headquarters. If, however, a policeman wishes to call police headquarters, he first depresses and holds the non-locking push-button switch inside the telephone set and then removes the handset from the switchhook; the selective routing circuit will connect him to police headquarters. Once he has lifted the handset, he may release the push-button switch. Immediately upon his hanging up, the circuit is automatically returned to the normal or fire-reporting condition.

Another feature provided in Indianapolis is a line identity recorder. This device prints on a ticket the station code number, date, and time of day of every call that is started from a reporting station. When used at police headquarters, the resulting positive printed record of all routine police calls provides a check on the whereabouts of police personnel.

Obviously, a direct-line system in a large city can lead to considerable cable usage. In addition, the size of the switchboard necessary to properly terminate all the lines might present problems. Here it is felt that concentration of lines will prove attractive. In view of this a concentrator arrangement is being developed to provide all the basic features of the direct-line system. Introduction of the concentrator will not eliminate the need for the direct-line system, but the new arrangement will serve as an alternate where cable plant usage becomes a large factor. Since a large number of lines are concentrated onto a few trunks, Figure 2, the switchboard needs only enough keys and jacks to take care of the trunks. The individual station number is identified and indicated on a lamp panel.

At the present time, direct-line systems have been installed in Omaha, Indianapolis, and Sioux Falls. In addition, more than a dozen other cities have systems of an earlier design, and some of them are using the newly-developed telephone set. It is expected that more extensive systems, involving the use of concentrators to save cable plant, will be applied in the larger cities in the near future.

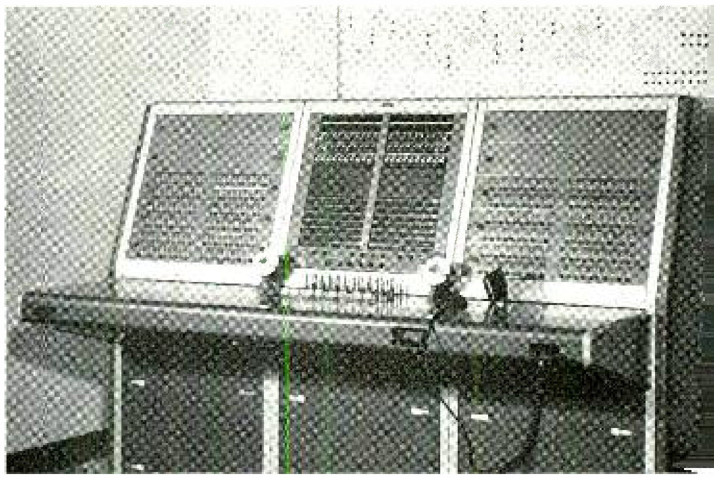


Fig. 5 — The emergency reporting switchboard in Omaha.

THE AUTHOR

Henry J. Michael joined the Laboratories in 1929. He has engaged in studies relating to transmission quality including the physical characteristics of speech and the structure of telephone conversation, signaling and switching development and, during the war, the design of underwater weapons. Since the war, Mr. Michael has engaged in the design and development of the No. 5 Crossbar System. He joined the American Telephone and Telegraph Company in 1952 and, after two years in its Administration B Department, he rejoined the Laboratories in the Special Systems Engineering Department. He now heads a group concerned with studies of private line switching and signaling systems. Mr. Michael is a graduate of New York University with degrees of B.A. in mathematics and M.S. in physics.

"Fingerprinting" Relays

H. W. HERMANCE and T. F. EGAN
Chemical Research

Contact contamination is a continual problem to the Bell System, and only thorough study of the various contaminants can lead to possible methods for eliminating their effects. Because of the small size of relay contacts and the difficulty of isolating microscopic contaminants without interrupting telephone service, a new technique was needed. This technique utilizes plastic replicas of the actual contact surfaces, effectively providing "fingerprints" of troublesome relays.

Both the reliability of telephone switching and the quality of transmission are vitally dependent on thousands of electrical contacts used for establishing each call. Despite all reasonable efforts to maintain cleanliness of the conditions around these contacts, proper contact functioning can still be impaired by a variety of factors. Airborne dusts, fumes, corrosive gases, and various products resulting from erosion all have adverse effects on contact functioning. The sources of some contaminants are often far from obvious.

The discovery and control of such contaminants has been a continuing task at the Laboratories for many years. In recent years, a new approach to the problem was made with the use of a plastic replica technique as a micro-analytical tool. This technique is somewhat like that used in crime detection, where "fingerprints" of the guilty relays taken at the scene, Figure 1, are removed to the laboratory for study, classification, and comparison with those of previously discovered or suspected culprits. A transparent plastic blank is heat-softened to receive an impression of a pair of contacts: when cool, it provides a moulage or exact negative replica of the contact surfaces. Contaminants on the contacts will adhere to the tacky surface of the softened plastic. The replica, with the embedded contaminants, can then be transported or stored, and studied wherever or whenever desired.

To meet the objectives of contact design, control the operating environment, and develop maintenance methods to minimize contamination effects, an engineer needs to know as much as possible about the nature of contaminating substances and the way in which they behave. Some materials, for example are fragile and poorly adherent. They crush easily to permit electrical closure and hence rarely give rise to "opens". An "open" condition occurs whenever the contact resistance is high enough to cause malfunctioning of associated apparatus, just as if the circuit were actually broken. Other materials may adhere tenaciously and are tough enough to resist the impacts of thousands of contact closures before electrical continuity is reestablished. Arcing usually burns away most organic materials, thus making a contact pair less susceptible to these contaminants. On the other hand, the occurrence of both arcing and friction, in

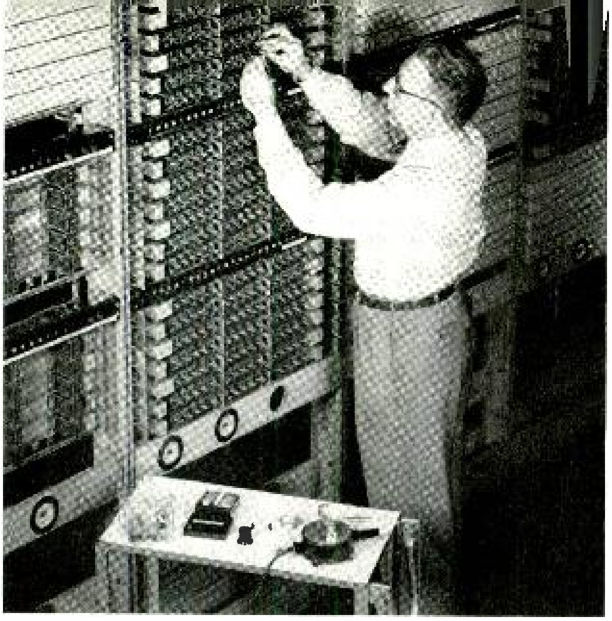


Fig. 1 — The plastic replicas are made in a working office with practically no interruption of service.

special cases, may generate contaminating deposits.

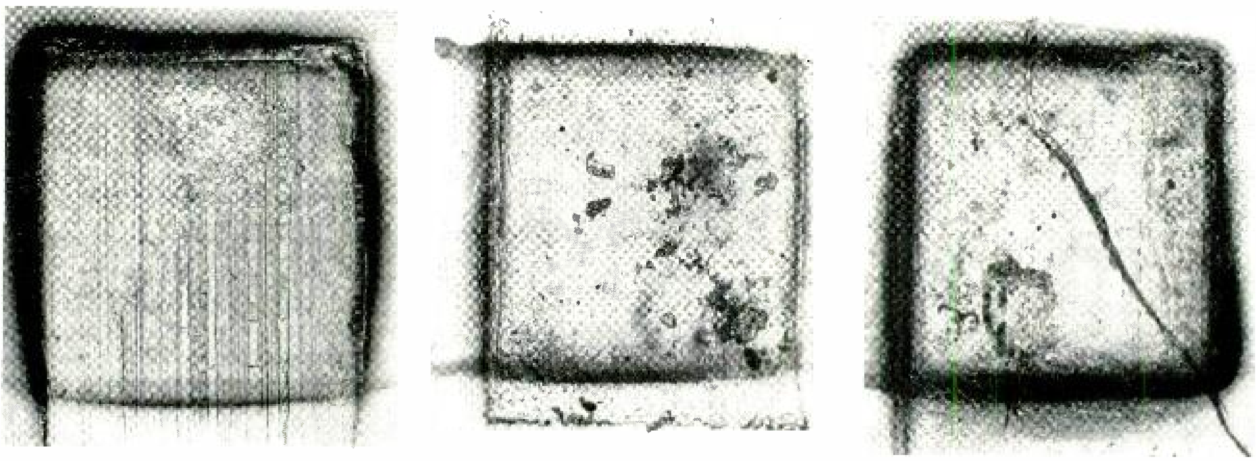
Thus, the ultimate impairment may result from a complex interplay of impact, sliding friction, and arcing acting on a wide variety of gaseous, liquid, or solid contaminants present in the environment. Such effects can be understood only when critical methods of observation and diagnosis are used. Direct examination of contacts with various magnifying devices is a logical first step, but necessarily has serious limitations, especially when the contacts are on equipment still in service. Rarely can positive identification be obtained. The contact surface provides a poor background for viewing a contaminant, and does not permit the use of transmitted light by which form, structure, and color may be determined. Chemical tests on the contact surface are almost out of the question. In addition, the maximum area of contact mating is only 0.0016 square inch, and usually only a small fraction of this tiny area contains the contaminants about which information is being sought.

Occasionally, by extremely delicate and tedious micro-manipulative techniques — and with good luck — a deposit may be transferred to a microscope slide for further study. Even then, removal of the deposit from its original site deprives the observer of valuable diagnostic evidence. The relation of the deposit to the critical area of electrical closure is usually lost in this procedure and any interpretation of the part it may have had in causing contact failure is always open to question.

The replica technique of contact study circumvents most of these difficulties. The resulting impression reproduces faithfully all surface details of the contact, in reverse relief. Conversely, it has been determined by microscopic observations, X-ray diffraction studies, and delicate resistance measurements that, when properly performed, the method transfers no detectable contamination to the contacts. In fact, the warmed plastic has been found to be a highly effective means for cleaning contacts used in laboratory studies.

Solid deposits on the contact, almost without exception, adhere to the plastic surface and are lifted off without appreciable shift of position relative to the contact topography, Figure 2. Thus, foreign material suspected of impairing contact operation is made available for microscopic study on an optically clear and relatively inert base to which various chemical tests may be applied. Interpretation is greatly aided by the presence of the original contact surface features on the replica. The area

Fig. 2 — Replicas of contacts: (left) eroded by 20,000 operations on an inductive load; (center) caused to "open" by phenol fiber fragments; and (right) caused to "open" by cotton fiber surrounded by fiber fragments and erosion dust.



on a contact pair involved in closure and electrical transmission can be found on the replica by texture changes produced by impact, sliding friction, and electrical erosion. The manner in which a foreign particle or deposit is related to this area becomes apparent under the microscope.

Naturally, there are certain limitations to this method. Oily films or materials that would melt, decompose, or dissolve in the plastic at the softening temperature (135 to 145 degrees Centigrade for about 30 seconds) could not be satisfactorily studied in this way. Adherent tarnish films may not transfer, although silver sulphide is often found to lift off onto the plastic. When a loose, powdery deposit is present in considerable depth on the contact surfaces, there will be a limit to the quantity that can be lifted off because of saturation of the tacky surface. Several replicas may then be necessary for complete removal.

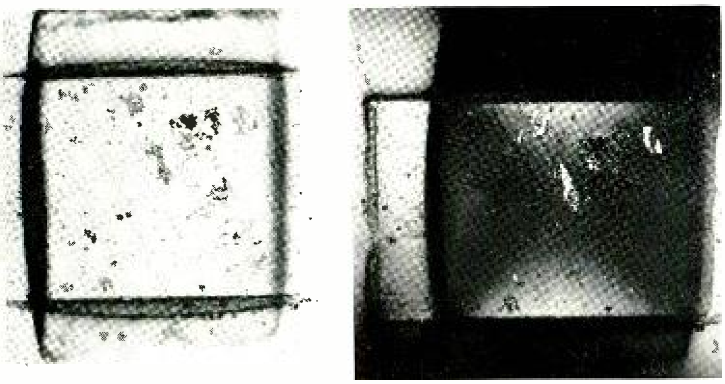


Fig. 3 — Replica with fiber fragments photographed with ordinary light (left) and as seen through crossed Nicol prisms (polarized light).

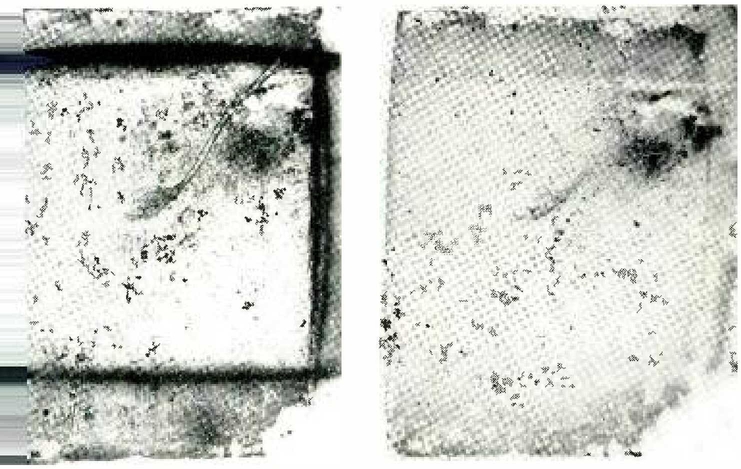


Fig. 4 — Replica of silver contact in air (left) and in oil. Immersion in oil shows up a silver sulphide film.

Fig. 5 — The replica is returned to the slide immediately after it is made to reduce hazard of contamination.

Vinylite (trade name for a polyvinyl chloride-acetate co-polymer) is excellent as the thermoplastic material. It has good optical transparency for microscopic examination and is inert enough chemically to withstand strong reagents. Vinylite sheet is easily cut or punched to form the small blanks used for micro-contacts. It also has a reasonably low softening point and good impressions can be obtained at 135 to 145 degrees Centigrade. The softened Vinylite is tacky and most deposits on the contacts adhere to it tenaciously.

The individual blanks are first agitated in water containing a wetting agent, because the plastic is water repellent, and are then blotted dry on lint-free paper. They are next inspected under a 40-power stereoscopic microscope, and those having bad scratches or imbedded material are discarded. Any remaining loose particles are removed under the microscope with a small glass suction tube.

Without delay, the clean blank is placed in the cavity of a special, carefully-cleaned microscope slide. The cavity is closed by a rectangular cover glass, hinged at one end by adhesive cellulose tape. The free end of the cover is temporarily held down by a small tab of the tape. In this way a supply of clean blanks can be prepared ahead for field studies and stored in standard indexed plastic slide boxes. The replica is returned to the slide as soon as it is made, Figure 5, reducing the hazard of contamination by air-borne dusts. Preliminary microscopic examinations may be made without again raising the cover glass, thus preserving cleanliness until the slide reaches the laboratory.

To make a replica, the blank is introduced between the opened contacts without touching their surfaces. The contacts are then gently closed on the plastic to hold it in position. The next step is to heat the contacts to the softening point of the plastic and to apply enough pressure to produce an imprint. These operations will vary somewhat with the contact actuation and arrangement. The U-type telephone relay serves as an example of an uncomplicated design that lends itself well to replica sampling. Here, disc-shaped blanks punched from 0.015 inch sheet are convenient to handle. Initially, the contacts should be in the closed position. A tapered glass probe is used to spread the springs sufficiently for insertion of the plastic blank between the contacts, Figure 7. On removal of the probe, the spring pressure holds the blank in place.

Heating of the relay contacts is accomplished by a special clamp that is closed on the springs near the contacts, Figure 6. The jaws are formed by short copper bars having enough mass to store the necessary heat. The clamp is pre-heated to 140 degrees Centigrade on a thermostatically-controlled heater block, and is applied to the contact springs by special spring tongs with heat-insulated finger grips. The tongs engage in slots milled in the copper bars.

After the impression is made, the contacts are allowed to cool for a few seconds before the plastic disc is removed. The depth of impression should be no greater than necessary to include the area of interest. Deep impressions introduce lighting difficulties under the microscope, especially when projected or photographed. Chemical treatments and micro-manipulations are also rendered more troublesome. Heating is continued no longer than necessary to avoid as much as possible any changes in form or composition of foreign organic deposits. With care, materials of such delicate structure as epidermal scales can be readily transferred in identifiable condition.

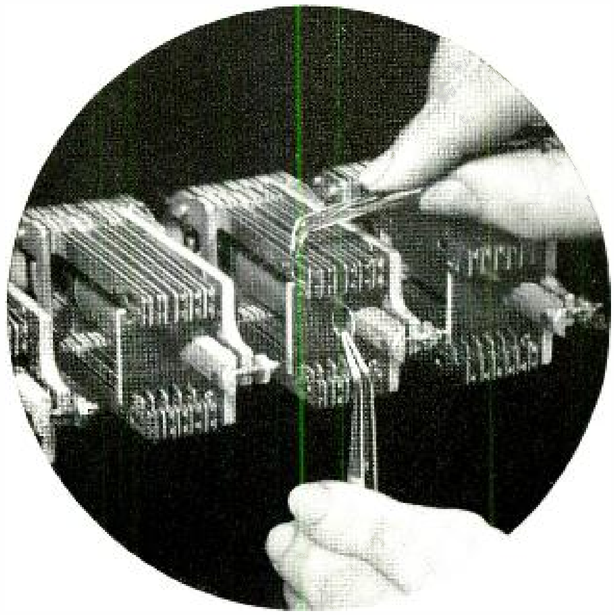


Fig. 7 — A glass probe spreads the springs for insertion of the blank.

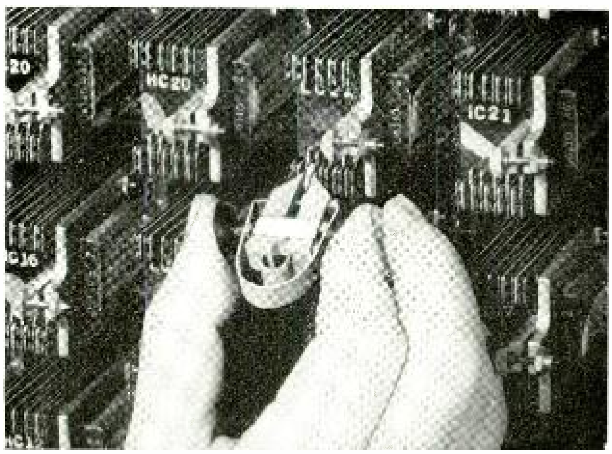


Fig. 6 — Special spring tongs hold the heated clamp while it is applied to the springs.

Space limits a full discussion of the techniques used in examining the replicas; these will vary depending on the particular objective. This may be a simple inspection of contact cleanliness as part of a routine quality control. On the other hand, it may be a more fundamental study of contact contamination requiring specific identification of all foreign materials. Replicas may also be used to record contact wear or erosive deterioration. In any event, microscopic examination will be necessary.

A general-purpose microscope is used, with equipment for illuminating the replica by axial and angular transmitted light as well as by reflected light. Where possible, provisions are made for the use of polarized light. Various sequences of these lighting arrangements are useful in bringing out the detail, color, and form of the particular particles or deposits under study.

It should be remembered that the impressions are negatives of the original contact surfaces. Low spots on the contacts are raised on the impression surface. Pits become domes. Scratches become ridges. Transferred deposits will have their originally exposed surfaces embedded in the plastic, and the surfaces originally adjacent to the contact metal will now be exposed. Surface texture details are usually best viewed by transmitted light. Since the plastic is transparent, a handy trick, when possible, is to focus the microscope on the bottom impression, *through* the plastic. This then gives, by the use of this method, a contact topography similar to the original, instead of being reversed.

Special microscopic and microchemical techniques are used to identify deposits transferred to the replica. Many materials will be recognizable immediately from their form, structure or color under the microscope. Their microscopy is often benefited, however, by optical aids such as polarized light, Figure 3, or immersion of the replica in a fluid having a refractive index similar to that of the plastic, Figure 4. The latter procedure subdues the distracting background structure and brings out greater detail in the particles. An effective aid is a reference file of known contaminants. Such particles are dusted onto a polished metal plate, transferred to a Vinylite sheet as in making a replica, and then permanently mounted on microscope slides.

When a deposit is not recognizable, microchemical treatments may be introduced. Such treatments may serve to establish the general classification of the substance – organic, inorganic, metallic, fatty, starchy, proteinoid – or they may separate components of complex mixtures, or provide specific tests for key components. Gaseous chemical reagents such as acid vapors and iodine are the most desirable, for they permit localization of the reactions and resulting products on the site of the original particle. When gases cannot be used, tiny droplets of reagent may be applied to individual particles from fine capillary tubes while the reaction is watched through the microscope. Staining techniques are also useful both for classification and for specific identification.

This brief description by no means exhausts the possibilities of the replica method. The unique feature is that contact surface variations can be duplicated with only a very short interruption of service, and the replica transported for future detailed analysis. The techniques of analysis used on the resulting replicas are almost limitless, depending only on the ingenuity of the analyst.

THE AUTHORS

H. W. Hermance joined the Laboratories in 1927 after two years with the Western Electric Company working on the analytical control of materials. Previously he had worked with the Crucible Steel Company and had spent four years with Procter & Gamble developing analytical methods for controlling the quality of raw materials and manufactured products. During this period he carried on part-time study at Newark Technical School and later at Columbia University. His experience includes chemical analysis gained in toxicological and criminological work. Since coming to the Laboratories he has specialized in micro-analytical methods and has had a prominent part in developing the techniques and laboratory facilities for this relatively new phase of analytical chemistry.

Thomas F. Egan has specialized in analytical chemistry since joining the Laboratories in 1930. During the years 1930-1937, he also attended Brooklyn Polytechnic Institute and the College of the City of New York. His work has included microchemical analyses of electron tubes, contacts, capacitors, and insulating materials. From 1938 to 1944, he engaged in chemical diagnoses of central-office problems relating to noise and resistance of contacts. Since 1945, Mr. Egan has concentrated on problems of dust and its relation to open-contact failures, dust exclusion in relay cabinet design, and the efficiency of central ventilating systems. During the war, he worked on a project for the Office of Scientific Research and Development.

The New Aluminum Outdoor Telephone Booth

J. M. HAYWARD *Apparatus Development*

Because of the great popularity of outdoor booths, travelers and others away from home are now never very far from a telephone. The new aluminum booth has been engineered for resistance to weathering, for economy of manufacture, installation, and maintenance, and for attractiveness of appearance. It has the distinct advantage of being in a convenient location for use twenty-four hours per day.

Providing telephones at accessible and convenient outdoor locations is a step toward the Bell System goal of giving the broadest type of communication service so that people can converse with one another at any time from any place. The demand for outdoor booths has risen sharply, particularly because of the popularity of telephones along highways, parkways and turnpikes, where they are a great convenience and a necessity in time of emergency. Outdoor booths have the important advantage of being available for use twenty-four hours a day.

Wooden booths of the No. 9 Type* have been used for many years in outdoor locations and have required frequent repairs, regardless of special efforts made to protect the most suitable woods and other materials available against constant exposure to all kinds of weather. The desire to reduce maintenance expense, and to provide a more modern appearance, appropriate for a wide variety of installations, led to a review of outdoor booth design.

* Record, *January*, 1943, *page* 113.

As a result of extensive studies and discussions with representatives of the Operating Companies, a new metal and glass booth, shown above, has been developed. The new booth is durable and efficient. Particular effort was made to design it along functional lines that would harmonize with modern architectural trends.

Outdoor booths are not so restricted as indoor booths by limitations of space. For the greater comfort of the user, the new booth is wider and deeper and has more inside height than the indoor and older outdoor booths.

Experience has indicated that clear opening of approximately 22 inches is a satisfactory width for the entrance, and it has been found that the right rear corner of a booth is the most suitable position for the pay station type of telephone. These were controlling considerations in the design of the structure. For economical manufacture and ease of assembly, it was also desirable to have as much uniformity as possible in the various parts. Standardized sizes for panels and signs were obtained by having the necessary variations for other features designed into the corner posts. Figure 2, which is substantially a horizontal cross section, illustrates the different corner arrangements that permit the use of the same panels for the sides and back of the telephone booth.

Aluminum was decided upon as the most suitable material for the framework because of its durability, lightness, strength and ease of fabrication to the shapes desired. The aluminum extrusion process makes possible the economical production of structural shapes that otherwise would be too costly to manufacture. The extruded form is produced by subjecting hot-cast billets of aluminum alloys to sufficient hydraulic ram pressure to force the material plastically through a die orifice. A continuous length of material is thus formed which corresponds in cross section to the shape of the orifice in the die. Since the cross sectional area of the desired part is less than that of the billet, the extruded piece may run to 50 or 60 feet in length for an average sized die opening. Any distortion or twisting which may occur in these long pieces is corrected by a stretching or rolling operation.

To force the hot aluminum through the die, great pressure has to be exerted, depending, of course, on the size of the part. For example, the full width of the door frame, measuring about 12 inches, is extruded as one piece. Before this large extrusion was evolved, door frames were constructed from a number of separate pieces with the corners welded together. The press used to extrude the one-piece door frame has a maximum effort of 4,250 tons and can exert pressures up to 150,000 pounds per square inch.

The aluminum alloys selected for the extruded parts of the telephone booth have good forming qualities, resistance to corrosion, and have a light aluminum color after being given an electrochemical surface treatment. Because the anodic treatment for protection from corrosion gives a different color appearance to various aluminum alloys, care has been exercised to determine the proper alloys for the flat plates or panels so that they will match the color of the extruded parts with which they are associated.

The booth is so designed that practically all exterior screws are eliminated. The clean outside appearance is enhanced also by a minimum of junction lines. The interlocking joints within the corner posts and the extrusion flanges inside the booth serve to secure the parts. These joints also fasten the side assemblies together, so that only a wedge-type engagement of the corners is visible outside. This further permits engineering the booth so that five main sub-assemblies constitute a complete "knock-down" shipment.

The "knock-down" assembly facilitates merchandising the booth through numerous Western Electric Distributing Houses across the country, where booths are assembled with the varied panels and signs desired by the telephone companies to suit their specific needs. Moreover, if by accident the booth should become damaged, repairs can readily be made with the insertion of new panels at the point of installation.

In an outdoor telephone booth, lighting and color are primary considerations. Versatile arrangements are possible by the easy insertion of glass windows or solid panels of red, green or blue. In some areas, plain aluminum panels are used in place of either glass or colored panels. The aluminum and colored panels are laminates (sandwich

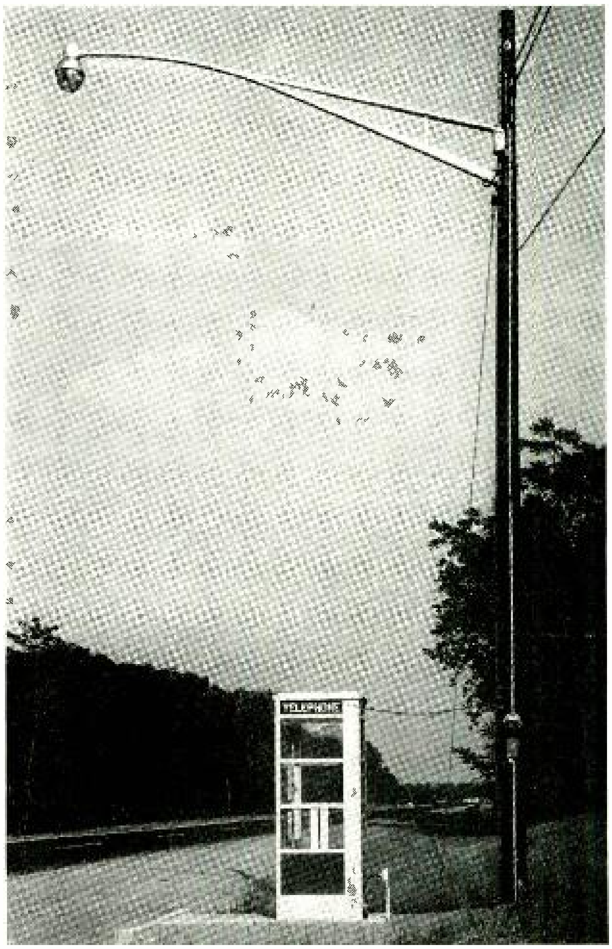


Fig. 1 — The new outdoor booth — a familiar sight along today's highways.

type construction) having a composition core with facings, on both sides, of anodized aluminum or thin sheet steel which has been given a colored porcelain finish. Any combination of panels can be initially installed to achieve the color scheme desired by the telephone company. For installations where the rear or side of the booth is near a wall or other similar surface, the transparent panels are unnecessary and solid panels are used from top to bottom.

All of the glass panels, including the signs, are of safety (shatterproof) type and are composed of three parts — that is, two pieces of glass with a vinylite center sheet. This is the standard method of making laminated safety glass, but to protect the lettering and background of the signs from abrasion or scratching, the painted portion is on the inside surface of the glass adjacent to the vinylite. Adherence of the glass pieces with the vinylite takes place when the three parts of the assembly are processed in a vacuum oven, where heat and vacuum act to bond the parts without an adhesive.

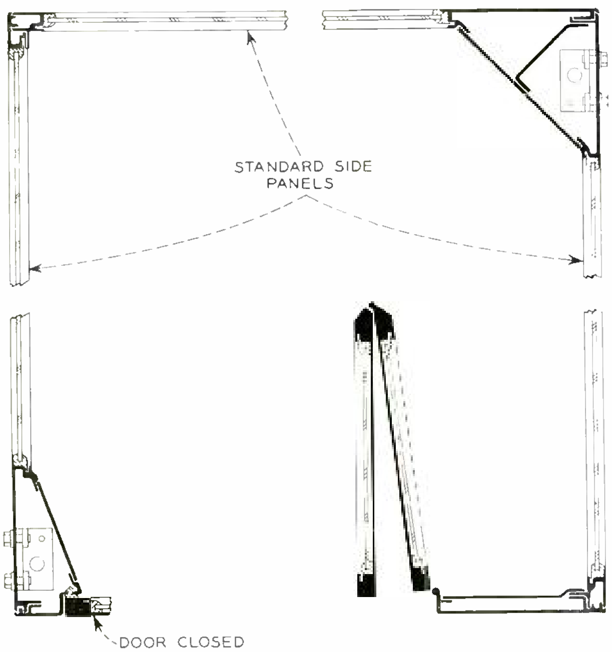


Fig. 2 — Different corner arrangements for the outdoor booth permit use of standard-sized panels.

A specially designed light fixture is located in the ceiling. Two large fluorescent lamps, which give approximately three times the lumen output of equivalent wattage incandescent lamps, illuminate the inside of the booth as well as the telephone sign panels. Also, a large area around the outside of the booth is illuminated at night by the light transmitted through the windows. The advantage of a well lighted booth beside a highway is illustrated by Figure 3. Fluorescent lamps are normally intended for indoor use, since they operate more favorably in warm temperatures (optimum 80 F.). To give satisfactory starting and operation of the lamps outdoors at below freezing temperatures, thermal starters and preheat type of ballast coils are used in the lamp circuit. The safety factor of having two lamps in the booths, which may be at remote locations, and the long life of fluorescent lamps (approximately 10,000 hours compared to about 1,000 hours for ordinary incandescent lamps) assure illumination without the necessity of frequent examination for replacement.

Fluorescent lamp life is greatly affected by the number of times the lamps are started. The emissive coating on the filaments in each end of the lamp is gradually used up, especially during starting before fluorescence takes place inside the lamp. Once the lamp is lit, the starter could actually be removed from the circuit without extinguishing the lamp. However, the starter used in the telephone booth light fixture is essentially a thermal relay which performs other functions in addition to starting the lamp. A recycling mechanism operates to restart the lamp if there is a temporary interruption in the power supply. Also, after several recycles occur with a defective or deactivated aging lamp, a bimetal mechanism in the starter serves to cut off the power. When the power has been removed at the source, the starter cools sufficiently to restore its bimetal mechanism to the initial starting condition. Besides preventing excessive blinking of the lamp, this automatic cut-off and reset feature protects the ballast coils in the lamp circuit and avoids the necessity for costly replacements.

Incorporated in the telephone booth is a folding door with equal-sized extruded frames, mentioned before. They are so designed that although only three hinges are used to join the two frames, a bead on one of the extrusions gives the appearance of a continuous hinge. This bead not only improves the appearance but retards the entrance of driving rain. The handle of the door is shaped to be suitable for production by the extrusion process and to provide an assuring grip for opening the door from the inside. A spring-operated, self-closing device is built in the upper door hinge. It keeps the door partially closed to protect the interior of the booth and the telephone apparatus from much of the rain or snow that otherwise would enter if the door were left fully open. The hinges and other hardware items of the booth are made of corrosion-resistant steel to assure long life with good appearance.

The booth is ventilated by louvered panels at the bottoms of the sides and rear. Space around the four sides of the ceiling, and long openings behind the overhang of the roof, permit passage of air to the outside of the booth. To augment the natural flow of air, a fan or blower is being made available for warm southern areas or installations that are particularly sunny.

An important accessory for the outdoor telephone is the directory rack, which is combined with a large shelf area. Various sizes of directory books can be accommodated, or a small auxiliary shelf can be attached over part of the rack. This extends the shelf when only half of the directory space is required. The directory binders are supported by one hinge at the back. To consult the telephone listings, the user raises the directory and opens it on the shelf. It will normally stay open or can be held easily while reference is being made. When the user closes the directory, it automatically falls back into its compartment by its own weight.

The absence of combustible materials and the elimination of possible fire or electrical hazards have resulted in approval of the booth by Underwriters' Laboratories, Inc.

Fig. 3 — The lighting of the new booth illuminates interior, the signs, and an area outside.

The improvements in appearance, lighting, and other convenience features are attracting an ever increasing number of telephone users as evidenced by the growing volume of calls from outdoor telephone pay stations. Furthermore, the additional advantages of easily obtainable variety of color in the panels and signs, greater resistance to deterioration from the effects of weather, and the reduced cost of maintenance and repair have met with widespread approval of the operating companies.

THE AUTHOR

J. M. Hayward graduated from Pratt Institute in 1916. After service as a pilot in Europe during World War I, he joined the Laboratories in 1920 where he has been concerned mostly with the development of various types of station apparatus. As a Colonel during World War II, he was in charge of one of the Air Force engineering laboratories at Wright Field. Later he was in command of technical intelligence activities, investigating the products of German and Japanese research and design. In recent years Mr. Hayward has been engaged in development work on the 500-type telephone set and the outdoor telephone booth.

Telephone Protectors

A. C. KANE
Outside Plant Development

A telephone must not only be a reliable instrument capable of supplying the best possible communication service; it must also be a completely safe instrument. One possible source of hazard is accidental high voltages such as those that might result from lightning discharges. To guard against this, a protective device is installed between the telephone and the outside lines. Continuing improvements in design and materials have made it possible to provide new protectors that are extremely reliable, yet more economical and more easily maintained than their predecessors.

Since the early days of the telephone it has been general practice to provide protective apparatus on customers' premises to safeguard people – both the public and Bell System employees – and to minimize the possibility of fire or other damage to the customer's property. Such protection is required because of the possibilities of dangerous lightning potentials, and of accidental contact between the telephone lines and electric power distribution circuits. The protective apparatus also, of course, guards against damage to telephone equipment and against service interference.

In providing protection it is important to minimize the voltage which might develop between conducting objects that a person might touch simultaneously, or that might give rise to a discharge that could cause fire or other damage. In other words, the relative potentials between adjacent objects are far more important than absolute potentials measured to a distant reference point. Since the nature of the circuit generally makes it impossible to ground telephone wires directly, connections to ground are made through protectors, which keep the circuit isolated under normal conditions, but make direct connections to ground in the presence of abnormal voltages.

The protectors used for many years at customers' telephone installations consist of low voltage arresters and fuses. One such arrester, which will break down at about 350 volts rms, is connected from each telephone wire to ground. A seven-ampere fuse is also provided in each line wire ahead

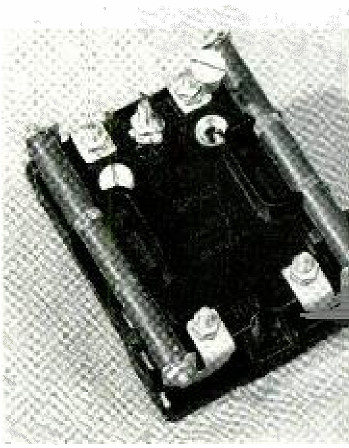


Fig. 1 — The 106A protector with carbon blocks mounted in moisture-proof cylindrical wells. The cap has been removed from the well in the upper right part of the protector.

of the arrester. This fuse interrupts power contact current if that current is large enough, and persists long enough, to overheat the protector and possibly start a fire.

One of the most commonly used protectors is illustrated in Figure 2. The drop wire termination, fuses, protector blocks, grounding connection and the wire to the telephone instrument are shown diagrammatically in this figure. The cutaway view of the protector block shows a three-mil gap between a carbon insert in the porcelain block, and a rectangular carbon block with which it mates when it is assembled between a protector spring and ground plate. In the event of a voltage surge from a lightning discharge to the outside telephone plant, the resulting high voltage causes the current to jump across the gap between the protector blocks. The surge is thus discharged to ground. The magnitude and duration of such a surge is usually insufficient to blow the fuses. Hence at the end of the surge, service is still available. With sustained power contacts, blowing a fuse prevents overheating the protector and eliminates a possible fire hazard on the customer's premises.

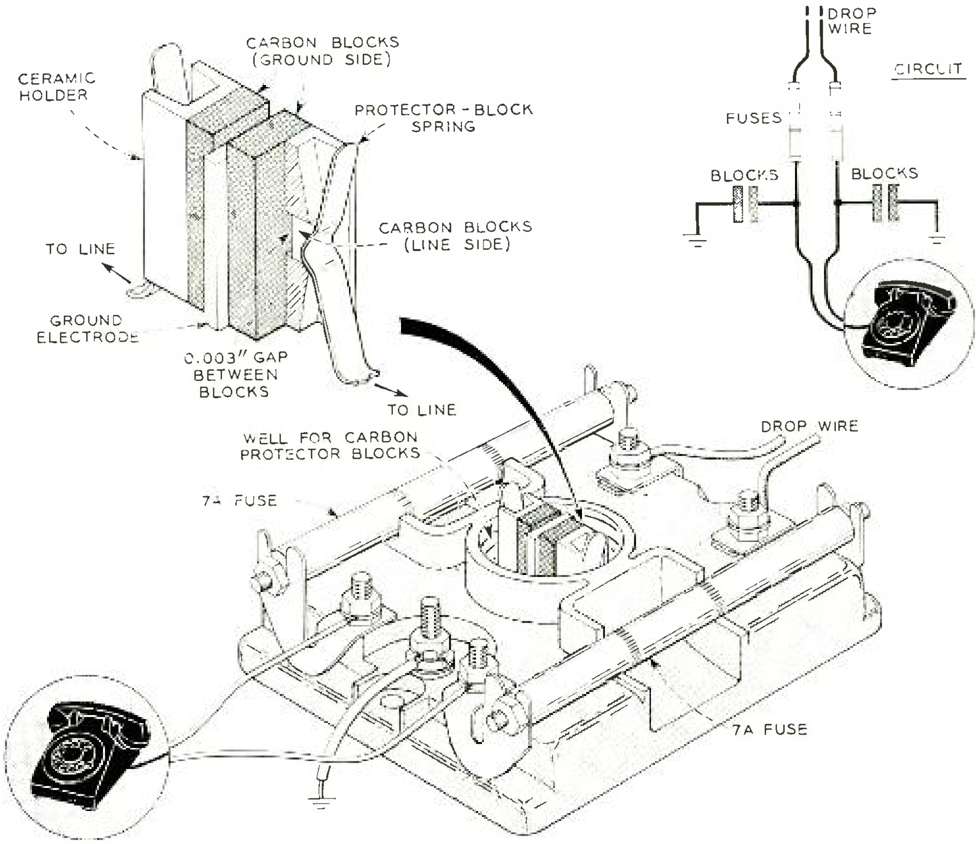


Fig. 2 — The 98A protector, with details showing circuit schematic and assembly of carbon blocks.

As a result of development work in recent years, several changes have been made in the design of station protectors to reduce the number of service interruptions and maintenance visits that result from causes other than normal operation. The principal source of these interruptions has been the action of moisture on the fuse shell and on the carbon blocks. The fuse shell that encloses the lead fuse wire expands and contracts with changing humidity and thus causes the fine wire to recrystallize. This may break the element or make it more susceptible to melting on lightning surges which it might otherwise carry. Moisture bridging the air gap of the protector block promotes electrolysis of the carbon, thus increasing the possibility of permanent grounding by normal telephone operating voltages.

The 106A protector shown in Figure 1 was developed to reduce moisture troubles in protector blocks. The rectangular blocks were replaced by smaller cylindrical blocks mounted in two moisture-proof cylindrical wells, each having a screw type cap. In the photograph, the cap from the upper right hand well has been removed. Also the fuses were redesigned and lead fuse wire was replaced by a lead-antimony-zinc alloy wire that is less susceptible to recrystallization when the fuse is subjected to varying moisture conditions. Field trials indicated that this protector substantially eliminated moisture troubles, and service experience in humid areas has fully confirmed the improved performance of the protector.

An extensive analysis of the factors involved in a contact between power-supply conductors and telephone lines led to the conclusion that it was safe to omit fuses in station protectors where the station was served by drop wire from grounded metallic sheath cable, provided the protector had adequate current-carrying capacity. According to this concept, the small-gauge conductors in the stub cable of the terminal, from which the customer is served, are fusible links which will melt and open the circuit if sufficient current flows because of a power cross. Under these circumstances, the protector must be able, without overheating, to withstand sustained current either until the small-gauge outside wires fuse or until the power contact is cleared.

Existing types of protectors lacked this current-carrying ability. Since about 90 per cent of protected Bell System telephones are served by grounded metal-sheath cable, however, there was strong incentive for development of a fuseless protector having the required current-carrying properties. The requirements have been met in the design of the new 111-A protector, shown in Figure 3. This protector has been approved for the intended use by the Underwriters' Laboratories, as required by the National Electrical Code, and is now in production.

Fig. 3 — The 111A protector incorporating carbon blocks and improved current-carrying elements.

The make-up of this new protector is illustrated in Figure 5. Like the 106A, it has a sealed, moisture-proof carbon-block assembly, and includes a low melting-point alloy spacer mounted in the cap above the blocks. With sustained current, the heat generated in the blocks melts this spacer. A spring on the underside then forces the blocks up into the cap until a metal-to-metal contact is obtained between the spring assembly and the lower part of the screw-in cap. A low-resistance path to ground is thus provided to carry possible sustained power

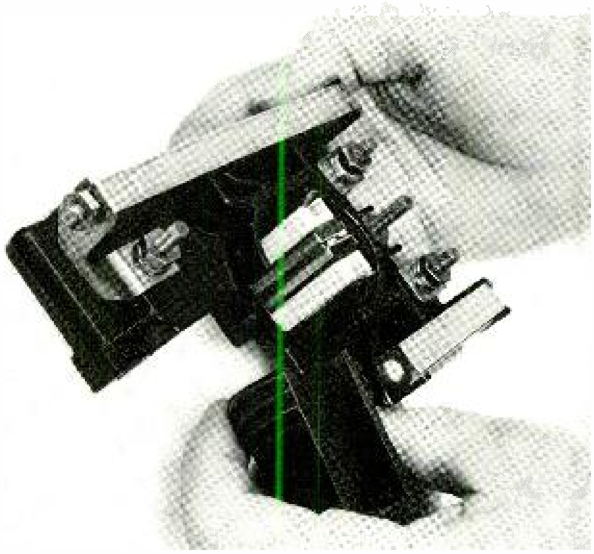


Fig. 4 — Cutaway model of the converted 98A protector showing adapter tabs around carbon blocks.

currents. A heavy low-resistance spring is used in this protector, and the contacting members are plated to reduce the over-all resistance. These features provide a fuseless protector capable of safely carrying any currents that may be impressed upon it. In earlier protectors, any voltage high enough to cause an arc across the carbon blocks, if sustained for an appreciable time, would melt the cement holding the smaller carbon block in its ceramic frame. Under pressure from the mounting spring, the small carbon block would then move into contact with the large one and permanently ground the line. In the new design, a similar action takes place but it is relatively unimportant since the fusing of the low-melting alloy spacers leads to grounding over a metallic path as described.

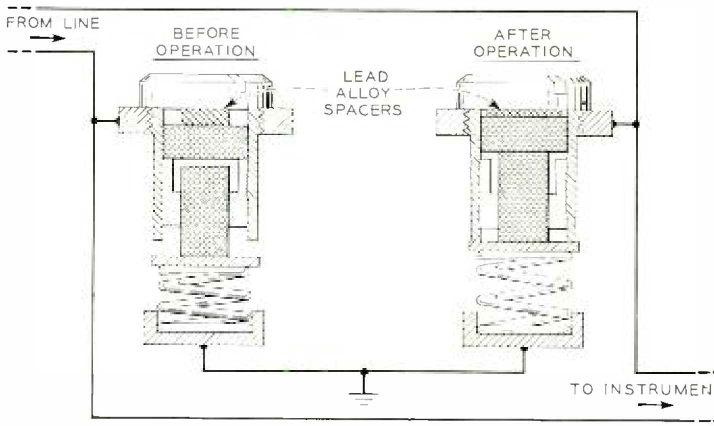


Fig. 5 — Operation of the 111A protector — the alloy spacer melts and causes metal-to-metal contact between spring assembly and cap.

Since it would not be economical to replace present protectors with the new type in existing installations, two other devices have been designed for converting presently installed 98A protectors. This conversion may be made as stations are visited by repairmen for any reason. A cutaway view of a converted 98A protector is shown in Figure 4. Brass strips bypass the fuses and metal adapters are placed in back of the larger rectangular protector block of each pair. The make-up of this protector-block arrangement is illustrated in Figure 6. The protector-block springs normally hold the blocks in their proper positions and also provide contact to the line side of the circuit. The large blocks formerly made direct contact with the ground plate but, as shown in the figure, they now make contact with the ground plate through the adapter. When current is sustained, the heat generated by the blocks anneals the springs, and the softened metal contacts the tab on the lower part of the adapter. In addition, the adhesive holding the smaller blocks in their ceramic holders softens sufficiently to permit the block to move into contact with the larger block and provide another path to ground. Thus, as in the 111A fuseless protector, a low-resistance path to ground is provided to carry possible sustained power discharges.

These protectors are a good example of the continuing effort at the Laboratories directed toward effectively safeguarding the telephone customer and his property.

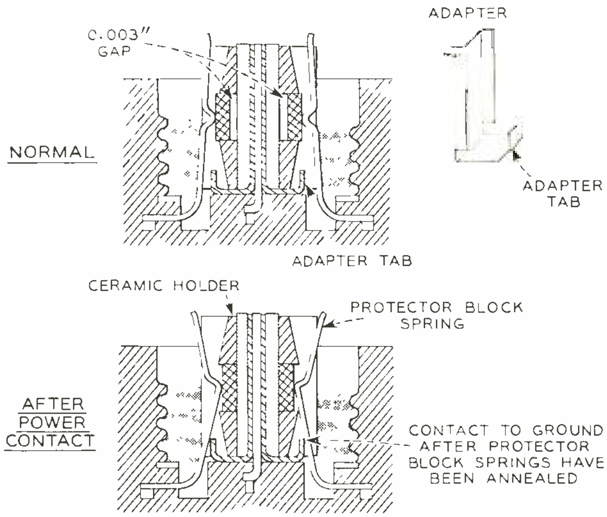
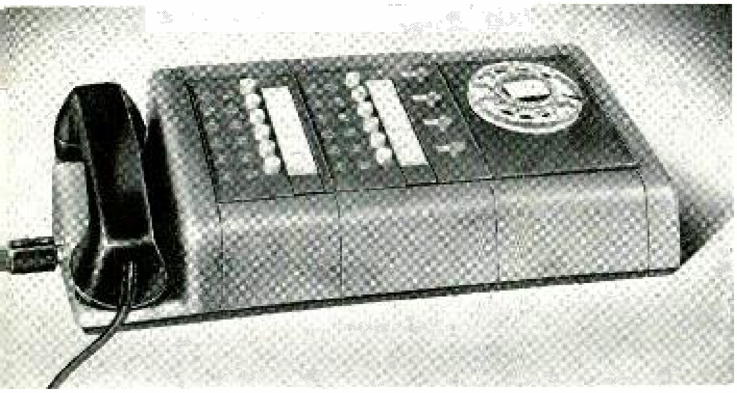


Fig. 6 — Operation of adapters — springs sag when heated and make contact to adapter tabs.

THE AUTHOR

A. C. Kane joined the Laboratories in 1927 and received the B.S. degree in E.E. from New York University in 1936. As a member of the Transmission Instruments group, he was early concerned with the development of telephone handsets, including work on the combined set and on the use of plastic materials for the housing and handle. During World War II he transferred to a group working on the development of high-powered loudspeakers for public address systems used in military aircraft and landing operations. After the war, Mr. Kane engaged in work on lateral feedback recorders, reproducers, and magnetic tape recorders, and in 1949 he transferred to the Outside Plant Development Department, where he was concerned with cable terminals and protectors. In February of 1956, Mr. Kane was transferred to the Laboratories location at Point Breeze, Maryland, where he is a supervisor of a group concerned with development work on cable terminal apparatus.



Attendant's Equipment for Small Dial PBX's

R. D. WILLIAMS *Switching Development*

Early in the evolution of dial PBX's, the volume of calls requiring operator assistance would frequently be too small to justify a switchboard. A cordless turret was therefore developed for such applications, so that an attendant could perform other duties in addition to handling telephone calls. Smaller key equipment was subsequently developed. The latest version of this key equipment is a modular design featuring push-buttons instead of lever-type keys and a modern streamlined housing.

In the early days of small dial PBX's, generally there was not sufficient work for a PBX attendant to keep her busy all the time. One or more cord-type switchboard positions, such as that shown in Figure 1, could be used to full advantage only in a large dial PBX or in a manual PBX. The attendant at a small dial PBX did not usually handle enough calls to justify attendant's equipment the size of a switchboard. Consequently, in the 1920's the 740-type PBX's were designed so as to use an attendant's turret. This turret, as shown in Fig. 4, was a key-operated device that could be located on a desk or a table and leave the attendant free to handle other business, such as typing or acting as a receptionist, in addition to handling telephone calls.

About a year ago, new designs were completed to permit the use of a more compact turret known as the 101-type key equipment,* originally designed for multi-line answering and key telephone secretarial service. This turret can be mounted on a desk, Figure 2, or recessed into a desk or table top.

Recently, the more modern key cabinet shown in the headpiece was developed. This provides essentially the same service features as the earlier 101-type equipment except that mechanically interlocking pushbuttons are used instead of lever-type keys.

Each unit of the 101-type key equipment has five two-way pickup keys with two supervisory lamps above and two lamps below each key. Ten different trunks can be served by these five keys by operating them either up or down in response to signals on the associated lamps. An incoming call flashes one of the two lamps associated with the trunk and sounds a buzzer at the rate of 60 interruptions per minute. The attendant answers the call by operating the indicated pickup key and the flashing lamp then remains lighted. When the destination of the call

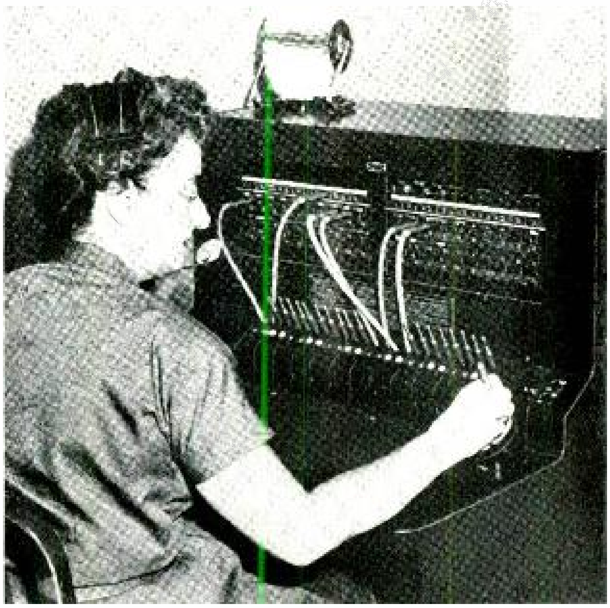


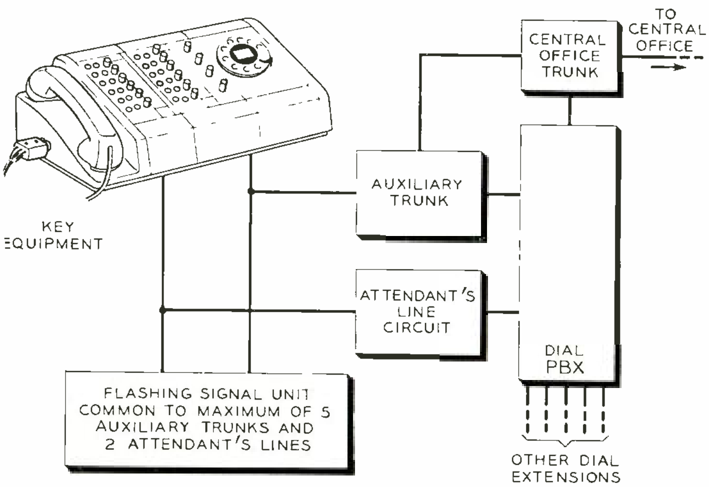
Fig. 1 — A 556A switchboard used with the 740E private branch exchange.

* RECORD, *August*, 1937, *page* 370.

Fig. 2 — 101 key equipment used for night service at the Laboratories in New York City.

has been determined, the attendant momentarily operates the common hold key (the white-handled key in Figure 2), waits for dial tone, dials the desired number into the PBX, restores the pickup key, and hangs up. The second lamp (station line lamp) associated with the trunk "winks" at the rate of 30 interruptions per minute until the extension answers, and then remains lighted. When the call is finished and both the outside and inside parties hang up, the connection is automatically released and the lamps are extinguished.

After the attendant has released from the call, the PBX station user can recall the attendant, to transfer the call or request information, by momentarily depressing his switchhook. This causes the station line lamp associated with the trunk to which he is connected to flash continuously at the rate of



ig. 3 — How key equipment is used with a dial PBX.

120 interruptions per minute. The attendant answers this recall by re-operating the pickup key indicated by the flashing lamp. If it is desired to transfer the call, the attendant merely operates the common hold key momentarily to disconnect the first extension, and then re-operates the hold key, waits for dial tone, and dials the number of the second extension.

Ordinarily, PBX stations can make calls to outside points by dialing 9 and then continuing to dial the call after receiving a second dial tone. In some cases, though, certain stations may be restricted from making outside calls directly; these calls may be made via the attendant who is reached by dialing 0.

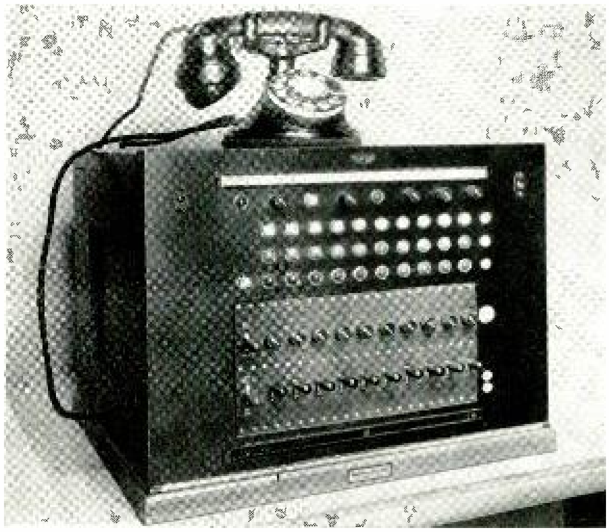


Fig. 4 — Early attendant's turret for a 740A PBX.

These new smaller equipments and the associated circuitry provide advantages over the earlier turret shown in Figure 4, not only with respect to the physical size and appearance of the attendant's equipment, but also with respect to supervisory signals transmitted to the central office. With the older equipment, when an extension flashed to recall the attendant, the switchhook signals were also sent to the central office; in some cases, this flashing caused the central office to disconnect the call. The new arrangement, however, delays the transmission of switchhook signals to the central office for from one to two seconds, eliminating the possibility of premature disconnection. Also, a single momentary operation of the switchhook automatically causes the station line lamp to flash continuously until the attendant answers. Release of calls without involving the attendant is a further operating advantage.

Each unit of the 101 key equipment can accommodate a total of ten central-office trunks, attendant trunks, or attendant lines. The new modular key equipment can accommodate six circuits per modular unit. As many units as necessary can be grouped together to provide access to the desired number of circuits. In those cases where four central-office trunks and one attendant trunk is adequate to serve a PBX, a 6-button key telephone set* can be used instead of one of these key equipments. This provides a combined trunk and line lamp with each pickup key, but otherwise the equipment operates in the same general manner as the 101 equipment.

The new key equipment arrangement may be used as the main attendant's position for small PBX's, or it may be used as an attendant's or night watchman's auxiliary position in conjunction with a switchboard. The advantage of the key equipment for night service is that a watchman or similar night employee can complete calls to any PBX extension. From an extension user's viewpoint, his service is the same at night as in the daytime. The block diagram of Figure 3 shows how auxiliary trunk circuits interconnect the key equipment, the central-office trunks, a switchboard, and the PBX switching equipment.

* Record, *June*, 1940, *page* 315.

THE AUTHOR

R. D. Williams was graduated from Case Institute of Technology in 1945 with a B.S. degree in E.E., spending three of his years there in the V-12 program. After a tour of duty with the Navy as a Radar Officer, he joined the Laboratories in 1946, engaging in trial installations of No. 5 crossbar. In 1947 he was concerned with equipment engineering on dial PBX and small community dial offices, and then turned his attention to circuit engineering on step-by-step circuits. Currently he is with a PBX circuit group. Mr. Williams is a member of Tau Beta Pi, Eta Kappa Nu and Theta Tau.

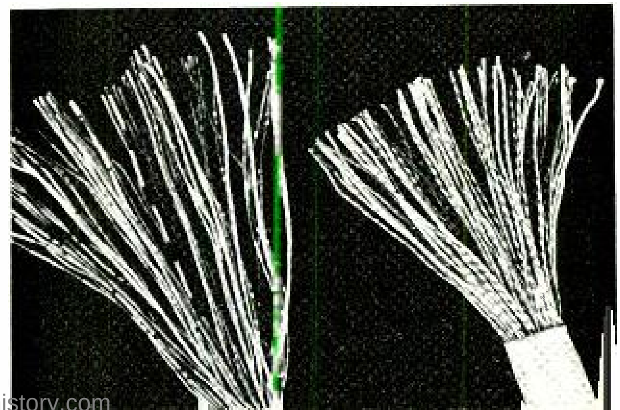
Dot-and-Dash Coded Wire

A new wire developed jointly by Laboratories and Western Electric engineers uses a dot-and-dash system of color coding to make it possible to identify and connect various combinations of wires. It is being used initially for local cable in No. 5 crossbar central office equipment, and will ultimately be used in switchboard cable as well.

The wire, insulated with polyvinyl chloride plastics, may eventually replace the more familiar wire spirally wound with colored textile insulation for central office use. The color coding of the new wire is much simpler than that used with the older type. A switchboard cable, for example, may include from 12 to 312 conductors in combinations of pairs and singles, and 24 different color combinations for the pairs and an additional 24 color combinations for the singles are required. With the new dot-and-dash method, the three wires constituting a pair with its associated single can be the same color — the first wire in a pair is identified by a series of single dots, and the second by a series of double dots. The single wire in the combination is identified by a series of repeated dashes. With eight different colors of plastic coating and four different colored inks, many combinations are possible.

In addition to the identification feature, the new wire is less expensive to manufacture, is more fire and moisture resistant, has a smaller diameter and has better insulating properties than the textile covered wire.

Left, plastic-insulated dot-and-dash wire, and right, textile covered, spiral-wound wire.



High-Speed Magnetically-Operated Coaxial Switch

A. H. VOLZ
Transmission Systems Development II

As is the case with many engineering developments, the TD-2 automatic protection switching system depended to a large extent on the development of a particular piece of special apparatus. Because switching in the TD-2 system is done at 70 mc, a switch was needed that would meet impedance and crosstalk requirements and at the same time operate at high speed with negligible transmission loss. The new switch that resulted uses four mercury switch elements in a specially-designed mounting to simulate the characteristics of coaxial cable.

A considerable proportion of the Bell System's long-haul telephone and television transmission is over the TD-2 microwave radio relay system, where each of six microwave channels in each direction is capable of handling either several hundred telephone messages or one television program. The impact of a system failure is so great that monitoring and manual operation to restore service is far too slow. This led to the development of an automatic protection switching system* for TD-2.

One of the six available channels is reserved as a protection channel to be substituted for a regular channel encountering fading or other troubles that affect transmission. The automatic protection switching system consists essentially of circuits that recognize an interruption or degradation of a regular channel and actuate switches at each end of the troubled microwave link to substitute the protection channel.

Basically, the switching job at the transmitting end is that of connecting to the protection channel the same signal that is on the regular channel that appears to be in trouble. The system then compares the transmission of the signal through both channels and if the protection channel is superior, it is then used for the transmission. At the receiving end, the outgoing signal circuit must be connected to the proper one of the two incoming circuits. It would seem, then, that a simple single-pole double-throw switch at each end of each channel of the switching sections would be sufficient.

However, in the TD-2 system, switching is done at an intermediate frequency of 70 megacycles. Requirements imposed on the switches were: a return loss† of at least 38 db for any transmission path through a switch, assuming a characteristic line impedance of 75 ohms; the crosstalk between signal and unused paths should be at least 90 db below the signal level; the transmission loss through a switch should not exceed 0.1 db; and a switch should operate in less than two milliseconds. It is apparent that conventional types of transfer switches fall far short of these requirements.

It appeared that either an electronic switch or an electromechanical switch having a coaxial structure would be most likely to meet the severe requirements of this application. Electronic switches were considered too bulky, complex, and expensive. Available coaxial switches, both electrically and manually operated, were unsuitable

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* Record, *March*, 1956, *page* 98. † Return loss is a measure of the impedance match at a termination.

primarily because they could not meet the requirement of high-speed operation. It was therefore decided that a new coaxial switch should be designed, using the 222A switch* as the basic switching element. This – a glass-sealed, reed-type, mercury-contact transfer switch – had been used previously in experimental models of coaxial switches designed for various laboratory purposes and seemed suitable for this application.

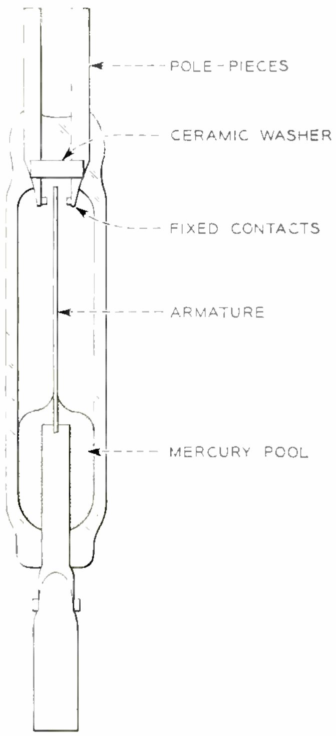


Fig. 1 (left) — The switch comprises a magnetic reed armature and two contacts attached to pole pieces, sealed in glass with a reservoir of mercury.

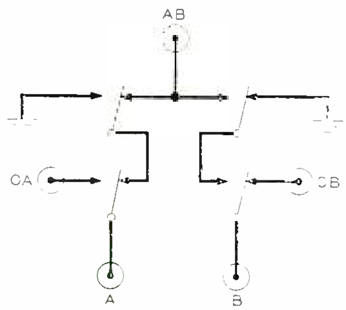


Fig. 2 (above) — Simplified schematic of the signal circuit of the 223-type coaxial switch.

A symmetrical structure, Figure 1, the 222A switch comprises a slender magnetic reed armature and two contacts attached to magnetic pole-pieces, sealed in a glass tube with a reservoir of mercury. With no external magnetic field applied, the reed assumes a neutral position, not touching either contact. Mercury rises along the reed by capillary action, wetting the contacts at all times and providing a low and stable contact resistance. When incorporated into a suitable magnetic structure, the armature can be moved rapidly from one contact to the other because of its small mass. The physical shape and symmetrical arrangement of the switch lends itself to mounting in a structure such that transmission characteristics through the switch at high frequencies are approximately those of coaxial cable.

Figure 3 represents a transverse section through one switching element of the new 223-type switch shown in Figure 4. The reed switch is surrounded by a coaxial pipe. To maintain the proper ratio between inner and outer conductors, the coaxial pipe is enlarged at its lower end to form a coaxial cavity around the pool of mercury. Top and bottom supports, top and bottom covers containing coaxial channels, an operating coil, and a pair of permanent magnets complete the structure.

This switch is adjusted by magnetizing the two permanent magnets to unequal field strengths so that with no current in the operating coil the reed is held in a normal position against the contact associated with the stronger magnet. When the coil is energized with current of a predetermined magnitude (operate current), the reed will release from its normal position and transfer to the second contact. When the current is reduced to a lower value (release current), the reed will return to its normal position.

Considering such a structure as a single switching element, the two fixed-contact terminals and the armature terminal of the reed switch would be connected directly to coaxial jacks to provide a single-pole, double-throw coaxial switch. Inasmuch as either transmission path of such a switch would be essentially coaxial in nature, the impedance characteristics would be quite satisfactory. Measurements have indicated that the return loss of either path at 70 megacycles is greater than 40 db.

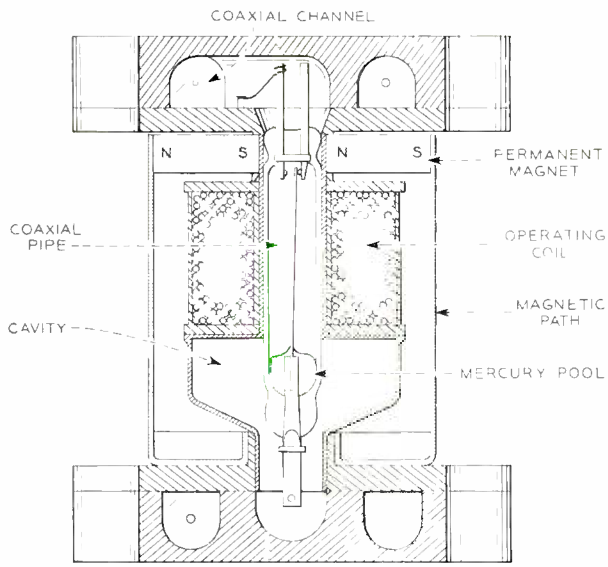


Fig. 3 — Transverse section through one element of a 223-type coaxial switch.

* Record, *September*, 1947, *page* 342.

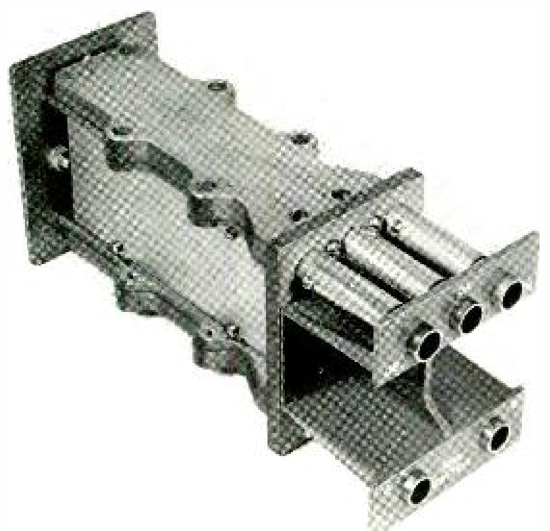


Fig. 4 — The new 223-type switch.

However, the parasitic capacitance (about 0.5 micromicrofarad) between used and unused paths is sufficient to cause rather high crosstalk — only about 45 db below the signal level. This may not be objectionable in some applications, but for the TD-2 automatic protection switching system the crosstalk requirement was set at a minimum of 90 db below the signal.

The 223-type switch developed for the TD-2 automatic switching system, Figure 4, achieves the crosstalk requirement without changing the impedance characteristics by using four reed switches in a specially-shaped metal structure utilizing many die-cast parts. Figure 2 is a simplified schematic of the signal circuit of the switch, in which each of the two transmission paths consists of two switch elements in series. Normally, input jack A connects to the output jack AB and input B is properly terminated through jack OB. In the 223B switch, jack OA is replaced by a built-in 75-ohm resistive termination. When the switch is operated, input B connects to output AB, and input A is terminated through jack OA in the 223A switch and by the 75-ohm internal termination in the 223B switch. The unused intermediate link is grounded so that no direct capacitance exists between the two transmission paths. This permits the switch to meet the crosstalk requirement.

One physical requirement was that six switches could be mounted on a standard relay rack in a horizontal row 19 inches wide and 3½ inches high. It was also required that the switch should mount interchangeably with associated bridging amplifiers.* This dictated a design with the four reed switching elements mounted vertically in a row from front to back. All jacks appear on the front of the assembly, Figure 5, to permit patching to other parts of the automatic protection switching system with coaxial patching plugs.† The four operating coils, one associated with each switch element, are connected in series and the two control leads are brought out through a plug-in connector at the rear of the assembly.

The various interconnections between jacks, switching elements, and upper and lower levels form coaxial paths consisting of inner conductors running in channels and pipes, so proportioned as to maintain a 75-ohm characteristic impedance throughout the structure. The four pairs of permanent magnets are supported on side plates. The switch assembly is magnetically adjusted at the factory by means of an automatic relay-adjusting circuit,‡ permitting a complete switch to be adjusted in about five minutes. The operate current through the 6,000-ohm series resistance of the coils is adjusted to 4.0 milliamperes dc and the release current to 2.0 milliamperes. In actual use in the automatic protection switching system, the

* RECORD, *March*, 1956, *page* 98. † RECORD, *December*, 1955, *page* 450. ‡ RECORD, *February*, 1955, *page* 63.

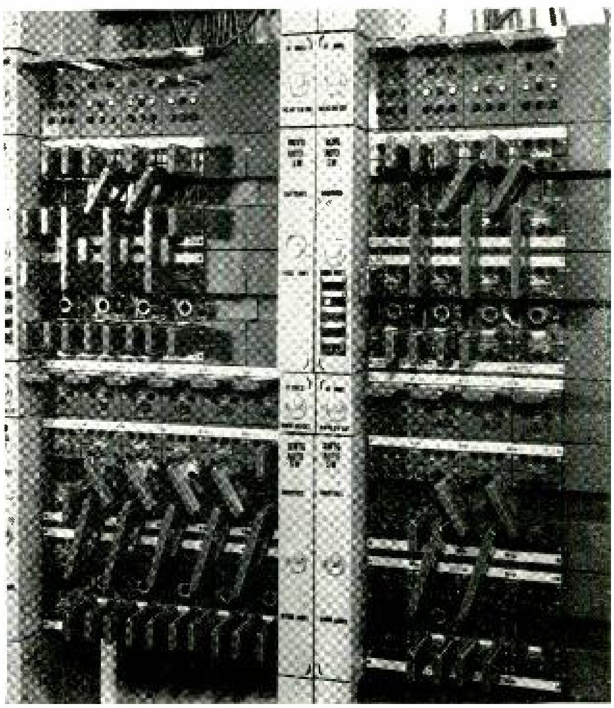


Fig. 5 — Some 223-type switches in the TD-2 automatic protection switching system.

current values are 10.0 ma and 0.1 ma, providing an ample margin to assure proper operation.

While the 223-type switch assembly was primarily designed for the TD2 automatic protection switching system, it is also being used in TD-2 program and maintenance switching* and it is expected to be used in other applications where high-speed, high-frequency switching is required.

* Record, *November*, 1955, *page* 415.

THE AUTHOR

Arthur Volz joined the Laboratories in 1920 and received the degree of E.E. from Brooklyn Polytechnic Institute in 1932. His field of endeavor has been that of apparatus manufacturing specifications and mechanical design of potentiometers, rheostats, attenuators, rotary switches, and transmission testing apparatus. This includes testing and evaluating similar apparatus supplied by outside manufacturers. Among the latest of Mr. Volz' efforts, in cooperation with G. R. Yenzer, was in the development of the new coaxial switch. More recently, Mr. Volz has been engaged in the design of high-frequency components such as coaxial switches, coaxial rheostats and precision variable air capacitors.

Dew Line "Radome" Constructed at Whippany Laboratory

A radar installation employing an unusual "radome" was recently constructed at Whippany by the Western Electric Company for experimental use by the Laboratories. This radome, of the type designed for the Distant Early Warning (DEW) Line, was completely assembled in less than 24 hours. It is believed that further improvements in erection equipment will make it possible to complete an installation of this sort in less than 18 hours, the maximum period for which weather can be predicted accurately in the Arctic.

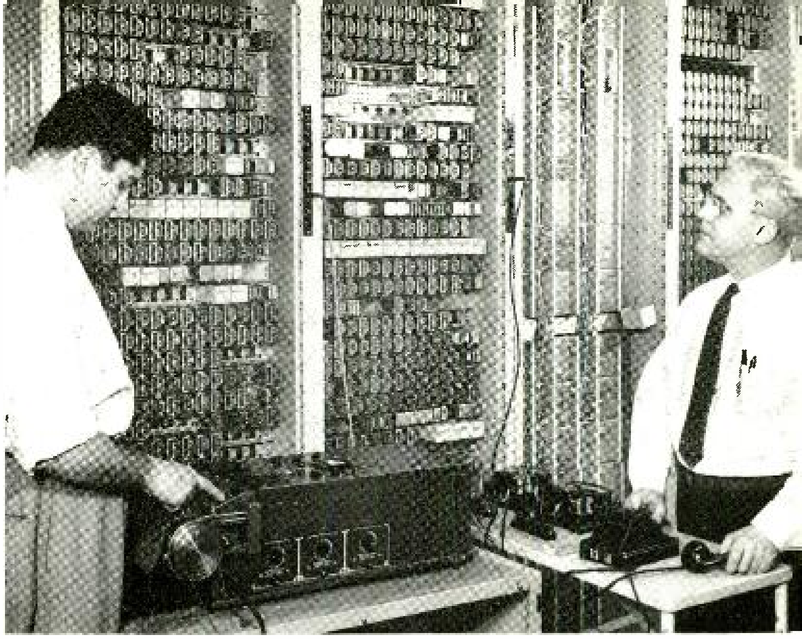
The Whippany radome is 55 feet in diameter and is mounted on a platform about 45 feet high. It is of a new design using translucent Fiberglas panels instead of the inflated rubber material formerly employed. The dome is self-supporting, without struts or trusses, and consists of 275 diamond-shaped sections bolted together. It was designed by Geodesics, Inc., of Cambridge, Mass.

Radomes of this sort are used to cover radar antennas, shielding them from the high winds and ice accumulation common in the Arctic. Antennas thus protected, can be of less rugged design. The Whippany unit will be used to facilitate tests and investigations of radar equipment. It is expected that the presence of this unit will eliminate the need for many trips to the Arctic by Laboratories engineers. When technical problems arise on the DEW line, it will be possible to simulate equipment conditions at Whippany and so determine solutions to the problems by using the local radome installation.

The design of the DEW line and its equipment was undertaken for the government in 1952 by the Laboratories and the Western Electric Company with advice and assistance from the Lincoln Laboratory of the Massachusetts Institute of Technology. The Laboratories assignment in the project was to determine a reasonable over-all set of requirements for the radar system and its communications networks, to see that the equipment was engineered to meet these requirements and perform well in practice.

Construction of the DEW line is the responsibility of the Western Electric Company.

A Modern Method of Current-Drain Calculation



E. A. LOONEY
Switching Systems Development

An electrician can easily determine the size of a circuit merely by adding the current requirements of the electrical appliances that may be used. In the modern telephone office, however, with its thousands of complex circuits, the job of determining current drains is an engineering problem often requiring months of study. A faster procedure for determining current drains has been developed at Bell Laboratories, and is aiding the more efficient design of power-plant equipment and power-distribution circuits.

Time- and labor-saving methods and devices are important factors in the approach to communication problems of the Bell System, and current-drain determinations are no exception. Many present-day readers may ask, "What is current drain?" and "What is it used for?" Current drain data provide the basic information for determining the capacity and size of the power plant. The data also determine the sizes of the feeders and fuses needed in the distribution system which carries the power needed by a telephone central office.

Power requirements for a central office may reach sizable proportions. The storage battery plant for a typical dial central office in an average-sized city may be called upon to deliver momentary current of as much as 1,500 amperes and, if the commercial power supply fails, to carry the complete office load for as much as four hours or until auxiliary generating equipment can be put into use.

Batteries, bus bars, feeders, fuses, and charging and auxiliary generating equipment are expensive. A 1,500-ampere power plant might cost between 30 and 40 thousand dollars, with annual charges of about 15 thousand. For a multi-unit office or a large toll plant, the first cost might approach 250 thousand dollars, with proportionate annual charges. A mistake as to the proper size of power plant may result in inability to provide service in emergencies if the power plant is too small, or it may result in many thousands of dollars of unnecessary first cost and annual expense if the power plant is too large.

To provide the data upon which these important calculations of battery, feeder, and fuse sizes are based, the Laboratories prepares current-drain data for every circuit, except those that require only negligible power for their operation, or that are so few in number or used so seldom that their total power requirements in any given period are negligible.

Laboratories' information is of two kinds. First, the Laboratories supplies data from which the Telephone Company engineers can calculate the required capacity of the battery and the size of the charging and emergency generating equipment. These data are called "List 1" drains. They are usually expressed in ampere-hours per busy hour per circuit, or in terms of some other unit measuring the volume of telephone traffic. Second, the Laboratories supplies data used by Western Electric Company to engineer the power distribution system – that is, the size of power feeders and fuses. These are called "List 2" drains, and are expressed in units convenient for calculating conductor and fuse sizes. Both List 1 and List 2 drains are provided for each circuit.

The bases of current-drain calculations are the average and peak currents required per circuit operation by a particular circuit or unit of equipment. List 1 drains are based on average current which, for any given call, is the sum of the individual current-time products of the several pieces of apparatus in the circuit, divided by the over-all time of the call. To convert average current into ampere-hours per busy hour, the average current is multiplied by a factor that includes an estimate of the anticipated busy-hour traffic of the circuit. These multipliers are based on traffic engineering data. Where List 1 values are expressed in ampere-hours per 100 call-seconds (another way of measuring volume of traffic), the average current is multiplied by the factor for converting to this value. List 2 drains are based on peak current for circuits involved in a particular telephone call for only a

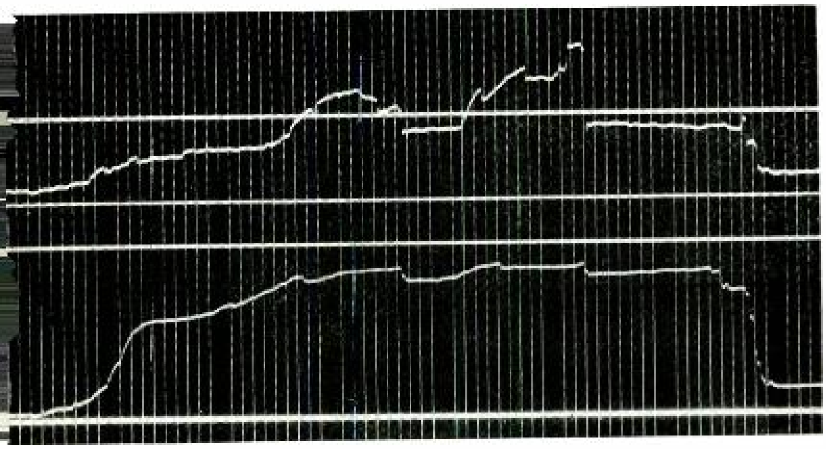


Fig. 1 — Typical oscillograph record; straight lines caused by fixed spots of light are for reference.

brief period (short holding-time circuits), and on average current for circuits that are connected for longer periods (long holding-time circuits).

The calculations of average and peak currents are the responsibility of the current-drain engineers in the Switching Development Department at the Laboratories. When central office circuits were simple, these calculations were easy. They could be made in a relatively short time by a straightforward calculation of individual apparatus currents and a simple time study, covering the length of time each component took current while the telephone call was in progress. Peak current determination was equally simple. As central office circuits became more complicated and increased in size and number of components, however, the task became more and more complicated and time-consuming. It was obviously approaching a point where it could not be done at all unless the old methods were replaced by a more modern and faster procedure.

It had long been obvious that if a graph of sufficient amplitude could be made showing the instantaneous current taken by a circuit as a function of time, the average current could be determined by dividing the area under the current curve by the base and that the peak current would be represented by the maximum current ordinate. In other words, both the List 1 (average) values and the List 2 (peak) values could in this manner be obtained from the same graph. For this purpose, a technique was developed through the use of the multi-unit, magnetic oscillograph, shown in the illustration on the previous page.

Essentially, this instrument is the common reflecting type of galvanometer. A beam of light is reflected from a tiny mirror mounted on a galvanometer coil, and appears as a spot of light on a sensitized film. A line is thus traced on the film to record instantaneous values of current through the galvanometer coil. So far, this is nothing more than the common recording oscillograph. The instrument used for current-drain work, however, has several important characteristics which make it peculiarly adaptable for this purpose. First, it is capable of an extremely wide deflection – 4 to 6 inches – which permits resolution of widely varying current values. In some circuits the peak current may be many times the average value. It can be readily calibrated at any degree of sensitivity within its range, so that current values can be measured quantitatively. It is very fast, a necessity with modern fast-acting common-control circuits, in which the peak currents may be of a millisecond duration. It has multiple galvanometer units, and these permit observations on a number of leads simultaneously. It is thus possible to obtain, in one measurement, complete data on six different circuits. The equipment has film capacity sufficient for the longest sequence of operations found in common-control equipment, and it is portable so that it can be taken into the field and used in working central offices.

To make a measurement with this oscillograph, the current-drain engineer connects a galvanometer unit to a lead of the circuit whose current drain is to be determined. The circuit is then blocked in some convenient step in its operation and the

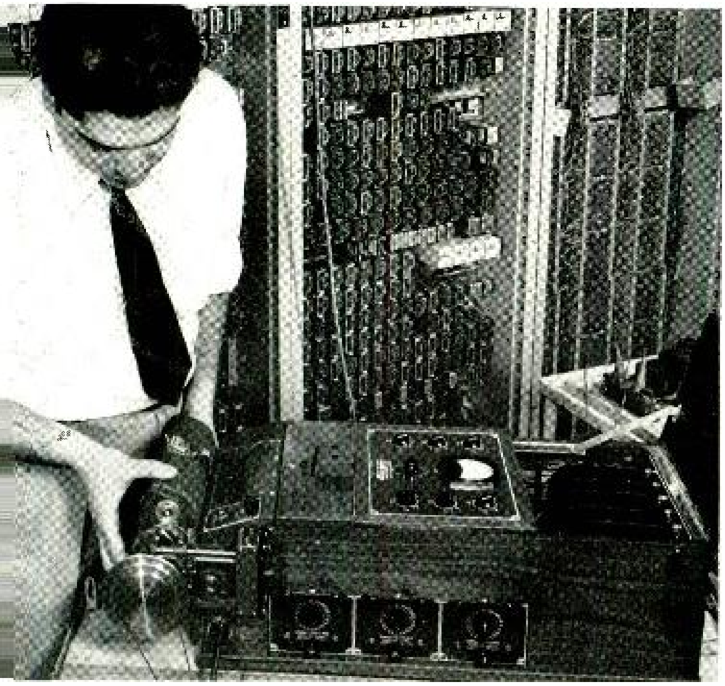


Fig. 2 — T. J. Palermo attaching photographic film holder to oscillograph; six mirrors for reflecting light to the film are in compartment at right.

galvanometer is calibrated and adjusted to give approximately half-scale deflection. Two mirrors that are not a part of the electrical system of the galvanometer are then positioned. A fixed spot of light from one of the mirrors is made to coincide exactly with the movable spot in its deflected position. The other spot is made to coincide with the position of the movable spot when the circuit is unblocked and the current in the galvanometer returns to zero to indicate no current in the circuit.

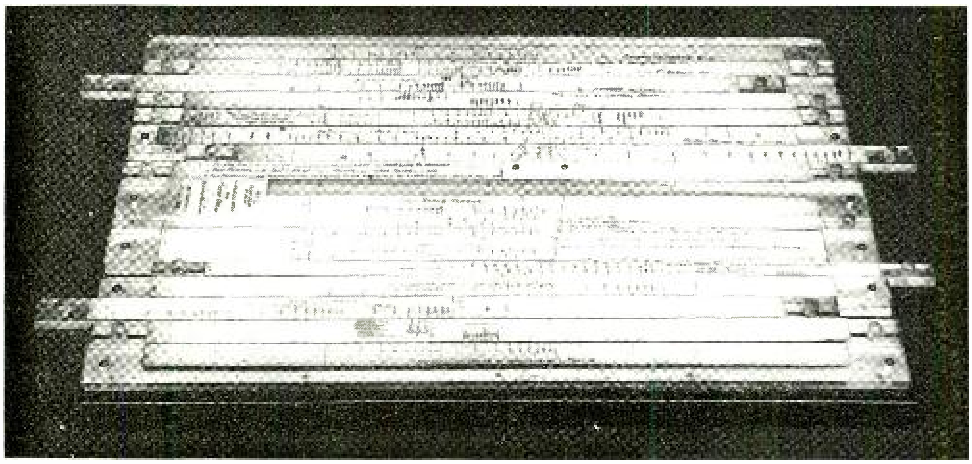
A telephone call is now made through the circuit, and a continuous trace of the instantaneous current in the lead under measurement is recorded on film. Since the fixed mirrors are not a part of the galvanometer system, their spots appear as straight lines; one shows zero current and the other a current corresponding to the initial calibrate reading. A typical oscillograph record for a step-by-step transverter circuit is shown in Figure 1.

After the film is developed, the curves are analyzed and, if no unusual conditions indicating a need for further measurements are found, the average and peak currents are determined by simple comparison of areas and ordinates. Briefly, the average currents are determined by a process of measuring areas under the curves with a planimeter. Peak current is then measured merely by proportioning the maximum height of the curve. Additional computations are usually necessary in order to make allowances for skeletonized circuits measured in the Laboratories, field traffic conditions, and also for variations in circuit holding-time.

With these new methods and facilities, what was rapidly becoming for common-control circuits an almost impossible task involving many days of study and computation has been materially reduced. Accuracy has been improved, which has reduced the chances of errors in the engineering of power plants and of power distribution systems. Vital time is being saved in the continuing process of providing the Telephone Companies and the Western Electric Company with the information they use in their engineering and installation of our rapidly expanding telephone system.

THE AUTHOR

Earl A. Looney entered the Laboratories in 1922 and, following preliminary courses in circuit study and relay design, was engaged in the design of manual and machine switching circuits of local telephone systems. During this time he was a co-author of a student text on the step-by-step system. In 1932 he transferred to laboratory and circuit design work on toll systems. At present he heads a group engaged in the determination of the current drain data for all telephone and telegraph systems. Mr. Looney was graduated from Rensselaer Polytechnic Institute with an M.E. degree, is a licensed Professional Engineer, President of the Morris County, N. J., Association of Professional Engineers and Land Surveyors and formerly Trustee of the State Society. He is also President of the Rensselaer Alumni of New Jersey and Chairman of its Scholarship Committee.



Special desk-model slide rule for the rapid design of direct current meters.

Slide Rule for Design of DC Meters

Individual varieties or "codes" of the Western Electric dc meter are designed to provide the desired scale ranges and to function properly in specific circuits. The moving-coil and pointer system is designed to have the required electrical circuit performance, including accuracy and stability, combined with proper mechanical balance and damping characteristics.

It is well known that correct damping is an important requirement for good design of moving-coil meters. With too little damping, the indicating needle oscillates about the desired value, and with too much damping, the needle takes an excessive time to swing to this value. With "critical" damping, the needle swings to the indicated value and settles there. The "actual" damping selected is a percentage (usually 80 per cent) of critical damping. This allows a rapid swing to the indicated value without objectionable oscillations. Actual damping depends upon the retarding forces produced by generation of current in the moving-coil circuit and in the coil frame, if one is used. Its value is derived from electrical factors such as resistances, number of turns of wire on the coil, and the strength of the magnetic field. Critical damping characteristics depend upon the moment of inertia of the complete moving system and its elastic "stiffness." This elastic stiffness is produced by the return spring, which at full scale provides a torque designed to balance that established by the current, number of turns of wire on the coil and the magnetic flux.

The physical and mathematical relationships are well established, so that the characteristics of any specific coil can be computed with two equations – one for actual damping and one for critical damping. However, because these equations involve seven variables, the engineer's attempt to meet both the specified electrical characteristics and the 80 per cent relationship requires essentially trial and error computations or a series of successive approximations. An experienced designer is able to choose the most promising or likely combinations of design factors and to recognize by intuition what changes

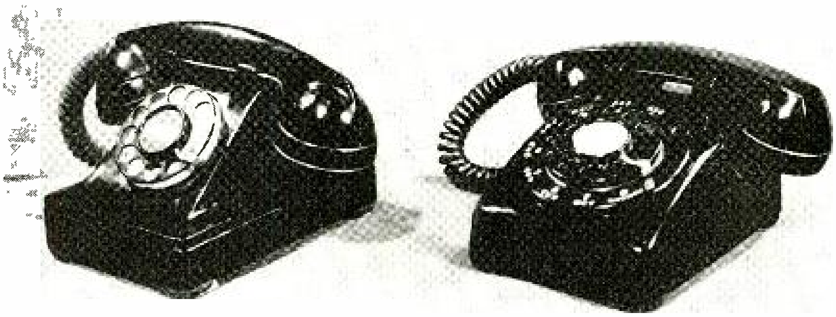
P. M. Mackoff using the new slide rule for the design of meters.

in assumptions will tend to direct his calculations to the desired solution. The process is always tedious and time-consuming, and in particularly difficult cases can be very protracted. This situation can easily result in stopping with a design just barely "good enough" when viewed with the charity born of many frustrating trial calculations. A quick and easy way of performing the necessary calculations can not only save time and effort but should raise the level of "accepted" designs nearer the optimum.

Some time ago, charts were developed by which the proper dynamic relationships could be graphically determined. They were complicated charts and had to be rather large to cover the required range of possible design with the necessary accuracy. The operations of two graphic charts were then condensed to a special desk-model slide rule. shown in the illustrations on the opposite page. It is 15 inches wide by 20 inches long and is in two sections. The upper or left section, which does the damping calculations described, has six sliding scales and two stationary scales. The lower or right section has four sliding scales and four stationary scales. This section performs supplementary design calculations necessary to determine the numerical value of the spring torque. This value is obtained from the design constants chosen on the basis of the damping calculations. It also calculates the weight of coil for different wire sizes and checks the ratio of torque to the total weight of the moving system, which is a design criterion held within certain broad limits.

By the use of this slide rule, the meter designer can make individual calculations of dynamic design in seconds and work out a final design in minutes.

W. W. Werring
Switching Systems Development



Laboratories Introduces 5300-Type Telephone

Although many of the new 500-type telephone sets have been installed in the field, there are still more than twenty-seven and one-half million 300-type sets in use. These telephones, which have an engineered life of twenty years, represent a considerable investment in the Bell System plant. To preserve this investment and still provide many telephone customers with the improved appearance and operating characteristics of the new set, the Laboratories' Station Apparatus Development Department has introduced the 5300-type telephone.

To make this new telephone, a 300-type set is stripped of its old housing and enclosed in a new one that resembles the 500-type in all respects, including a dial with numbers outside the finger wheel. In addition, the base of the 5300 set can be modified to provide for adjusting the volume of the ringer, just as in the 500 set. Transmission characteristics can also be modified according to the conditions of use. The cradle of the 5300-type set has been designed so that it can hold either the "F-type" handset normally used with the "300" telephone or the newer "G-type" handset used with the "500" telephone.

At present, the modified housing produced at the Western Electric Indianapolis Works is available only in black. They may be furnished in color at a later date if customer demand warrants.

Diffused-base Transistors Available for Military Use

Urgent and widespread demands have been made recently by the military services for diffused-base germanium transistors. These transistors are made possible by the diffusion technique, one of the latest developments in transistor technology to come from the Laboratories. To meet the pressing need for these transistors, the Western Electric Company has undertaken immediate manufacture of "state-of-the-art" units for exploratory development work.

The diffusion process, a major advance in transistor technology, provided a means for developing units which can operate at the high frequencies necessary in many military applications. It has been necessary, therefore, to provide substantial quantities of the new transistors to the military services and their contractors even before final specifications for the product have been decided upon. Production of these transistors so soon after the introduction of diffusion techniques is the result of extensive planning by Bell Laboratories, Western Electric and the U. S. Army Signal Corps.

The diffused-base germanium transistors have a high-frequency performance that surpasses any other transistor now available. They are particularly suited to VHF oscillator, medium power IF and broadband video amplifier applications. Representative units, which were recently described at a symposium held by the Laboratories, have provided 50 milliwatts output as oscillators at 200 mc. Other units of this type have yielded about 19 db gain per stage with an 8-mc bandwidth as video amplifiers.

Although they are subject to change with state-of-the-art diffusion techniques employed, typical units produced at present have a median alpha cutoff frequency value of approximately 400 mc. The alpha cutoff frequency in some units, however, exceeds 600 mc. Power dissipation is 150 mw maximum at 25°C with an appropriate heat sink. Common emitter short circuit current gain at 50 mc is a minimum of 12 db.

Comparison of these figures with presently available transistors indicates the striking advance toward higher operating frequencies in these diffused base transistors. Key to the success was accurate control of base layer thickness, one of the critical dimensions which seriously restricts the upper frequency limit of transistor operation. Dimensional control inherent in the new processes permits diffused surface layers in the order of 0.001 cm thick. Such dimensions were not possible with previous production techniques.

To make these p-n-p transistors, p-type single crystal germanium is cut into slices which are subsequently processed to size. After being properly prepared, they are placed in a furnace for diffusion of an n-type impurity into the surface. An important characteristic feature of the diffusion process, in addition to its base layer thickness control, is that an impurity gradient is produced in the base region. This gradient enhances the transport of minority carriers from emitter to collector by virtue of a "built-in" electric field.

The geometry of the transistor is controlled by masking and etching. The emitter layer and base contact are made from films of aluminum and gold-antimony by vacuum evaporation and alloying.

The improved performance of the diffused base transistor has opened up an entirely new frequency domain to the semiconductor art and, as a result, an extensive range of new applications may be possible.

Hal S. Dumas, A.T.&T. Executive Vice President, Retires

After 45 years of Bell System service, Hal S. Dumas, executive vice president of the American Telephone and Telegraph Company, retired at his own request on July 1. Mr. Dumas, who announced last fall that he would retire this year, was president of the Southern Bell Telephone and Telegraph Company for eight and one-half years before he was elected to his present position with A. T. & T. on July 18, 1951.

Mr. Dumas' first telephone job was in the Southern Bell plant department in Atlanta in 1911, shortly after he received his degree from the Alabama Polytechnic Institute at the age of 18. Traffic jobs in Birmingham and Atlanta followed, and in 1929 he was appointed general traffic supervisor in Atlanta. In 1935 he became assistant to the president and was appointed general plant manager the following year. He was elected vice president in charge of operations in 1938 and on January 1, 1943, he was elected president. Mr. Dumas, on the board of directors and on the executive committee of A. T. & T., is also a director of the Southern, Southwestern, Pacific and Bell of Canada companies, the 195 Broadway Corporation and Long Lines.

A. B. Goetze Elected to Laboratories Board of Directors

A. B. Goetze, Vice President – Manufacturing of Western Electric Co., has been elected to the Board of Directors of the Laboratories. He succeeds H. C. Beal, former Vice President – Manufacturing of Western Electric Co., who retired July 1. Mr. Beal had been a member of the Board since September 1947.

Mr. Goetze, Vice President – Finance since 1954, succeeded Mr. Beal as Vice President – Manufacturing on May 1, in anticipation of Mr. Beal's retirement. He is also a Director of Western Electric. He was previously Vice President and Works Manager of the Kearny Works and later Vice President—Manufacturing, Eastern Area. He joined Western Electric as a draftsman in 1917.

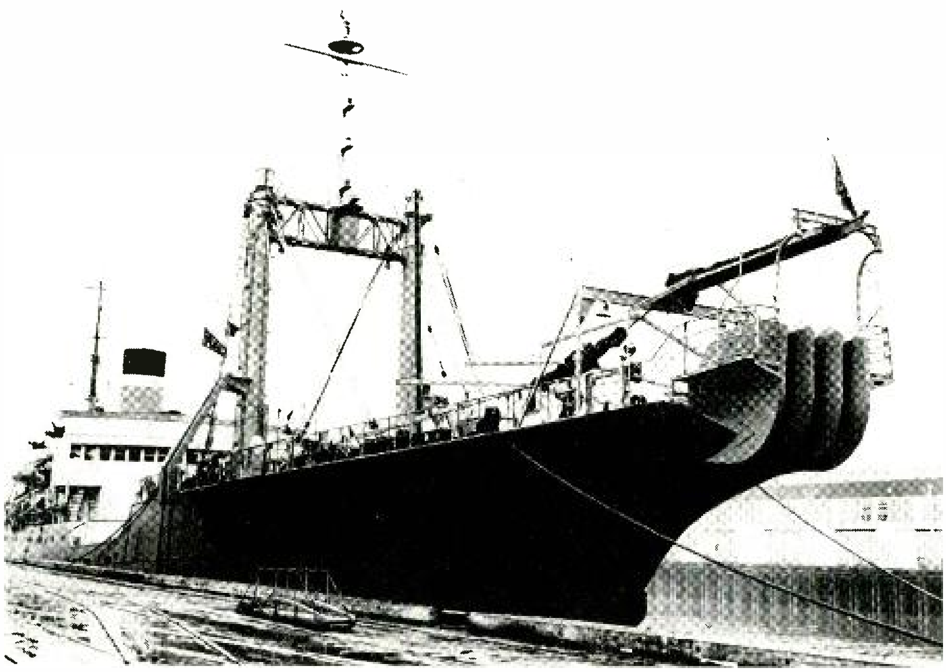
In addition to Mr. Goetze, the Laboratories' Board includes Vice Presidents G. L. Best, H. R. Maddox, and H. I. Romnes of A.T.&T., President F. R. Kappel and Vice President H. V. Schmidt of Western Electric, and President M. J. Kelly, Executive Vice President J. B. Fisk and Vice President and General Manager J. E. Dingman of the Laboratories.

Submarine Cable Laying Operations in Progress

Laying operations are well along on the second cable for the transatlantic submarine system and the cable for the system between the United States and Alaska. The cableship *H.M.T.S. Monarch* is expected to complete the transatlantic cable laying operation by late August.

The United States-Alaska cable is being layed by the cableship *Albert J. Myer.* This new telephone system, a $15 million project undertaken by the Long Lines Department of A.T.&T., will include twin cables stretching some 750 miles between Port Angeles, Wash., and Ketchikan, Alaska. At Ketchikan, the underseas cables will be connected with the facilities of the Alaska Communication System, a branch of the U. S. Army Signal Corps which furnishes long distance communication service throughout Alaska. From the southern terminus near Port Angeles, the circuits will be carried to Seattle over a new radio relay route provided jointly by Long Lines and the Pacific Telephone Company. At this point, the circuits will be fed into the Bell System's nationwide telephone network. The Alaska cable system will provide 36 voice circuits, more than twice as many as are now available between the U. S. and Alaska over radio and land-line facilities.

The first step in the laying operation was splicing



The Albert J. Myer, *cable ship used for United States-Alaska submarine cable.*

the heavy shore-end cable with the deep-sea cable in the tank aboard the cableship *Albert J. Myer*, a 7,800-ton vessel. The cableship then started paying out cable at the rate of six nautical miles an hour as it headed on a northerly course.

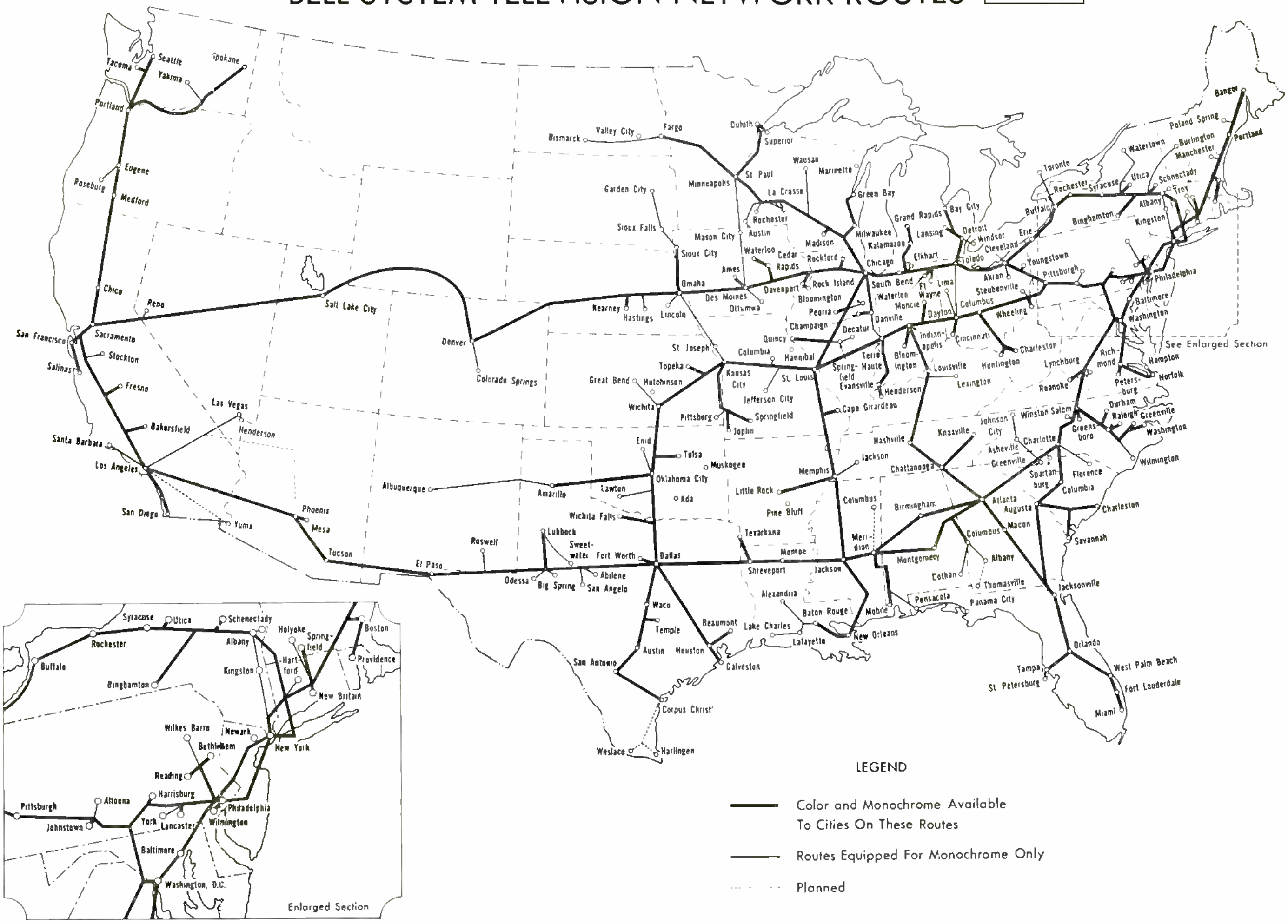
The *Albert J. Myer's* four cable tanks can carry 530 miles of deep-sea cable, or enough to cover about two-thirds of the route. The first segment was buoyed while the ship returned to Seattle to pick up enough cable to finish the run to Ketchikan. Laying of the second cable is being carried out in the same fashion, except that operations will start from Ketchikan.

The cable contains built-in amplifiers, each capable of amplifying voice currents a million times. Thirty-nine repeaters, built for the over-all system by the Western Electric Company will appear as long tapering bulges in the cable about every forty miles along the route.

W. E. Expands Manufacturing Plants

Due to the growing needs of the Bell System, the Western Electric Company will expand the facilities at its Merrimack Valley plant in North Andover, Mass., and at the Indianapolis Works. For the new Merrimack Valley plant, still under construction, an additional 480,000 square feet of space will be added to the 900,000 previously planned for manufacture of carrier and radio relay equipment, and switching components. At Indianapolis, plans call for 140,000 square feet for merchandising functions, including warehousing, packaging and shipping. Including these two projects, Western Electric has more than 3,000,000 square feet of manufacturing space either under construction or in the planning stage. Additions at Allentown and Point Breeze are in progress. Plans for a new plant at Omaha, Nebraska, were announced earlier this year.

BELL SYSTEM TELEVISION NETWORK ROUTES JULY 1, 1956



Talks by Members of the Laboratories

During June, a number of Laboratories people gave talks before professional and educational groups. Following is a list of speakers, titles, and places of presentation.

A.I.E.E. Summer General Meeting, San Francisco, Calif.

Bowers, F. K., *What Use Is Delta Modulation to the Transmission Engineer?*

Gryb, R. M., *Error Checking with Particular Reference to Telegraph Systems.*

Hamming, R. W., *Some Comparisons of Digital and Analog Computers.*

Hovgaard, O. M., *Capabilities of Sealed Contact Relays.*

Joel, A. E., Jr., *Electronics in Telephone Switching Systems.*

Kelly, J. L., Jr., *The Cash Value of Information Rate.*

Klemm, G. H., *Automatic Protection Switching for TD-2 Radio System.*

Knapp, H. M., *Design Features of Bell System Wire-Spring Relays.*

May, H. F., *A Magnetic Drum Storage System Considered for Use as a Common Sender in Nationwide Dialing.*

Meszar, J., *The Full Stature of the Crossbar Tandem Switching System.*

Moore, E. F., *Reliable Circuits Using Less Reliable Relays.*

Rea, W. T., *The Communication Engineer's Needs in Information Theory.*

Sproul, P. T., *A Video Visual Measuring Set with Sync Pulses.*

Weber, L. A., *Influence of Noise on Telephone Signaling Circuit Performance.*

A.I.E.E. – I.R.E. Conference on Semiconductor Research, Purdue University, Lafayette, Ind.

Batdorf, R. L., see Smits, F. M.

D'Asaro, L. A., see Loar, H. H.

Frosch, C. J., *The Oxidation of Silicon for Surface Passivation and for Selective Masking Against the Diffusion of Some Impurities at High Temperatures.*

Goldey, J. M., and Tannenbaum, M., *Silicon p-n-p-n Transistors.*

Iwersen, J. E., *Alpha in Silicon Transistors.*

Knowles, C. H., *Characteristics of the Drift p-n Junction.*

Loar, H. H., D'Asaro, L. A., and Ross I. M., *A New Semiconductor Counting Device.*

Miller, S. L., *The Effects of Avalanche Multiplication in Silicon Transistors.*

Miller, S. L., and Nervik, J. M., *Interpretation of the Alpha of Transistors at Very Low Current Levels.*

Miller, R. C., see Smits, F. M.

Moll, J. L., see Ross, I. M.

Nervik, J. M., see Miller, S. L.

Read, W. T., Jr., *A Proposed High-Frequency, Negative Resistance Diode Using Breakdown and Transit Time.*

Ross, I. M., and Moll, J. L., *Theory of p-n-p-n Transistor Switches.*

Ross, I. M., see Loar, H. H.

Smits, F. M., and Batdorf, R. L., *Vacuum Diffusion in Silicon.*

Smits, F. M., and Miller, R. C., *Boundary Conditions for Diffusion out of Germanium.*

Tannenbaum, M., see Goldey, J. M.

Wahl, A. J., *Alpha Stability of Diffused Base Transistors.*

American Physical Society Meeting, New Haven, Conn.

Brattain, W. H., see Garrett. C. G. B.

Buck, T. M., and McKim, F. S., *Experiments on the Photomagnetoelectric Effect in Germanium.*

Feldmann, W. L., see Pearson, G. L.

Garrett, C. G. B., and Brattain, W. H., *Distribution and Cross-Sections of Fast States on Germanium Surfaces,* and *Photo-effects and Field-effects at Germanium Surfaces.*

Hrostowski, H. J., and Kaiser, R. H., *Infrared Absorption of Oxygen in Silicon.*

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

Mandel, M., *Microwave Spectra of Gallium Chloride, Bromide and Iodide.*

McKay, K. G., *Breakdown in Semiconductors.*

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

Pearson, G. L., Read, W. T., Jr., and Feldmann, W. L., *Deformation and Fracture of Small Silicon Crystals.*

Read, W. T., Jr., see Pearson, G. L.

Reiss, H., *Ion Pairing in Semiconductors.*

Wertheim, G. K., *Energy Levels in Electron Bombarded Silicon.*

American Crystallographic Association Summer Meeting, French Lick, Ind.

Bala, V. B., see Geller, S.

Geller, S., *A Set of CN (12) Radii for the β-Wolfram Structure Elements.*

Geller, S., and Wood, Mrs. E. A., *Crystallographic Studies of Perovskite-Like Compounds I. Rare Earth Orthoferrites.*

Geller, S., and Bala, V. B., *Crystallographic Studies of Perovskite-Like Compounds II. Rare Earth Aluminates.*

Geller, S., *Crystallographic Studies of Perovskite-Like Compounds III. Rare Earth Orthochromites, Galliates, Scandates and Vanadites.*

Gilleo, M. A., *Crystallographic Studies of Perovskite-Like Compounds:* $La(M_xMn_{1-x})O_3$ *with* $M = Co$, *Fe and Cr.*

Prince, E., *Crystal Structures of Two Tetragonal Pseudospinels.*

Remeika, J. P., *Growing Single Crystals of Rare Earth Perovskite-Like Compounds.*

Wood, Mrs. E. A., see Geller, S.

Talks by Members of the Laboratories, Continued

Acoustical Society of America Meeting and Second International Congress on Acoustics, Massachusetts Institute of Technology, Cambridge, Mass.

Andreatch, P., and Thurston, R. N., *Disc-Loaded Torsional Wave Delay Line I.*

Cook, R. K., *Absorption of Sound by Patches of Absorbent Material.*

David, E. E., Jr., *Implications of Recent Speech Research.*

David, E. E., Jr., see McDonald, H. S.

Dudley, H. W., *Introductory Remarks on the Why and How of Speech Synthesis.*

Kramer, H. P., *Statistics of Speech.*

McDonald, H. S., and David, E. E., Jr., *A Technique for Coding Speech Signals for Transmission over a Reduced Capacity Digital Channel.*

Miller, R. L., see Weibel, E. S.

Rienstra, A. R., *Acoustical and Organ Design for Church Auditoriums.*

Thurston, R. N., *Disc-Loaded Torsional Wave Delay Line II.*

Thurston, R. N., see Andreatch, P.

Weibel, E. S., and Miller, R. L., *Measurement of the Fundamental Period of Speech Using A Delay Line.*

I.R.E. Transistor Circuits Subcommittee Meeting, Cornell University, Ithaca, N. Y.

Anderson, J. R., and Wolfe, R. M., *Comparison of Ferroelectric, Ferromagnetic and Transistor Shift Registers.*

Andrews, F. T., Jr., *Application of Magnetic Core Logic and Switching Circuits in Control Systems.*

Simkins, Q. W., *Compatibility of Transistor and Magnetic Core Circuits for Logic and Storage Systems.*

Sumner, E. E., *Diffused-base Transistor Digital Circuits.*

Wolfe, R. M., see Anderson, J. R.

Electron Tube Research Conference, Bureau of Standards, University of Colorado, Boulder, Colo.

Cutler, C. C., *Instability in Hollow and Strip Electron Beams.*

Harker, K. J., *Non-Laminar Flow in Cylindrical Electron Beams.*

Karp, A., *Status of Crossed-Field Emitting-Sole Experiment at 5 MM Wavelength.*

McCarthy, J. A., and Sears, R. W., *Interaction Between Storage Elements in Barrier Grid Storage Tubes.*

Poole, K. M., *Velocity Distribution Measurements in a Diode.*

Sears, R. W., see McCarthy, J. A.

Tien, P. K., *Noise Properties at the Potential Minimum of a High Frequency Diode.*

Conference on the Physics of Semiconductor Surfaces, University of Pennsylvania, Philadelphia.

Brattain, W. H., see Brown, W. L.; Garrett, C. G. B.

Brown, W. L., Brattain, W. H., Garrett, C. G. B., and Montgomery, H. C., *Field Effect and Photo Experiments on Germanium Surfaces I. Equilibrium Conditions Within the Semiconductor.*

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

Garrett, C. G. B., Brattain, W. H., Brown, W. L., and Montgomery, H. C., *Field Effect and Photo Effect Experiments on Germanium Surfaces II. Non-equilibrium Conditions Within the Semiconductor.*

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

Herring, C., *Physical Theory of Surfaces.*

Law, J. T. and Meigs, P. S., *The High Temperature Oxidation of Germanium.*

Meigs, P. S., see Law, J. T.

Montgomery, H. C., see Brown, W. L.

Montgomery, H. C., see Garrett, C. G. B.

Other Talks

Arnold, S. M., *The Growth and Properties of Metal Whiskers,* American Electroplaters Society, Washington, D.C.

Bacon, W. M., *What Do We Do About the Shortage of Engineers,* Cornell University, Ithaca, N. Y.

Baker, W. O., *Communications* on the general theme of *Plastics Shaping Tomorrow's Products,* Society of the Plastics Industry Annual Meeting, N. Y. C.

Beck, A. C., *Waveguides for Long Distance Communication,* I.R.E. Baltimore Section.

Becker, J. A., *Seeing Individual Atoms or Molecules,* and *The Combination of Field Emission and Flash-Filament Techniques,* Field Emission Symposium, Notre Dame University, South Bend, Ind.

Bommel, H. E., *Ultrasonic Attenuation and Velocities in Normal and Superconducting Metals,* Institute for the Study of Metals Colloquium, University of Chicago, Ill.

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

Brattain, W. H., *Distribution and Cross-Sections of Fast States on Germanium Surfaces,* American Physical Society Meeting, Eugene, Oregon.

Chapin, D. M., see Pearson, G. L.

Cornell, W. A., *Transistors and Electronic Circuits,* Naval Reserve Research Co. 3-1, Cornell Medical College, N.Y.C.

D'Asaro, L. A., *Use of the Field Emission Microscope for Investigating Surface Conditions on an Alloy,* Field Emission Symposium, Notre Dame University, South Bend, Ind.

Talks by Members of the Laboratories, Continued

Dillon, J. F., Jr., *Motion of Single Domain Walls in Manganese Ferrite*, I.B.M. Research Laboratories.

Dodge, H. F., *Discussion of Sampling Inspection Plans*, American Society for Quality Control Annual Convention, Montreal, Canada.

Golm, G. R., see Torrey, Miss M. N.

Hamming, R. W., and Weiss, Miss R. A., *A General Purpose System for the IBM 650*, International Business Machines, Inc. Endicott, N. Y.

Harris, J. R., *Transistor Circuits for Digital Computers*, University of Michigan, Ann Arbor.

Harvey, W. H., see Kock, W. E.

Haworth, F. E., *The Glow-to-Arc Transition*, Electrical Contacts Seminar, Pennsylvania State University.

Howard, J. B., and Wallder, V. T., *Trends in Materials for Extrusion on Communications Wire and Cable*, Society of the Plastics Industry Annual Conference, N. Y. C.

Ingram, S. B., *The Role of Evening Engineering Education in the Training of Technicians*, A.S.E.E., Ames, Iowa.

Jacobson, M. J., *Correlator Output Noise and Multiple Signal Interference*, 13th U.S. Navy Symposium on Underwater Acoustics, White Oak, Maryland.

Kock, W. E., and Harvey, W. H., *Speech, Music and Hearing*, I.R.E. New York Section, N. Y. C.

McMillan, B., *Probability in Engineering*, Mathematics in Engineering Conference, University of Michigan.

Pearson, G. L., and Chapin, D. M., *Electricity From the Sun*, Alumni Association, Willamette University, Salem, Oregon.

Phair, R. J., *Abrasion Resistance of Clear Floor Coatings*, A.S.T.M. Committee D1 Symposium on Floor Finishes, Atlantic City, N. J.

Rose, D. J., *Resolution of the Field Emission Microscope*, Field Emission Symposium, University of Notre Dame, Notre Dame, Ind.

Smith, J. L., and Boyle, W. S., *Short Arc Extinction and Welding*, Electrical Contacts Seminar, Pennsylvania State University, University Park.

Snoke, L. R., *Testing Organic Materials for Resistance to Marine Biological Attack*, Sea Horse Institute and Marine Borer Conference, Wrightsville Beach, N. C.

Terry, M. E., *The Statistical Design of Engineering Experiments*, Cornell University Industrial and Engineering Seminar, Ithaca, N. Y.

Torrey, Miss M. N., and Golm, G. R., *A Study of Statistical Treatments of Fatigue Data*, A.S.T.M. Atlantic City, N. J.

Upthegrove, H. N., *Transatlantic Cable*, Naval Reserve Group, Princeton, N. J.

Wallder, V. T., see Howard, J. B.

Weiss, Miss R. A., see Hamming, R. W.

Papers Published 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

Atalla, M. M., see Preston, K., Jr.

Baker, W. O., see Winslow, F. H.

Benson, K. E., see Goss, A. J.

Bennett, W. R., *Electrical Noise. Part V. Noise Reduction in Communication Systems*, Electronics, **29**, pp. 148-151, July, 1956.

Bogert, B. P., *The VOBANC – A Two-to-One Bandwidth Reduction System*, J. Acous. Soc., **28**, pp. 399-404, May, 1956.

Chynoweth, A. G., *Spontaneous Polarization of Guanidine Aluminum Sulfate Hexahydrate at Low Temperatures*, Phys. Rev., **102**, pp. 1021-1023, May 15, 1956.

Fuller, C. S., *Some Analogies Between Semiconductors and Electrolyte Solutions*, Record of Chem. Progress, **17**, pp. 75-93, No. 2, 1956.

Garrett, C. G. B., see Law, J. T.

Geller, S., *The Crystal Structure of Gadolinium Orthoferrite, $GdFeO_3$*, J. Chem. Phys., **24**, pp. 1236-1239, June, 1956.

Gilleo, M. A., *Magnetic Properties of a Gadolinium Orthoferrite, $GdFeO_3$, Crystal*, J. Chem. Phys., **24**, pp. 1239-1243, June, 1956.

Giloth, P. K., *A Simulator for Analysis of Sampled Data Control Systems*, Proc. Natl. Simulation Conf., pp. 21.1-21.8, Jan., 1956.

Goss, A. J., Benson, K. E., and Pfann, W. G., *Dislocations at Compositional Fluctuations in Germanium-Silicon Alloys*, Acta Met., Letter to the Editor, **4**, pp, 332-333, May, 1956.

Harrower, G. A., *Dependence of Electron Reflection on Contamination of the Reflecting Surface*, Phys. Rev., **102**, pp. 1288-1289, June 1, 1956.

Law, J. T., and Garrett, C. G. B., *Measurements of Surface Electrical Properties of Bombardment-Cleaned Germanium*, J. Appl. Phys., **27**, p. 656, June, 1956.

Lewis, H. W., *Two-Fluid Model of an "Energy-Gap" Superconductor*, Phys. Rev., **102**, pp. 1508-1511, June 15, 1956.

Lozier, J. C., *A Steady State Approach to the Theory of Saturable Servo Systems*, I.R.E. Trans., PGAC, **1**, pp. 19-39, 1956.

Matthias, B. T., and Remeika, J. P., *Ferroelectricity in Ammonium Sulfate*, Phys. Rev., Letter to the Editor, **103**, p. 262, July 1, 1956.

Pfann, W. G., *Zone Melting: A Fresh Outlook for Fractional Crystallization*, Chem. & Engg. News, **34**, pp. 1440-1443, Mar. 26, 1956.

Pfann, W. G., see Goss, A. J.

Phelps, J. W., *Protection Problems in Telephone Distribution Systems*, Wire and Wire Products, 31, pp. 555-596, May, 1956.

Pondy, P. R., *Dust-Lint Control in Tube Fabrication*, Electronics, **29**, pp. 246-250, June, 1956.

Preston, K., Jr., and Atalla, M. M., *Transient Temperature Rise in Semi-Infinite Solid Due to a Uniform Disc Source*, J. Appl. Mechanics, **23**, p. 313, June, 1956.

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

Winslow, F. H., Baker, W. O., and Yager, W. A., *The Structure and Properties of Some Pyrolyzed Polymers*, Proc. Conf. on Carbon, pp. 93-102, 1956.

Yager, W. A., see Winslow, F. H.

Patents Issued to Members of Bell Telephone Laboratories During May

Alsberg, D. A. – *Method of and Means for Measuring Impedance and Related Quantities* – 2,746,015.

Anderson, A. E. – *Conditioning of Semi-Conductor Translators* – 2,746,121.

Bachelet, A. E., and Bomba, J. S. – *Air Raid Warning System* – 2,746,028.

Belek, E. – *Wire Wrapping Tool for Coated Wire* – 2,746,124.

Bellows, B. C., Jr. – *Very High Frequency Gas Discharge Noise Source* – 2,745,011.

Bode, H. W. – *Automatic Curve Follower with Vibrating Stylus* – 2,744,224.

Bomba, J. S., see Bachelet, A. E.

Bostwick, L. G. – *Vibrating Reed Oscillator of the Contact Type* – 2,747,092.

Bowen, A. E. – *Ultra-High-Frequency Electronic Device* – 2,745,039.

Boyd, R. C. – *Radiant Energy Relay System* – 2,748,266.

Christensen, H. – *Method of Producing a Taut Thin Member* – 2,746,129.

Depp, W. A. – *Translating Arrangement* – 2,745,958.

Dickten, E., Jr., Riesz, R. P., and Wallace, R. L., Jr. – *Fabrication of Junction Transistors* – 2,748,349.

Ekstrand, S. O., and Ronci, V. L. – *Fabrication of Electrodes for Electron Discharge Devices* – 2,746,123.

Felker, J. H. – *Transistor Blocking Oscillators* – 2,745,012.

Fox, A. G. – *Transmission Meter* – 2,746,014.

Frantz, G. R. – *Linearizer for Frequency Modulation Generator* – 2,747,163.

Gannett, D. K. – *Transistor Negative Impedance Converters* – 2,745,068.

Goddard, C. T., and Wittwer, N. C., Jr. – *Broad Band Amplifier Devices* – 2,747,138.

Hagelbarger, D. W., and Walker, L. R. – *Microwave Oscilator* – 2,745,984.

Hewitt, W. H., Jr. – *Microwave Magnetized Ferrite Attenuator* – 2,745,069.

Hill, H. E., and Parkinson, D. B. – *Alternating Current Operated Relay Distributor* – 2,744,215.

Hines, M. E. – *Very High Frequency Gas Discharge Noise Source* – 2,745,013.

Hogan, C. L. – *Non-Reciprocal Wave Guide Attenuator* – 2,748,353.

Kock, W. E. – *Wave Refracting Devices* – 2,747,184.

Llewellyn, F. B. – *Two-way Repeaters* – 2,748,200.

Loman, G. T. – *Semi-conductor Translating Device and Method of Manufacture* – 2,744,308.

Low, F. K. – *Rectangular Coordinate Registering Circuit* – 2,744,245.

Mallina, R. F. – *Wire Connecting Tool* – 2,743,503.

Mallina, R. F. – *Code Tape Perforators* – 2,744,578.

McMillan, B. – *Multiple-Feedback Systems* – 2,748,201.

Merrill, F. G., and Thomas, L. C. – *Frequency Multiplier Apparatus* – 2,748,283.

Mertz, P. – *Measurement of Transmission Time Delay* – 2,746,013.

Miller, S. E. – *Ultra-High Frequency Selective Mode Directional Coupler* – 2,748,350.

Miller, S. E. – *Non-Reciprocal Wave Transmission Networks* – 2,748,352.

Parkinson, D. B., see Hill, H. E.

Potter, J. L. – *Electromagnetic Apparatus* – 2,747,159.

Raisbeck, G. – *Transistor Trigger Circuits* – 2,744,198.

Rea, W. T. – *Power Supply System* – 2,744,229.

Reck, F. – *Wire Connecting Tool* – 2,743,502.

Riesz, R. P., see Dickten, E., Jr.

Ronci, V. L., see Ekstrand, S. O.

Rorden, H. C. – *Automatic Curve Follower* – 2,744,225.

Shockley, W. – *Semiconductor Signal Translating Devices* – 2,744,970.

Stansel, F. R. – *Transistor Oscillators* – 2,745,010.

Thomas, L. C., see Merrill, F. G.

Walker, L. R. – *Device for Coupling Between Free Space and an Electron Stream* – 2,746,036.

Walker, L. R., see Hagelbarger, D. W.

Wallace, R. L., Jr. – *Machine for Automatic Fabrication of Tetrode Transistors* – 2,748,235.

Wallace, R. L., Jr., see Dickten, E., Jr.

Wittwer, N. C., Jr., see Goddard, C. T.

Young, W. R., Jr. – *Radiant Energy Signaling Systems* – 2,745,953.