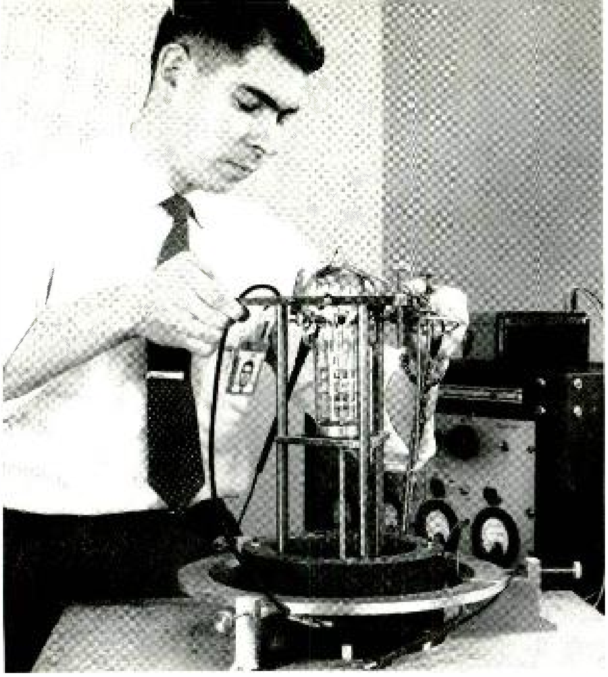


Ferrite Attenuators for Traveling-Wave Amplifiers

R. KOMPFNER and J. S. COOK
Electronics Research

Ferrite materials have found numerous important applications in communications equipment because they have a property exhibited by no other magnetic material — they can be arranged in a circuit to allow microwave energy to pass in one direction but not in the other. Devices for electrically isolating one circuit from another, for routing microwave energy over different waveguide paths, and for many other purposes have therefore been constructed with ferrites. In recent research investigations, this material has also been used experimentally in traveling-wave tubes to eliminate reflections that cause troublesome oscillations.

Because of their high amplification over a great range of frequencies, traveling-wave tubes are now being used extensively in broadband microwave transmission systems. Like most important technological developments, however, the traveling-wave tube did not suddenly appear overnight in its most efficient form. A number of fundamental problems had to be solved first. One of the most important of the problems concerns the efficiency of traveling-wave tubes as amplifiers. The nature of these tubes is such that reflected signals may set up unwanted oscillations that greatly reduce their effectiveness.

The simplest form of traveling-wave tube,* as shown in Figure 1, consists of a helical conductor through which a beam of electrons is passed. An electromagnetic wave to be amplified is launched on the helix at the end where the electrons enter (left in the illustration), and travels at about the velocity of light along the path of the helical conductor. Its effective velocity along the axis of the helix, however, will be considerably smaller, and will have a value depending somewhat on the frequency of the wave, but mostly on the pitch angle of the helix. Typically, the helix is wound with a pitch that reduces the effective axial velocity to about one-sixteenth the velocity of light. The beam of electrons is then adjusted to the same velocity (accelerating potential about 1,000 volts). Amplification results because the electron beam continuously "boosts" the electromagnetic wave over the helix length, so that a much more powerful signal is taken off the output end.

Unfortunately, it is practically impossible to extract all of the output signal without permitting some signal energy to reflect back along the helix. The reflected signal may travel to the input end and be reflected again, with the result that the helix itself becomes a feedback circuit and causes unwanted oscillation. This effect is particularly troublesome because of the tremendous gain of which most traveling-wave amplifiers are capable; a very small reflected signal can produce a very large

* RECORD, *December*, 1946, *page* 439.

amount of re-transmitted energy. An integral part, then, of every high-gain traveling-wave amplifier is some means of preventing reflected signals from returning to the input end of the tube.

In the past, these oscillations have been overcome by introducing a certain amount of loss into the tube. This loss reduces somewhat the amplification of the signal traveling in the forward direction, but the weaker reflected signal is drastically reduced. For example, if we had a tube with an amplification of 45 db, we could insert a "cold" loss (loss with no signal present) of the same value. It is a significant feature of the helix-electron beam arrangement that this 45 db of loss would reduce the net gain by only about one-third, to about 30 db, while the reverse loss of 45 db would be sufficient to absorb the reflected energy. In other words, we sacrifice 15 db of gain to prevent oscillation. In practice, such attenuation has usually been provided by coating parts of the helix-supporting structure with a re-

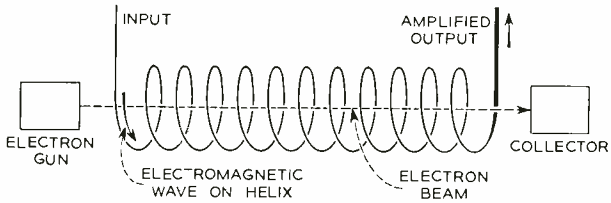


Fig. 1 — Simplest form of traveling-wave tube; electron beam amplifies electromagnetic wave traveling along the path of the helical conductor.

sistive film. The resistance can be distributed over the entire length of the helix, or it can be "lumped" in a small section of this length.

More recently, an alternative solution to the problem of traveling-wave tube oscillations has been suggested. This is based on the unique property of the ceramic-like ferromagnetic material called "ferrite" to exhibit non-reciprocal attenuation;* that is, a properly magnetized ferrite can be arranged to pass an electromagnetic wave in one direction with very little loss, but to attenuate greatly any electromagnetic energy returning from the opposite direction. Such non-reciprocal attenuation may now be obtained in helix-type traveling-wave tubes through the use of ferrite materials.

Figures 2 and 3 can be used to illustrate an experimental method of using this non-reciprocal property of ferrite. In Figure 2 a "cut-away" of the helix is shown, and lines of magnetic flux are drawn around the conductor at several places to show their

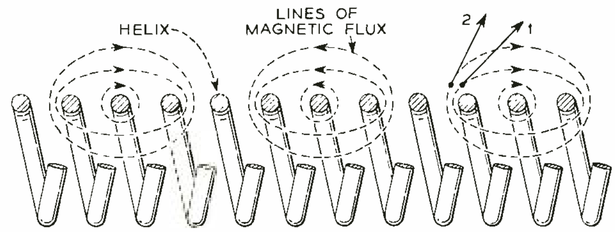


Fig. 2 — Rotation in direction of lines of magnetic flux; when wave moves left to right, arrow appears to rotate in a counterclockwise direction.

pattern at a given instant of time. Arrows indicate the direction of the magnetic field at the points where the arrows are tangent to the lines. Now, if a hypothetical observer were standing beside the helix, and if he were able to watch one of the arrows as the wave went by, this arrow would appear to rotate. Assume, for instance, that the wave is passing from left to right in the illustration. The observer would first see the arrow in position number 1, then later would see it in position number 2, closer to the vertical. That is, the arrow would appear to be rotating counterclockwise. If the wave were passing from right to left, he would see the arrow first in position number 2 and later in position number 1, or clockwise rotation.

Let us now slip a hollow cylinder of ferrite over the helix, and with a dc field magnetize it in a cir-

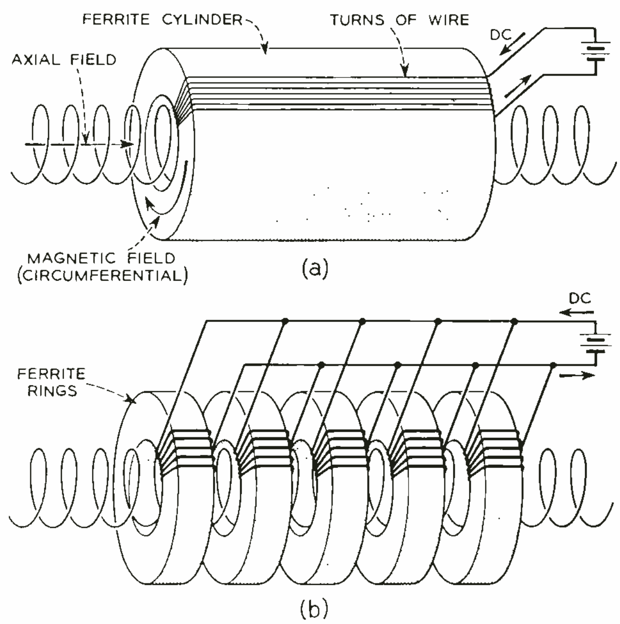


Fig. 3 — (a) Ferrite cylinder over helix assembly of traveling wave tube; direct current in turns of wire magnetize ferrite in circumferential direction; (b) "Life-Saver" ferrite rings used to decrease distortion of beam-focusing magnetic field.

* RECORD, *October,* 1955, *page* 385; *December,* 1955, *page* 419.

cumferential direction. The ac field from the helix and the dc field in the ferrite will interact, and there will be some frequency for which a wave traveling in one direction will be attenuated, while a wave traveling the other way will not.

A ferrite cylinder surrounding a helix is illustrated in Figures 3(a) and 6. The first experiments were performed with this arrangement, the circumferential field being furnished by a direct current passing through several turns of wire wound about the ferrite in toroidal fashion as shown in the drawing. Non-reciprocal attenuation of about 1 db in the forward direction and 10 db in the reverse direction was observed with this arrangement. Unfortunately, however, such a ferrite cylinder is not practicable for use in an actual traveling-wave tube. To see the reason for this, we must consider that we are here dealing with three different magnetic fields. The circumferential field in the ferrite and the electromagnetic field around the helix conductor have already been mentioned; but for the operation of a traveling-wave tube, we need in addition an axial magnetic field to focus the electron beam. This field is represented in Figure 3(a) as a vector or arrow through the center of the helix pointing in the direction of electron flow. The complicating aspect of the ferrite cylinder is that ferrite has a high magnetic permeability, which means that lines of magnetic force, instead of passing along the axis of the helix, much prefer to shift over to an easier path in the ferrite. The axial field is thus shorted out or shunted, and hence the electron beam cannot be properly focused.

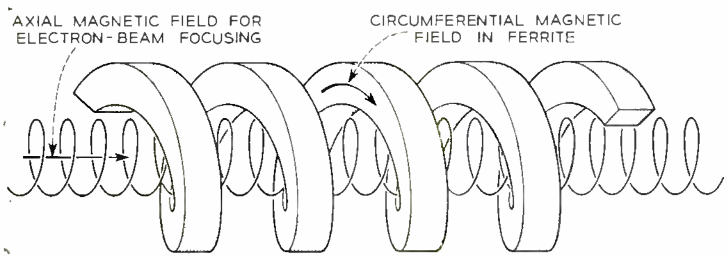


Fig. 4 — Ferrite helix eliminates need for dc coils to establish circumferential field.

In the course of these investigations, two solutions to this problem were attempted. The first, as illustrated in Figure 3(b), was to chop the ferrite cylinder into very short lengths to form "Life-Saver" like rings. Thus, there are introduced between the rings low-permeability paths which greatly reduce the tendency for the axial field to be shunted by the ferrite. The rings, in fact, reduced the field-shunting effect almost to the vanishing point, but two attendant difficulties were encountered. The high currents required in the induction coils tended to heat the ferrite and thus reduce its magnetic permeability, and the relatively large-diameter conductors required in the coils meant that the ferrite had to be positioned too far from the helix for efficient non-reciprocal action.

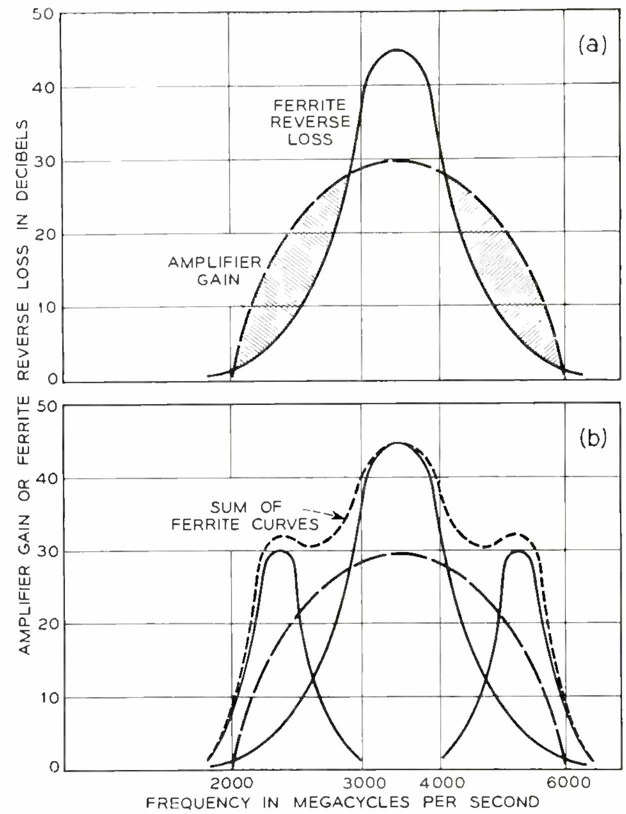


Fig. 5 — (a) Narrow band of reverse loss of one type of ferrite; (b) broad loss characteristic from sum of three ferrite curves, adequately covering traveling-wave tube amplifier gain over a bandwidth region from 2,000 to 6,000 megacycles.

The most successful method of applying the ferrite to the helix, however, was to make the ferrite itself into a helix, as shown in Figures 4 and 7. This turned out to be an elegant solution to all the problems we have so far discussed in connection with the cylinder and rings methods. It was found that with a properly dimensioned ferrite helix, the beam-focusing axial field would produce the circumferential field required in the ferrite. The reason is that a part of the axial field, instead of following the direction of the axis, will "see" an easy high-permeability path through the ferrite helix. The necessary circumferential field around the helix is therefore established without the use of induction

Fig. 6 — Cylindrical ferrite over tube helix as used in the original attenuation experiments.

coils. At the same time, the magnetic field on the axis of the helix is not appreciably reduced. It turns out that for an axial field of about 300 gauss, necessary to focus the electron beam, ferrite materials can be compounded to provide non-reciprocal attenuation covering various frequency ranges from 1,000 to 7,000 mc.

Early experiments with the helical ferrites brought out two additional problems. First, ferrites were effective over only a relatively narrow bandwidth; the best bandwidth achieved with a single type of ferrite was about 1,000 mc. This is large enough to satisfy almost any system requirement, but it is small compared with the intrinsic bandwidth of a traveling-wave tube. The bandwidth of a traveling-wave tube may be as much as 1½ times the frequency that the tube was designed to amplify. A tube designed to operate at 3,500 mc, for example, might amplify a range from 2,000 to 6,000 mc. Thus, even though an amplifier with 1,000-mc width would be adequate for most practical applications, the amplification range of a typical traveling-wave tube outside this width permits undesirable oscillations which hamper the tube's effectiveness. Figure 5(a) shows the sort of bandwidth situation that is encountered. The gain of a typical traveling-wave tube is seen here as covering the 2,000- to 6,000-mc range, whereas the reverse loss of the ferrite is much narrower. In the shaded portions of the diagram, amplifier gain is greater than reverse loss — a state that results in the unwanted oscillations.

THE AUTHORS

Rudolph Kompfner was an architect in London until 1941, pursuing physics and radio engineering as a hobby until he accepted a position from the British Admiralty to serve in the Royal Naval Scientific Service, at Birmingham University. His work on the traveling-wave tube, done during his association with Birmingham University, was of considerable significance to the field of microwave repeater development. In 1951, after three years at Birmingham, and seven years as a member of a research team at the Clarendon Laboratory, Oxford University, Mr. Kompfner joined the Laboratories. He is currently investigating various developments related to millimeter-wave tubes and their potentialities. Vienna-born, Mr. Kompfner received his engineering degree at Technische Hochschule, Vienna, in 1933, and his Ph.D. at Oxford in 1951. He is a fellow of the I.R.E.

J. S. Cook received the B.E.E. and M.S. degrees from Ohio State University in 1952. He joined Bell Telephone Laboratories in the same year and has been engaged principally with research on the traveling-wave tube. He is now engaged in research on high-frequency amplifiers as a member of the Research in High Frequency and Electronics Department. Mr. Cook is a member of the Institute of Radio Engineers, and he belongs to the organization's Professional Group on Electron Devices.

The first difficulty was solved at one time by distributing along the tube a number of different types of ferrites, each with a different bandwith characteristic. A better solution was furnished, however, by L. G. Van Uitert of the Metallurgical Research Department. Ferrites with different characteristics were combined into one composite material that covered the required frequency range. As shown in Figure 5(b), the sum of several reverse-loss curves adequately covers the 2,000- to 6,000-mc bandwith.

The second major difficulty was that the ferrite caused electron beam defocusing. Most ferrite materials have a relatively high coercive force – that is, they may have a certain amount of permanent magnetism. It was found that the defocusing was caused partly by local permanent magnetism existing along the ferrite, and partly by the distortion of the focusing field at the ends of the ferrite. The Metallurgical Research Department again helped to solve this problem by providing materials with a greatly reduced coercive force. Further improvement in beam focusing was achieved by reducing the radial thickness of the ferrite helices.

Based on the knowledge gained from these investigations, a narrow-band "double helix" traveling-wave tube was subsequently designed. This tube will be described in a companion article to appear in a future issue of the RECORD. The work described here, however, resulted in a significant improvement in traveling-wave tube performance. Through the use of ferrites, more of the potential maximum gain of traveling-wave tubes could be realized. Instead of sacrificing a large part of the output power, a tube could be operated at very close to maximum efficiency without incurring the penalty of feedback oscillations.

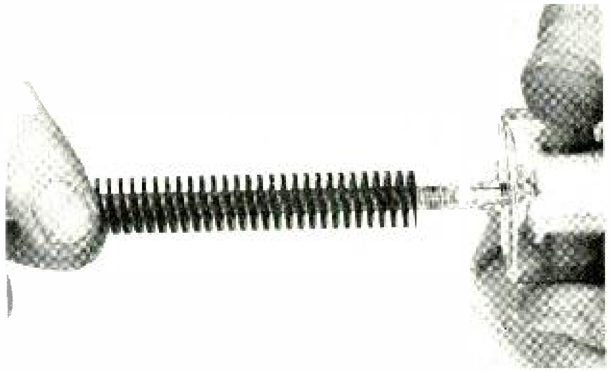


Fig. 7 — A ferrite helix placed over the wire helix inside a traveling-wave amplifier tube.

Transatlantic Cable Opened To Public Service

The transatlantic telephone cable system, first physical voice link to be established between North America and Europe, was inaugurated and opened to public service on September 25. Cleo F. Craig, Chairman of the Board of Directors of the American Telephone and Telegraph Company, was the first to speak over the $42,000,000 system. Frederick R. Kappel, who succeeded Mr. Craig as President, also participated in the inaugural ceremonies. Mr. Craig exchanged greetings with Dr. Charles Hill, head of the British Post Office, who spoke from London. Their conversation, carried with the clarity and naturalness of a neighborhood call, highlighted inaugural ceremonies held here and in Canada and Great Britain. Mr. Craig also exchanged greetings with Mr. George Marler, Canadian Minister of Transport, in Ottawa.

The November issue of the BELL LABORATORIES RECORD will include an additional account of the inaugural ceremonies that opened the translatlantic cable system for public service.

The cable system, under construction for more than two years, is not only the first of its kind to cross the Atlantic, but the first underwater telephone link to span any ocean. The American Telephone and Telegraph Company, the British Post Office and Canadian Overseas Telecommunication Corporation are partners in the historic enterprise. The deep-sea portion of the system was laid under the supervision of the Long Lines Department of the American Telephone and Telegraph Company. Engineers and scientists of Bell Telephone Laboratories designed and tested the system.

The transatlantic system can carry 36 conversations simultaneously. Thus, it is able to handle about three times the traffic now transmitted between this continent and Great Britain by radiotelephone. The deep-sea segment of the system extends 2,250 miles from Clarenville, a small village on the east coast of Newfoundland, to Oban, Scotland. From Oban, new trunk lines link the system to switchboards in London. On this continent, newly constructed land and water sections bring the transatlantic circuits to Portland, Maine, and to Montreal, where they connect to the established American and Canadian networks.

Switching at TV Operating Centers

A. L. STILLWELL
Transmission Systems Development II
A. D. FOWLER
Transmission Engineering I

Nationwide television networks, made possible by the Bell System, require television operating centers where various incoming programs can be rapidly switched to the proper outgoing channels. The Laboratories has developed new video switches for such operating centers that offer greatly improved operating features. These new video switches require a minimum of equalization and can be remotely controlled.

A television program from New York finishes, and in seconds is replaced by one from Hollywood, Chicago, or any of numerous cities throughout the country. Network television is such a widely accepted entertainment medium today that few people realize the tremendous resources of the Bell System that are called into play with each change in program. Not only does the Bell System supply the long-haul transmission facilities for such telecasts; it also supplies the necessary switching of circuits.

In the early days of network TV, such switching was done with patch cords. However, today's heavy load on transmission facilities, coupled with complex programming schedules, requires switching equipment at television operating centers – commonly known as TOC's – that is faster and easier to operate. The Laboratories has recently developed a new video switching system for such operation.

One objective of a TOC is remote control of switches at TD-2 radio relay * and coaxial carrier terminals. Primarily, however, the switching job of a TOC is that of interconnecting video (TV) lines. These may be long-haul inter-city transmission facilities or local intra-city facilities to TV stations or studios. Studio A, for example, originates a program that must be sent over one or more inter-city circuits, while station B in the same city wants to receive a program from a different inter-city network for local telecasting. At the same time, station C wants still another network program. All these signals come into the TOC and are there sorted out and distributed to their proper destinations.

From the point of view of video switching at a TOC, there are only two kinds of circuits: incoming and outgoing. The switching problem is that of connecting certain outgoing circuits to appropriate incoming circuits according to a pre-arranged schedule or, as is sometimes required, "on cue". The flexibility of the switch must be such that any input can be connected to any or all outputs. Thus, to serve M inputs and N outputs requires an M x N switch. In the smaller TOC's, M and N may be on the order of 10; in some of the largest TOC's, 30 x 36 switches will be required.

This seems like a fairly simple switching job until it is remembered that a normal video channel extends up to 4 mc, a bandwidth equal to 1,000 voice-frequency telephone channels. For color TV, the transmission requirements are particularly stringent. For example, transmission through the TOC switching unit at the color subcarrier frequency (about 3.6 mc) should match that at low frequencies within about ±0.01 db. Foreseeing such possibilities as theater TV, three-dimensional TV, and others, the new TOC switching unit has been engineered for ultimate transmission up to 10 mc instead of 4 mc.

Since the initial size of TOC's varies considerably, and rapid growth should be anticipated, the number of inputs and outputs is by no means constant. For this reason, the switching unit is a basic building

* RECORD, *November*, 1955, *page* 415.

block that can be used economically in the smaller TOC's, even though only partially equipped, and singly or with other units in the larger TOC's. The basic unit provides 100 per cent flexibility between 10 inputs and 12 outputs. These units can, when desired, be interconnected to provide 30 inputs and 36 outputs – a total of 1,080 possible paths through a Television Operating Center.

Video switching must be accomplished without

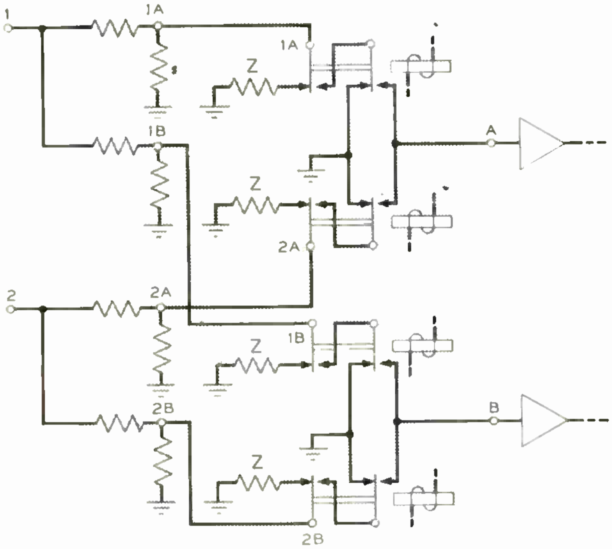


Fig. 1 — Principles of the new switching system can be seen from this 2 x 2 switching arrangement.

the introduction of unwanted impedance irregularities; these cause echoes or "ghosts" in the television picture. In the past, the high-impedance input of an amplifier was bridged across an incoming circuit to accomplish the switch. The effect was the same as if a small capacitance had been placed across the incoming line, causing a small loss and phase shift at the higher video frequencies. Where one input had to feed several outputs, the effect on transmission became more noticeable. On color TV transmission, the effect was intolerable. The new video switch unit solves this problem by "constant-impedance" switching. Each incoming line is terminated by a multiple-output resistance pad, and each output of the pad is connected at all times either to a low-impedance amplifier input or an equal terminating resistance. Each incoming line sees a constant impedance regardless of the number of outputs it is feeding.

A simple version of a switching unit is shown in Figure 1, where each of 2 inputs is split by pads and distributed to 2 outputs by 4 relays. The output leg from each pad is always terminated by the proper impedance, either internally or by an output circuit. Unused relay contacts are grounded to help suppress crosstalk. Although either input can feed either or both outputs, the TOC control circuit prevents any output from being fed by more than one input. Wideband output amplifiers are included to compensate for the pad loss. The transmission circuits actually used are balanced to ground.

Pads such as those in Figure 1 introduce a predetermined amount of loss between an input and an output, depending on the pad resistances. By properly proportioning the values of these resistances, several pads can be connected in parallel, Figure 2, providing a number of outputs from a single input while maintaining constant impedances at the various terminals. However, the pad loss increases with the number of outputs, and must be balanced by the gain of the output amplifiers. In a reasonable compromise with economically feasible gain values, the number of outputs decided on is 12. Figure 3 shows the 1 x 12 splitting pad finally developed. The overall transmission loss between any input and any of the outputs is 27 db while the separation loss between outputs is 54 db. Thus, should any output be momentarily disconnected, the other legs will remain relatively unaffected.

While the amplifier gains limit the number of output legs on a splitting pad, the limiting factor on the number of output relays that can be grouped together is the parasitic capacitance of all the relay

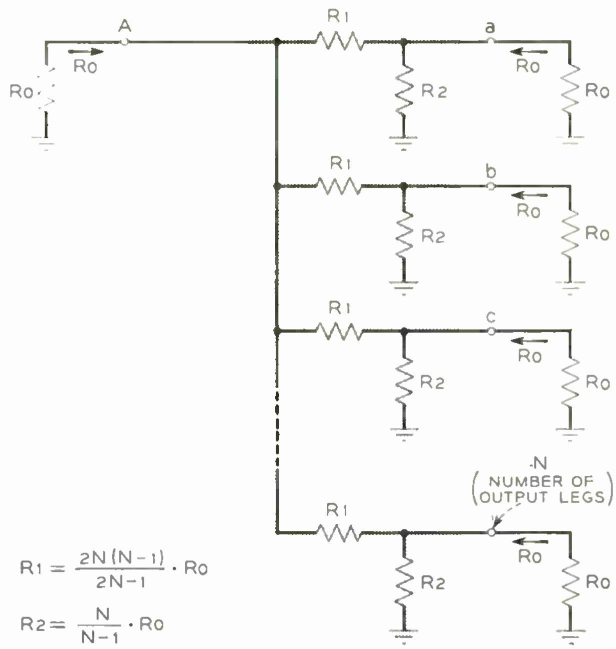


Fig. 2 — The splitting pad isolates each output.

Secretarial Answering Services

R. J. BRAUND *Special Systems Engineering*

For many years, private business concerns have offered telephone answering services to the public, an attendant at a switchboard intercepting calls to absent clients and acting as a secretary for those clients. Ever alert to the various needs of the Bell System, the Laboratories has developed two new switchboards to meet the present-day needs of such concerns, and has adapted line concentration and identification techniques to permit economical coverage of larger areas by such concerns.

Secretarial answering service is a type of business wherein telephone calls are answered by a private agency at some remote point during the absence of a telephone customer from his place of business or home. In large business organizations, telephone calls to absent personnel are usually answered by secretaries, associated employees, PBX attendants or night watchmen. However, many small businesses, professional men such as doctors and lawyers, and others with offices that are manned only part of the time find it advantageous to have incoming telephone calls answered during their absence by telephone answering bureaus.

Today, over 1,500 concerns provide answering service for about 200,000 telephone lines, and this service is increasing at the rate of approximately 30,000 lines per year. These concerns contract to answer calls to a client's line during such periods as he may desire. They take messages, make appointments, quote prices, transmit messages, give out information, and in other ways perform as the client's representative. Many answering-service bureaus operate around-the-clock so that their clients' lines may be covered as much as 24 hours a day, seven days a week, if such coverage is desired. For more than 30 years, the Telephone Companies have been furnishing switchboards and asso-

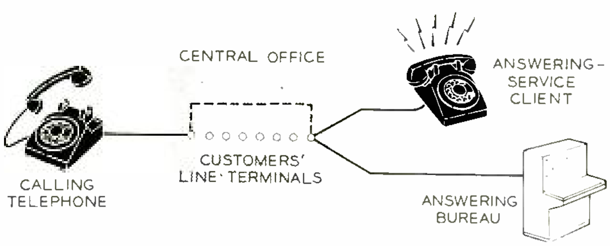


Fig. 1 — Basic plan of telephone answering service.

ciated facilities to permit the answering bureaus to handle large numbers of clients' lines efficiently.

The arrangement is shown in Figure 1. The telephone line of an answering-service client is extended from the central office to the bureau over wires connected in multiple with the wires to the telephone. At the bureau, the line appears in a switchboard at a jack or key, plus a supervisory lamp. The Telephone Company receives rental from the answering bureau for the terminating facilities and from the telephone customer for the wire plant involved in the bridge on his line.

During the early phases of telephone answering service, a variety of switchboard arrangements were used to terminate clients' lines at answering bureaus. The need for standard switchboards to meet the requirements peculiar to this type of service resulted in the development in 1935 of the 554-type PBX's* These switchboards were designed to handle all the switching possibilities within the

Fig. 2 — An answering service attendant demonstrates the use of the new 557B switchboard.

restrictions prescribed by the commercial requirements at that time.

As answering services became more widespread, however, various interested commissions and regulatory bodies established certain additional requirements applicable to answering services in their particular areas. In some areas, a combination of regular PBX and answering services is permitted, whereas in other areas the regulations do not allow the extension of an intercepted call beyond the attendant at the answering bureau. In nearly all instances, however, the regula-

* Record, *February*, 1936, *page* 190.

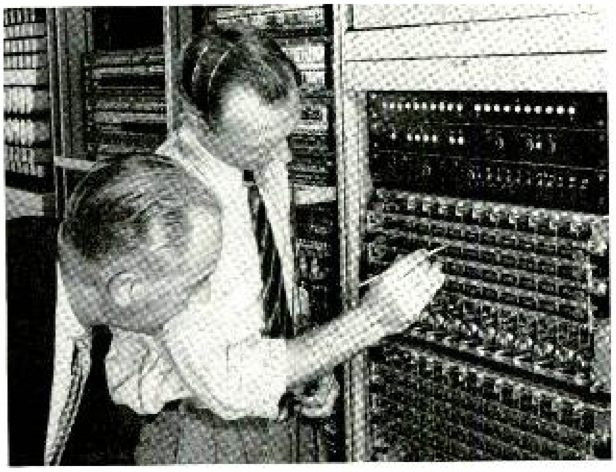


Fig. 3 — The author watches while F. R. Lehman of the New York Telephone Company checks a crossbar switch in the concentrating equipment.

tions demand certain guard features to insure privacy and to prevent unauthorized use of a client's telephone service. As a result of numerous changes in the basic requirements, and in recognition of the continuing growth and popularity of answering services, the development of modern switchboards for this use was stimulated.

Studies indicated that Bell System needs would best be met by the development of two new switchboards for answering-bureau use, one for those areas where combined PBX and answering service operation is permissible and another for areas where tariff restrictions do not permit this combination. Development of the 557A and 557B PBX's has been completed and both of these switchboards are now completed and available for Bell System use.

Each of these PBX's is a manual, single-position switchboard used primarily to answer calls at an answering bureau. The 557A, as installed in a bureau in Chicago, may be seen in the headpiece. It has a maximum capacity of 100 answering-service lines, 40 PBX station lines, 15 central-office and tie trunks and 15 cord pairs. This board uses the self-contained single-circuit cord units presently in use in the 555 switchboard.* The lower portion of the jack panel is arranged for trunks and PBX station lines using individually-mounted or strip-mounted jacks and lamps. The upper portion of the panel is arranged to accommodate five answering-service line units. These units are self-contained and each one serves 20 line circuits.

A privacy feature of the answering-service line circuits prevents the attendant from establishing a

* Record, *April*, 1949, *page* 125.

connection to a client's line except during the ringing interval of an incoming call. During specified periods when a client elects to answer his own calls, a plug of insulating material may be inserted into his jack to open the line lamp circuit. An incoming call on an answering-service line may be extended to an administrative station within the bureau, if this is desired. Connections between administrative stations or between these stations and the trunks may be established with the cord pairs. The trunks and administrative station lines associated with 557A switchboards afford the regular PBX services required by certain bureaus.

The 557B is available for use in areas where regular PBX functions are required to be independent of, and segregated from, the answering-service functions. As in the 557A, this switchboard also provides all necessary safeguards to prevent unauthorized use of clients' lines. Its single-ended cords, however, effectively prevent extending a call on a client's line beyond the bureau attendant. As in the 557A, lines terminating in the 557B PBX will be extensions of the lines normally provided for the telephone customer's regular service.

This switchboard, Figure 2, also has a maximum capacity of 100 lines, but provides for only 5 central-office trunks and 3 cord-ended administrative station lines. The 3 administrative stations are answered with listening keys, and may then be connected to outgoing trunks through cords. Answering-service lines can be answered only with the single cords. A maximum of 8 intercept and dial cord circuits can be used for answering service and for outward dial calls by the attendant.

The 557B employs new individual plug-in cord units with cord reels instead of the usual cord weights. The cord-ended administrative-station lines

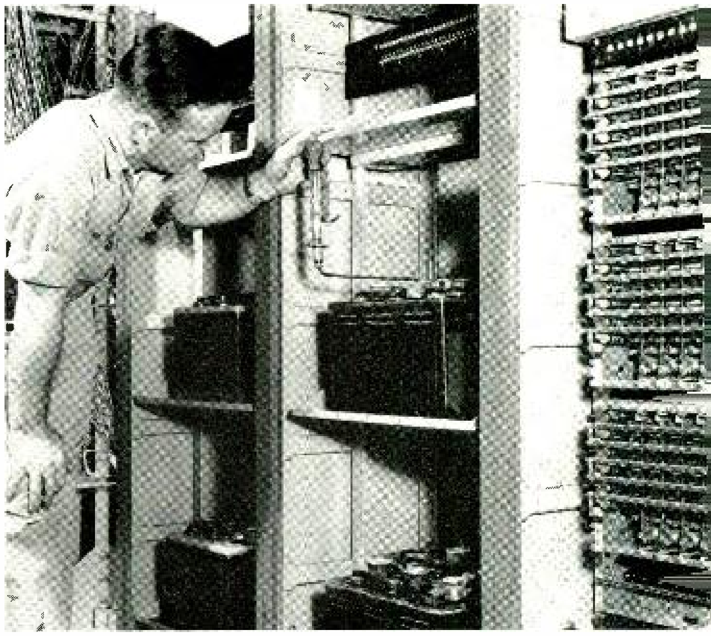


Fig. 4 — J. E. Walsh, New York Telephone Company installer, makes a routine check of the batteries in an answering bureau. Over a dozen identifiers use a common power supply.

also use plug-in units similar to the intercept and dial cord units, except that a combined line and supervisory lamp is included in the assembly. The face equipment of this switchboard consists of conventional strip-mounted jacks and lamp sockets but features a new combination designation strip and lamp cover for the answering-service lines.

Until recently, telephone answering service required an individual pair of wires between the bureau and the central office terminals for each customer's line, Figure 1. With this arrangement, it was generally not economically feasible, in view

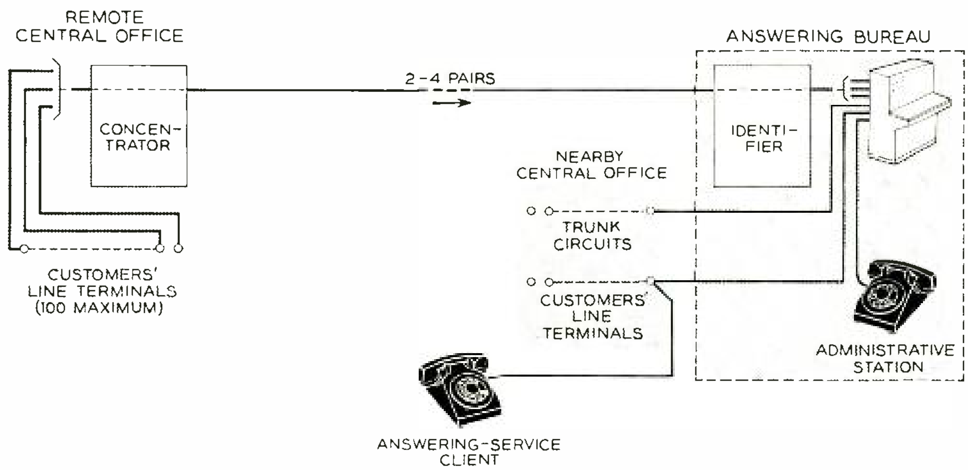


Fig. 5 — Concentrator-identifier arrangements permit a bureau to be located a long distance from a central office.

of the inter-office wire plant costs, for a bureau in one central-office area to serve clients in another central-office area. This required that a concern furnishing answering services provide separate bureaus in each central-office area in which they wished to offer their services. This, in turn, meant costly duplication of office space, equipment and personnel, and restricted the establishment of branch bureaus to only those areas housing sufficient clients to warrant the expenditure.

Line concentration techniques have long been used in Bell System switching systems to effect economies in wire plant, and it was natural to consider similar techniques for answering services. With such arrangements applied to this service, the fundamental needs were to concentrate a large number of customers' lines onto a relatively few pairs of conductors to the answering-service bureau and, by appropriate signals, to identify the individual lines.

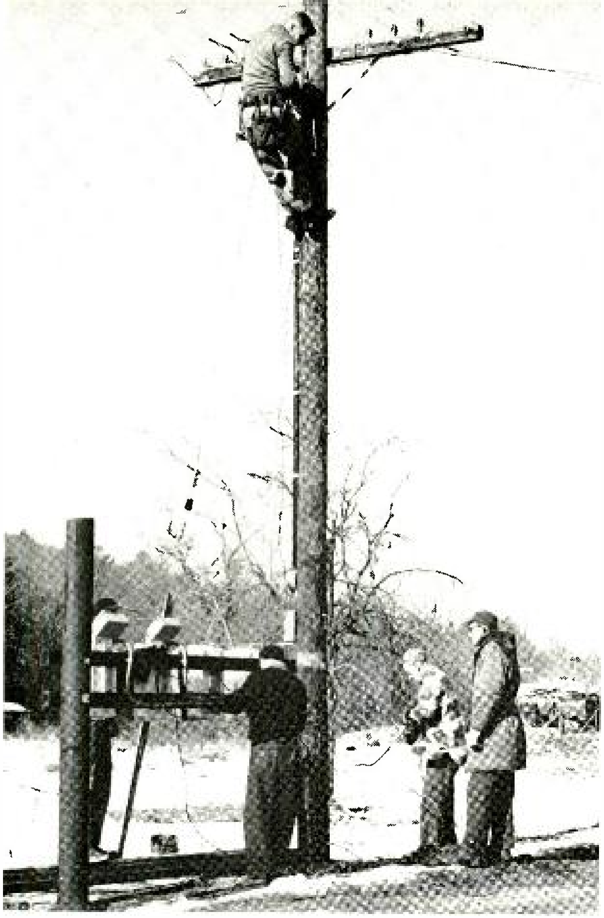
It was found that through the application of concentrator-identifier equipment it was possible to concentrate and identify as many as 100 different answering-service lines over only four pairs of wires between a reasonably remote central office and an answering bureau. This application now makes it possible, by greatly reducing the number of conductors from a distant central office, to realize economies sufficient to permit the centralization of an answering service, and the offering of the bureau's service to areas where heretofore it was financially unattractive. Thus, it is possible for an answering bureau at a central point in a particular city to serve clients who are located in a number of surrounding central-office areas.

As applied to answering services, Figure 5, the concentrator-identifier consists essentially of two units interconnected by a minimum number of trunks. The "concentrator" or originating equipment, located in the central office, concentrates the clients' lines over 2, 3 or 4 trunks (depending on traffic conditions) to the "identifier" or terminating equipment at the answering bureau. The identity of a particular line connected to any trunk at any one time is established by the lighting of a line lamp in the answering bureau 557-type switchboard. Each line has its own lamp and associated jack, arranged in the same manner as if connected directly to the client's line with an individual pair of wires. With this arrangement, both individual lines and concentrated lines can be terminated in the same answering service switchboard.

Laboratories efforts with regard to answering services are continuing with studies of various means to derive greater customer and System benefits through lower costs and improved facilities.

THE AUTHOR

R. J. Braund entered the Bell System with the New York Company in 1924, where he remained until he transferred on loan to A.T.& T. in 1952. In 1954, he joined Bell Telephone Laboratories. His work has included equipment engineering of PBX's and switchboard service engineering. While with A.T.& T., he engaged in studies to determine developmental needs of operating companies and to establish a Laboratories developmental program in the PBX area. Since joining the Laboratories, Mr. Braund has engaged in PBX systems engineering.



In the P1 rural carrier system, each channel, capable of serving eight telephones on a party line, requires one terminal at the central office and another mounted on a pole near the customers' premises. To help make the rural carrier system economically feasible, the Laboratories design of the terminals, as well as other parts of the system, included some of the most modern devices and techniques available. These include transistors, silicon-aluminum varistors, ferrite inductors, plug-in subassemblies and printed wiring on phenol-fiber boards.

R. E. YAEGER

Transmission Systems Development

Terminals for the New Rural Carrier System

When the Type-P1 transistorized rural carrier system was being considered as a new Bell System facility, broad objectives, both economic and technical, were established. Unlike most carrier systems, the new system was intended to operate between a telephone office and small groups of rural customers, instead of between two offices. The system, therefore, had to be capable of handling all standard forms of customer signaling, including 8-party semi-selective and divided-code ringing. Terminals were expected to be placed in all types of offices as well as in remote locations near a group of customers. For ease of maintenance, the remote terminals and their power supplies were to be pole-mounted.

In addition to fulfilling the technical requirements, the P1 carrier system had to be lower in cost than new pole-line construction. It was, in effect, an alternative means of transmission intended to supplant new cable or open-wire lines. Over the years, carrier systems for use on toll and exchange circuits have been improved, miniaturized, and lowered in cost, yet at the time of the development of P1 none of the existing systems was economical enough for use on customer lines. The only way to achieve the economy desired in the new system was to apply the latest devices and techniques.

As a result, the P1 rural carrier system utilizes transistors, silicon-aluminum varistors, ferrite inductors, Mylar and dry tantalum capacitors, and specially-designed miniature voice-frequency and carrier-frequency transformers. The various equipment units consist of apparatus mounted on phenol-fiber boards and connected by printed wiring. These board assemblies are plugged into a special wire grid built into an inner terminal housing, Figure 1, which provides all of the interconnections among the assemblies. The plug-in feature also permits rapid equipment changes for maintenance purposes or for making changes in frequency assignments or signaling conditions.

One system objective was to be able to add carrier channels to a line pair one or two at a time so, as far as terminals are concerned, P1 carrier operates as a single-channel system. As a matter of fact, as many as four channels can be applied to a single pair above a voice-frequency channel. The proper carrier frequencies for each channel are provided by appropriate plug-in boards. Three different arrangements are available for frequency assignments: stacked, grouped, and staggered.

On non-repeatered lines, the stacked arrangement can be used; both directions of transmission for each channel are side by side in the frequency spectrum, Figure 2. Since attenuation is a function of frequency, the lowest-frequency channel is used for the most remote customer and higher frequencies are used for shorter distances. Where repeaters are necessary, frequencies in one direction for all channels are grouped together, with those in the other direction forming another group. This simplifies the filter arrangements in repeaters. The transposition design of open-wire lines constructed for voice transmission only is such that crosstalk at carrier frequencies is too great for adjacent pairs to be fully equipped with P1 channels of the same frequencies. For such lines, another group arrangement is used where the channels are staggered so as to fall between the frequencies of a regular group.

In addition to crosstalk on rural customer lines, noise is frequently induced from adjacent power lines and from lightning. The P1 system reduces the effect of crosstalk and noise through the use of compandors * in the terminals. A compandor is a device consisting of a "compressor" that boosts the level of weak speech at a transmitting terminal and an "expandor" at the receiving terminal that restores the speech levels to their proper relative values. Weak speech is thus boosted during transmission to a level where it can over-ride crosstalk and noise.

* Record, *December*, 1934, *page* 98 and *November*, 1953, *page* 452.

Fig. 1 — Two terminals mounted as in a central office. The line board will be moved from its storage place and plugged into the terminal at the top.

The use of these compandors in the P1 rural carrier system results in crosstalk and noise being effectively reduced by about 25 db.

Regulation is provided in the receiving terminal amplifiers to compensate for changes in line losses caused by changes in weather and temperature. This regulation also compensates for small differences in line lengths not taken care of by span pads used to "build out" short lines to a specified loss.

The office and remote terminals are electrically and mechanically identical except for the signaling circuits and terminal mounting arrangements. A block diagram of a remote terminal is shown in Figure 3. Each block represents a separate functional sub-assembly that can be individually tested in manufacture and can be maintained independently from the rest of the terminal. The function of these sub-assemblies might best be illustrated by tracing

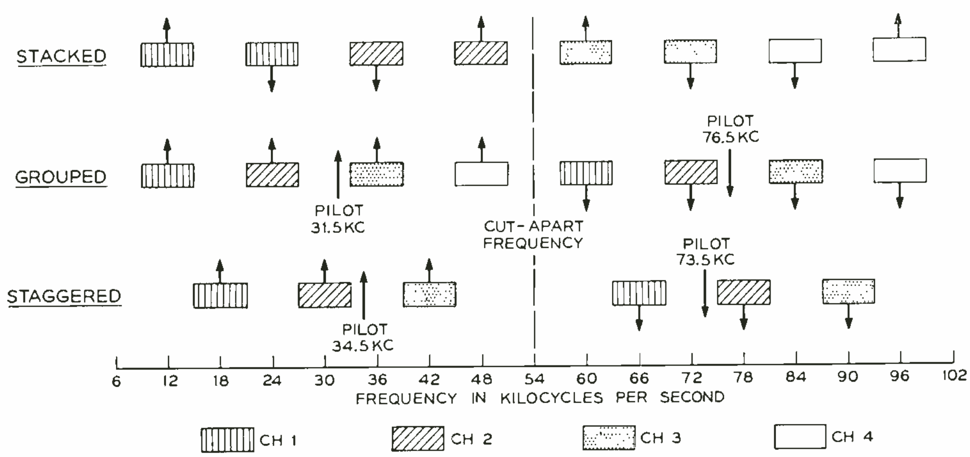


Fig. 2 — Frequency allocations for the rural carrier system.

the path of a voice-frequency signal through a terminal. For the usual voice-frequency circuits, the on-off supervisory and dial-pulse signals from a customer which initiate a connection through the central office are dc, while ringing signals from the office consist of 20-cycle and dc voltages. None of these signals can be transmitted directly over a carrier channel. However, the P1 carrier signaling unit translates these signals to information that can be transmitted over the channel, and this information is translated back at the receiving end to the same form as the original signals, thereby initiating a call between the two carrier terminals.

Consider a customer's speech being transmitted over a drop wire from his subset to the 2-wire voice-frequency input of a remote carrier terminal. It is transmitted first through the 2-wire to 4-wire hybrid circuit, then to the vario-losser of the compressor. The vario-losser consists essentially of a pair of silicon-aluminum alloy diodes that compress the normal volume range of 40 db at the input to about 20 db at the output. The amount of compression is controlled by a dc current that is a function of the syllabic envelope of the compressor output. The voice-frequency output is modulated to carrier frequency by a double-balanced modulator circuit; balancing out both voice and carrier frequencies leaves only the two resulting sidebands of the carrier in the output. A controlled amount of carrier signal is then added to these sidebands in a bridge circuit following the modulator. The sidebands and carrier, at a comparatively low level at this point, are next amplified by a two-stage transistor feedback amplifier and are then applied through a coordinating pad and transmitting band-filter to the line circuit.

The oscillator circuit, which supplies carrier to the modulator and the carrier re-insertion circuit, consists of a crystal-controlled transistor oscillator followed by a single-stage transistor amplifier. The carrier output of this circuit is maintained constant, independent of power supply and temperature variations, by a silicon-aluminum voltage-limiting diode between the oscillator and amplifier stages. A coordinating pad following the transmitting amplifier permits adjusting the terminal output to the proper level for transmission over the line. This level is determined by the carrier frequency and by the distance from the remote terminal to the central office or, when used, the nearest repeater. In this way, the levels of all carriers associated with a particular pole line can be coordinated to minimize crosstalk.

Now, consider that the block diagram of Figure 3 represents the terminal at the central-office end of the line instead of the remote terminal. The receiving filter selects the proper channel and transmits it to the input span pad. Span pads provide a coarse adjustment to increase the loss of a short line to that of the maximum-length line. A regulating amplifier, employing a vario-losser similar to that of the compressor circuit, boosts the received carrier and sidebands to a constant level at its output to compensate for variations at its input due to span length and changes in line loss with temperature and weather. The reference voltage against which the carrier is compared for regulation is maintained constant by another silicon-aluminum voltage-limiting diode.

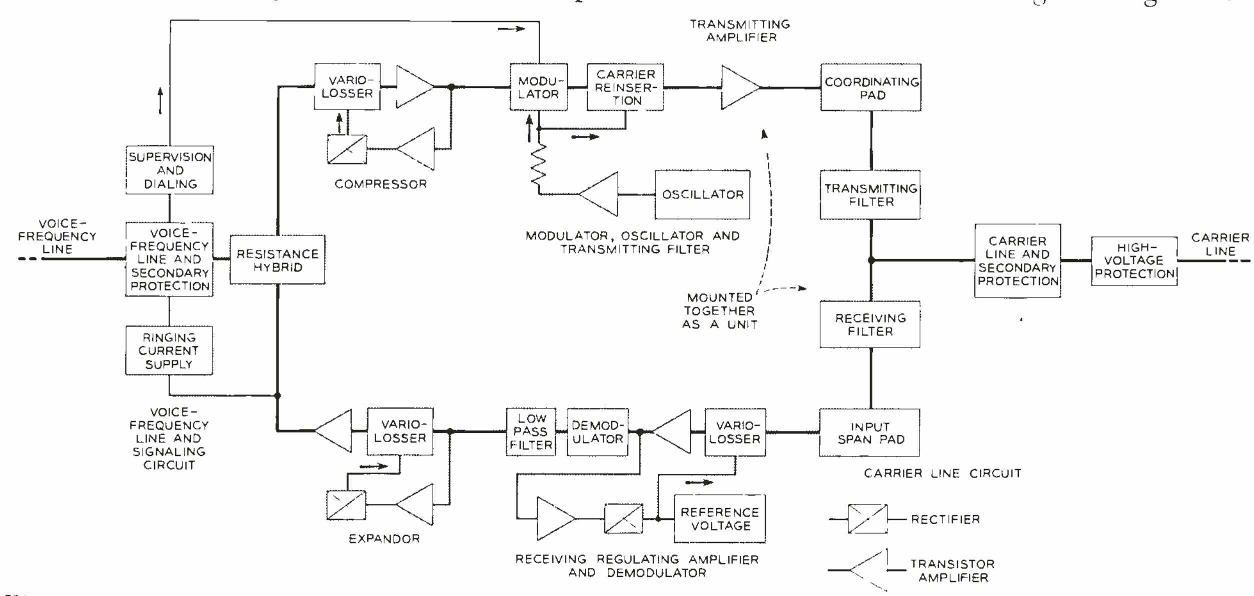


Fig. 3 — Block diagram of a pole-mounted remote terminal for the P1 rural carrier system. The same diagram is applicable to a central-office terminal except for the signaling equipment.

The amplified output is then demodulated in a balanced-bridge varistor circuit and transmitted through a low-pass filter to an expandor. The expandor is complimentary to the compressor; it attenuates weak speech more than strong speech and thereby restores the over-all dynamic range of the voice. At the same time, the signal-to-noise ratio is improved because noise and crosstalk that may have been induced into the carrier-frequency circuits are generally weak and therefore are also attenuated. From the expandor, the speech is passed through the hybrid coil and applied to the 2-wire voice-frequency line in the central office.

Operation at either terminal is essentially identical, hence the use of one block diagram to illustrate both. However, the signaling sub-assembly in a central-office terminal is somewhat different from that in a remote terminal. Supervisory and dialing signals at a remote terminal operate relays to turn the carrier on and off as required for signaling and transmission to the central office. Received ringing signals in the form of voice-frequency tones control a 20-cycle ringing generator and a dc supply to provide proper ringing currents at the desired customer's telephone. At the central office, on-off conditions of the received carrier operate a relay that duplicates the dc conditions existing on the customer's loop at the remote terminal. To ring the remote telephone, three keyer circuits in the central office control tone generators to provide the proper voice-frequency tones over the carrier system.

Normal carbon-block protectors limit lightning and power surges at the termination of a line to between 500 and 1,000 volts. Since these surges are in general higher than transistor circuits can tolerate, a secondary protection circuit is required in both the 2-wire voice and carrier-line connections. It consists of a pair of silicon-aluminum voltage-limiting diodes and a series resistance to further limit surges

Fig. 4 — A Western Electric draftsman uses black tape to lay out a circuit to agree with an engineering model of a printed-circuit board.

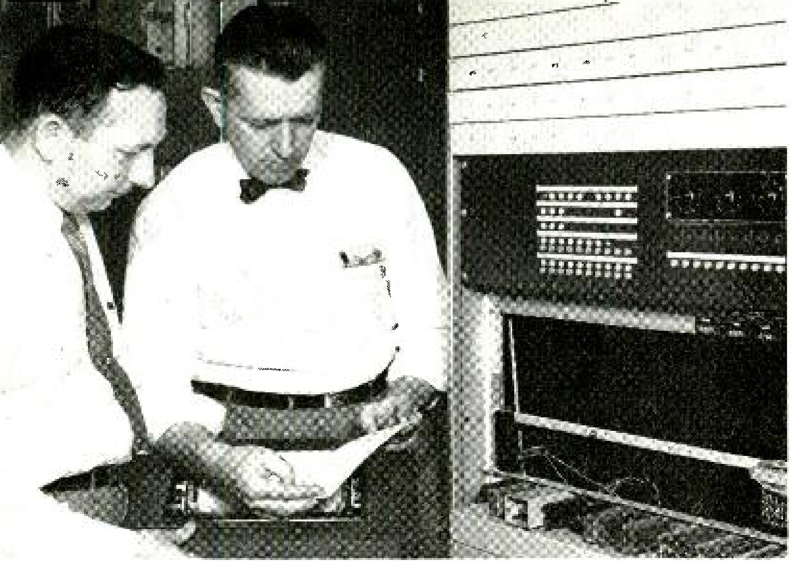
to the order of 50 volts. This also permits the use of low breakdown-voltage components, such as miniature transformers and capacitors.

Measured performance characteristics and field experience with the P1 carrier system, indicate that a voice-frequency circuit derived by this carrier system provides transmission equal to or better than the usual metallic customer circuit. The principal reason is that, even for long distances, the net loss of the carrier system is held to about 4 db while the equivalent physical circuit may result in a loss as high as 15 db. In general, a compandor produces a quieter telephone circuit.

In addition to the transistor, the P1 carrier system employs a number of new types of apparatus recently developed. New equipment design techniques, too, were coordinated with the Western Electric Company's mechanization program. Consequently, close cooperation between the Laboratories and the Western Electric Company has contributed to the successful development of this new system.

THE AUTHOR

R. E. Yaeger received a B.S. degree in 1942 from Worcester Polytechnic Institute, and joined the Laboratories in the same year. In 1944 he was called to active service by the U. S. Naval Reserve and served as a radio-radar officer until 1946. After his return to the Laboratories, Mr. Yaeger was engaged in the design of voice-frequency and carrier equipment, and later worked on the development of program transmission circuits. He joined the transistor development group in 1950, and in 1951 he worked on the early development of the Type-P carrier system. Recently, Mr. Yaeger transferred to the Merrimack Valley Laboratory.



Rapid Line Testing in Crossbar Offices

D. H. MacPHERSON
Switching Systems Development

An important part of the job of providing good telephone service is to make sure that lines running from the central office to customers' telephones are continuously trouble-free. Because the electrical resistance of the insulation on these lines is a good measure of their condition, an automatic insulation-test circuit has been designed and developed. This equipment will test the insulation resistance of all lines in a central office in about one hour to provide effective preventive maintenance and location of line troubles.

Automatic equipment for testing the insulation of customer lines is another "tool" for use by maintenance forces in No. 1 and No. 5 crossbar offices. Particularly during wet weather, when line troubles often increase, this equipment is valuable for directing maintenance forces to those lines that are a potential source of service difficulty or interruptions. In many instances, corrective action can then be taken before any impairment to service occurs.

Troubles can occur in the drop wire leading from the telephone pole to the customer's premises, in pole terminals, in open-wire lines, in pole-mounted cables, and in underground cables. The purpose of these lines, of course, is to provide a good metallic path from the central office to the customer's telephone set. Open circuits, short circuits, crosses, grounds, and excessive resistance must be guarded against to provide efficient telephone service.

The automatic test equipment now available can test more than 10,000 lines per hour. This test equipment consists of three parts: a test circuit, a control circuit and a trouble recorder. The test circuit measures the resistance of the insulation of the telephone lines, and can measure a resistance as high as ten megohms. The control circuit governs the switching of the test circuit to the lines. For trouble recording, No. 5 crossbar offices use either teletypewriter equipment or the regular No. 5 trouble recorder, while No. 1 crossbar offices use only the teletypewriter equipment. The test circuit, which incorporates a magnetic amplifier as the detecting element, has been described in a previous article,* and this discussion concerns the control circuit and the methods of trouble recording.

In a No. 5 crossbar office, customers' lines appear on "line-link" frames, which are a part of the switching equipment involved in a connection through the office between a calling and a called telephone. Associated with these frames are line-link connectors (see Figure 1) that provide a path to a marker – the main controlling element of a No. 5 crossbar telephone switching office. It is through these connectors that the test control circuit gains access to the customers' line equipment. For the purpose of making the tests, the control circuit chooses connectors associated with a particular marker, and then determines whether this marker is idle. If it is idle, it is then made busy to all calls. While performing tests through these marker connectors, however, the control circuit keeps careful watch on all other markers in the office so that normal telephone service will not be degraded. If all the other markers become busy and remain busy for five to eight seconds, the testing action stops, and the made-busy marker is restored to service. After the load of telephone traffic decreases – as

* Record, *October*, 1954, *page* 393.

evidenced by at least one marker being idle for five to eight seconds – the marker is again made busy and testing resumes.

In the telephone central office, the test equipment is started locally by operating a key on the test frame or remotely from a control point. For remote control, the attendant selects a trunk to the test circuit and starts the test by dialing two digits and then operating a ringing key. The first digit selects the level assigned to the test circuit on a step-by-step switch, and the second digit determines the type of test to be made. Depressing the ringing key then begins the testing. One of nine different tests may be selected, depending on the condition of the outside plant. The tests relate to the electrical condition of the two conductors in the line – tip and ring – and consist of three resistance ranges for each of the following types of test: (1) test for a short circuit or low-resistance path between the tip and ring conductors and between the ring conductor and ground, (2) test of resistance between both the tip and ring conductors together and ground, and (3) test for foreign potentials on the conductors. By monitoring the tests, the attendant can determine by an audible tone whether the circuit is progressing satisfactorily or is in an alarm condition. The test equipment can also be started by a program clock set for a particular time of day on selected days of the week.

As indicated in Figure 1, connections between the test circuit and the customers' lines are established via the so-called "no-test" crossbar switches, which are used by operators or maintenance personnel to gain access to a busy line. The line-link frame is held busy to all traffic while lines are being tested, and for this reason the testing time and the number of lines tested on each frame are held to a minimum. The control circuit is arranged to connect not more than five customer lines on each seizure, and on completing the test on the five lines, the control circuit advances to the next higher numbered frame. At the end of a cycle through all the line-link frames in the office, the first frame is re-seized and a different group of five lines is tested. The testing proceeds in this manner, so that all lines in the office are tested without keeping any one frame busy for an excessive length of time.

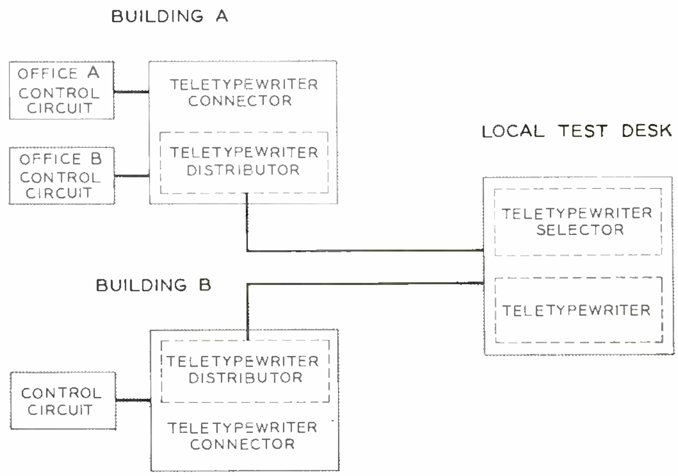


Fig. 2 — One teletypewriter serves a number of connectors in different buildings, and each connector serves a number of different automatic insulation test control circuits.

Upon seizing the line-link frame, the test control circuit simultaneously tests the equipment associated with each line for a busy and a "pass-by" condition. The pass-by condition is employed so that some lines such as dial PBX's, which because of their different electrical arrangements would normally indicate a trouble, may be passed without test. A resistance is connected across the contacts of a relay associated with such lines to indicate this con-

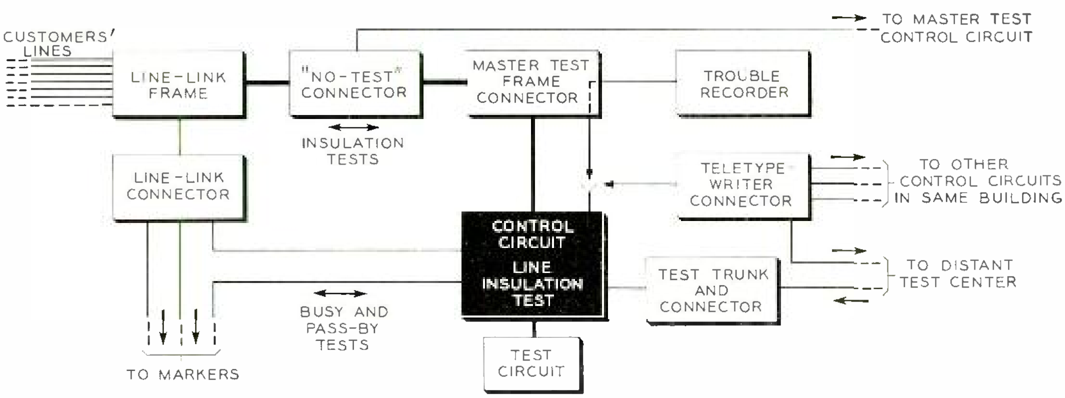


Fig. 1 — No. 5 crossbar line-insulation test-control circuit and circuits associated with it during tests. Customers' lines appear on line-link frame in upper left.

dition. As soon as the busy and pass-by tests are performed, a connection is established through the no-test switches, and the individual insulation-resistance tests are performed on each line. All busy lines are passed without testing, and if the no-test switch is busy, all five lines will be skipped. If a line fails to meet the preset test condition, the results of the test are registered in the control circuit and a retest is made. Since operator-observed lines, and lines that go off-hook while being tested, will cause a false indication of trouble, the test control circuit determines whether either of these conditions exists and in such cases cancels the record.

After completing the second test and registering the results, the control circuit releases the line-link frame and requests a teletypewriter connector so that a record can be made of the line in trouble. As illustrated in Figure 2, one teletypewriter connector is used for all test control circuits in a building. After the control circuit seizes the teletypewriter connector, the connector in turn attempts to seize a teletypewriter in the local test bureau. In this attempt, the connector is in competition with other connectors serving control circuits in other buildings. When the path is established, the connector transmits the type of test made, the result of the test, and the identification of the line. As shown in Figure 3, all of this information is typed out on a single line on a page, so that maintenance men can quickly find the line in trouble and take the necessary corrective steps. Once the trouble has been recorded on the teletypewriter, the control circuit releases the teletypewriter connector, and testing resumes.

It was mentioned earlier that in No. 5 crossbar offices, either teletypewriter equipment or the regular trouble recorder may be used for indicating the trouble information. Since the No. 5 trouble recorder is used by a number of different test control circuits, a method for seizing it in competition with other circuits is provided. Information that would appear on the teletypewriter record is punched on the trouble recorder card, and an indication identifies the card as a line-insuluation record.

In a No. 1 crossbar office, the operation of the control circuit is substantially identical, but there is one exception. No. 1 crossbar switching arrangements are such that a terminating marker connects to four line-link frames instead of the one line-link frame seized in No. 5 crossbar switching. This connection is made through a "line-choice connector",

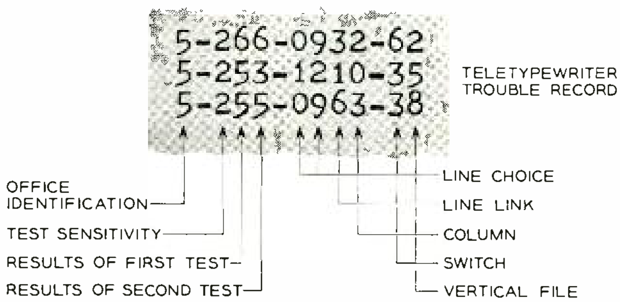


Fig. 3 — Trouble information as it appears on a teletypewriter record. Information enables maintenance personnel to locate line and make repairs.

whose function is analogous to the line-link connector seen in Figure 1. To avoid holding four line-link frames busy for an excessive length of time, the test control circuit in a No. 1 office arranges for test of only five lines on any one of the four line-link frames. After test, the control circuit advances to another group of four line-link frames, and tests are made of five lines on any one of these frames.

Both No. 1 and No. 5 crossbar installations have been using this automatic line-insulation test equipment for many months. The circuits are performing according to design expectations, and are successfully directing the maintenance attention to those lines that are a potential source of trouble.

THE AUTHOR

D. H. MacPherson was graduated from Manhattan College in 1942 with a B.S. in E.E. degree. During 1942-43, he was employed by the Naval Ordnance Laboratories on the development of naval mines, and from 1943 to 1946 was a naval officer engaged in the development of special underwater weapons. Mr. MacPherson joined Bell Telephone Laboratories in 1946 as a member of the Systems Development Department, where he was early concerned with the circuit design of No. A4A and No. 4A toll circuits. Subsequently, he engaged in circuit design work on a number of other projects, including the concentrator-identifier for secretarial service, the line-insulation test control circuit, and trunk circuits for No. 1 and tandem crossbar. At present, Mr. MacPherson is supervisor of a group designing common-control circuits for the Sage System.

A Portable Telephone Set for Military Use

L. J. COBB *Apparatus Development*

A new military telephone set illustrates how civilian developments can be adapted to meet the needs of national defense. After the introduction of the 500-type telephone set into the Bell System, Bell Laboratories modified this basic design to develop a versatile and efficient telephone set for use by the armed forces. Without sacrifice in performance, the set operates under extreme conditions of climate and rough handling.

Most people are familiar with the improvements in the performance and appearance of the customer's telephone brought about by the introduction of the 500-type telephone set into the Bell System. But it is not so widely known that since World War II the Signal Corps' field telephone set has been similarly improved.

Under a development-production contract with the Signal Corps, the Laboratories has developed, and the Indianapolis Plant of the Western Electric Company is now producing, a new field telephone set, the military nomenclature for which is Telephone Set TA-43/PT. As in the case of almost all military equipment, the necessity for the highest degree of reliability, even under the most rigorous and unfavorable service conditions, imposed many difficult problems for its designers to solve.

The new field telephone set, in addition to retaining the sensitivity and excellent transmission performance of the best civilian sets, meets all of the military reliability and ruggedness requirements. The set is ready for instant use even though it might have been submerged in the surf during an amphibious landing operation, delivered by parachute drop, hurriedly tossed into a jeep or truck and transported without protection over miles of roadless, rough terrain, and even dropped on a rock in unloading. It will also withstand without damage, the terrific acoustic blasts from large guns operating nearby. The telephone set will operate satisfactorily under arctic conditions where mercury thermometers freeze and become useless, or in the broiling heat of a desert sun. In addition it is light in weight (9 pounds), convenient to carry and easy to use.

As shown in Figures 1 and 2, all of the component parts of the telephone set, except the handset, are mounted in a two-piece, die-cast, immersion-proof aluminum housing. The electrical terminals, switches, and controls are brought out on a panel, which also provides a mounting for the handset. A hinged and gasketed door on this panel covers the battery compartment. A canvas carrying case, closed with a zipper, encloses the set except for openings for the audible signal (ringer) and the hand-ringing generator. The telephone set may be used in any position. It is suitable for use on a table or desk and can be attached to a wall, tent pole or tree.

The handset, which is also immersion proof, is made of a phenolic molding compound containing rubber. In addition to a transmitter and a receiver

Fig. 1 — The author (left) and W. G. Turnbull with new military field telephone set.

unit, the handset includes a push-to-talk switch, a click-reducing varistor, and a jacketed seven-conductor retractile cord. The handset can be held comfortably and securely with or without arctic gloves. A de-icing membrane protects the transmitter against ice accumulation from breath moisture at sub-freezing temperatures. Ice gathering on the membrane is easily wiped off. The thinned-down receiver end of the handset permits it to be inserted under a battle helmet.

The receiver of the military telephone is essentially the Bell System U1 receiver unit * which forms a part of the 500-type telephone set. However, gaskets have been added in the military unit to make it watertight. The click-reduction varistor has been removed from the back of the receiver unit and located in the transmitter end of the handset. Also, the terminal plate has been modified to reduce the thickness of the unit.

Although the transmitter in the military handset has the general appearance of the T1 unit * used in the 500-type telephone, several important internal differences were required by the severe conditions of military service. The new carbon transmitter unit is designed for efficient and stable operation in both local and common battery circuits. In common battery circuits the transmitter current is supplied over the telephone line from a battery at the switchboard. The magnitude of this current is determined primarily by the resistance of the circuit rather than by that of the transmitter. On the other hand, in local battery circuits the transmitter current is supplied from a battery associated with the telephone set, and since the resistance of the local circuit is usually quite low, the transmitter resistance plays a larger role in controlling the transmitter current.

It is unusual for a telephone transmitter to be designed for interchangeable use in both types of circuits, as was done in this case. Ordinarily, a transmitter for common battery operation is designed with its diaphragm cone directed toward the electrodes, as shown in Figure 3. This is done so that the inward thermal expansion of the diaphragm, which occurs when the current is first turned on, operates to limit the resistance of the transmitter to desirably low values. In this way, excessive voltages across the transmitter which might produce objectionable carbon noise or "burning" are avoided.

For local battery operation, where the battery supply is only three volts or so, burning is seldom a problem. However, to avoid an inward motion of the diaphragm as the current is turned on in local battery circuits (which could result in a very low transmitter resistance and an undesirably high current drain) the diaphragm cone is normally directed away from the electrodes.

The dual operation problem for the new military telephone was solved by designing the transmitter as though it were intended for use only in common battery circuits, and then modifying the design for use in local battery circuits.

Design of the new set was further complicated by the need for the transmitter to operate properly during, or soon after, a large change in ambient tem-

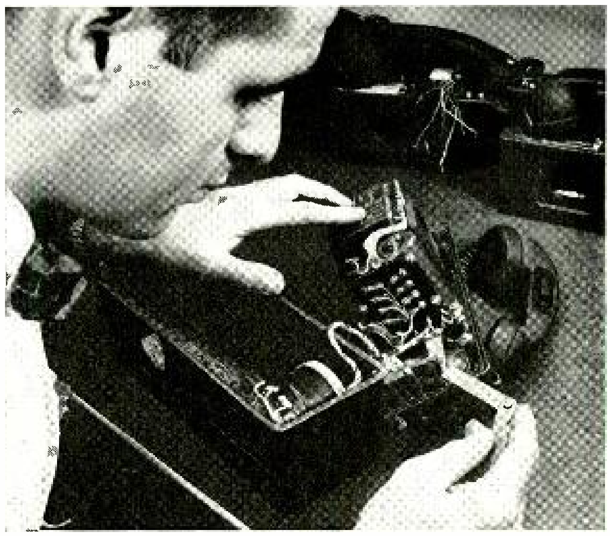


Fig. 2 — R. T. Ferri checks line switch spacing on a Signal Corps military field telephone set.

* RECORD, *August*, 1952, *page* 317.

perature. The magnitude of the problem will be better appreciated if it is realized that thermo-mechanical displacements of the electrodes of the order of the wavelength of light, 0.00002 inch, are often sufficient to produce decidedly undesirable effects. The required degree of thermal stability was achieved by carefully shaping the various transmitter parts, and by the judicious use of brass, Zamak (a zinc-base die-casting alloy), and Nilvar (a nickel-steel alloy having a high degree of dimensional stability with temperature). These three metals differ by about thirty to one in their temperature coefficients of linear expansion. In the military transmitter unit they have been combined in such a way that the dimensional change of one part with temperature is compensated by the change in an associated part, thereby maintaining the desired relative position of the two electrodes.

In addition to aiding in the solution of the thermal stability problem, the use of Nilvar in the diaphragm reduces the possibility of gun-blast damage because of its relatively high strength. Additional strength is obtained by forming long radial ribs in the conical surface of the diaphragm. A fixed stop, located just behind and very close to the diaphragm, is provided for further protection against gun-blast damage.

A push-to-talk switch, which can be operated readily even when the user is wearing arctic gloves, forms a part of the handset. It has two electrically independent sets of contacts, one to close the local battery current circuit to the transmitter, and the other for remote control of a radio set. To reduce fatigue when the switch is held in the operated position for extended periods, the holding force has been made less than the operating force. A boot made of a special rubber compound, suitable for use at low temperatures, seals the switch in the handle and prevents ice or dirt from interfering with its operation. The push-to-talk switch feature of the system is not used when the telephone set is employed in common battery systems.

For maximum flexibility the new telephone set is equipped with a three-position circuit-selector switch. This provides a choice of circuits for three types of service: common battery talking and signaling, local battery talking with hand-ringing generator signaling, and local battery talking with common battery signaling. Two flashlight batteries within the set provide transmission power for the two local battery talking conditions. If no battery supply is available, emergency transmission can be obtained over distances up to about four miles by using the receiver of the handset as a sound powered transmitter.

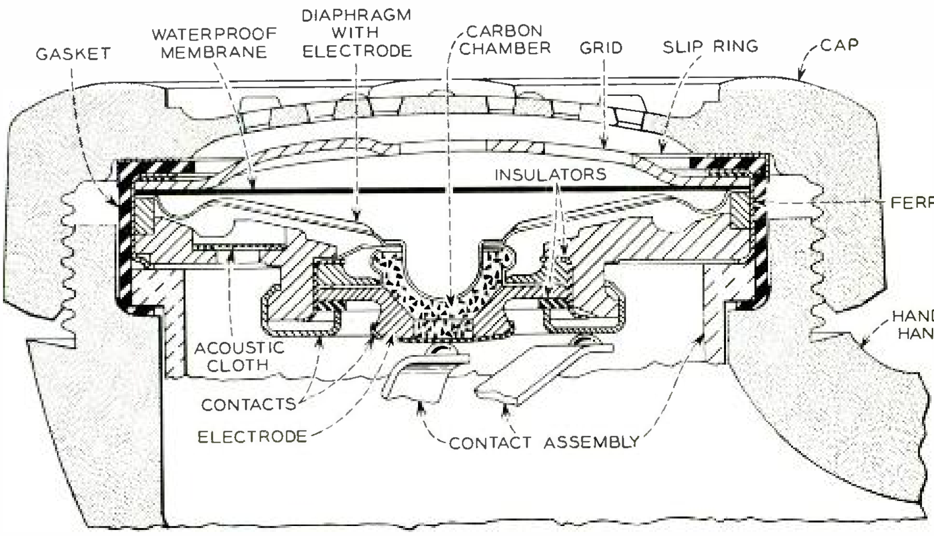


Fig. 3 — Cross-section of military handset transmitter unit.

As in the case of the Bell System 500-type telephone set, equalization in the common battery circuit is provided by two silicon carbide varistors, which decrease in resistance as the voltage across their terminals increases. This non-linear characteristic of the varistors makes the transmitting and receiving performance in common battery circuits less dependent on loop length, reduces crosstalk, and provides protection against high voltage surges. The varistors also limit the transmitter current, thereby reducing transmitter noise and increasing the life of the transmitter. The circuit keeps the sidetone (speaker's voice heard in his receiver) at desirably low levels over the range of loops and trunks that are likely to be encountered in service. The demodulation of radio signals by the non-linear varistors in the new telephone set is reduced to a negligible amount by capacitors shunting the varistors. Also, a small capacitor is bridged across the transmitter unit to prevent it from demodulating radio signals and to bypass radio-frequency transients which otherwise would cause the carbon granules to cohere and impair the efficiency of the transmitter.

The local battery circuit is designed so that current to the transmitter is supplied through a coil shunting the transmitter when the push-to-talk switch in the handset is operated. This coil has a low dc resistance and a high impedance at voice frequencies. In this arrangement, the batteries are not in the voice-frequency output circuit of the transmitter, and thus provide better transmission performance over the useful life of the batteries.

Provision is made in the local battery circuit for push-to-talk operation of remote-control equipment associated with a radio set. This is accomplished by connecting another coil across a portion of the telephone set circuit when the handset push-to-talk switch is depressed. In this way, a dc path for telephone line current is provided from an auxiliary source to operate a relay at the radio set. This relay switches the radio set between transmitting and receiving conditions in synchronism with the operation of the push-to-talk switch. The coil also serves as a holding coil in the local-battery-talking, common-battery-signaling circuit. All of the principal circuit elements – including the induction coil, local-battery feed coil, hold coil, equalizing varistors, capacitors and resistors – are combined in one hermetically sealed unit known as the network.

The audible signal of the new field telephone set is unique, and was developed to meet the need for a signaling device to form a part of a waterproof telephone set. In the new signal, designated by the Signal Corps as a buzzer, the clapper strikes the bottom of a formed cup set into the wall of the telephone set thereby radiating the acoustic energy directly to the outside (see Figure 4). To obtain the best signal, the clapper strikes the bottom of the cup off center. Further, to increase the loudness of the signal, the cup acts as a resonator so proportioned as to reinforce its fundamental frequency of approximately 2,700 cps. With this arrangement, practically all of the sound is concentrated in a 1,000-cycle band centered about the resonant frequency. The clapper of the new signal is actuated by a highly efficient magnetic structure to insure that the signal will operate satisfactorily over telephone lines

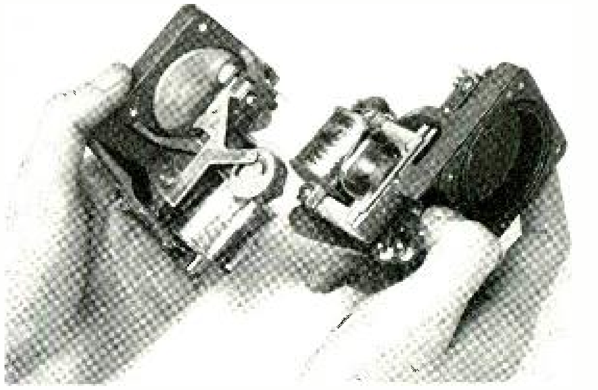


Fig. 4 — Front and back views of audible signaling device for the new waterproof telephone set.

at least as long as those which the improved transmission of the new field set now makes usable.

Because of the character of the sound produced, this signaling device has been dubbed the "woodpecker." Outdoor tests in the presence of background noise show that this type of sound has excellent carrying power and attention-attracting qualities. It is superior to the usual gong signal in the certainty with which it can be heard under marginal conditions and also in that its perception is much less dependent on the listener's high-frequency hearing acuity. Thus, the new signal should be more readily heard by men suffering from battle fatigue than the conventional form of signal.

The loudness of the signal may be adjusted from a gentle buzz to a noise-piercing "woodpecker" tone by controlling the stroke of the clapper with a cam-adjusted stop. The rotatable shaft associated with the cam is brought through a water-tight gland in the panel of the telephone set and terminated in a suitable knob. A friction device built into the volume-adjusting mechanism prevents accidental changes in the setting of the loudness control.

The hand-ringing generator is a newly designed, small yet powerful unit manufactured by Holtzer-Cabot. At a crank speed of 200 revolutions per minute, the generator is capable of delivering 1¾ watts at 20 cycles per second to a matched load. A centrifugally operated transfer-contact switch built into the generator connects the output voltage to the line when the crank is turned at about 140 revolutions per minute or higher. This switch also opens the circuit to the signaling unit in the telephone set to prevent its operation on an outgoing call, and to remove its shunting effect.

As previously stated, the telephone set housing and the handset in which all of the components are mounted are watertight. It is essential, however, that both of them be vented to equalize internal and ambient pressure differences resulting from barometric pressure changes, temperature changes, or transportation or use at high altitudes. Failure to do so could result in improper operation of several of the components or even in permanent damage to the delicate parts of the receiver and transmitter units. Breather valves are used to provide the required pressure equalization. These valves are made of porous ceramic material which is coated with pyrolytic carbon because of its non-wetting properties. When water comes in contact with the carbon treated surface, it does not pass through the porous valve but, because of surface tension, acts as though separated from it by an invisible membrane. The valves will withstand a pressure equivalent to submersion in several feet of water without leakage.

Throughout the design of Telephone Set TA-43/PT, the material most suited for each part was selected by the engineers working on the project. In making these selections, many factors were considered in addition to those dealing solely with the physical characteristics ordinarily required of such a part. Availability in time of war, machinability, long life under conditions conducive to corrosion, light weight, resistance to mechanical damage, long life at both low and high temperatures, immunity to the effects of fungi, and dimensional stability are a few of the many such factors. As the result of these considerations, well over one hundred different metals or metallic alloys, plastic materials, rubber compounds, cements, waxes, papers, paints, and other miscellaneous materials are used in the manufacture of the new field telephone set. In many instances, alternate materials are specified in order to facilitate procurement.

The development of Telephone Set TA-43/PT by the Laboratories and its production by the Western Electric Company soon after the introduction of the 500-type telephone set is another example of the Bell System's ability and willingness to make its technical advances in the field of communications available to our military forces.

THE AUTHOR

Leonard J. Cobb joined Bell Telephone Laboratories in 1922, and received a degree in Electrical Engineering, cum laude, from the Polytechnic Institute of Brooklyn, in 1933. During his early experience at the Laboratories, Mr. Cobb was assigned the job of developing testing procedures for shop inspection of telephone transmitters and receivers, and in this connection he later designed and built specialized measuring facilities for laboratory use. In 1949, he took over additional responsibilities, being placed in charge of a group developing telephone instruments. Mr. Cobb is presently continuing in this work, and in April of 1956 was appointed Apparatus Development Engineer at the Indianapolis Laboratories.

R. A. Heising Receives Founders Award from I.R.E.

Dr. Raymond A. Heising, Laboratories Patent Engineer prior to his retirement in 1953, has been named to receive the Founders Award by the Institute of Radio Engineers.

The award, which is given only on special occasions to an outstanding leader in the radio industry, was granted to Dr. Heising "for his leadership in Institute affairs, for his contributions to the establishment of the permanent I.R.E. Headquarters, and for originating the Professional Group System." Presentation of this award will be made at the annual I.R.E. banquet to be held at the Waldorf-Astoria Hotel, New York, on March 20, 1957 during the Institute's national convention.

Dr. Heising played a major role in the original development of transoceanic and ship-to-shore radio telephone systems for the Bell System and contributed many firsts in this field. He conducted and supervised research work on ultra-short waves, electronics and piezoelectric crystal devices that underlie modern radio.

He is a Fellow and Life Member of the Institute of Radio Engineers and a Fellow of the American Institute of Electrical Engineers and American Physical Society. He received the I.R.E. Morris Liebmann Memorial Prize in 1921, and the Modern Pioneer Award from the National Association of Manufacturers in 1940.

New "Watchcase" Terminal for Urban and Rural Wire

Two new types of exchange facilities, rural wire and urban wire, have been introduced into the Bell System plant during the past three years. Both structures consist of twisted pairs of plastic-insulated copper conductors (6 color-coded pairs for rural wire and 16 color-coded pairs for urban wire) wrapped around an insulated steel support wire. The line wires are not enclosed in a common sheath, as is the case with conventional cable, but depend entirely upon the weather-resistant characteristics of their individual insulations for protection from the elements.

Rural wire* is designed for distribution in sparsely-settled areas where the line may be several miles in length. Urban wire is intended for use in more densely-populated areas, along property lines or streets, in lengths usually not exceeding 1,000 feet. The chief advantages of both types of wire are low material and construction costs. The fact that the conductors are not enclosed in a sheath permits ready access to each pair anywhere along its installed length, greatly simplifying the terminating procedures and equipment required. It is now possible for the first time to arrange for customer's drop-wire connections to a distribution facility without planning for and installing multipair terminals, and without the necessity for complex pair multipling.

This is accomplished by means of a new type of terminal that mounts directly on the urban or rural

*Record, *May*, 1954, *page* 167.

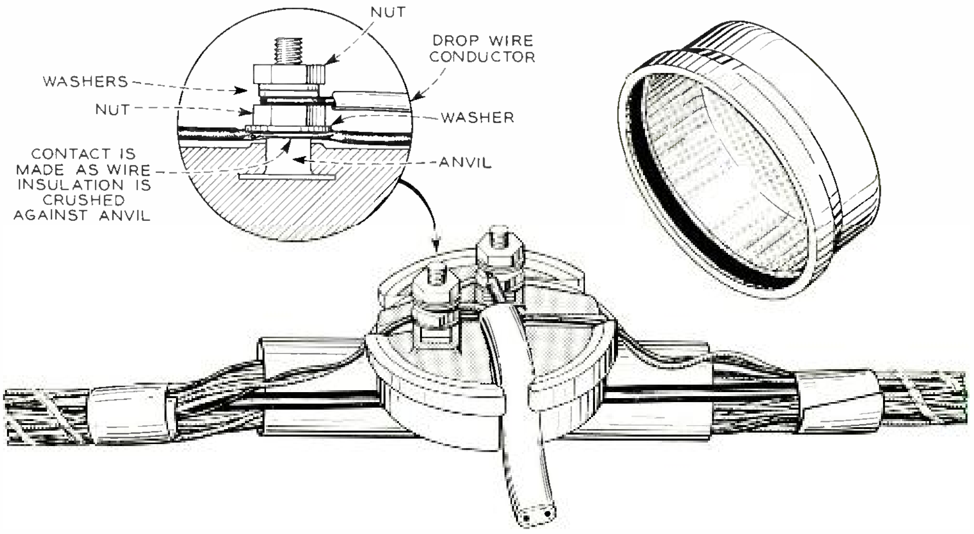


Fig. 1 — Diagram of the new "watchcase" terminal.

wire supporting member. This terminal, known as the "watchcase" terminal, consists of a molded phenolic block and a neoprene snap-on cover, Figure 1. The block is equipped with two binding posts on its face for attachment of line and drop wires, and a mounting clamp in back.

To install the terminal on urban wire, the pair of conductors to be terminated is selected and separated from the group. The insulated conductors are placed tangentially alongside the binding posts and under the lowest washers; no cutting, skinning, or piecing-out of conductors is required. The steel support wire is simply skinned and the block is clamped on. Then electrical contact is established by tightening the lower binding-post nuts with a standard wrench, and the conductors are tucked into the small grooves provided in the face of the molded block. The drop wire is attached under the upper binding-post nuts and, after edgewise insertion through a keyhole slot, rotated 90° into a locked position. A second drop wire may be accommodated by removing a small knock-out portion of the slot with pliers. Finally, the cover is snapped on, providing a weatherproof assembly, Figure 2.

The attachment of urban-wire conductors without first removing the insulation is important for several reasons. These conductors are No. 24 AWG (0.020-inch diameter) soft copper, insulated with polyvinyl chloride. Skinning such fine-gauge conductors under many kinds of working conditions presents considerable chance for wire breakage. In addition, the force exerted in clamping the bared portion in a screw-type binding post, if not applied carefully, may deform the wire to the point where it might break.

A novel type of binding post consisting of a threaded stud with a flat, narrow anvil base, a washer and a nut is employed to attain an electrical connection with the insulated urban-wire conductors. This design is based upon several considerations: while toothed or serrated members designed to pierce insulation may seriously damage or even sever fine-gauge conductors, plastic insulation may be safely split and displaced by proper compression of the insulated conductor between two flat surfaces. The size of the contact area between the conductor and the pressing surfaces must be kept between such limits that the pressure developed by tightening the binding post nut with standard tools will suffice to establish intimate metal-to-metal contact without damaging the wire. This objective is achieved by giving the anvil a suitable width and shape. In addition, the stresses set up in the crushed portion of the insulation increase with applied pressure and thus protect the wire from excessive deformation.

The terminal may be installed on rural wire in the same manner, except that it is necessary to remove a suitable length of insulation from each conductor to be terminated. These conductors are No. 19 AWG (0.036-inch diameter) soft copper, covered with an inner insulating jacket of polyethylene, and an outer abrasion-resistant jacket of polyvinyl chloride. The insulation-crushing feature of the terminal is not adequate to pierce this double jacket; however, skinning and clamping such heavy-gauge conductors presents little difficulty or danger of damage and the "watchcase" terminal is used on both urban and rural wire. Exploratory work is now in progress to adapt the insulation-crushing feature for more general use on all types of plastic-insulated wire.

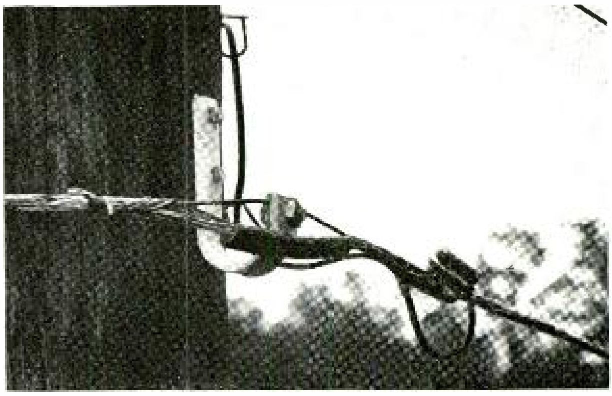
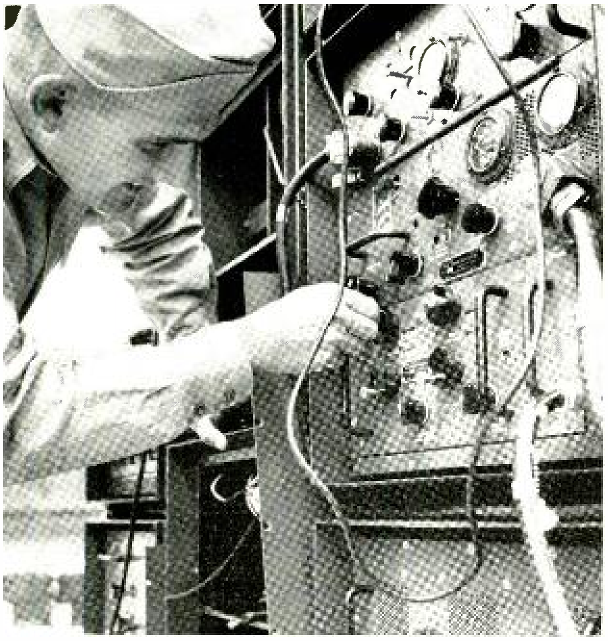


Fig. 2 — An installed terminal with drop wire.

Installation of a "watchcase" terminal takes about five minutes. From one to six terminals may be installed at a pole. Three terminals may be mounted on either side of the pole. Even in this instance the outer terminal is easily reached from the working position on the pole.

H. E. Pawel
Outside Plant Development



AN/TRC-24 Transmitter— RF Power Stages

E. L. LeBRIGHT and P. J. BEARER
Military Communication Development

Operation of the new AN/TRC-24 military radio transmitter, with its many channels over a wide radio-frequency range, required a continuously variable tuning system. In the RF power stages, a number of challenging mechanical and performance problems were encountered in achieving the necessary tuning range with good output power. The design of this transmitter uses only two compact plug-in units for RF power amplification over a band that extends from 100 to 400 megacycles per second.

Transmitter power-amplifier stages were developed to provide radio-frequency carrier power for Radio Set AN/TRC-24.* This is a radio-relay set used by the armed services for multi-channel telephone communication circuits. To meet Signal Corps requirements, the power amplifier stages were designed to be easily tuned, rugged, light in weight and capable of withstanding extremes of climatic conditions.

Two plug-in RF power units cover the frequency band in two steps from 100 to 225 mc and from 225 to 400 mc, respectively, with a carrier power output of 50 to 120 watts. These units follow the "exciter" unit,† which supplies the basic frequency-modulated RF carrier. The lower frequency unit is a single-stage electron-tube amplifier; the other unit, in addition to an amplifier stage, employs a frequency doubler to provide the higher 225- to 400-mc frequencies. These units are extremely compact and were designed to fit into a space only 11 inches wide by 6½ inches high by 13½ inches deep. The units are interchangeable, and all controls are mounted on the front panel. The various power and mechanical connections are held to close tolerances to insure satisfactory engagement.

In first considering the design for the plug-in amplifier stages, it was necessary to select mechanically rugged electron tubes that were adaptable either to coaxial circuits or to those consisting of more conventional components – the so-called "lumped" circuits. Also, for very high frequency operation, the tube should have low input and output capacitances, and a high power output should be obtainable with a low driving power. Fortunately, a tetrode electron tube (4X150A) used in a previous step and its coaxial version (4X150G), were found to fulfill most of these requirements and were chosen. Forced air cooling was necessary to remove the heat dissipated in these tubes.

Electrically, the 100- to 225-mc band is an awk-

* Record, *August*, 1955, *page* 290; *October*, 1955, *page* 382; *November*, 1955, *page* 428; *December*, 1955, *page* 466; *January*, 1956, *page* 21; *February*, 1956, *page* 70.
† Record, *July*, 1956, *page* 272.

ward range, since in this region it is often necessary to change from lumped circuits to coaxial-cavity types. Instead of the usual coil-like inductors, this type of circuit incorporates a coaxial cavity, which consists of a cylindrical outer shell with a concentric inner conductor. A plunger short circuits the inner to the outer conductor and is driven along the longitudinal axis of the cylinder to vary the length of the cavity. Varying the length tunes the cavity to the desired resonant frequency. In addition to their low loss and good shielding, these coaxial cavities provide the required tuning range in a practical physical size.

The electrical design of the 100- to 225-mc amplifier stage was the responsibility of W. C. Hunter, now with the Sandia Corporation. This unit can be seen in cutaway form in Figure 1, and in simplified schematic form in Figure 4. The variable tuning elements for the grid (or input) and plate (or output) circuits are the two coaxial cavities. Both cavities are physically close to the high-frequency power tetrode (4X150A), and are placed parallel to each other and perpendicular to the tube. The inductive lead-lengths from the cavities to the tube elements are thus very short, which permits tuning to the higher frequencies of the 100- to 225-mc band. A variable capacitor is also incorporated to reduce the length of the cavity required for tuning to the low frequency end of the band. This capacitor can be seen near the tube end of the grid cavity in Figure 1; it is actuated by a cam, which is driven by the short circuiting plunger.

Each cavity is formed by a three-inch diameter cylinder concentric with a one-half inch diameter center rod. The short circuiting plunger forms one end of the cavity and the electron tube elements are attached to the other end, together with the variable capacitors mentioned above. As seen in Figure 1, each plunger is driven by two threaded rods which are turned in synchronism by a stainless steel chain connected to a control knob. An adjustable idler sprocket reduces chain slack and the resulting backlash. The contacting fingers on the plungers are formed from beryllium-copper material and are silver plated after micropolishing. The contact force is about 40 grams, which is sufficient to provide good self-cleaning action without excessive galling of the mating parts during life expectance. The finger deflection was designed for 45 mils maximum movement to allow for clearances and eccentricities of the coaxial cavity. This provides flexible contact fingers that are not too delicate for bench handling.

To avoid applying tube operating voltages to the cavities (which would require insulating them from ground), the cavities are electrically coupled to the tube elements through capacitors. The plate capacitors were specially constructed of flat sheets of silvered mica concentrically clamped. This type of

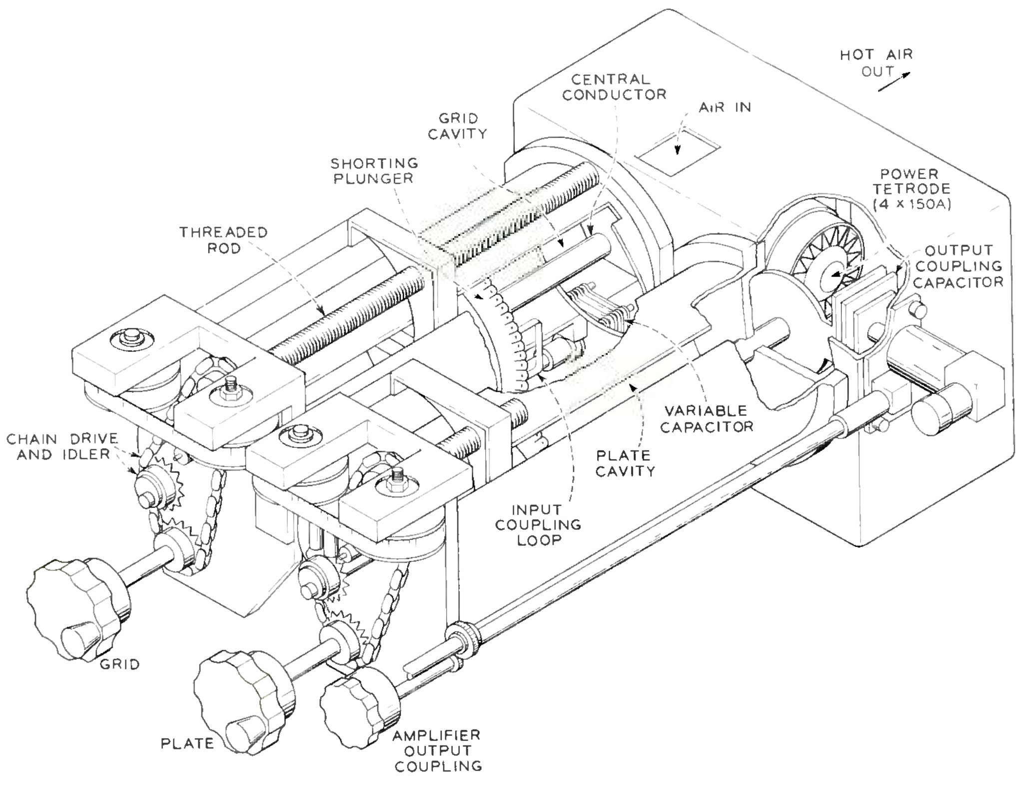


Fig. 1 — Cutaway drawing of the 100- to 225-mc tuning unit, showing positions of coaxial cavities, power tube, and other components.

construction allows the capacitors to withstand wide temperature ranges, because the effect of the different linear expansions in mica and metal is reduced. Furthermore, it provided a low-loss capacitor with very low inductance connections.

The driving power for this stage is provided by the exciter unit, which is electrically coupled to the grid cavity by an input coupling loop. This loop can be seen near the shorting fingers in Figure 1. It consists of a small, one-turn "hairpin" mounted on the shorting plunger. The output power from the plate cavity is coupled into the antenna by means of the output coupling capacitor. With a tube plate voltage of 900 volts and a high dc grid bias (class C operation), the amplifier supplies about 85 watts output of RF carrier at a plate efficiency of 60 per cent. Its total weight is about 15 pounds.

The plug-in power unit for the 225- to 400-mc range differs from the 100- to 225-mc unit in that it is first necessary to double the driving frequency before producing the desired power output. This required two electron tube stages – one as a frequency multiplier and the second as a power amplifier. Each stage contains two coaxial cavities. To fit the four cavities into the limited space, it was necessary to use a "folded back" construction, which can be described with the aid of Figure 2. This is a cutaway drawing of the multiplier section only; however, the principles of construction are the same for the power amplifier half of the circuit. In this design, the four-inch (outside) diameter output circuit is constructed around the input circuit in a concentric manner; that is, the smaller input cavity is contained within the two-inch diameter central conductor of the larger output cavity. This arrangement results in a compact and neat package (see Figure 3, left) with easy access to the electron tubes at the rear end for replacement and for air cooling.

As in the previous unit, the cavity-shorting plungers are driven by threaded rods operated by means of a stainless steel chain. To fit into the space allowed, the multiplier input cavity was reduced in physical length by including a variable capacitor, which operates in conjunction with the shorting plunger. The construction of this stage is shown in more detail by Figure 3, center and right. The 4X150A tube is used in the multiplier stage, and its coaxial tube equivalent, the 4X150G, is used in the power amplifier stage because of the higher input frequency. All major by-passing and feed-through capacitors were constructed of silvered mica sheets and were used to remove dc voltages from the cavities. As in the lower frequency unit, the exciter unit was electrically coupled to the input cavity by a single-turn hairpin loop, mounted on the shorting plunger of the inner cavity. The output of the multi-

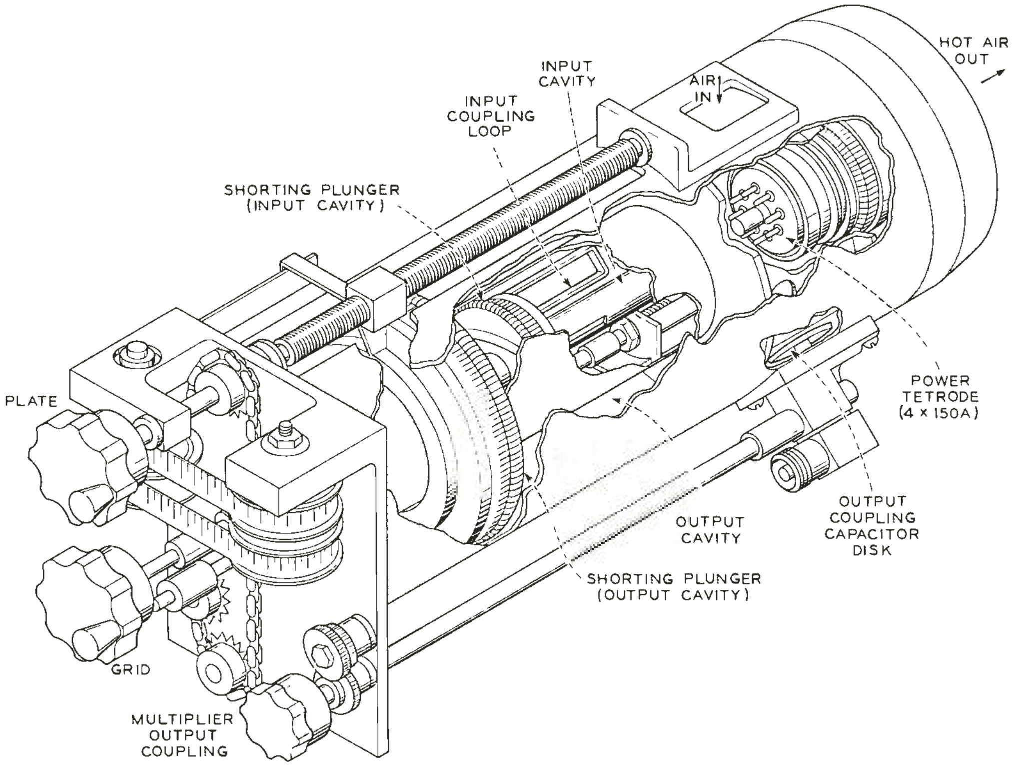
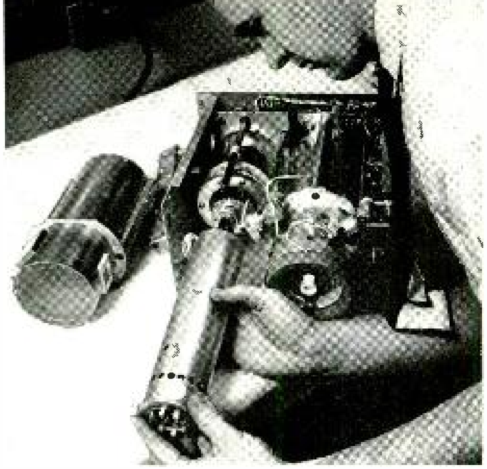
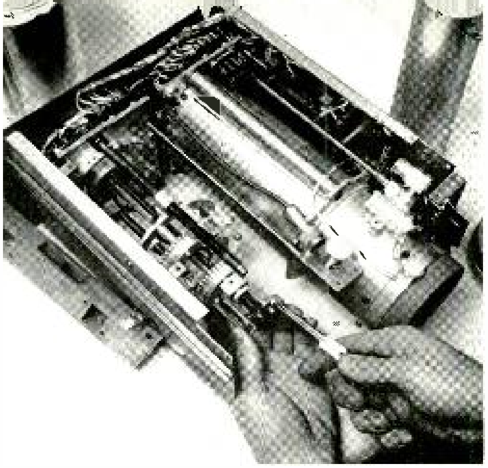


Fig. 2 — Cutaway view of the multiplier half of the 225- to 400-mc tuning unit, showing "folded back" arrangement of coaxial cavities.





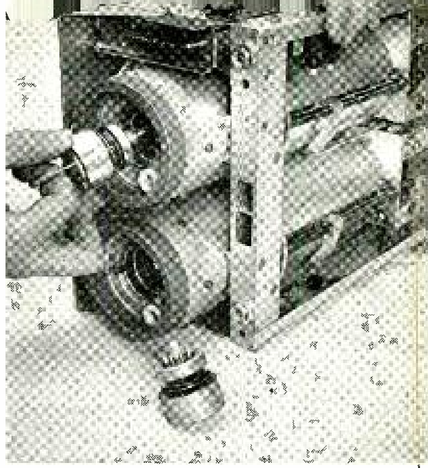


Fig. 3 — Left, H. R. Beurrier inserting inner sleeve of "folded back" cavity arrangement in multiplier of the 225- to 400-mc unit. Center, connecting variable capacitor of input cavity in multiplier stage of 225- to 400-mc unit. Right, rear of 225- to 400-mc unit. Power tube is being removed from socket surrounded by rubber seal of the forced-air cooling system. The RF power stage contains four coaxial cavities and weighs twenty-three pounds.

plier is electrically coupled to drive the power amplifier by means of the small disc seen in the lower right part of Figure 2. This disc acts as a capacitor and is arranged to move radially from near the inner conductor to the outer conductor of the plate cavity. A knob on the front panel controls this coupling by acting through reduction gearing and through a small rack and pinion arrangement that translates rotary to linear motion.

In the complete multiplier-amplifier circuit, the multiplier supplies about 20 watts of output power at the doubled frequency. The power amplifier, operating under high grid bias (Class C condition) and with a plate efficiency of 66 per cent, raises the output power to about 100 watts. The amplifier power gain is low because of the amplitude-limiting or saturation condition desired in order to maintain a relatively constant output with input drive variations. The weight of this tuning head is about twenty-three pounds.

As used in these circuits, each tetrode power tube dissipates about 85-100 watts of heat, which required considerable design effort for cooling. For the 4X150A tetrode tube it was found that best cooling could be accomplished by directing the air flow around the tube base and through the plate radiator. This required baffles and channeling, and the resultant increase of back pressure necessitated an air source in the transmitter capable of providing pressures equal to about 6 inches of water at a delivery rate of about 40 cu. ft. per minute. To cool the coaxial 4X150G tetrode tube, an additional jet air stream was directed at the cathode heater terminal.

Guide rails on the sides of these plug-in units mate with corresponding rails on the transmitter frame. As the head is inserted in place, guide pins on the frame engage the rear of the plug-in units to ensure proper mating of the coaxial jacks and air connections. The dc power plug also contains self-alignment features. Silicone rubber seals are used against the intake and exhaust ducts of the air system and are held under a slight pressure when the head is locked in place by half-turn panel locks. After insertion, the guide pins at the rear, the guide rails, and the front panel locks serve to restrain movement in any direction.

In designing equipment for military service, many

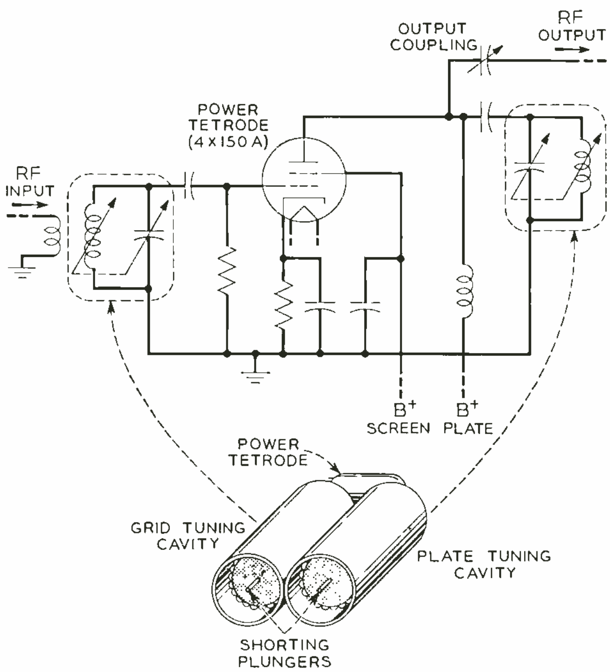


Fig. 4 — Simplified circuit schematic of the "B"-band 100- to 225-mc unit.

of the techniques are the same as those used in the design of Bell System equipment, but as we have seen, there are usually some additional and quite interesting electrical and mechanical problems. These two units were designed to meet stringent mechanical and electrical requirements, so that the radio set is easily transported and operated to supply reliable telephone service under all field conditions.

THE AUTHORS

E. L. LeBright joined Bell Telephone Laboratories in 1925, and later completed studies at the Pratt Institute in Mechanical Design in 1931 and in Electrical Engineering in 1940. For a time he was concerned with the development of radio communication equipment for aircraft and ground use, and in 1943 became a member of the Manufacturing Relations Department. In this group, he worked as a liaison representative on air-to-air and air-to-ground military radio equipment, and during this period was also for a time at the North Carolina location, where he was engaged in manufacturing relations in connection with a mobile telephone system. Mr. LeBright was later concerned with a radar project, and since 1949 has been engaged in development work on short- and long-haul microwave equipment, on Radio Set AN/TRC-24, and more recently on other special military communication systems.

P. J. Bearer received the B.S. degree in Electrical Engineering from the University of Pittsburgh in 1939, and was an instructor in electrical engineering at the same university during 1940-41. In 1950, he received his M.S. in E.E. from Stevens Institute of Technology. From 1941 to 1945, he served in the Navy, with the Research and Development Division of the Bureau of Ordnance, where he engaged in work on underwater weapons. Mr. Bearer joined the Laboratories in 1945, where he was first concerned with a radar project, and in 1947 transferred to the mobile radio group, where he worked on the reduction of intermodulation products of the RTE-540 land station transmitters. Later, Mr. Bearer participated in the development of the Radio Set AN/TRC-24 equipment, and in 1955 transferred to the Military Communication Systems Engineering Department, where he is presently engaged in studies of military communications systems.

Contents of the September B.S.T.J.

The September, 1956, issue of The Bell System Technical Journal contains the following articles:

Electronics in Telephone Switching Systems by A. E. Joel.

Combined Measurement of Field Effect, Surface Photo-Voltage and Photo-Conductivity by W. H. Brattain and C. G. B. Garrett.

Distribution and Cross-Sections of Fast States on Germanium Surfaces by C. G. B. Garrett and W. H. Brattain.

Transistorized Binary Pulse Regenerator by L. R. Wrathall.

Transistor Pulse Regenerative Amplifiers by F. H. Tendick, Jr.

Observed 5–6 mm Attenuation for the Circular Electric Wave in Small and Medium-Sized Pipes by A. P. King.

Automatic Testing in Telephone Manufacture by D. T. Robb.

Automatic Manufacturing Testing of Relay Switching Circuits by L. D. Hansen.

Automatic Machine for Testing Capacitors and Resistance-Capacitance Networks by C. C. Cole and H. R. Shillington.

A 60-Foot Diameter Parabolic Antenna for Propagation Studies by A. B. Crawford, H. T. Friis and W. C. Jakes, Jr.

The Use of an Interference Microscope for Measurement of Extremely Thin Surface Layers by W. L. Bond and F. M. Smits.

The several hundreds of thousands of miles of paper insulated exchange cable, nerves of the Bell System telephone network, can now be air-conditioned. Methods have been developed by the Laboratories to supply dry air to these cables and so ward off the detrimental effects of moisture within the cable sheath. This advantage of gas-filled cable, long used for toll service, can bring still better service to telephone customers.

J. M. JACKSON *Outside Plant Development*

Dry-Air Pressure System for Exchange Cable

Throughout the Bell System today, more than 25,000 tons of paper are being maintained in a nearly moisture-free atmosphere by the continuous supply of some type of dry gas to telephone cables. This paper is in the form of conductor insulation in approximately 72,000 miles of pressurized telephone toll cables, enough to extend almost three times around the earth at the equator.

Since individual cable conductors are usually insulated from each other with a paper covering, moisture inside the cable sheath seriously decreases the insulating properties of the paper and will ultimately result in circuit difficulties. To prevent or minimize the effect of moisture entering the cable through breaks in the sheath, toll cables have been maintained under gas pressure, usually dry nitrogen, for almost three decades.

Two methods are used to supply this gas. In the first, called the "continuous feed" tank system, a reservoir of gas constantly supplies the cables. An alarm is used to notify local maintenance personnel when the gas in the reservoir has dropped to about 10 per cent of capacity. In this way, the tanks can be replaced well before the supply of gas is exhausted. The continuous feed method is used where cable systems are known to consume comparatively large amounts of gas as a result of leakage, which is usually due to small breaks in the cable sheath.

The second method, used in supplying relatively gas-tight toll cable systems, is called the "periodic charge" method. In this system, cables are charged to the desired pressure, and the source of gas removed. Gas pressure may be maintained in this way for as long as several months before recharging is required it becomes necessary to recharge the cables.

The excellent maintenance and service record established by gas-filled toll cable over the years has stimulated a growing interest in techniques for pressurizing exchange cable systems. Such systems, however, do not lend themselves to pressurization as readily as do toll cable systems. There are many reasons for this. Among the most important of these are the gas leakage usually associated with the older types of distribution terminals, and the resistance to gas flow presented by the many branch cables with small diameters, which usually exist in the exchange plant. In addition, the sheaths of distribution cables must be opened frequently to rearrange customer circuits. This would result in high gas loss and would make it necessary to recharge the cable frequently if it were maintained under the "periodic charge" system, or to replace the reservoir tanks frequently under the "continuous feed" system. Field cost studies have shown that it is not economically feasible to supply cables from a tank reservoir system where the gas consumption is greater than approximately 50 cubic feet per day.

Because of the inherent differences between toll and exchange cable systems, new methods, techniques and apparatus had to be developed to provide for pressurizing exchange cable plant. * To make this economically feasible, methods were sought to supply dry air rather than nitrogen to exchange cables. A compressor-dehydrator system, which is equally suitable for pressurizing toll and trunk cables, was developed at Bell Telephone Laboratories to fulfill this need.

Essentially, this apparatus, shown in Figures 1 and 3, consists of an air compressor, two drying towers filled with a desiccant, an electrically operated timer for switching the air supply from one tower to the other, and the valves, piping and alarms necessary to ensure a continuous delivery of dried air under controlled pressure. In operation, this apparatus compresses and delivers air at a pressure of 150 pounds per square inch to a storage tank. Any water released by this air during compression accumulates in the tank and is expelled periodically through a manually operated drain valve. The air required by the cable system passes from the storage tank through a regulator where the pressure is reduced to 30 pounds per square inch and from there to one of the two drying towers where the water vapor present in the air is adsorbed by the dessicant. From the drying tower, the air with a relative humidity not higher than three per cent is delivered to the cables through a regulator which reduces the pressure to the desired value of from seven to ten pounds per square inch.

* Record, *September*, 1952, *page* 359 and *July*, 1954, *page* 257.

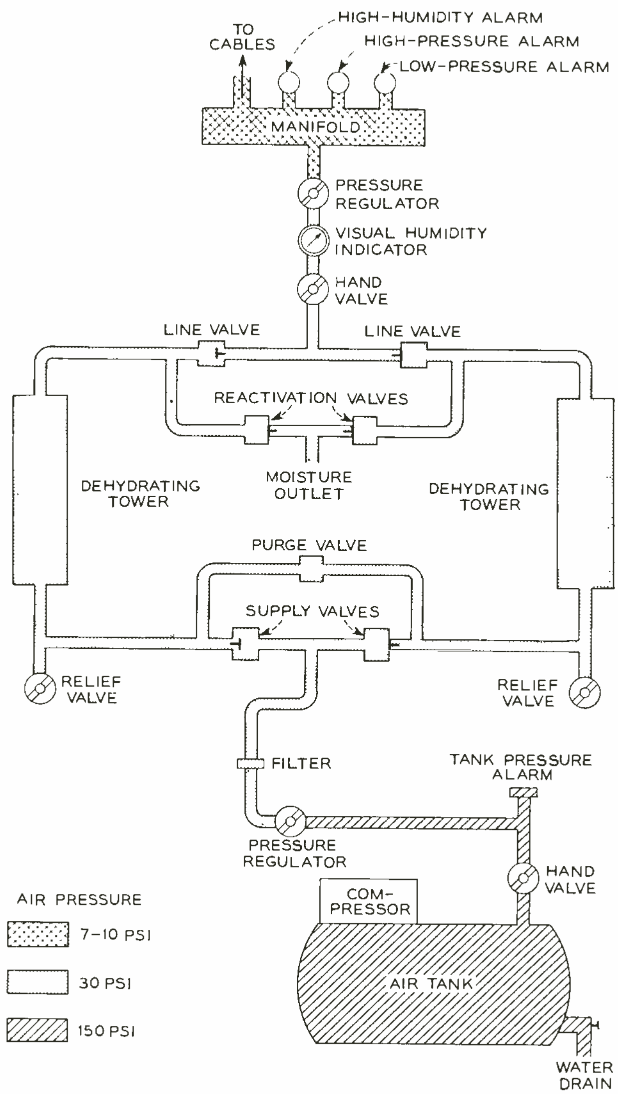


Fig. 1 — Diagram of apparatus used to supply dry air to an exchange cable network.

Fig. 2 — G. W. Hausold, New Jersey Bell switchman, records dry air flow to exchange cable systems.

The drying towers are used alternately; one dries the required air while the other is being reactivated. Reactivation consists of heating the desiccant with internally embedded heaters to release the entrapped moisture, and purging it from the system with a stream of air. Air is routed through the proper drying tower automatically by the use of timer-actuated solenoid valves.

This completely automatic unit is designed to deliver dry air continuously in quantities up to several hundred cubic feet a day, depending on cable needs. Since the drying cycle for the dehydrator is based on cumulative hours of compressor operation rather than a definite elapsed time cycle, the drying capacity of the desiccant is efficiently used even when the cable system being supplied is relatively gas tight. Adequate dry air is available, however, should the cables require increased quantities as a result of large temperature changes or sheath damage.

In many cases, the volume of air delivered to each cable system in a pressurized exchange cable network is monitored by a gas meter. A typical panel installation of such meters in a central office is shown in Figure 2. By comparing weekly gas-meter readings for each cable system, maintenance personnel can determine the volume of air consumed by the cables. A sharp rise in air consumption indicates that a serious leak has developed, whereas small sheath breaks such as fatigue cracks, or porosity in solder, show up as a gradual increase in the amount of air consumed. Leak locating work can then be scheduled on an emergency or routine basis depending on the need.

Compressor-dehydrators of this type with a total rated capacity of over thirty million cubic feet of dry air a year (equivalent to more than 150,000 high pressure nitrogen cylinders) are now in use in the Bell System to supply dry air to cable systems. A number of these units have been operating in the plant continuously for as long as five years with satisfactory results. Although the toll cable plant is still the biggest user of the gas pressure systems, the compressor-dehydrator makes the advantages of pressurized cable available to the several hundreds of thousands of miles of exchange cable plant throughout the Bell System.

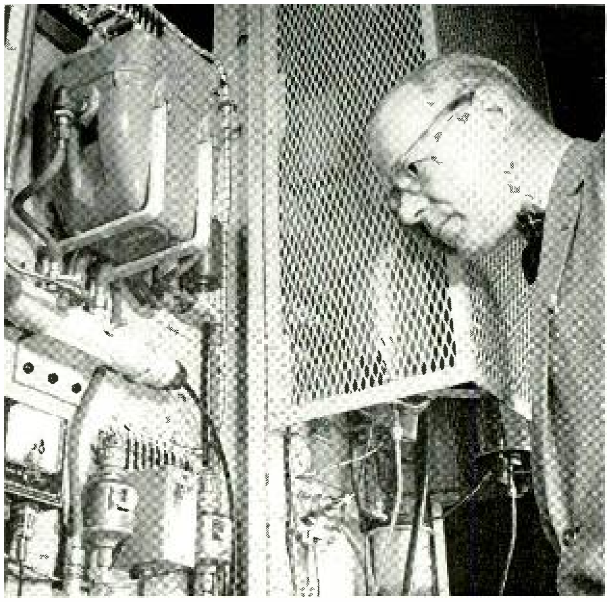
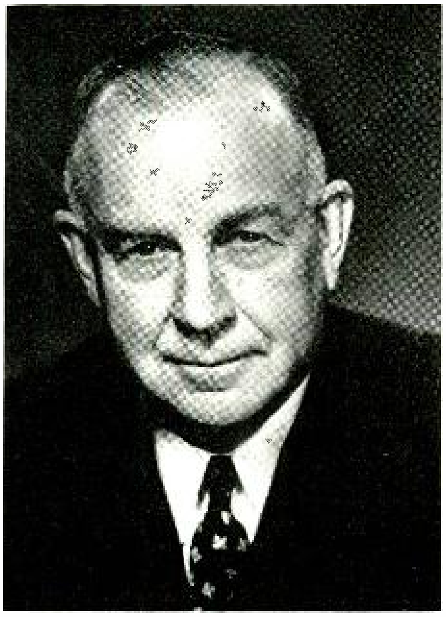


Fig. 3 — T. A. Durkin checks alarm control on apparatus used to supply dry air. Drying towers can be seen within the screened enclosure.

THE AUTHOR

J. M. Jackson joined the Outside Plant Development Department of the Laboratories in 1942 and shortly thereafter entered the Navy where he served until 1945. Upon his return from the Naval Service, he was associated with projects on joining and maintenance methods for telephone cables. During the Korean conflict Mr. Jackson was recalled to Naval Service for two years. Since his return to the Laboratories in 1952, he has been engaged in the design of equipment for supplying dry air to cable systems, and waveguides and antennas of radio relay networks. While working at the Laboratories, Mr. Jackson attended Rutgers University where he received a certificate in Mechanical Engineering.



Cleo F. Craig

Frederick R. Kappel

Arthur B. Goetze

F. R. Kappel Elected President of the A. T. & T. Co.
C. F. Craig to Chairman of A. T. & T. Board
A. B. Goetze Heads Western Electric Co.

Frederick R. Kappel, formerly President of the Western Electric Company, was elected President of the American Telephone and Telegraph Company on September 19. He succeeds Cleo F. Craig, American Telephone and Telegraph Company President since 1951, who was elected Chairman of the Board of Directors. On September 26, Arthur B. Goetze was elected President of the Western Electric Company to succeed Mr. Kappel.

Mr. Goetze, Vice President – Manufacturing of the Western Electric Company, is succeeded by Paul A. Gorman, who has been Vice President – Finance. At the same meeting the Board elected Paul R. Brousse, Comptroller of the Company's Manufacturing Division, to succeed Mr. Gorman.

Earlier in September, the Western Electric Board of Directors elected four other vice presidents. Clyde C. Randolph, Works Manager of the Hawthorne Works, was elected Vice President and will be in charge of manufacturing operations for the Western Area. Mr. Randolph succeeds Reese F. Clifford, who retired on September 30 under the Company's Age Rule.

The other Vice Presidents elected were Noble Armstrong, Distribution Manager, who became Vice President – Distribution; James N. Cost, Installation Operating Manager, who became Vice President – Installation; and Charles D. Dugan, Comptroller, who became Vice President – Comptroller.

Mr. Kappel, new President of the A. T. & T. Co., started his Bell System career as a groundman with the Northwestern Bell Telephone Company in 1924. After holding various positions of increasing responsibility in the Company, Mr. Kappel became Assistant Vice President of Operations in 1936. Three years later he was elected Vice President of Operations and a Director of the Northwestern Bell Telephone Company.

Mr. Kappel came to the A.T.& T. Co. in January, 1949, as Assistant Vice President, Operation and Engineering. In February of that year he was elected Vice President of the Long Lines Department. In November, 1949, he returned to the General Departments of the A. T. & T. Co. as Vice President in charge of Operation and Engineering. He remained in that post until he was elected President of

JAMES N. COST

CLYDE C. RANDOLPH

NOBLE ARMSTRONG

CHARLES D. DUGAN

the Western Electric Company on January 1, 1954.

Mr. Craig started his telephone career as an equipment man in St. Louis in 1913. He rose through various positions, primarily in the plant department of Long Lines, until he became Vice President in charge of Long Lines in 1940. The following year he joined the General Departments of the A. T. & T. Co. and served at different times as Vice President in charge of Personnel Relations, Operation and Engineering, Revenue Requirements, and Finance. He was elected President of A. T. & T. on July 2, 1951.

Mr. Goetze started with the Western Electric Company in 1917 as a draftsman at its Hawthorne Works in Chicago. After advancing through positions of increasing responsibility, Mr. Goetze served as Manager of several manufacturing locations and Personnel Director of the company. In 1949, he was elected Personnel Vice President of the Chesapeake and Potomac Telephone Companies and in 1950, Operating Vice President and a Director of the Ohio Bell Telephone Company.

PAUL A. GORMAN

PAUL B. BROUSSE

Returning to Western Electric in 1952, Mr. Goetze was elected Vice President and became Works Manager of one of the company's major plants at Kearny, N. J., and subsequently of all manufacturing in the eastern area. In 1954 he was placed in charge of the company's finance division and in May, 1956, he became Vice President – Manufacturing. Mr. Goetze is a Director of the Laboratories.

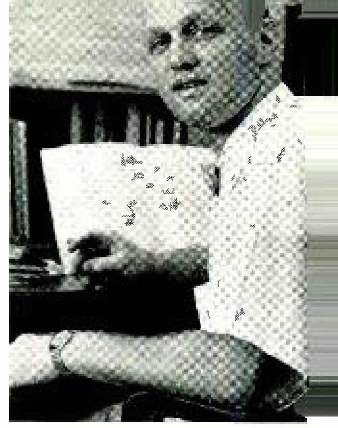
Share Owners Approve A. T. & T. Stock Issue

Share owners of the A. T. & T. Co. at a special meeting held recently approved an increase in the amount of authorized stock in the company from 60-million to 100-million shares. This constitutes the largest direct offering ever made by an American corporation. The company made, on October 1, 1956, a direct offering of additional stock to share owners, for purchase at par, $100 per share, on the basis of one new share for each ten shares outstanding on Sept. 14. It has been estimated that approximately 5,750,000 shares, or $575,000,000 par value of stock, will be involved in the offering.

J. R. KLAUDER

I. P. KAMINOW

S. H. WEMPLE



HOWARD CRAVIS

Laboratories Fellows Enter Graduate School

Four members of the Laboratories entered graduate school in September to work toward Ph.D. degrees while continuing as regular employees of the Laboratories. Howard Cravis and John R. Klauder of the Communications Development Training Class of 1953, and Ivan P. Kaminow and Stuart W. Wemple of the Class of 1954 were the first recipients of Laboratories fellowships previously described.*

Mr. Cravis, who has chosen to work toward his degree in Electrical Engineering at Columbia University is a member of the Laboratories Systems Engineering Department. He has received a B.S. degree in Electrical Engineering from Columbia, and a Master of Arts degree in Applied Physics from Harvard University.

Mr. Klauder, of the Military Systems Engineering Department, will work toward a degree in Theoretical Physics at Princeton University. He has a B.S. in Engineering Physics from the University of California and a M.S. degree in Physics from Stevens Institute of Technology.

Mr. Kaminow, also of the Military Systems Engineering Department, plans to pursue work toward a Ph.D. degree in Electrical Engineering in the microwave field at Harvard University. He has a B.S. degree in Electrical Engineering from Cooper Union and a M.S. degree in the same field from the University of California at Los Angeles.

Mr. Wemple, of the Military Design Engineering Department, will work toward a Ph.D. degree in the general field of electronics at the Massachusetts Institute of Technology. He has a B.S. degree in Mechanical Engineering from the Northwestern University and a M.S. degree in the same field from the California Institute of Technology.

One or two additional fellows from the Communications Development Training Class of 1955 will be selected in the near future to pursue academic work toward Ph.D. degrees in universities of their choice.

* RECORD, *June*, 1956, *page* 231.

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.

Anderson, O. L., *Effect of Pressure on Glass Structure,* J. Appl. Phys., **27**, pp. 943-949, Aug., 1956.

Anderson, P. W., *Ordering and Antiferromagnetism in Ferrites,* Phys. Rev., **102**, pp. 1008-1013, May 15, 1956.

Arnold, S. M., and Koonce, S. Eloise, *Filamentary Growths of Metals at Elevated Temperatures,* J. Appl. Phys., Letter to the Editor, **27**, p. 964, Aug., 1956.

Bozorth, R. M., Walsh, Dorothy E., and Williams, H. J., *Magnetic Properties of Some Ferrites and Cyanides at Low Temperatures,* Phys. Rev., **103**, pp. 572-578, Aug. 1, 1956.

Chase, F. H., *Power Regulation by Semiconductors,* Elec. Engg., **75**, pp. 818-822, Sept., 1956.

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

Darrow, K. K., *Electron Physics in America,* Physics Today, **9**, pp. 23-27, Aug., 1956.

David, E. E., Jr., *Naturalness and Distortion in Speech Processing Devices,* J. Acous. Soc. Am., **28**, pp. 586-589, July, 1956.

Dewald, J. F., and Lepoutre, G., II – *The Thermoelectric Power of Sodium and Potassium Solutions at –78° and the Effect of Added Salt on the Thermoelectric Power of Sodium at –33°.* III – *Theory and Interpretation of Results,* J. Am. Chem. Soc., **78**, pp, 2953-2962, July 5, 1956.

Eder, M. J., see Veloric, H. S.

Embree, M. L., and Williams, D. E., *An Automatic Card Punching Transistor Test Set*, Proc. 1956 Electronic Components Symposium, pp. 125-130, 1956.

Fthenakis, E., *A Voltage Regulator Using High Speed of Response Magnetic Amplifiers with Transistor Driver*, Proc. Special Tech. Conf. on Magnetic Amplifiers, **T-86**, pp. 185-199, July, 1955.

Gohn, G. R., *Fatigue and Its Relation to the Mechanical and Metallurgical Properties of Metals*, S.A.E. Trans., **64**, pp. 31-40, 1956.

Gohn, G. R., Fernick, H. S., and Guerard, J. P., *The Mechanical Properties of Wrought Phosphor Bronze Alloys*, A.S.T.M. Special Tech. Pub., **STP 183**, pp. 1-114, Jan., 1956.

Guerard, J. P., see Gohn, G. R.

Koonce, S. Eloise, see Arnold, S. M.

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

McMahon, W., *Dielectric Effects Produced by Solidifying Certain Organic Compounds in Electric or Magnetic Fields*, J. Am. Chem. Soc., **78**, pp. 3290-3294, July 20, 1956.

Merz, W. J., *Effect of Hydrostatic Pressure on the Hysteresis Loop of Guanidine Aluminum Sulfate Hexahydrate*, Phys. Rev., **103**, pp. 565-566, Aug. 1, 1956.

Merz, W. J., *Switching Time in Ferroelectric $BaTiO_3$ and its Dependence on Crystal Thickness*, J. Appl. Phys., **27**, pp. 938-943, Aug. 1, 1956.

Nelson, L. S., *Windowed Dewar Vessels for Use at Low Temperatures*, Rev. Sci. Instr., **27**, pp. 655-656, Aug., 1956.

Prince, M. B., see Veloric, H. S.

Shulman, R. G., *Hole Trapping in Germanium Bombarded by High-Energy Electrons*, Phys. Rev., **102**, pp. 1451-1455, June 15, 1956.

Slichter, W. P., *On the Morphology of Highly Crystalline Polyethylenes*, J. Poly. Sci., **21**, pp. 141-143, July, 1956.

Veloric, H. S., Eder, M. J., and Prince, M. B., *Avalanche Breakdown in Silicon Diffused P-N Junctions as a Function of Impurity Gradient*, J. Appl. Phys., **27**, pp. 895-899, Aug., 1956.

Walsh, Dorothy E., see Bozorth, R. M.

Wilkinson, R. I., *Beginning of Switching Theory in the United States*, Elec. Engg., **75**, pp. 796-802, Sept., 1956.

Williams, D. E., see Embree, M. L.

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

Wood, Mrs. E. A., *Guanidinium Aluminum Sulfate Hexahydrate: Crystallographic Data*, Acta Crys., **9**, pp. 618-619, July 10, 1956.

Wood, Mrs. E. A., *The Question of a Phase Transition in Silicon*, J. Phys. Chem., **60**, p. 508, 1956.

Patents Issued to Members of Bell Telephone Laboratories During July

Albersheim, W. J. — *Precision Phase Measuring Circuit* — 2,756,390.

Barry, J. F. — *Point Contact Translators* — 2,753,495.

Blair, R. R. — *Apparatus for Testing Resistors* — 2,754,467.

Bogert, B. P. — *Impedance Inverters* — 2,757,345.

Carbrey, R. L. — *Code Translator* — 2,755,459.

Duane, W. R. G., Jr. *Multiplex System Employing Polar Modulation* — 2,756,418.

Dunlap, K. S., and Ferrell, E. B. — *Telephone System* — 2,754,368.

Ehrhardt, R. A. — *Electroplating with Antimony* — 2,753,299.

Enright, D. J. — *Apparatus for Zero-Setting Direct-Current Amplifiers* — 2,754,374.

Ferrell, E. B., see Dunlap, K. S.

Houtz, C. C., and McLean, D. A. — *Electrolytic Capacitors* — 2,756,373.

Ingerson, W. E., and Lovell, C. A. — *System Producing Nulls in Electrical Networks* — 2,757,283.

Ketchledge, R. W. — *Transmission Line Distortion Correction* — 2,753,526.

Koehler, D. C. — *Test Fixture for Welded Relay Contacts* — 2,754,680.

Linvill, J. G. — *Wave Transmission Branching Arrangement* — 2,757,342.

Lovell, C. A., see Ingerson, W. E.

McLean, D. A., and Wehe, H. G. — *Method of Making Electrical Capacitors* — 2,754,230.

McLean, D. A., see Houtz, C. C.

Merrian, F. F. — *Regulated High Voltage Power Supply* — 2,753,509.

Pearson, G. L. — *Fabrication of Silicon Translating Devices* — 2,757,324.

Rogie, J. M. — *Electrical Connector* — 2,755,452.

Ruggles, D. M. — *Cleaning of Small Articles* — 2,756,168.

Scaff, J. H., and Theuerer, H. C. — *Method of Preparing Germanium for Translating Devices* — 2,753,281.

Shockley, W. — *Semiconductor Signal Translating Devices* — 2,756,285.

Smith, D. H. — *Current Supply Apparatus* — 2,753,510.

Theuerer, H. C., see Scaff, J. H.

Thomas, D. E. — *Transistor Circuits* — 2,757,243.

Treptow, A. W. — *Vitreous Enamels and Enameling Processes* — 2,753,271.

Wallace, R. L., Jr. — *Four-Electrode Transistor Modulator* — Re 24,183.

Wehe, H. G., see McLean, D. A.

Talks by Members of the Laboratories

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

Western Electronic Conference, Los Angeles, Calif.

Barney, H. L., *Magnetic Drum Signal Storage for a Narrow Band Picture Transmission System.*

Becker, F. K., *Signal Stretching by Stroboscopic Sampling.*

Becker, F. K., Eilenberger, R. L., and Hefele, J. R., *Electronic Camera Storage.*

Blecher, F. H., *Transistor Circuitry for Analog to Digital Conversion.*

Desoer, C. A., *Network Design by First Order Predistorsion Techniques.*

Eilenberger, R. L., see Becker, F. K.

Hefele, J. R., see Becker, F. K.

Hempstead, C. F., *Milliwatt Backward Wave Oscillators for the 3 to 7 mm Wavelength Region.*

Kock, W. E., *Video Transmission over Channels having Narrow Frequency Bands – Section 1: General Considerations.*

McDowell, H. L., *Gain of a Low-Level Signal in the Presence of a High Level Signal in Traveling-Wave Tubes.*

Miller, R. L., *Electronic Picture Storage.*

Monk, N., and Winbigler, H. S., *Communication with Moving Trains in Tunnels.*

Sears, R. W., *Flash Coding Tube.*

Stubner, F. W., *Influence of Mechanical Factors on Tubes and Shorts Testing Equipment Instrumentation.*

Warters, W. D., *The Effect of Mode Filters on the Circular Electric Wave Transmission Properties of a Long Multicode Circular Waveguide.*

Winbigler, H. S., see Monk, N.

Massachusetts Institute of Technology, Cambridge, Massachusetts

Benes, V. E., *A Continuous Time Treatment of the Waiting-Time in a Receiving System Having Poisson Arrivals, A General Distribution of Service-Time and a Single Service Unit.*

Hamming, R. W., *How to Control a Digital Computer.*

Kronacher, G., *Resolver Shaft Angle Encoders.*

Mason, W. P., *Piezo and Ferroelectric Devices.*

International Conference on Semiconductors and Insulators, Garmisch Partenkirchen, Germany.

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

Haynes, J. R., *Radiation Resulting from the Recombination of Holes and Electrons in Silicon.*

Herring, C., *The Role of Low-Frequency Phonons in Thermoelectricity and Thermal Conduction.*

Lander, J. J., *Hydrogen as a Donor in ZnO.*

McKay, K. G., *Photon Emission from Breakdown in Silicon.*

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

Smits, F. M., Miller, R. C., and Batdorf, R. L., *Surface Effects on the Diffusion of Impurities in Semiconductors.*

Other Talks

Anderson, O. L., *The Quenching of Strong Glass Fibers,* Gordon Conference on Glass, Meriden, N. H.

Andreatch, P., and Anderson, O. L., *Teflon as a Pressure Medium, Gordon Research Conferences,* American Association for the Advancement of Science, Meriden, N. H.

Blecher, F. H., *Design Principles for Wideband Transistor Feedback Amplifiers,* I.R.E. Subcommittee on Transistor Circuitry, Los Angeles, Calif.

Dudley, H. W., *What We Learn From Speech Synthesis,* Speech Institute, University of Wisconsin, Madison, Wis.

Dudley, H. W., *Bell Telephone Laboratory Research on Speech Synthesis,* Wisconsin Telephone Company, Milwaukee, Wis.

Geballe, T. H., *The Nernst and Related Effects in Germanium,* University of Washington, Seattle.

Gupta, S. S., *Selecting a Group Which Contains the Best of K Populations,* Gordon Research Conference on Statistics in Chemistry and Chemical Engineering, American Association for the Advancement of Science, New Hampton, N. H.

Lee, W. A., *The Visual Recognition Threshold as an Index of Verbal Response Probability,* American Psychological Association, Chicago, Ill.

Matlack, R. C., *The Future Role of Record Communication Systems,* Association of Police Communications Officers, Los Angeles, Calif.

Mayzner, M. S., and Tresselt, Margaret E. (NYU), *The Judgmental Process in Verbal Concept Formation,* American Psychological Association, Chicago, Ill.

Mealy, G. H., *Switching Theory – A Status Report,* IBM Research Laboratories, Poughkeepsie, N. Y.

Pearson, G. L., *Silicon in Modern Communications,* New England Association of Chemistry Teachers, University of New Hampshire, Durham.

Read, W. T., *Electrical Properties of Dislocations in Semiconductors,* Tung Sol Electric Corporation, Bloomfield, N. J.

Read, W. T., *Structural Defects in Semiconductors,* Royal Military College, Kingston, Ontario, Canada.

Schimpf, L. G., *A Transistorized 150 MC Radio Receiver,* I.R.E. Subcommittee on Transistor Circuitry, Los Angeles, Calif.

Snoke, L. R., *Some Needed Basic Research on Wood Deterioration Problems,* Society for Industrial Microbiology, American Institute of Biological Sciences, Storrs, Conn.

Wier, J. M., *A Learning Process Suitable for Mechanization,* Conference of the Association for Computing Machinery, University of California, Los Angeles.