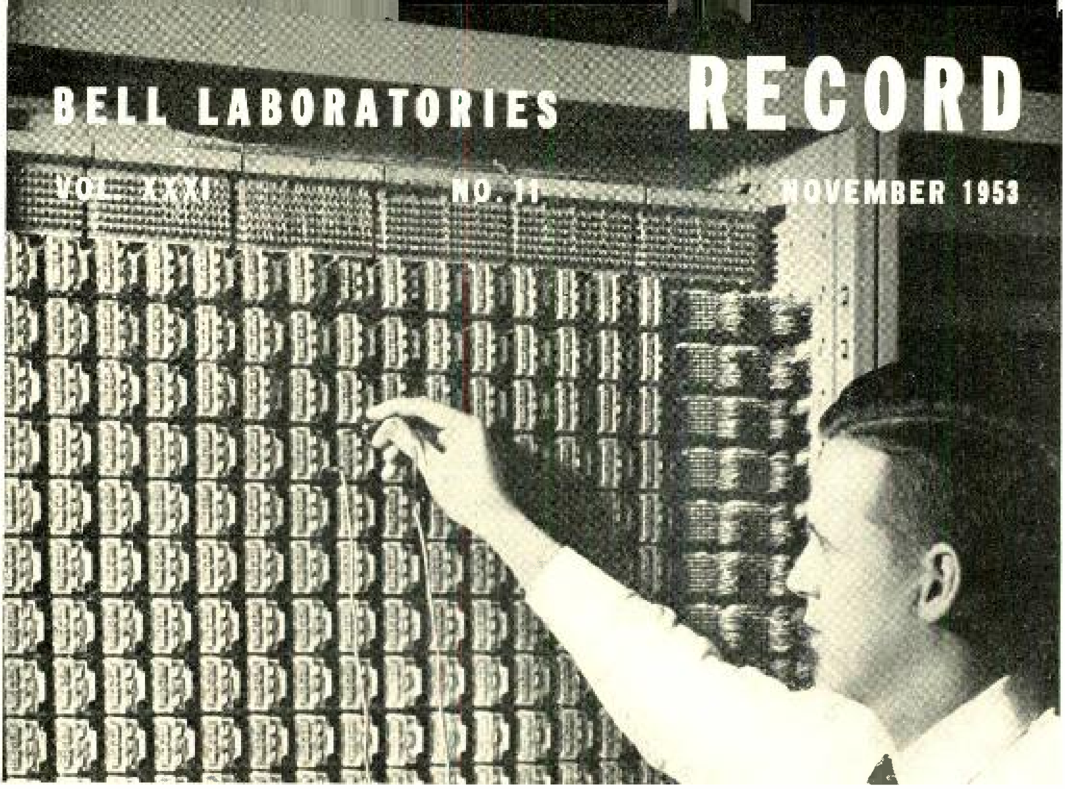
BELL LABORATORIES RECORD
VOL. XXXI NO. 11 NOVEMBER 1953



New Wire Spring General Purpose Relay

H. M. KNAPP
Switching Apparatus Development

General purpose relays constitute the most repetitive "building blocks" in telephone switching equipment. It is logical, therefore, that these relays should be under constant study to provide more reliable performance, low manufacturing, operating, and maintenance costs, and longer life. New design procedures and improved manufacturing methods have resulted in a new relay that has shown considerable improvement over the older relays in attaining the desired objectives.

One of the recent major developments of Bell Telephone Laboratories and the Western Electric Company is the wire spring general purpose relay (Figure 1.) Its first application is in the No. 5 crossbar system, which is being modified to use the new relay in place of the former U-type relays. Substantial economies in manufacture, operation, and maintenance are anticipated with the wire spring relay.

Basically, the telephone relay performs a relatively simple operation in closing and opening contacts. Because relays appear so often in telephone circuits – in the order of 60,000 in a 10,000 line crossbar office – they become one of the most important

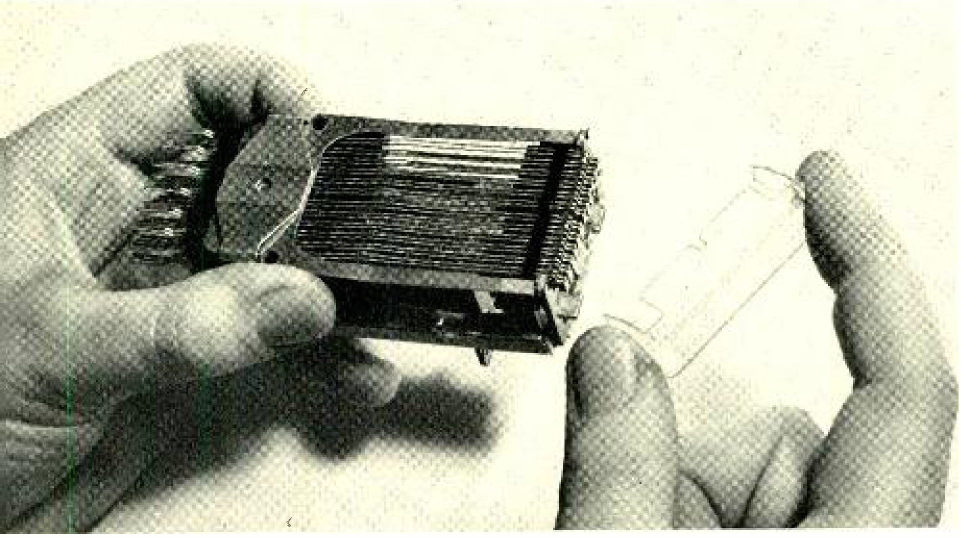


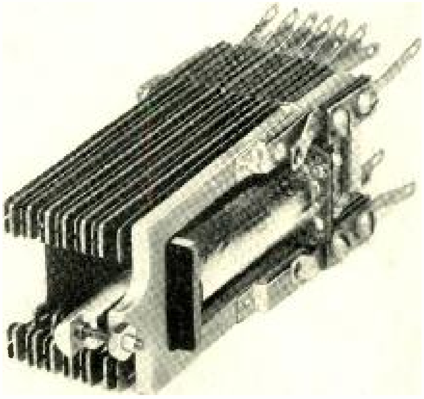
Fig. 1 – The wire spring relay.

components of telephone switching systems. For this reason, and because these systems are constantly undergoing improvements, studies directed toward improved relays have been carried on for many years, taking advantage of improved designs, newer materials, and better construction methods as these develop. The new wire spring relay will be cheaper to manufacture, faster in operation, require less power, have longer life, provide improved contact performance, and require less maintenance than earlier types of relays.

At first glance, it is not immediately apparent why the wire spring relay should be cheaper to manufacture. It appears to be more intricate than the flat spring relay (Fig. 2) because of the larger number of closely mounted contacts and wires. It is in this construction, however, that a large part of the expected reduction in cost lies. Figure 3 helps to make this clear. This picture shows a comparison of the springs and insulators needed for a contact arrangement consisting of twelve normally open contacts. For the U type relay, fifty-four individual parts must be assembled by hand to provide the contact assembly; for the wire spring relay, two molded sub-assemblies of wire springs accomplish the same purpose.

It is, of course, important that the sub-assemblies be produced and assembled at a cost below the corresponding cost for the U relay. Production of these sub-assemblies is accomplished by mechanized manufacture, in which the necessary number of wires are fed through straightening dies into the molding press in a continuous automatic operation. Wire spring assemblies are shown in Figure 4 as they come from the molding press and prior to cutting to length and welding contacts to them. Since a contact pair consists of a stationary contact mating with a pair of twin contacts, two kinds of wire assemblies are required. After cutting to length, these assemblies are passed through another line of automatic operations in which the wires are formed

Fig. 2 – The U-type relay.



to provide tension and offsets, the contacts are welded to the wires, and the terminal ends tinned.

Another feature that contributes to lower manufacturing cost is the similarity of parts of the relay regardless of the ultimate application of the relay. The eleven standard parts of the relay are shown in Figure 5. These can readily be assembled without using screws, a factor in itself that contributes to lower assembly costs. The relationship of these parts is shown in Figure 6. A special jig, illustrated in Figure 7, has been devised for use in the laboratory to assemble the relays. In this assembly, the clamp that takes the place of screws in holding the relay together, must have sufficient clamping force to insure a stable relay. Figure 9 shows the laboratory set-up for checking the tightness of the relay assembly.

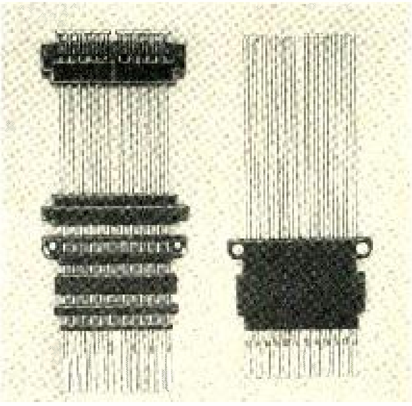
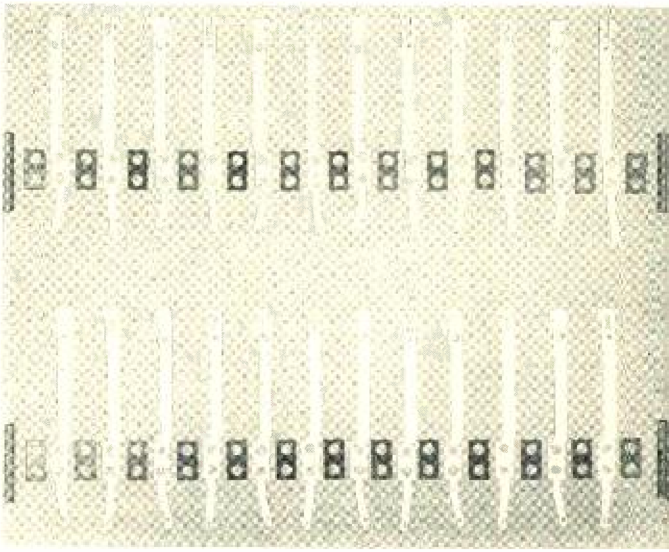


Fig. 3 – Comparison of the molded wire assemblies for 12 make contacts with the corresponding parts used on the U-type relay.

For maximum economy in manufacture, it is desirable that the number of different types of relays be held to a minimum. Circuit requirements, however, make it necessary to provide a wide variety of contact combinations. These combinations consist essentially of those that are normally open (make), normally closed (break), or sequences of both of these, such as "break before make" (transfer) and "make before break" (continuity).

In the wire spring relay, it is possible to combine these relatively simple fundamental arrangements to obtain a wide variety of spring combinations using few parts. A phenol fibre card, which can be seen on the front end of the relay in Figure 1, is used to operate the contacts in a manner similar to the one used on the UB relay previously described.[*] The moving contact spring of a make contact is tensioned against one edge of the card, as shown diagrammatically in Figure 8(a). When the armature of the relay operates, the card moves with it, permitting the moving contact to touch the stationary one. In the case of a break contact, the tension of the moving spring is against the stationary contact, and the card moves to separate the contacts when the armature operates, as indicated in Figure 8(b). Sequences between make and break contacts are obtained by the use of shoulders or steps in the actuating edges of the card, as illustrated in Figure 9.



Equally important in keeping manufacturing costs low is reduction of adjusting effort. In the earlier relays, adjustments consisted primarily of hand-bending the contact springs to obtain the proper contact separations and tensions. The new wire spring relay, by its design and construction,

---

[*] Record, *October*, 1949, *page* 355.

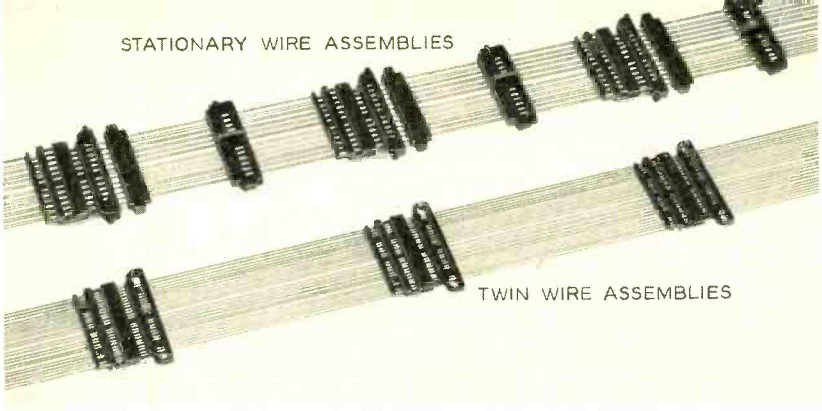


Fig. 4 – Molded stationary and twin wire assemblies before cutting to the proper length.

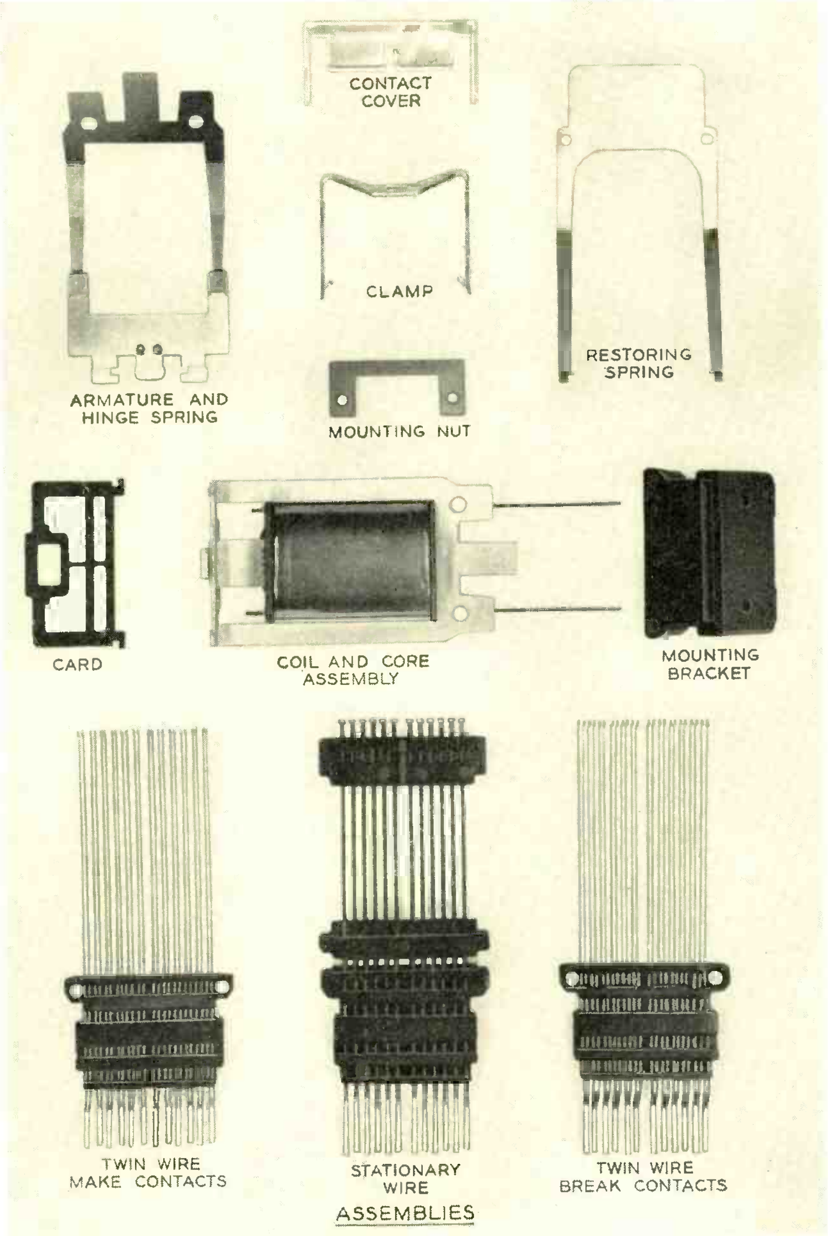


Fig. 5 – The eleven standard parts of the wire spring relay.

avoids both hand tensioning and positioning of the individual contact springs.

Elimination of hand tensioning is accomplished by machine-forming suitable bends in both the single and twin wires, the restoring spring, and the armature hinge spring. These are readily visible in Figure 6. The bend in the single (stationary) wires holds the front molded block in position against the core plate. The tension provided by the bends in the armature hinge spring positions the armature and provides tension at the hinge point against the core legs. Tension of the restoring spring keeps the make contacts open when the relay is unoperated, and holds the armature against its backstop with a suitable force. The bends in the twin wires provide the required contact force. Control of the tensions is accomplished primarily by large pre-deflections, as indicated in Figure 11.

Similar pretensioning of contact springs is being applied to the U relay*, but manual bending of individual spring tangs is still needed to position the contacts properly. On the wire spring relay, however, this operation is avoided by minimizing the number of dimensions controlling the operation of the contacts and by close control of these dimensions during manufacture.

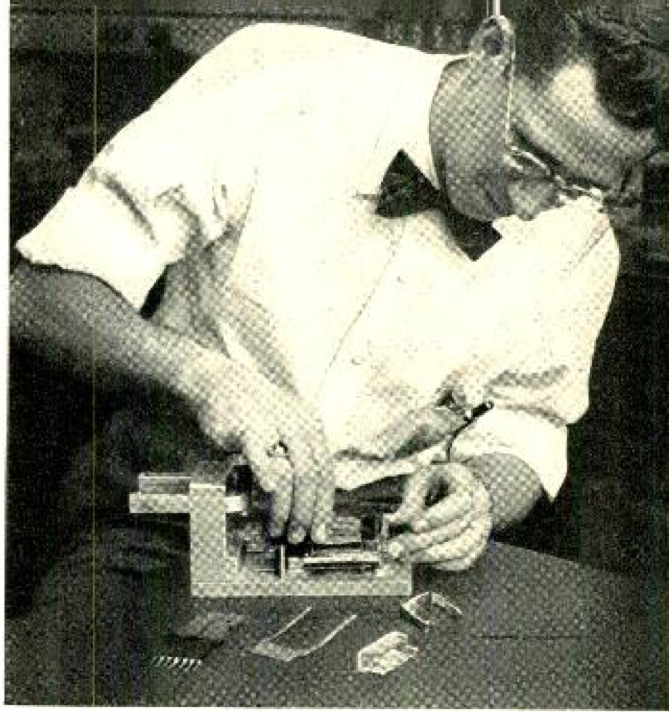


Fig. 7 – V. J. D'Entrone assembles an AF type relay in a special jig designed for the purpose.

Close control of contact position during manufacture reduces to a minimum the adjustment required on the new relay. It is the design objective that only a small fraction of the relays may require adjusting, and this is in the form of a gang adjustment, in which the contacts are positioned as a group. As illustrated in Figure 12, the contacts can be gang adjusted to operate at the proper point in the armature travel by bending the arms of the core plate with a screwdriver. This positions the stationary contacts relative to the core. The armature restoring springs, shown at the top in Figure 6, are pretensioned, and may frequently need no adjustment, but when this is required, a simple spring-bending tool is used.

In fastening the new relay to its mounting plate, two screws engage a tapped U-shaped detail indicated in Figure 5 as the mounting nut. During assembly of the relay, this nut

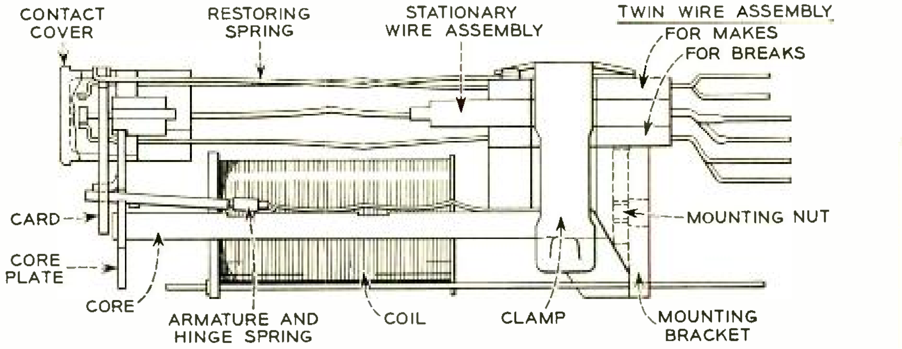


Fig. 6 – Top view of the relay showing the locations of the several parts.

---

* Record, *October*, 1949, *page* 355.

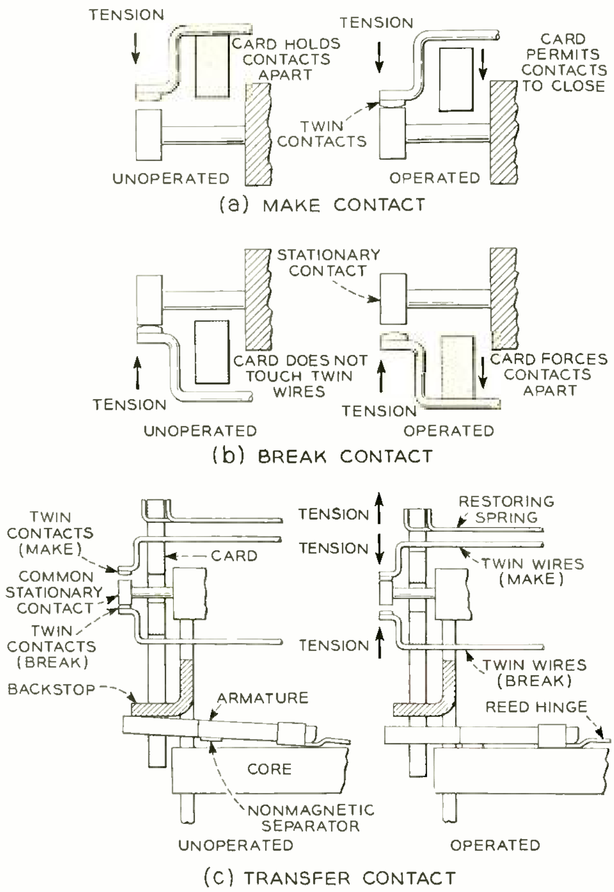


Fig. 8 – Principle of operation of (a) make contacts, (b) break contacts and (c) transfer contacts.

is inserted in a recess of the mounting bracket, also shown in Figure 5, where it is trapped when the bracket is assembled in the relay. Figure 6 illustrates this assembly. This construction insulates the core and armature from the mounting plate, eliminating the need for the insulators that were used for this purpose with the older relays.

Instead of using a cover over the entire relay or group of relays, a molded transparent contact cover is provided for individual relays. Its prime function is to protect the contacts from dust and dirt, and to retain the moving contact wires in their individual guide slots, which are molded into the front section of the stationary wire block. This cover may be put in place in the final assembly operation, and need not be removed through subsequent inspection, adjustment, wiring, shipping, installation, and use of the relay. Of course, in clearing circuit troubles during manufacture, installation, and use, the cover may readily be removed for access to the contact springs. There is good reason to believe that with the protection afforded by this cover, together with the use of completely independent twin palladium contacts, open contact troubles should be reduced greatly. The contact covers also avoid the need for frame covers or common can covers now employed in the various switching systems.

Reduction in sticking contacts too, is anticipated, because of the method of actuating the contacts. This method is similar to that of the UB relay[*], in which relatively large restoring forces are applied close to the contacts, by means of the actuating card. Another feature of this method of actuation is that a uniform contact force is obtained, even though wear of the contacts and other relay parts takes place. A comparison of the decline of contact force due to wear on the U relay and on the wire spring relay is shown in Figure 13.

Of major importance in speed and capability of operating a large number of con-

---

[*] loc. cit.

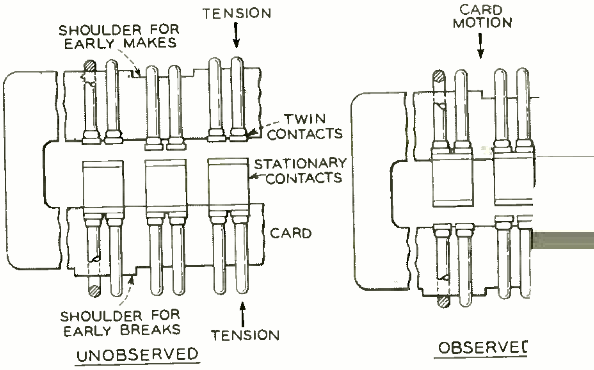


Fig. 9 – Sequences between making and break contacts are obtained by means of shoulders on actuating card.

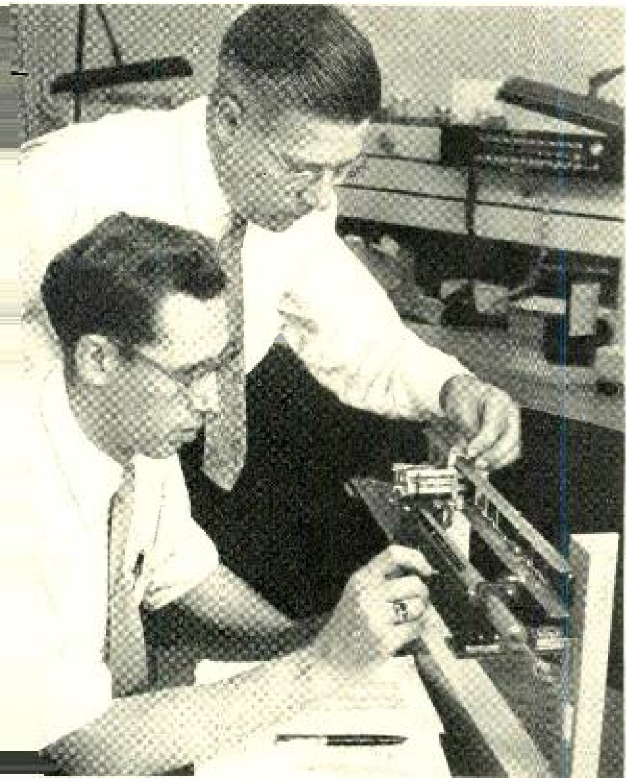


Fig. 10 — J. H. Mogler demonstrates to V. J. D'Entrone how to determine the tightness of the relay assembly.

tacts, is the efficiency of the electromagnet. This efficiency contributes also to lower power consumption. The magnetic structure of the wire spring relay is shown in Figure 14. The central core, on which the operating winding is mounted, is the center leg of a flat, punched, E-shaped member, and the outside legs serve as magnetic return pole pieces. This one-piece construction minimizes the reluctance of the magnetic circuit.

The armature is a flat, punched U-shaped member that bridges the three legs of the core. The armature illustrated in Figure 14 is used on the AF type relays and is made relatively short to aid in obtaining high operating speed and to reduce rebound.

For maximum efficiency of the magnet, all three mating surfaces of the armature and core must be closely aligned. As an aid in doing this, a punched detail called a "core plate," is forced over the ends of the core, as shown in Figure 15. This core plate also provides a back stop for the armature and, as mentioned previously, serves as the means for mass adjustment of the contacts.

Switching circuits require that relays differ widely in their operating characteristics; some must be fast operating, some slow release; others must operate, hold, or release on certain values of current within rather limited ranges. Still others must have high sensitivity; they must operate on a minimum of power. To build these characteristics into the general purpose relay and still retain the principle of mechanized manufacture and standardized assembly requires that differences in design of parts be reduced to a minimum.

Much can be accomplished toward these objectives by merely varying the design of the coil, that is, selecting the wire size and number of turns to meet the particular circuit needs. High speed, for instance, can usually be obtained by the use of low resistance windings having an optimum number of turns; sensitivity, by using full windings containing a large number of turns. There are cases of severe circuit requirements, however, where the special windings must be supplemented by other changes and additions to the relay. Figure 16 illustrates these.

For example, assume that a more sensitive relay or one having greater pulling power than that of the standard wire spring relay, is needed. An armature as shown on the right in Figure 16, which is longer than the one normally used, provides lower reluctance in the magnetic circuit. Laminations are added to the center leg of the core (under the winding) to provide greater core section. Because of the relatively small demand for such relays, it would not be economical to provide this thickness of core for all relays.

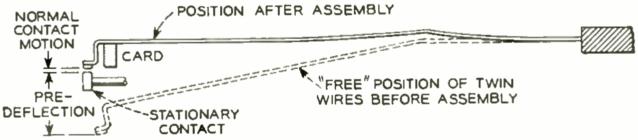


Fig. 11 — Contact forces are controlled by relatively large predeflections of the twin wires.

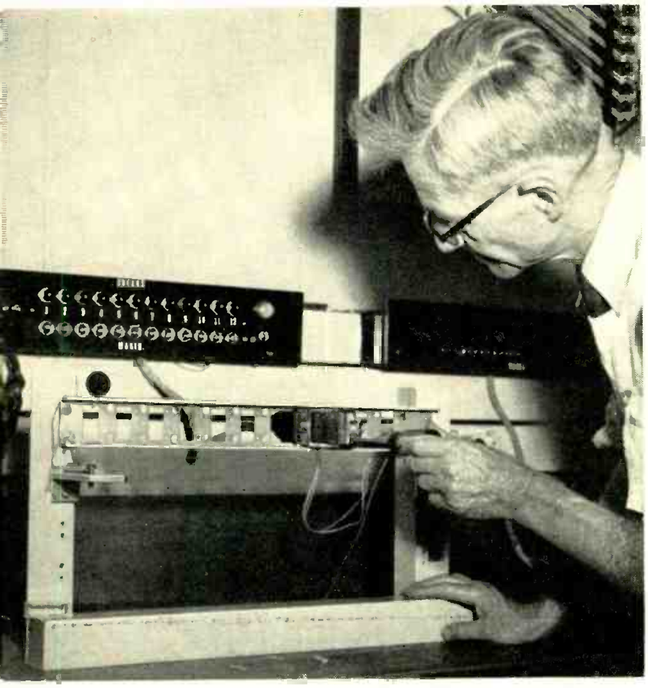


Fig. 12(*a*) – *A. T. Hammerle adjusts the contacts by bending the arms of the core plate with a screwdriver.*

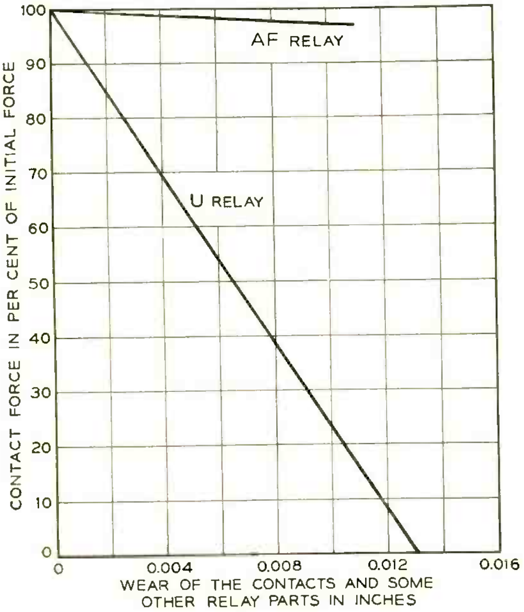


Fig. 13 – *Contact forces on the wire spring relay remain almost constant for limited amounts of wear. On the U relay however, contact forces drop rapidly with wear.*

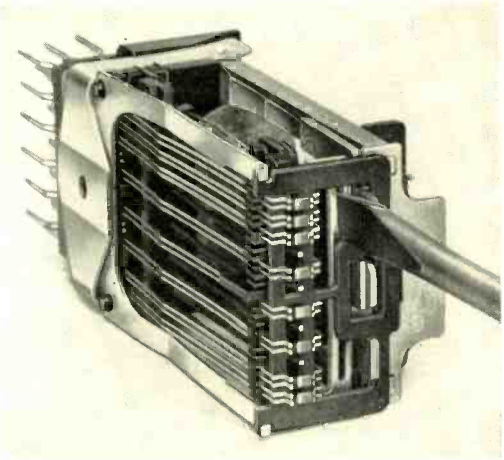


Fig. 12(*b*) – *Contacts may be gang adjusted by bending the arms of the core plate with a screwdriver.*

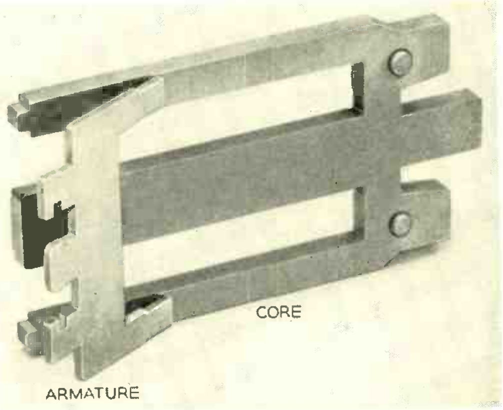


Fig. 14 – *The magnetic structure of the AF wire spring relay. A relatively short armature aids in obtaining high operating speed.*

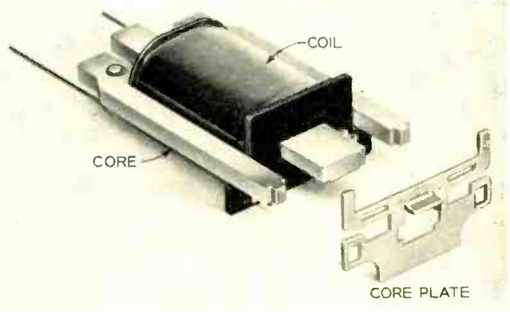


Fig. 15 – *After the coil is assembled to the core of the relay, a core plate is forced over the ends of the core legs to hold these legs in alignment.*

To meet slow release requirements, the relay is equipped with a long armature having a spherical embossing where it engages the core, similar to the Y type relay*, and a copper or aluminum sleeve is used under the winding. To control the release time, a buffer spring is used, which adds to the load on the armature during its last few mils of travel. Slow release wire spring relays are coded in the AG series; marginal and sensitive relays are coded in the AJ series. The majority of the relays, including fast operating relays, are coded in the AF series.

Besides aiding the pulling capability of the new relay, the magnetic circuit has the advantage of reducing external flux leakage to a negligible amount. Consequently, equipment precautions such as large spacing of relatively critical relays, or the use of magnetic shields are no longer needed to avoid magnetic interference from adjacent relays. This in turn saves mounting space; for example, in the No. 5 crossbar intra-office trunk circuits, equipment for two trunks will now mount on two mounting plates instead of three, as required by U relays.

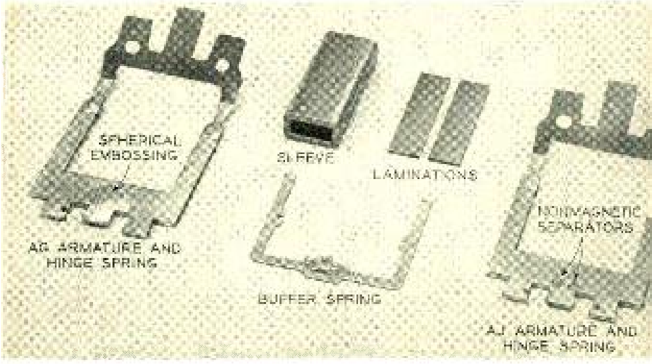


Fig. 16 – Additional parts used on the wire spring relay to aid in obtaining different operating characteristics.

Because of the higher speed attainable with the wire spring relay, common control equipment is able to handle more calls in a given period of time, thereby reducing the amount of control equipment such as markers needed in a central office. This is a very important advantage economically because of the high cost of markers and associated equipment. Besides, the new relays are capable of operating approximately twice the number of contacts as the older relays, so that one relay can take the place of two in many applications, with a resulting saving in relays, power, and space.

---

* Record, *May,* 1938, *page* 310.

THE AUTHOR: H. M. Knapp joined the Laboratories in 1928 with an M.E. degree received that year from Stevens Institute of Technology. A member of Apparatus Development, he was first engaged in precious metal contact studies, transferring during World War II to supervisory work on the mechanical design of magnetic fuses for the Bureau of Naval Ordnance. Since the war he has been in charge of a group working on relay development, with particular attention to the UB relay, and more recently to wire spring relays. Mr. Knapp is a member of Tau Beta Pi.

Office of Naval Research Honors the Laboratories

By authority of the Secretary of the Navy, the Laboratories has been awarded a Certificate of Commendation "for outstanding service to the U. S. Navy" by the Office of Naval Research. The letter which accompanied the citation from Admiral Bolster, Chief of Naval Research, to Dr. M. J. Kelly, president of the Laboratories, follows:

DEPARTMENT OF THE NAVY
Office of Naval Research
Washington 25, D. C.

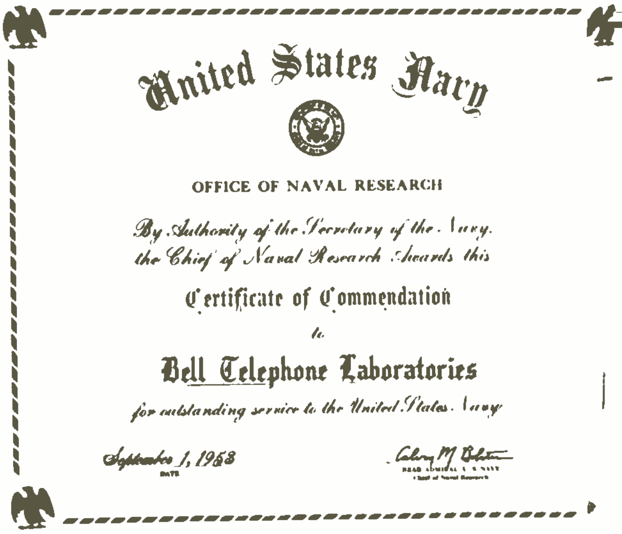
In Reply Refer to
ONR : 101 : aaj
Ser. 18143

Dr. M. J. Kelly, President
Bell Telephone Laboratories, Inc.
Murray Hill, New Jersey

My dear Dr. Kelly:

As you well know, the many post-war advances in technology have significantly improved the submarine warfare potential but without a corresponding improvement in the available defensive measures. This latter fact has been a matter of increasing concern to the Department of the Navy. Late in the fall of 1950, the Office of Naval Research called a conference for the purpose of exploring possible avenues of attack on this critical problem.

As a result of this conference, the Bell Telephone Laboratories undertook extensive research aimed at penetration of the underwater acoustic barrier that limited the effectiveness of antisubmarine warfare. This research program was expertly planned and vigorously prosecuted by outstanding competent scientific and engineering personnel of the Laboratories staff. The results which they have achieved have exceeded, in all respects, even the most optimistic expectations. By the fall of 1952, there had been developed by your Laboratories radically new tools and procedures, sufficiently effective as to profoundly influence future antisubmarine warfare techniques. Such success in your undertaking has been made possible not alone by professional competence, but by devotion to duty under difficult and trying field conditions and a sincere interest in the welfare of our country. For this the Navy is deeply grateful.



United States Navy

OFFICE OF NAVAL RESEARCH

By Authority of the Secretary of the Navy,
the Chief of Naval Research Awards this

Certificate of Commendation

to

Bell Telephone Laboratories

for outstanding service to the United States Navy

September 1, 1953

Therefore, it gives me great personal pleasure to award to the Bell Telephone Laboratories, on behalf of the Department of the Navy, a Certificate of Commendation for outstanding accomplishment in naval research and contribution to national defense.

Sincerely yours,
C. M. BOLSTER
Rear Admiral, USN
Chief of Naval Research

The citation refers to a research project which was started in 1950 in the Transmission Research Department of the Laboratories under the direction of R. K. Potter with W. E. Kock as Project Engineer. With the formation of the Acoustics Research Department in 1951, the research phases of the program were continued in that department under Dr. Kock as Director of Acoustics Research. Meanwhile, the results of this work had reached a point of such promise that development effort was initiated under C. F. Wiebusch, now Director of Underwater Systems Development, while more recently systems planning effort has been added under R. P. Booth, Director of Special Systems Planning.

Analysis of Materials

K. H. STORKS
Analytical Chemistry

It is often said that, sooner or later, every material in existence is brought to Bell Telephone Laboratories to find whether it can be of use to the telephone industry. The chemical composition and physical structure of these materials must be known in order to predict their suitability for service under a wide variety of conditions. Such information can be provided by the many methods available to the analytical chemistry group, whose work includes both routine analyses and fundamental research.

Miss B. E. Prescott measures the density of a spectrum line on a photographic plate, while W. Hartmann positions a sample in the arc stand of the spectograph. E. K. Jaycox is preparing a sample for analysis.

The wide variety of products necessary for the construction and operation of the telephone plant, and the broad interests of the Bell System in research and development, place unusual requirements on the chemical analysis group at the Laboratories. The problem is threefold – first, analytical service must be supplied to the research and development groups; second, analytical methods must be developed or modified for our own needs and for use in the control laboratories of Western Electric; and third, analytical research must be done in anticipation of future requirements and to assure that the most modern methods are readily available. In frequent instances a broad research problem requires specialized analytical techniques. In such a case a member of the analytical group may join with a physicist or physical chemist as a research team. Cooperative effort of this sort is an important part of the research program.

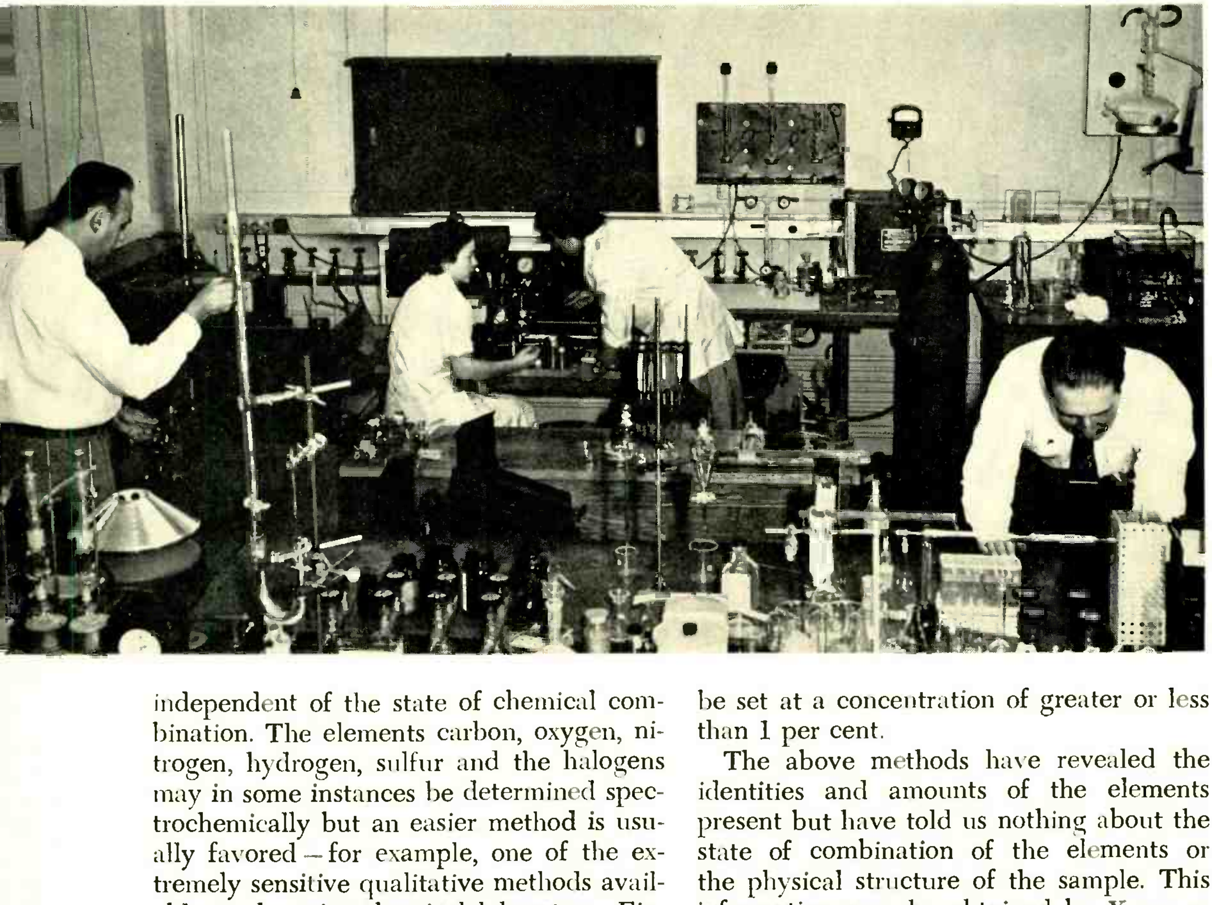
The various phases of the work of the analytical group can best be illustrated by a series of examples. The methods used will not be considered in detail. Previous publications have done this in some instances*, and future Record articles will

---

* Record, *March,* 1939, *page* 202; *June,* 1944, *page* 416; *February,* 1952, *page* 64; *June,* 1952, *page* 253; *July,* 1952, *page* 285.

describe a number of others in detail.†

Occasionally a single person can handle a request for analysis, but more often the coordinated effort of a number of people is required. Suppose very little information is available (new lots of raw material for the manufacture of ferrites or new alloys). A quick qualitative analysis first tells what elements are present and establishes an approximate concentration range for each. This work is done in the spectrochemical laboratory shown in the headpiece. Here most of the elements that occur in the solid state are quickly detected. The method is independent of the state of chemical combination. The elements carbon, oxygen, nitrogen, hydrogen, sulfur and the halogens may in some instances be determined spectrochemically but an easier method is usually favored — for example, one of the extremely sensitive qualitative methods available in the microchemical laboratory, Figure 1.



After the qualitative analysis is completed, more detailed information may be required. Accurate quantitative determinations of one or more major constituents are necessary if ferrites or alloys of exact composition are to be prepared. This work is done by methods selected from the variety available in the general laboratory, Figure 2. The exact concentration of one or more minor constituents may be needed because of the effect on some important property of a finished product. These determinations will be done by special methods available in one or another of these three laboratories. The choice depends on size of sample, kind of material, element sought and accuracy required. An arbitrary boundary between major and minor constituents may be set at a concentration of greater or less than 1 per cent.

The above methods have revealed the identities and amounts of the elements present but have told us nothing about the state of combination of the elements or the physical structure of the sample. This information may be obtained by X-ray or electron diffraction analysis. The diffraction patterns obtained with these short-wave radiations are characteristic of regularities in atomic arrangement, and therefore the identity of chemical compounds can be established. The particular method chosen depends on the size of the sample, or on

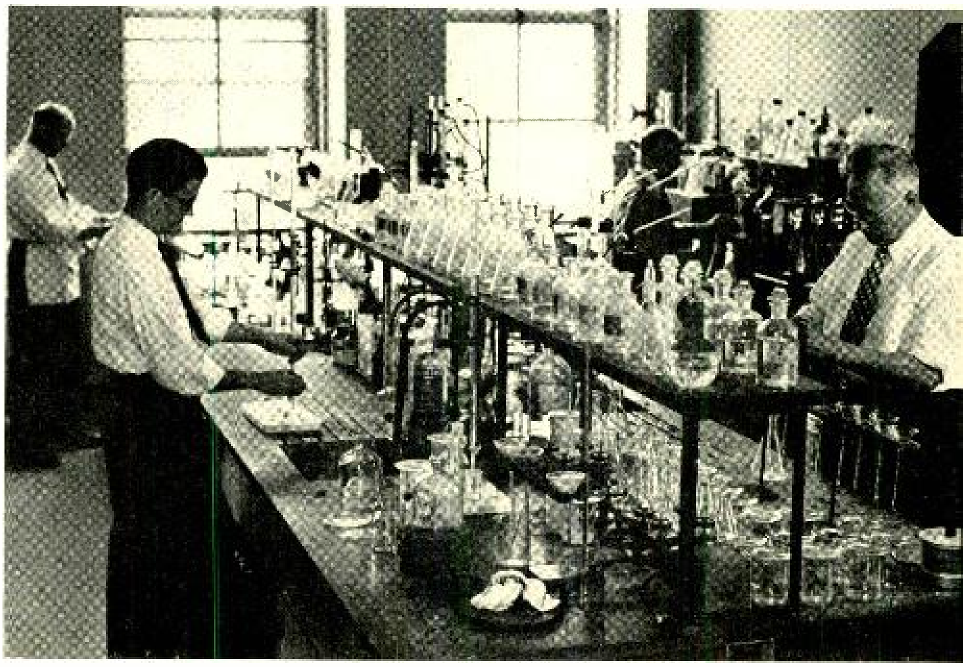
---

† This is the first in a series of articles dealing with the work of the analytical chemistry group.

whether an analysis of the bulk or surface is required. For example, X-ray diffraction reveals that a particular sample of powder is composed of nickel and nickel oxide, and electron diffraction establishes that the nickel oxide is on the surface of the particles.

The elemental and diffraction analyses just described have provided necessary information on an "atomic" scale (kinds, quantities and states of combination of a relatively few atoms). Many of the properties of materials, however, depend on larger scale structural features which are revealed by the methods of electron and optical microscopy. Many familiar things are composites consisting of two or more chemical compounds, and these compounds may be present as individual crystals held in some sort of cementing matrix. Outstanding examples are the ceramics used as insulators or cores for carbon resistors. The diffraction methods establish the identity of the compounds and tell us that the cementing material is a noncrystalline glass. Many of the properties of ceramics depend, moreover, on the size, shape and distribution of the crystalline particles of the compounds, and on the nature of the boundaries between glass and crystal. These features are all revealed by the methods of electron or optical microscopy. Again the method chosen depends on the sample and the nature of the information required. The diffraction and microscopic laboratories are shown in Figures 3, 4 and 5.

← *Fig. 1 – L. D. Blitzer is preparing to photograph a small sample, while Miss E. Croake and Mrs. E. Behr discuss a problem of microanalysis. H. V. Wadlow is preparing a chromatographic separation of the elements in a corrosion film.*



→ *Fig. 2 – J. P. Wright and E. Bloom are analyzing metal samples by volumet-ic methods. W. C. Jordan s examining asphalt for pecification purposes and . F. Jensen is filtering a netal compound to be eighed for a gravimetric etermination.*

The methods described do not provide for the determination of micro-quantities of some of the lighter elements in certain types of samples. The properties of many metals are influenced by very small quantities of the elements, hydrogen, oxygen, carbon or nitrogen. These elements may simply be dissolved in the metal or may be in minute segregated particles of chemical compounds known as hydrides, oxides, carbides, or nitrides. For instance, the presence of these elements in the nickel used to support the alkaline earth oxides in vacuum tube cathodes is especially important. Microscopic methods and electron diffraction tell us about the compounds, but accurate quantitative measurements of total amounts present are often required. The low pressure gas analysis laboratory shown in Figure 6 is equipped for these quantitative determinations. The metal may be burned in a low pressure of pure oxygen to deter-

Fig. 3 — Mrs. M. H. Read adjusts a sample in the electron diffraction camera.

Fig. 4 — Mrs. E. P. Berman and F. G. Foster examine an optical micrograph on a projection screen.

mine carbon, or it may be melted in high vacuum in a carbon crucible to determine nitrogen, hydrogen and oxygen. The gases carbon dioxide, water vapor, or nitrogen are collected and their quantities determined by measuring their volumes. Nitrogen is determined directly, whereas the other elements are converted to standard compounds by reaction with the oxygen atmosphere, carbon crucible, or appropriate reagents incorporated in the analysis system.

The methods mentioned have dealt largely with the analysis of inorganic materials, such as metals, oxides, silicates and many others. The analysis of organic materials (lacquers, polymers, etc.) may be handled in some of these same laboratories, but considerable additional information and sometimes a complete analysis can be obtained by the methods of absorption spectroscopy, Figure 7. A continuous spectrum of infrared, visible or ultraviolet radiation from a suitable source is transmitted through the sample. The radiation is then passed through an appropriate prism and is dispersed in such a way that successive narrow wavelength regions can be examined. When intensity versus wavelength is plotted, the curves show absorption bands that are characteristic of the molecular or electronic structure of the material. Comparison with standard curves completes the analysis. In some cases, it is only possible to obtain clues that require further checking, and sometimes more accurate quantitative data must be provided. In such a case, the problem is taken to the analytical research laboratory, Figure 8, where a variety of other methods are available. Among these, polarographic, nonaqueous titration, or chromatographic methods frequently provide the final answers.

In one form of the polarographic method, a material is oxidized or reduced in a special electrolytic cell, consisting of a pool of mercury as one electrode and a tiny drop issuing from a charged column of mercury as the other. The drop is the active electrode and, because of its small size, is easily polarized. The voltage on the cell is slowly increased and the current plotted as a function of the voltage. When the material begins to react at the drop, the current increases abruptly to a value characteristic of the rate of diffusion of the reacting material to the

Fig. 5 — Miss F. M. Berting and the author observe an electron micrograph on the fluorescent screen of the microscope.

electrode. The current is a function of the concentration, and the potential of the abrupt rise is a function of the material. Both qualitative and quantitative analyses are therefore possible.

In the second or nonaqueous titration method, the solution (organic solvent) of the material to be analyzed is made the electrolyte in a special cell designed as a small battery. The potential of this battery is measured with a sensitive electronic instrument. The solution of a standard material (having an acid-base reaction with the unknown) is slowly added, and potential is plotted as a function of the amount added. An abrupt change in the potential marks the completion of the reaction and the analysis is complete.

In a simple application of the chromatographic method — a third type of analysis in the analytical research laboratory — a solution containing several materials is washed through an absorbent column (*e.g.* alumina in a glass tube) by appropriate solvents. Under favorable conditions, the substances are separated and washed out in individual fractions. After this simple separation, a final analysis can be made. In the original applications of chromatography, color reactions were used to identify the fractions. These methods are still used but the present applications are much broader and in most cases no colored indicators are involved, although the name has been retained.

The preceding discussion describes in a very general way the analysis of materials by methods in more or less regular use. However, it is often necessary to remodel an unsatisfactory method or to provide a method for some new or unusual material. This type of work is usually done in response to a request from the Western Electric Company.

A recent example of such a problem was

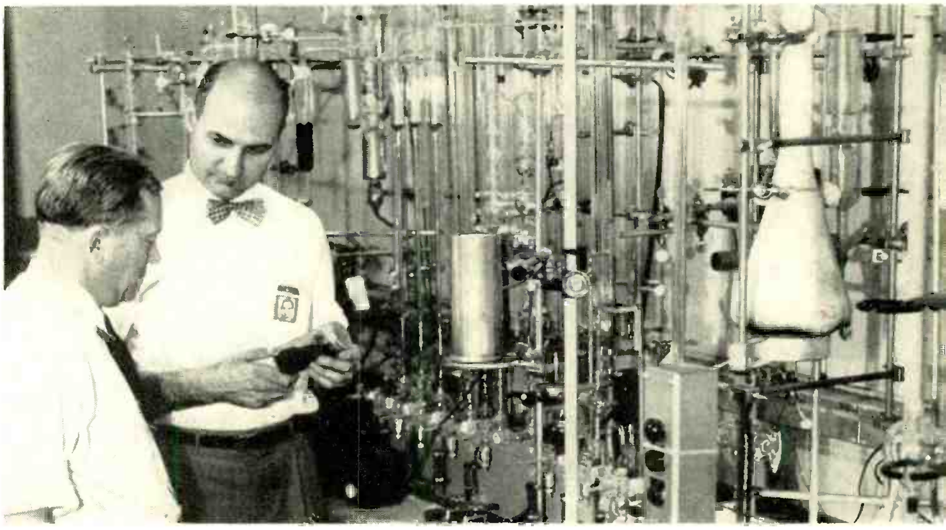


Fig. 6 — A. L. Beach and W. G. Guldner discuss the analysis of a metal sample.

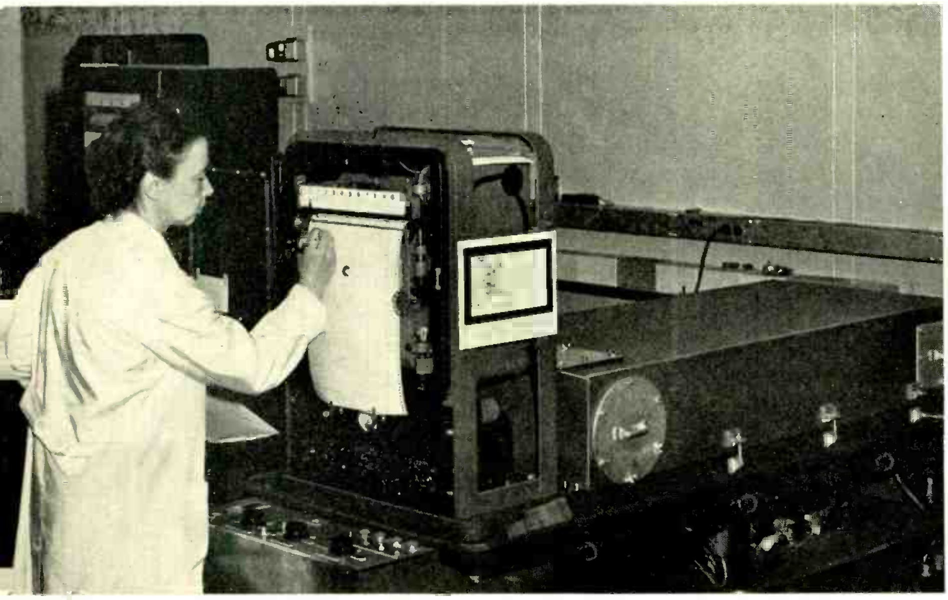
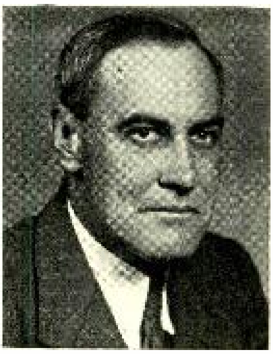


Fig. 7 – Miss D. M. Dodd examines a record from the recorder of the infrared spectrophotometer.

the determination of total pigment in black lacquers containing finely divided carbon and clay. The sample was ashed to remove all constituents but the clay, which was determined directly by weight. The carbon was determined, without separation, by photometric comparison with a standard lacquer. The decrease of light intensity due to absorption and scattering was the quantity measured.

In addition, a great deal of work is being done to adapt analytical methods and develop new ones in advance of specific needs. For example, a method developed in the Laboratories some years ago for the study of thin oxide and sulfide films on copper and silver is now in regular use in the analysis of the corrosion films occurring on the copper and silver alloys employed in the telephone plant. Experience gained in the study of electrometric titrations in organic solvents has been of assistance in extending

Fig. 8 – P. D. Garn operates the polarograph while Miss E. C. Wennerblad performs a titration.



THE AUTHOR: K. H. STORKS received his B.S. degree in chemistry in 1930 from Coe College and that year joined the Laboratories' chemistry department. He was first occupied with studies of the physical chemistry of transmitter carbon and textile insulating materials. In 1935 he transferred to the physics department, conducting electron diffraction studies. Since his return to chemistry four years later he has specialized in the application of physical methods to chemical problems, dealing principally with electron and x-ray diffraction. He is now in charge of analytical chemistry.

the thin film method to zinc compounds. This provides a useful tool for a more complete study of the corrosion of brass.

The contributions of analysts as members of research teams can be illustrated by two recent examples. Electron diffraction and electron microscopy, in conjunction with magnetic measurements, were used to obtain experimental proof of a theory explaining the permanent magnet properties of Alnico V. These two methods were able to establish the structure, size, shape, and orientation of a precipitated phase and to demonstrate the behavior of the precipitate when the alloy was heat-treated in a magnetic field. These structural properties were all important parts of the theory. In the second instance, the methods of low pressure gas analysis were employed in measurements of the diffusion of carbon in nickel. The diffusion of carbon is important in the behavior of vacuum tube cathodes.

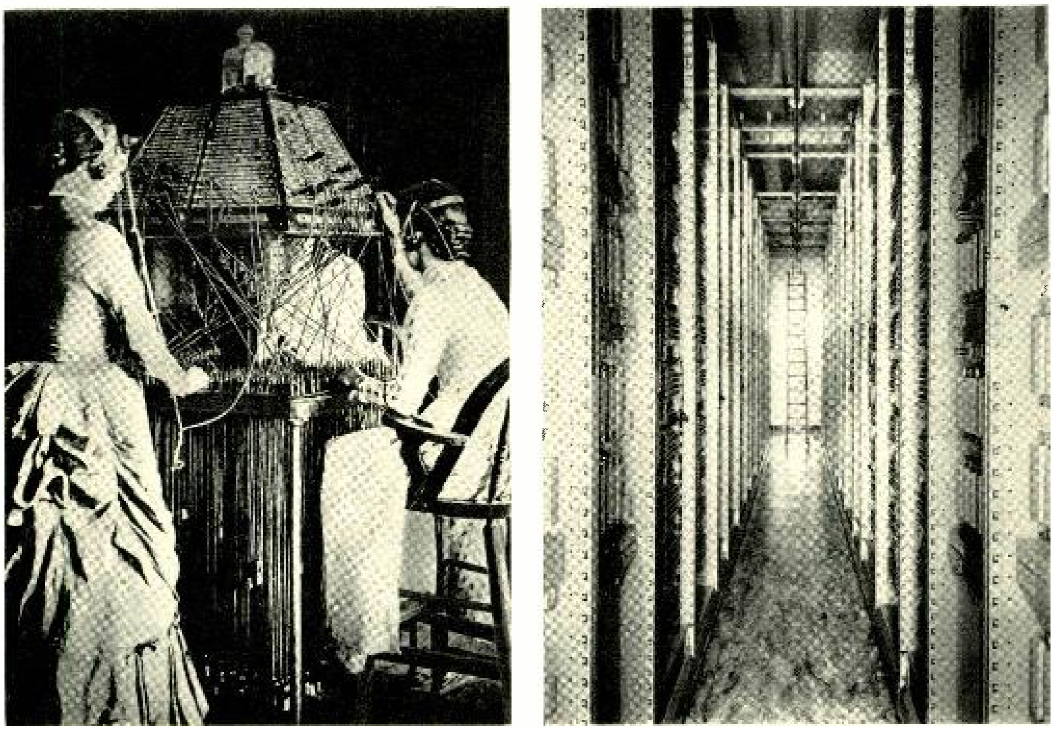
Approximately half of the total effort of the analytical chemistry group is the important day-to-day analysis assisting nearly all of the development and research groups in the Laboratories. The remainder of the time is spent in applied and fundamental research. The applied research comprises the bulk of the service to the Western Electric Company. The fundamental research is entirely in anticipation of future needs.

Network TV Stations Pass 200

In September, forty-one additional stations in thirty-five cities were connected to the Bell System's nationwide network of television facilities. This is the largest number ever added in one month and brings the total to 199 stations in 127 cities. These cities are located in thirty-nine states and the District of Columbia. Three stations in Canada are also connected to the network at Buffalo, bringing the total to 201 stations.

Commercial network service began only five and one-half years ago when the American Telephone and Telegraph Company provided a few hundred miles of facilities connecting twelve stations in five cities, starting at Boston in the North and extending to Washington in the South. Currently, some 38,500 channel miles of facilities are being used to provide network TV service.

The sharp increase in the number of stations added to the network last month raised the potential audience for events of national interest, such as the 1953 World Series, to about 100,000,000. This rapid expansion of network facilities illustrates the efforts put forth by the Bell System to meet its customers' requirements. The job has required the engineering and providing of thousands of miles of television facilities extending to almost every section of the country, as well as the manufacture and installation of tons of equipment.



Telephone switching: then – and now

The New Splendor of Switching

J. MESZAR
Director of Switching Systems Development II

Years ago the understanding and practice of switching technology were confined almost entirely to a limited group of telephone people. The advent of automatic digital computers has, however, stimulated a widespread interest in the ramifications of this art. In recent years there has even been intriguing speculation about the analogy between switching systems and the human brain.

Nature offers many examples of striking transformation from the plain, unadorned to the attractive and splendid. A hairy caterpillar becomes the beautiful Monarch butterfly; a colorless grub turns into the iridescent June beetle. In an imaginative sense, the technological world exhibits a similar transformation in the recent history of switching.

It was not long ago when switching was a little known, modest branch of modern technology. Its main field of application was in telephone communication where its job was to connect the two line wires of a calling subscriber to those of the called subscriber. How could there be any technical challenge in that simple assignment? A human being – the operator – accomplished it so unceremoniously in the early days; she inserted the plugs of a switchboard cord into the jacks terminating the lines of the two subscribers. It was felt that the products of switching technology – the electromagnetic switching systems – did no more than repeat endlessly the equivalent of this simple operation. This uninspiring appraisal received ample nourishment from the first succesful version of an electromagnetic switching system which established connections by simple switches obediently stepping to terminals as slaves of the dial twirled by the calling subscriber. Even the crossbar type switching system which went into service only a little more than a decade ago, and which had control circuits with a truly remarkable amount of "built-in" intelligence, evoked little philosophical admiration. After all, even this system was merely a collection of relays, switches, and so forth, which simply open and close contacts. Admittedly, such switching systems were associated with science, the science of electricity, because relays and switches are electrically operated devices. However, in spite of this association, switching in the final analysis appeared to reduce to the dull technique of: "relay A operates relay B." How could this technology measure up to the elegance of mathematics, the science of radio waves, the imaginative probings of physics?

Then came the early stirrings of a complete transformation. The hidden implications of the switching art, as employed in the telephone field, began to intrigue discerning technical people. More to the point, new forces were at work. Like the warm sunshine of early summer in nature's transformations, these new forces came from outside. The rapid expansion in other branches of technology such as areodynamics, ballistics, and atomics brought an avalanche of problems requiring the evaluation of complicated equations and volumes of computations. The challenge to create masterful robots to take over from human specialists some of these mathematical burdens intrigued many. Bell Laboratories demonstrated such possibilities in 1940 to the American Mathematical Society at Hanover, N. H.* The succeeding war and post-war efforts of scientists and engineers, within as well as outside the Laboratories, eventually culminated in automatic digital computing systems which in many ways equalled – and in certain respects outperformed – human beings. And (of all things) switching techniques were the essence of such systems! As a result, switching suddenly acquired social standing in the technical world. Its invasion of one of the sanctuaries of the human mind – mathematics – caught the imagination of far more people than did the intricate achievements of a modern dial telephone office. Professors, scientists, mathematicians have become intensely interested in it. What's more, to analyze some of the workings of the human brain itself in switching terms would have been only a far-fetched analogy some

---

* RECORD, *October*, 1940, *page* 5.

Bell Laboratories digital computer receives a problem and instructions for its solution.

years ago, but this is not the case today.

To support this sweeping implication, the formerly prevalent narrow view of the switching art has to be greatly broadened. Switching is not just the technology of connecting the line wires of telephone subscribers. This every day telephone problem is but one which requires the application of switching techniques. We can go even further and state that this problem of establishing telephone connections, sparked the development of switching techniques – as the effort to account for such everyday phenomena as falling apples sparked the formulation of the laws of gravitation. The laws of gravitation, however, cover not only the prosaic falling apple but also the motion of the planets and the stars of the great beyond. In the same way switching as a technique is far broader than, say, a crossbar central office installation. Switching is the technology of information processing. A switching system receives information, remembers, analyzes, interprets, makes logical decisions, and takes appropriate final action.

This view of switching is obviously a broad but not over-imaginative one. An automatic computing system receives a problem and instructions for its solution. It makes calculations using internally stored knowledge of mathematical processes. It memorizes the results of intermediate calculations for later use. It consults functional tables if necessary. It makes logical decisions when confronted with alternatives. It types its final output on a sheet of paper.

A crossbar telephone switching system also processes information. By dialing, a subscriber puts information into the system, specifying the particular telephone among millions that he wishes to have rung. No further information is needed from the subscriber because a telephone switching system has all the knowledge as to procedure, all the reference information needed to guide it to the specified telephone, all the ability to choose the preferred of many possible paths, all the means of accommodating the random demands of its thousands of customers, and so on. However, to accomplish what the subscriber asks of it, this switching system remembers, analyzes, interprets, makes many logical decisions, and takes appropriate final action. Sometimes the appropriate action is not to ring the requested telephone because it is already in use on another conversation and it would not be fair to intrude.

In establishing telephone connections, the crossbar switching system processes information.

There are in existence other good examples of switching systems to support the broad definition. And still others can, of course, be conceived to accomplish truly spectacular feats of information processing. For instance, a switching system could be designed to play skillful chess against a human opponent;* or reliable weather forecasts may someday be furnished by a switching system that will adequately evaluate the enormous number of interrelated factors.

---

* C. E. Shannon, Programming a Computer for Playing Chess, Phil. Mag. 41, pp. 256-275, March, 1950.

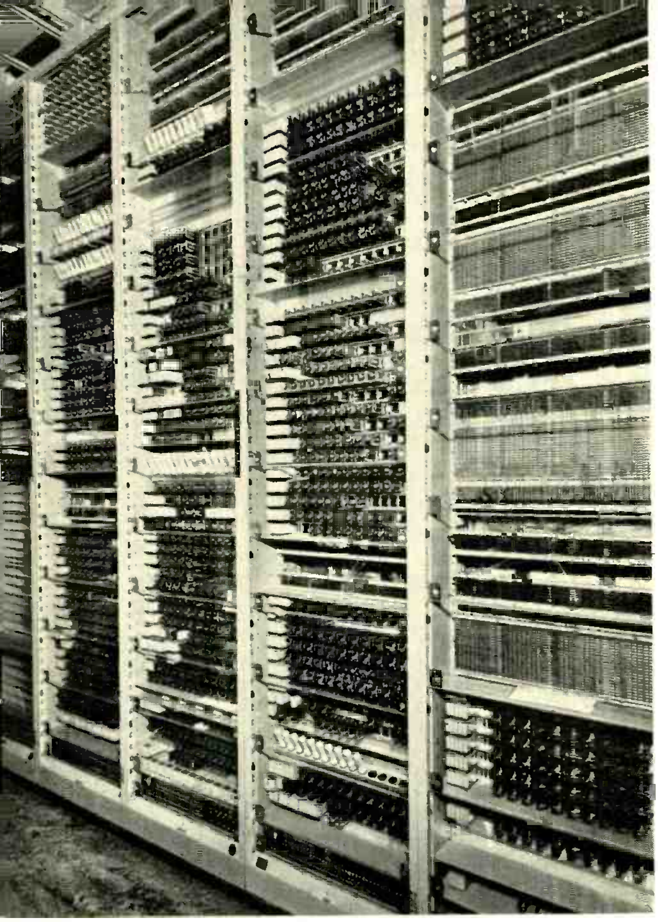
Neurons of the brain act – perhaps – as the elements of the ultimate in switching systems.

Such are the considerations that justify the assertion that switching systems can match many of the performances of the human brain, or – and this is the bolder assertion – that some of the workings of the human brain itself may perhaps be analyzed and understood in terms of a grand and glorious switching system. The human brain also processes information. It receives information from the sensory organs, remembers, analyzes, interprets, makes logical decisions (at times), and takes action by controlling muscular motions.

The analogy between a switching system and the human brain does not rest, however, on such general and perhaps superficial comparison of functions. Students of the human brain (and this is the most important part of our theme) are speculating that the human brain uses some of the same techniques as are used in switching systems. The characteristic most fundamental to the switching art is its use of discreet-valued, especially two-valued, elements and situations. A signal is either present or absent; a circuit is either closed or open; a relay is either operated or released; a decision is either yes or no; a situation is "this and that", "this or that", "this but not that", and so on. Accordingly, switching systems are built with devices which are either inherently two-valued, (electromechanical relays, gas tubes, etc.) or can be so used (vacuum tubes, transistors, etc.). The speculation is that some of the brain's processes are also based on two-valued elements. These elements are the nerve cells or neurons, which also have an "on or off", "yes or no", "all or none" behavior. Further, a switching system consists of a large number of two-valued elements interconnected by wires, and it accomplishes its functions by internal rearrangements of the states of these elements. In the same manner, the brain can be conceived as being an aggregate of two-valued neurons interconnected by nerve fibers, and all shades of feeling and action

---

THE AUTHOR: John Meszar, Director of Switching Systems Development II, joined the Laboratories in 1922 as a technical assistant in toll switching circuits. Five years later he became a circuit design engineer for toll switching systems, and in 1936 became supervisor of his group. During the war he was supervising instructor in the Laboratories' School for War Training, later returning to cicuit design supervision, with particular attention to the automatic message accounting system. Mr. Meszar received his B.S. degree in E.E. from Cooper Union in 1927. A member of the A.I.E.E., he is Secretary of the Institute's Communication Division Committee.



The No. 5 crossbar marker is a most complete ensemble of some 1,500 relays in several bays, but it has only adequate capability for setting up specified telephone connections . . .

of which human beings are capable may be the result of internal rearrangements in the states of these neurons of the nervous system. This, then, is the striking transformation of the technological world: modest, utilitarian switching suddenly finds itself cloaked with philosophical splendor; its technique may underlie the sublime system of the human brain.

We switching people should have two reactions to this new state of affairs. The first is a feeling of great satisfaction that our art has such exalted implications. This is doubly welcome because the actual practice of the art involves a great mass of drab details. The second reaction should be just the opposite: an intense humility in our puny accomplishments. We are proud, for instance, of our No. 5 crossbar marker as a most complex ensemble of some 1,500 relays, filling four 11-foot bays, and having adequate internal knowledge to set up specified telephone connections within a central office. In contrast, the human brain has an estimated ten billion neurons in a fraction of a cubic foot, and by the coordinated internal changes in the states of these neurons it can produce the brilliant rhapsodies of a Liszt, the magnificent paintings of a Raphael, the lofty theories of an Einstein.

. . . in contrast, the human brain has an estimated ten billion neurons, and it can bring forth such masterpieces as Raphael's "Creation of the Sun and Moon."

Braun and Cie., New York-Paris

Pressure on start button prepares the 1A telephone answering set to record an announcement. During subscriber's absence, the set transmits the announcement to calling parties and records their replies.

The New Telephone Answering Set

C. R. KEITH
Audio Facilities Development

The feasibility of making a machine that could answer a man's telephone in his absence has long been studied in the Laboratories. By 1935 a machine that could do this had been put together and successfully operated, but only as a laboratory model. At that time, it was the best that could be done with available components, but it was far too bulky and complex for subscriber use. Recently, advances in the electronic and recording arts have permitted the development of a telephone answering set which is both compact and economical enough for home use. Among the important enabling factors was the development of a resilient magnetic recording medium. This makes possible a machine which is simple to set up and operate and which can play back clearly millions of times.

"This is The Alpha Manufacturing Company, MAin 2-1234. Your call is being answered mechanically by Bell System Automatic Answering Service. Please leave your name and telephone number and a message . . ." If you should hear a voice over the telephone giving a message like this, you would probably be making use of one of the latest Laboratories developments for extending the usefulness of the telephone.

Since the early part of this century, inventors have dreamed of a machine which would automatically answer a telephone in the absence of the subscriber, and to do so has been a laboratory possibility for many years. It is only recently, however,

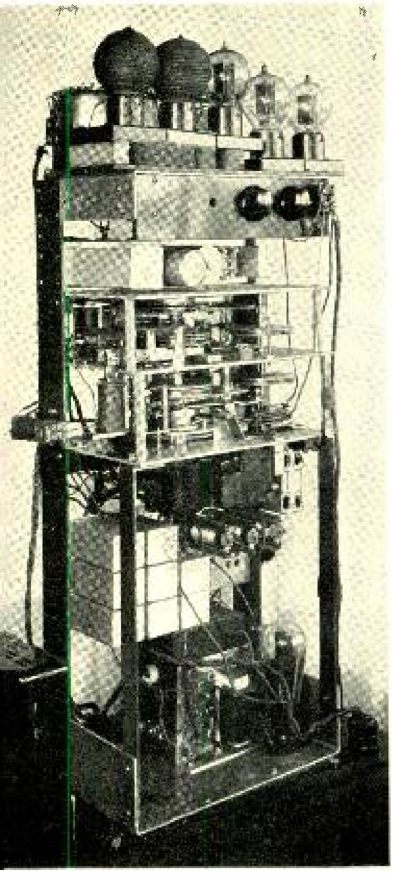


Fig. 1 — Telephone answering machine made by R. F. Mallina in 1935.

that both the art of recording and reproducing sound and the required materials of engineering have reached a stage such that the necessary equipment could be made sufficiently reliable, compact, economical and simple to operate.

Automatic answering devices have been given considerable study by the Laboratories and in the period 1930 to 1935 a working model was put together by R. F. Mallina, using a steel tape magnetic recorder. This machine, shown in Figure 1, would answer a call with a previously recorded message, record incoming messages, and in fact, perform practically all the functions of a modern telephone answering set. However, it was much too complex, expensive and bulky to be used commercially.

During the next ten years marked improvements were made by the Laboratories and others in electronic apparatus and in magnetic recording equipment. A Laboratories development which contributed importantly to the success of a commercial telephone answering set was the invention of a *resilient* magnetic recording medium by J. Z. Menard*. This form of magnetic record is capable of recording and reproducing a message millions of times with no appreciable wear or deterioration in either the recording medium or pickup head, and with no significant effect on the signal quality.

The 1A telephone answering set (Figure 2), about the size of a portable typewriter, is provided in conjunction with the usual telephone set at a moderate, monthly charge. The set is so connected to the line that the normal use of the telephone by the subscriber is possible whenever he so desires. But when he is away, and with the function knob (at left) turned to AUTOMATIC ANSWER, the set is automatically started by an incoming call, gives the calling party a message previously recorded by the subscriber, then records the incoming message, disconnects the telephone line and stops. The total message time available for incoming recordings is about 10 minutes, or twenty full length messages of thirty seconds each. In many types of central office areas the machine is under control of the calling party; that is, it will release if the caller hangs up before using the full 30 seconds recording time allowed.

Recording the announcement is a simple operation for the subscriber. He sees by the illumination of the Bell System Medallion that the set is switched on, turns the function knob to ANNOUNCEMENT DICTATE, and presses the START button below. When he sees a small red light under the word DICTATE, he starts talking, and then presses the STOP button as soon as he finishes, which may be any time between

---

* BELL SYSTEM TECHNICAL JOURNAL, 31, *pages* 530-540, *May*, 1953.

Fig. 2 — 1A telephone answering set.

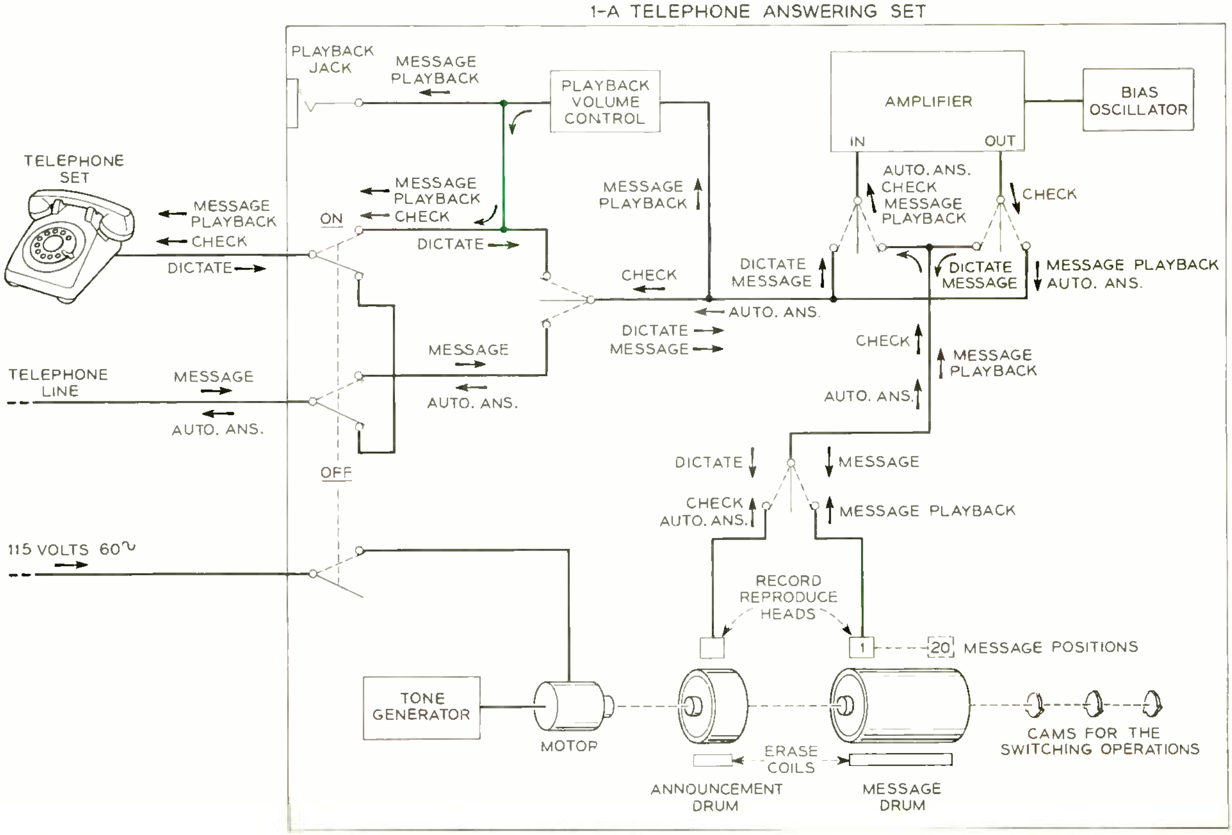


Fig. 3—Simplified diagram of speech paths.

15 and 30 seconds later. Any previous message is automatically erased before the new message is recorded. He may listen to his recorded announcement by turning the knob to ANNOUNCEMENT CHECK and again pressing the START button.

After he is satisfied with his announcement, he turns the knob to AUTOMATIC ANSWER and sets the message scanning knob (at right, Figure 2) to zero. Around this knob is an indicator dial which shows how much of the incoming message space has been used. When this dial is also returned to zero, a "ready" light shows through the function knob opposite AUTOMATIC ANSWER, indicating that the machine is ready to answer incoming calls. All previous incoming messages are then automatically erased by the first incoming call. As noted in the opening paragraph, the calling party first hears the announcement and, after hearing a tone signal, dictates his message.

When the subscriber returns, he turns the function knob to PLAYBACK, the message scanning knob to zero, and presses the START button. He may then listen to the recorded messages through the receiver of his telephone handset (or, if he prefers, by means of a separate receiver) as many times as he wishes, without danger of erasing them. If the subscriber wishes to keep these messages on the drum, and there is still unused record surface available, as shown by the indicator dial, he places the scanning knob at the end of the last recorded message. This closes an auxiliary contact lighting the "ready" lamp, assuring the subscriber that succeeding messages will not be recorded over previously received messages.

A simplified diagram of speech paths for the various functions of the answering set is shown in Figure 3. Although most of the switches and relays are omitted, the paths of speech currents may be traced for the functions just described.

In designing the set to be as useful as

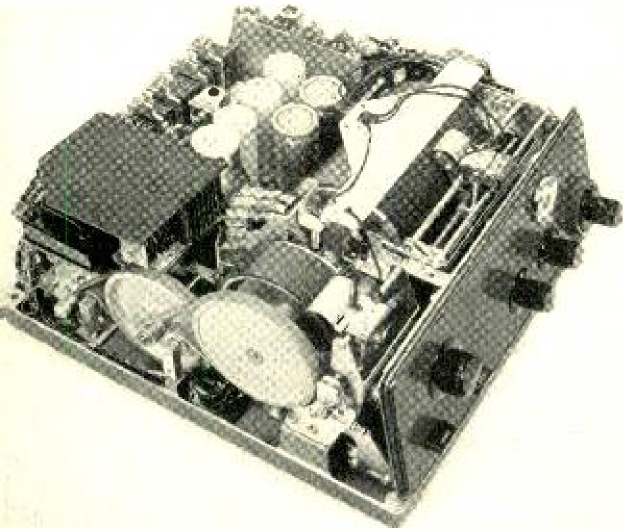


Fig. 4 — Answering set with cover removed. Announcement recording drum appears at center, larger incoming message drum at right.

possible, provisions have been made for using it with the various types of telephone sets and on either individual or selective ringing party lines. Since the subscriber may be called from telephones at great distances as well as from nearby stations, provision must be made for recording incoming messages having sound levels varying over a range of about 60 decibels. This is accomplished by means of an automatic volume control circuit in the recording amplifier. Since the same amplifier is used for playing back the recorded messages, the AVC circuit is disabled during this operation so that the subscriber may adjust the sound level to suit his own hearing.

The outgoing announcement message is recorded on a band of "magnetic rubber" on the smaller of the two drums (Figure 4). Long-life recording heads, specially developed for this project but similar to those used generally in commercial magnetic tape recorders, trace helical paths on the drums as the heads are moved laterally by lead screws. As soon as the carriage holding the announcement head reaches the end of the message, as determined by the time at which the subscriber presses the STOP button during the recording period, it operates a switch that controls relays and solenoids. These in turn stop the announcement drum, and return the head to the beginning of the outgoing message. The switch also starts the incoming message drum, and switches the amplifier from playing the announcement to recording the incoming message. It is positioned to operate just at the end of the announcement message, so that there is a minimum of silent time before the machine sends out a tone signal indicating that it is ready to record the incoming message.

Timing of the signal tones, and of the maximum incoming message length, is accomplished by cams driven by gears from the recording drum shaft. Since these cams

---

THE AUTHOR: **Clyde R. Keith** has been particularly interested in sound recording and transmission apparatus. He was associated with carrier telephone research at the Laboratories from 1922 until 1928 when he transferred to the Western Electric Company in London and six years of installation and personnel training for sound recording systems. Following this he devoted fourteen years at Electrical Research Products to the development of sound recording equipment, including distortion measurement methods and control track recording methods. He served as consultant on sound recording, supervisor of E.R.P.'s development cases at the Laboratories, and liaison between the Laboratories and E.R.P.'s East and West Coast offices. Since his return to the Laboratories staff in 1951 he has been a member of the Audio Facilities Department and is currently working on telephone answering machines. Mr. Keith received his B.S. degree (1922) in physics and engineering from California Institute of Technology, and his M.A. degree (1925) in physics from Columbia University. He is a member of the I.R.E. and a Fellow of the Society of Motion Picture and Television Engineers.

must be instantly reset at any time after they are started (in case a calling party hangs up before the end of the maximum time), they are driven through a solenoid-operated clutch and returned by a spring. Such provisions keep both the line holding time and dead space on the record to a minimum, and allow a maximum number of messages to be recorded on the incoming message space.

Interlocking controls are provided so that a "don't answer" signal is given to the calling subscriber if the set is not ready to take the incoming message either because the incoming message capacity is exhausted or because the machine is incorrectly set. To insure correct setting of the machine a "ready" lamp is provided behind the function knob which lights only if the machine is ready for the particular function set. Thus, if the user turns the dial to AUTOMATIC ANSWER when he has left the message scanning knob in a position within the area of messages already recorded, the "ready" lamp will not light until the scanning knob is moved so that incoming messages will be recorded on unused space.

The various manual and automatic switching functions require seven relays and 43 mechanically operated switches. About half of the latter are in a pair of slide switches operated by the function knob, and most of the remainder are actuated by the timing cams or by the motion of the recording head carriages.

Telephone answering service is now being furnished widely throughout the Bell System. The users, particularly small businesses and professional people, are finding it helpful in a great variety of ways.

Patents Issued to Members of Bell Telephone Laboratories During August

Albersheim, W. J. – *Wave-Guide Elbows* – 2,649,578.

Barney, H. L. – *Voltage and Current Bias of Transistors* – 2,647,958.

Blair, R. R. – *Motor System for Controlling Pressure* – 2,649,560.

Cisne, L. E. – *Filamentary Cathode Support Structure* – 2,649,553.

Davey, J. R. – *Electronic Subscriber's Loop Telegraph Repeater* – 2,649,504.

Ellwood, W. B. – *Machine for Manufacturing Switches* – 2,648,167.

Felch, E. P., Jr. and Merrill, F. G. – *Magnetometer* – 2,649,568.

Harrison, C. W. – *Interstage Coupling Circuit for Wideband Amplifiers* – 2,649,508.

Hickman, C. N. – *Magnetic Recorder* – 2,648,589.

Kock, W. E., and Schimpf, L. G. – *Thermoelectric Translation Device* – 2,648,823.

Lewis, W. D. – *Pseudohybrid Microwave Devices* – 2,649,576.

McDavitt, M. B. – *Radiant Energy Signaling Station* – 2,649,541.

Mallina, R. F. – *Motor Driven Hand Tool for Making Wrapped Wire Connections* – 2,649,122.

Mallinckrodt, C. O. – *Transistor Circuit* – 2,647,957.

Mason, W. P. – *Electro-optical System* – 2,649,027.

Mason, W. P.–*Hall-Effect Wave Translating Devices* – 2,649,574.

Melick, J. M. – *Selective Plural Digit Indicator* – 2,648,830.

Merrill, F. G., see E. P. Felch, Jr.

Newby, N. D., and Vaughan, H. E. – *Apparatus for Generating Time Position Dial Pulses* – 2,648,836.

Pearson, G. L. – *Semiconductor Magnetoresistive Devices* – 2,649,569.

Peterson, E. – *Decoder for Pulse Code Modulation Communication Systems* – 2,650,299.

Radcliffe, F. E. – *Test Equipment and Method for Measuring Reflection Coefficient* – 2,649,570.

Reck, F. – *Tool for Effecting Solderless Connections Between a Wire and a Terminal* –2,649,121.

Robertson, S. D. – *Microwave Carrier Telephone System* – 2,649,539.

Teal, G. K. – *Preparation of Two-Sided Mosaic* – 2,650,191.

Townsend, M. A. – *Cold Cathode Electric Discharge Device* – 2,650,320.

Vaughan, H. E., see N. D. Newby.

Vroom, E. – *Selective Signaling System* – 2,648,831.

Wallace, R. L., Jr. – *Polyphase Oscillator* – 2,648,773.

Young, W. R., Jr. – *Noise Detection Circuit* –2,648,765.

Schimpf, L. G., see W. E. Kock.

Outdoor Exposure Tests at Miami

Bell Laboratories maintains several outdoor test locations to study the effects of weather exposure on a variety of materials and products used or contemplated for use in the telephone plant. One of the more specialized of these plots is at Miami, Florida where several types of insulated wires with a variety of outer coverings are strung high over the garage yard of the Hialeah exchange. These lines are maintained by the Outside Plant Development Department of the Laboratories through special arrangement with the Southern Bell Telephone and Telegraph Company who install new lengths of wire, remove samples at periodic intervals for our evaluation, and do the necessary maintenance work. The accompanying photograph shows the test location.

Miami was chosen because it provides a relatively high temperature throughout the year, combined with bright sunlight and good soaking rains. This is a combination of weather that accelerates the degradation of organic materials usually employed on outside distributing wires. It is here that experimental wires with a variety of insulations and outer coverings are exposed and their durability evaluated against similar wires of standard construction. The information obtained from this rather severe outdoor weathering test is used in conjunction with the more accelerated laboratory evaluations to aid in the selection of new materials and wire designs.

The data obtained from experimental wires evaluated at the Miami test location were of exceptional value in reaching the decision to adopt neoprene jackets to replace weatherproofed cotton braids on drop wire and other insulated outside distributing wires. The decision to proceed with polyethylene compound as sheath for cable was influenced by the excellent weathering characteristics exhibited by a polyethylene insulated wire that had been prepared in the laboratory and exposed for at least 10 years at Miami.

In a similar manner, the performance of improved formulations of polyvinyl chloride jackets used on JKT Station Wire is being observed in the test location. This wire, originally intended for indoor use, has demonstrated its ability to withstand weathering so well that it is also being used for some outdoor applications.

W. S. Bishop
Outside Plant Development

Test location at Miami, Florida. Wires with various types of insulation are here exposed to determine their weathering characteristics.

A New Service Observing Desk

H. E. NOWECK
Switching Engineering

Telephone management is always interested in knowing the quality of service the public receives whenever it uses telephone equipment. A measure of this quality of service is also necessary in managing and engineering the telephone plant effectively. Service observing is one important way in which information regarding telephone service can be obtained to aid management in determining the need for operator refresher courses, customer education programs, more equipment, or additional preventive maintenance. An improved centralized type of service observing desk, designed to meet the needs of increasing dial toll traffic, has been developed.

An important means for measuring the quality of service received by customers when they use their telephones or encounter telephone personnel is to have trained operators actually observe and grade the service by obtaining basic service data on individual calls. Such observations are made on all types of services and traffic. Of particular interest, however, is the service rendered on toll calls. The growing number of toll calls and the extensive use of operator toll dialing, which involves complex switching equipment and outside plant, has made the methods and equipments heretofore available for observing toll calls inadequate.

A new type of service-observing desk, coded No. 12, has therefore been developed for centralized service. An over-all view of a typical desk of this type is shown in Figure 1. It is composed of a seven-panel, two-

Fig. 1 — Four sections of a No. 12 service observing desk at the 36th Street Building in New York City.

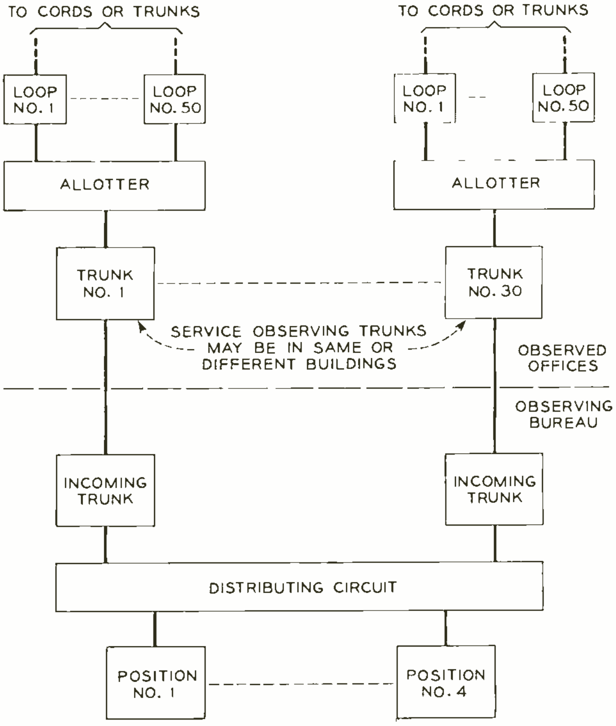


Fig. 2 — A block diagram of a No. 12 service observing system.

position section. Two of these sections, four positions in all, constitute a standard service-observing unit. Although this desk was developed primarily to provide improved facilities for toll observations, it may also be used for other types of observations. Circuits are provided for observing on local dial traffic, for determining the speed with which operators answer line-lamp signals, and for determining the service given by operators on such auxiliary services as information.

The toll and local dial circuits are arranged to pick up calls automatically and to distribute them to available observers at the service observing desk, which may be in a distant office. When an observation is completed, an observer may release the observing connection by operating a release key. Her position then becomes available for another call. Although the circuits for observing the speed of answering are also arranged for automatic distribution, an alternative arrangement is available in which an observer picks up a call by a key operation. Facilities for miscellaneous observations are all key ended.

Since an observed call is connected either automatically or by means of a key, service observing cords used in previous desks are not required. This results in a minimum amount of equipment on the key shelf and provides an unobstructed area that is free for use in keeping service-observing records.

Because of the different types of services to be observed, each requiring the transmission to the observing desk of different types of information, the board is arranged for association with six types of observing trunks: cord, intertoll, local dial, centralized automatic message accounting (CAMA), speed of answering, and key-ended trunks. Cord observing trunks are associated with operator's cord circuits at toll boards, and are usually employed for observing outgoing toll traffic. Both intertoll and local dial service observing trunks are used for dial traffic: the former, for observing on incoming intertoll trunks, and the latter, for observing on the subscriber lines. The CAMA observing trunk is used for observing on dial traffic to crossbar tandem offices equipped with CAMA equipment. Speed of answering trunks are associated with manual incoming positions — either toll or DSA.* In addition, there are the key-ended trunks, which are generally the same as those used in present service-observing desks.

A No. 12 observing unit may have as many as thirty observing trunks arranged for automatic distribution, and these trunks, depending on local conditions, may be of any of the five types of call-distributing trunks given above. At their distant ends, which may be in different buildings, each of them except the speed-of-answer trunk may be associated, through an allotter circuit, with as many as fifty trunks or cords that are to be "observed". The speed-of-answer trunk may be associated with one hundred trunks, since the duration of an observation of this type is much shorter

---

* Record, *August*, 1931, *page* 576. "DSA" gets its name from "dial system A board," when operators at small manual switchboards answer the subscriber when he dials "operator."

than that of the other types. This general arrangement is indicated in Figure 2.

To insure that the data from observations are truly representative of the service rendered by an office, it is necessary that the sample, or the number of observations from which data are computed, be adequate. Over a given period an observer must record a certain minimum number of observations. This is known as her quota of observations. Since calls of different types are automatically connected to an observer's positions, means have been provided so that an observer may control to some degree the number of a particular kind of call that may be connected to her position. Thus she need not be burdened with unwanted observations while desired ones are excluded.

Control over the type and number of observations received is exercised in several ways. Observations of a particular type from a given office may be excluded from all positions by the operation of an "out of service" key associated with the incoming end of the service-observing trunk. This key is located in the cable turning section of the desk. A particular type of observation from an office may be excluded from a given position by the operation of a key located in the face equipment at the given position. This key is termed a "Class Exclusion" key, and one is provided at each position for each type of observation that the position is equipped to handle. These keys are beside the display panel for each position in Figure 1. A third method of control is by means of a key called a "loop reduction" key, which is provided for each service-observing trunk and which is located in the cable turning section of the desk. When the loop reduction feature is provided, the loop, or connector, circuits in the distant observed office may be divided into two subgroups. The setting of the loop reduction key, which is a three position key, determines which of the two subgroups of loops is effective in accepting calls. In the normal position of the key both subgroups of loops will be effective. By means of these keys, it is possible to control the number of a particular type of observation a service-observing team may receive from a given operating unit, or to exclude a particular type of observation from a given position while allowing other positions to continue to receive that type of observation.

Different methods are employed at the distant offices for connecting the loops associated with each observing trunk to the circuits to be observed. For observation of manually handled traffic two methods have been provided. The first is by means of a jack having soldered connections to the cord conductors of the observed circuit. Each loop also terminates on a jack; and a patch is made between the two jacks with a cord having a plug at both ends. The second method is by means of a clip-on device called a "shoe" which has been developed for this purpose. A cord connected to this shoe has a plug on its other end which can be inserted in a jack connected to a service observing trunk. The shoe makes connection to the cord circuit conductors at the cord shelf in the rear of the switchboard. A typical connection using the latter arrangement may be seen in Figure 3. These methods permit representative data to be obtained which is not influenced by an operator's awareness of being observed.

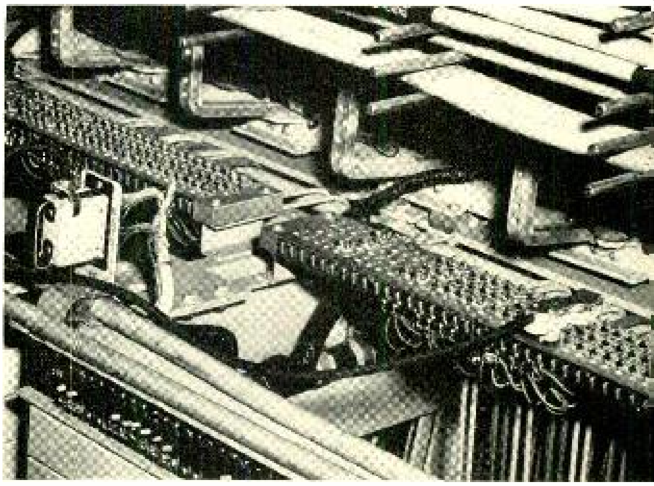


Fig. 3 — A closeup view of the cord shelf at the rear of a toll switchboard showing the shoe used for connecting cord circuits to the No. 12 observing desk.

For speed of answer observing trunks, connections are made to trunk circuits at an intermediate distributing frame (IDF)

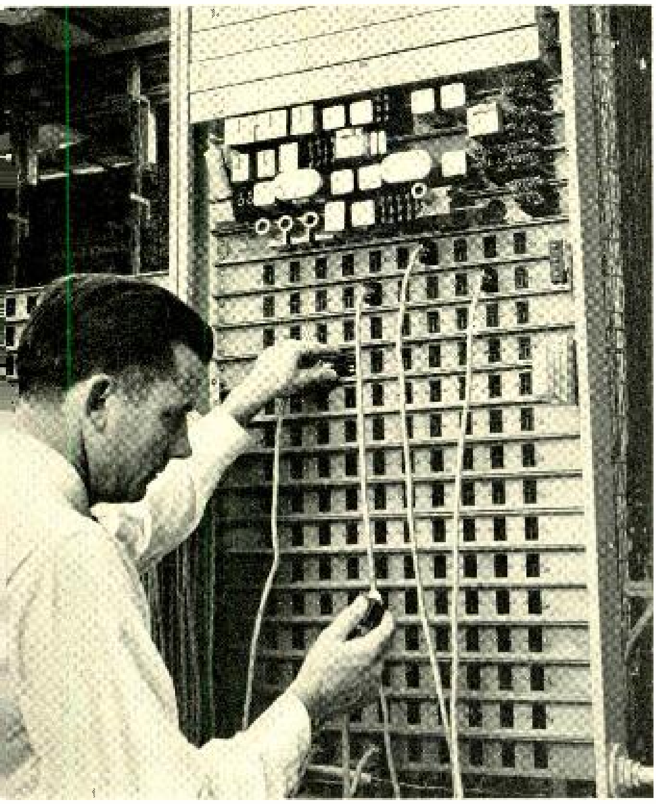


Fig. 4 – The author at a patch panel used for connecting dial incoming toll trunks to the service observing desk.

by means of a "shoe" connecting to a plug-ended cord which may be plugged into a jack box mounted at the top of the IDF.

For observing intertoll dial traffic and local dial traffic in crossbar offices, the necessary service-observing connections are wired to jacks on a patching panel. Mounted on this patching panel also are jack appearances of the loops that may be associated with an observing trunk. These may be patched to a service-observing appearance of an incoming trunk or subscriber's line by means of a patch cord. Assignment of trunks or lines for observations can readily be changed by changing the patching. A view of the patching panel is given in Figure 4.

A maximum of two hundred incoming intertoll trunks may be selected for observation. In panel and step-by-step offices, connections for local dial observing are made by means of a cord equipped with a "shoe". This shoe is clipped onto a subscriber's line terminal on an intermediate distributing frame and the other end of the cord is plugged into a jack box at the top of the IDF.

An important feature of this desk is that it may be centralized with respect to operating units to be observed within a range of thirty miles. To provide the necessary signaling range to permit such centralization, converters are used at the distant offices to accept either dial pulsing or dc key pulsing from a cord, and to convert the pulsing to Multi-Frequency (MF) pulsing for transmission to the desk. If MF pulsing is used in the switchboard position no conversion is necessary. If an operating position uses combined MF-DC key sets, a converter is automatically connected to the service observing trunk whenever a call is established on a dc key pulsing basis.

The principal features of the No. 12 desk as well as the manner in which an observer obtains typical information is brought out through the following discussion of the cord-service-observing circuit which is used in this desk principally for observing on outward toll calls. When a call has been connected to a service-observing position through the allotting circuit at the distant office and the distributing circuit of the No. 12 desk, a "Trunk" lamp, having a numerical designation of one to a maximum of thirty, according to the number of trunks equipped, lights as a signal for an observer to start an observation and also as an identification of the operating unit (office) originating the call. Since the loop circuits associated with a particular service-observing trunk at the observed office may be connected to cords of two different operating units, the trunk lamp may light steadily or may flash at a rate of 120 illuminations per minute. Thus through arbitrary assignment, the steady or flashing condition of the trunk lamp will identify which operating unit is connected. The lighting of the trunk lamp also serves to identify the type of call connected to the position – cord, intertoll, and speed of answer service-observing. Since each type of call requires different kinds of information, this identification enables an observer to select quickly the proper form for recording her observations.

An observer starts timing occurrences from the moment the trunk lamp lights. For this purpose, an electric stop-clock has been provided which is mounted in the face of the service observing desk as may be seen in Figures 1 and 5. The comfort of an observer in using this clock has been taken into consideration in its design. The mounting of the clock in the face equipment permits her to rotate the clock horizontally by as much as ± 10 degrees. Although the clock cannot be tilted in a vertical direction, it is mounted so that the face inclines upward at a 10-degree angle, which prevents any glare from striking the observer's eyes. For further insurance against glare, the clock window is made of anti-glare glass.

As shown in Figure 5, the clock is provided with three hands. The first is a minute hand which can total fifty minutes in one revolution – read on the inner dial in units of one hundred seconds. The second is a second hand which indicates one hundred seconds in one revolution. For each revolution of this latter hand, the minute hand moves one division. The third hand is a split second hand which rotates with the second hand except when stopped by the observer. The observer can control the stop clock by means of a hand switch fastened to a cord which may be plugged into a jack on the knee rail of the desk. This switch may also be seen in Figure 5. When an observer rotates a large knurled control knob on the hand switch a quarter of a revolution clockwise, the minute and second hands will begin to move. The observer can cause the split second hand to remain stationary by depressing and holding a button on the switch. The minute and second hands will continue to rotate and when pressure on the button is released, the split second hand will re-align itself with the second hand. When the observer returns the control button to normal all hands will stop. Rotation of the control button to the counterclockwise position will reset the hands to their starting position.

Lamps are provided in the face equipment of the service-observing desk which enable an observer to follow the progress and events of calls. The lamps may be seen just to the left of the dial in Figure 5. They are in two sets. The first set indicates events occurring on the rear cord and the second set indicates events occurring in connection with the front cord. By means of these lamps an observer is able to tell when an operator plugs up or pulls down a cord, when she rings on a cord, when either the calling or called customer hangs up, and also the type of supervisory flashes (reorder, overflow, master busy, etc.) being received by an operator in connection with the establishment of a dial call.

A very important feature of the No. 12 service-observing desk which has not previously been available is the provision of facilities which will permit an observer to follow all dialing and keying operations of an operator and will permit her to witness all supervisory signals an operator may receive during the course of her keying operation. The facilities for following dialing or keying operations have visible expression in the form of the display panel immediately above the stop clock in Figure 5. This

Fig. 5 – Closeup of a No. 12 service observing position.

digit display panel has a maximum capacity of sixteen digits which is adequate to record all digits required in establishing a call.

The lamps and display panel used for cord observations are also used with incoming intertoll observation for supervisory signals and for the display of the called number. However, not all of the supervisory lamps are used, and the signals received on those which are used have different interpretations for intertoll observations and cord observations. It is necessary therefore that an observer be thoroughly familiar with all types of traffic in order that interpretation of lamp signals be made correctly.

Both the speed of answer and incoming intertoll service observing trunks have many features in common with the cord observing trunk, such as high impedance connections, loop reduction, and class exclusion. In both speed of answer and cord observing, no effort is made to identify the operator handling a call even though this could readily be done in cord observations by identifying the loop originating a call. However, on incoming intertoll observations the incoming trunk originating a service observation is identified through identification of the loop. This is done for maintenance reasons, for determining the effect of traffic on the office, and the effect of momentary seizures on the call-handling capacity.

When a local dial or intertoll call is connected to a position, the number of the associated loop connector circuit is displayed on two rows of lamps. If for any reason this identification system fails, an "Identification Failure" lamp located in the face equipment will light.

For universality, an existing local dial service-observing arrangement which is used to determine the quality of local dial service rendered a customer has been arranged for inclusion in the desk. Similarly, existing key ended service-observing trunks which are used for miscellaneous observations have also been included. Whenever a key ended trunk is in use at a position, the position is made busy to calls which are distributed automatically.

The arrangement of the position circuit of the No. 12 service-observing desk varies considerably with the types of service-observing trunks handled at the position. When the position circuit is associated with a local dial circuit, for example, facilities are required to register the number dialed on a pen register. On the other hand an MF receiver and lamp display indicator is required to record the number keyed or dialed when the position circuit is associated with a cord or inward intertoll trunk. Similarly, a loop identification circuit is associated with either the inward intertoll or the local dialed circuit, but it is not required in connection with the speed of answer or the cord observing trunks. The proper arrangement of the position circuit to meet the different requirements for each type of call is automatically obtained through the operation of suitable relays controlled from the service-observing trunk connected to the position circuit.

THE AUTHOR: HERMAN E. NOWECK transferred to the Laboratories in 1945 after nine years with the Western Electric Company in Baltimore. As a member of Western Electric's Inspection Development Laboratory, he was first associated with laboratory testing and the provision of shop inspection equipment, later becoming supervisor of the Laboratory. He was later project test engineer on crew trainer radar and rocket launcher equipments during World War II. At the Laboratories, in Switching Development, his work has been in toll switchboard and trunk design, and sender and sender test frame design. Recently, in Switching Engineering, he has been responsible for the planning for auxiliary services and service observing. He is currently supervisor of a group conducting maintenance studies. Mr. Noweck received his B.S. degree in E.E. from Johns Hopkins University in 1936.

Talks by Members of the Laboratories

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

NATIONAL ELECTRONICS CONFERENCE, CHICAGO

Bashkow, T. R., Stability Analysis of a Basic Transistor Switching Circuit.

Blecher, F. H., Automatic Gain Control of Junction Transistor Amplifiers.

Kretzmer, E. R., An Amplitude-Stabilized Transistor Oscillator.

Linvill, J. G., R-C Active Filters.

May, John E., Characteristics of Ultrasonic Delay Lines Using Quartz and Barium Titanate Ceramic Transducers.

Pennell, E. S., A Temperature-Controlled Ultrasonic Solid Delay Line.

A.I.E.E. PACIFIC GENERAL MEETING, VANCOUVER, BRITISH COLUMBIA

Barstow, J. M. and H. N. Christopher, Measurement of Random Monochrome Video Interference.

Case, R. L. and I. M. Kerney, Program Transmission Over Type-N Carrier Telephone.

Christopher, H. N., see J. M. Barstow.

Coy, J. A., Heat Dissipation From Toll Transmission Equipment.

Fracassi, R. D. and H. Kahl, Type-ON Carrier Telephone.

Kahl, H., see R. D. Fracassi.

Kerney, Iden, see R. L. Case.

Mahoney, J. J., see E. H. Perkins.

Perkins, E. H. and J. J. Mahoney, Type-N Carrier Telephone Deviation Regulator.

OTHER TALKS

Baldwin, M. W., Subjective Measurements in Television, American Psychological Association Symposium, Cleveland.

Biggs, B. S., Accelerated Aging Studies on Polyethylene for Cable Sheaths, Middle Eastern District, A.I.E.E., Charleston, W. Va.

Blecher, F. H., Automatic Gain Control of Junction Transistor Amplifiers, I.R.E., Northern New Jersey Subsection, Murray Hill, N. J.

Bond, W. L., Crystal Symmetry and How It Affects the Outward Appearance of Crystals, Lapidary Society, Newark, N. J.

Bozorth, R. M., Mechanism of Magnetization and the Properties of Ferrites, Joint Meeting, Institute of Electrical Engineers of Japan and Institute of Communication Engineers of Japan, Tokyo.

Bozorth, R. M., Theory and Application of the Ferrites, University of Osaka, Osaka, Japan.

Calbick, C. J., see H. Christensen.

Campbell, W. E., Analytical Chemistry in the Solution of Field Problems, American Chemical Society, Cleveland.

Cherry, D. D., see J. C. Lozier.

Christensen, H., C. J. Calbick and E. E. Thomas, Cleavage Surfaces in Germanium Crystals, Two Papers, American Physical Society, Albuquerque, N. M.

David, E. E., Principles and Problems in Underwater Sound, U. S. Navy Research Unit 4-1, Princeton.

Felch, E. P., Panel Discussion, Instrumentation in Research and Development, National Instrument Conference, Instrument Society of America, Chicago.

Felch, E. P. and Prof. J. L. Potter, Rutgers University, Preliminary Development of a Magnettor Current Standard, National Instrument Conference, Instrument Society of America, Chicago.

Felker, J. H., Transistors in the TRADIC Digital Computer, Research and Development Board Symposium on Application of Transistors to Military Electronic Equipment, Yale University.

Ferrell, E. B., Control Charts Using Midranges and Medians, Conference Series, Statistical Quality Control, Rutgers University, Newark.

Fox, A. G., Non-Reciprocal Ferrite Devices with Transverse Magnetic Fields, Ferrites Symposium Under Auspices of Research and Development Board, Massachusetts Institute of Technology, Cambridge.

Greenidge, R. M. C., Electronic Component Reliability and Associated Problems, Engineering Research and Development Staff, General Mills, Inc., Minneapolis.

Karlin, John E., Psychology in Communications Research, American Psychological Association Symposium, Cleveland.

Lozier, J. C. and D. D. Cherry, A Transistor Feedback Amplifier for Carrier Frequency Application, Northern New Jersey Subsection, I.R.E., Murray Hill, N. J.

McMillan, B., The Role of Information Theory, American Psychological Association Symposium, Cleveland.

Morton, J. A., The Future of Transistors, Research and Development Board Symposium on Application of Transistors to Military Electronic Equipment, Yale University.

Munson, W. A., Hearing and Psychophysics, American Psychological Association Symposium, Cleveland. Read by J. E. Karlin.

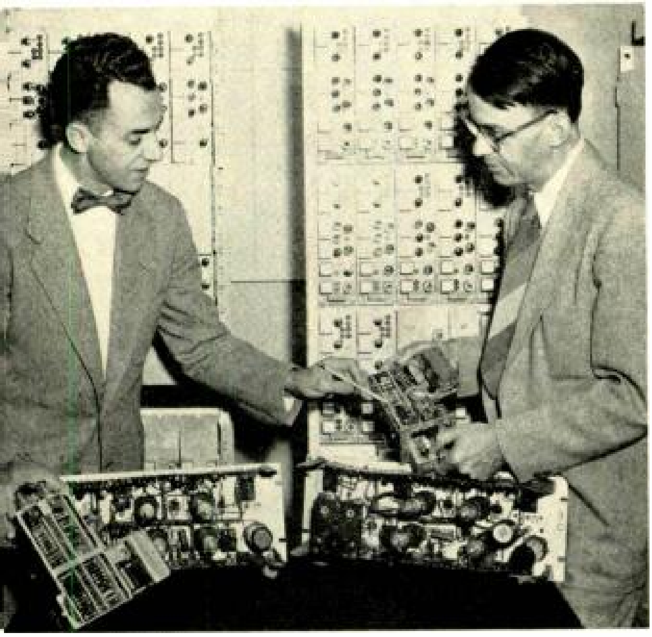
Stone, H. A., Miniaturized Components for Use in Transistor Circuits, I.R.E. Meeting, Cedar Rapids, Iowa.

Thomas E. E., see H. Christensen.

Vogel, F. L., Lineage Boundaries in Germanium Single Crystals, Physics of Metals Conference, Royal Military College, Kingston, Ontario.

Vogelsong, J. H., A Transistor Pulse Amplifier, Research and Development Board Symposium on Application of Transistors to Military Electronic Equipment, Yale University.

Wallace, R. L. Jr., Transistors, Society of Hearing Aid Audiologists and International Hearing Aid Association, New York City.



The author (left) discusses with S. Doba a feature of the N1 compressor. The reduction in size obtained by equipment miniaturization is illustrated by comparison with the older A1 compressor and A1 expandor panels shown on the table.

The Compandor in N1 Carrier

R. D. FRACASSI
Transmission Systems Development

Energy put into a telephone circuit by the voices of telephone customers varies over a wide range. The power ratio of the strongest to the weakest significant sounds often amounts to a million to one or 60 db. Part of this, about 35 db, is due to the fact that some people talk louder than others and also to the way people talk into transmitters. The remaining 25 db is due to the natural differences in energy intrinsic to different speech sounds. To prevent overloading amplifiers when speech is transmitted at volumes high enough to carry weak consonant sounds above the noise level, a "compandor" is used to automatically compress the intensity range before transmitting it, and to expand it to its original intensity range at the receiving end.

Over the years, telephone engineers have striven to extend the distance over which speech can be transmitted not only intelligibly, but also with practically no impairment of its original character. One of the chief problems continually facing the engineer is the preservation of sufficient amplitude in the signal being transmitted so as to override the disturbing influence of noise currents that are present in all transmission media. Although these noise currents are usually phenomena of nature, they can also be man-made, such as disturbances from other circuits in the same carrier system or from other systems in the same cable.

Signal-to-noise margin may be improved in a telephone circuit by the use of a device termed a "compandor". This is a device which automatically increases the amplitudes of the weak speech currents and permits their transmission over a circuit with an improved signal-to-noise ratio. At the far end, the signals are restored to their proper level by a compandor located at the circuit terminal. Although this process results in the desired higher levels of currents over the circuit for weak talkers, the action is controlled so that the increased amplitudes are not great enough to overload line amplifiers or other electronic circuits in the transmission path. The level changes produced by the device are greater for weak talkers than for loud talkers. In the case of the loudest talkers, where no enhancement of signal is necessary, the device produces no change.

The increase and the restoration of weak speech amplitudes by the compandor are accomplished at high speeds. This feature permits a signal enhancement which is controlled according to the need of each individual syllable.

The term "compandor" is a coined name derived from the two basic functions of the device. Its function is to "compress" the intensity range of the speech before transmitting it, and then, at the receiving end, to "expand" it to its original intensity range. Hence the name "compandor" suggests the functional operation of the two component parts of the apparatus.

Early in the development of the N1 carrier system, it became evident that the most important single feature needed for the system was the compandor. A device of this type was already available in commercial form, but because of size and cost, it could only be used on the longer carrier systems.* For the N1 system, therefore, it was necessary to develop an inexpensive compandor that would provide an economical design for shorter distances and still meet the specified transmission requirements.

Economies were foreseen in more lenient filter requirements, elimination of balancing networks for reducing crosstalk between cable pairs, and greater repeater spacings than would be possible if a voice frequency compandor for each message channel were not used. Somewhat relaxed requirements permitted the elimination of temperature control ovens, which in previous compandor circuits had been needed to house critical non-linear elements. Making the compandor an inherent part of each channel permitted the use of normally required circuit features for dual purposes, and, of course, miniaturization of components aided in reduction in space requirements.

A compandor serves to reduce appreciably the interference effects of noise and crosstalk in a channel. The manner in which this is done can be illustrated by Figure 1, which shows a compressor and an expandor connected by a transmission line. The compressor raises the level of the weak speech input so that it is transmitted over the line at a considerably higher level, thus improving materially the signal-to-noise ratio. Since strong speech signals are already of sufficiently high level to override noise and crosstalk, they are transmitted over the line with little or no change in level. At the expandor, the reverse process occurs, which restores the speech to its original range of levels.

A typical input-output characteristic of the compressor and expandor is shown in

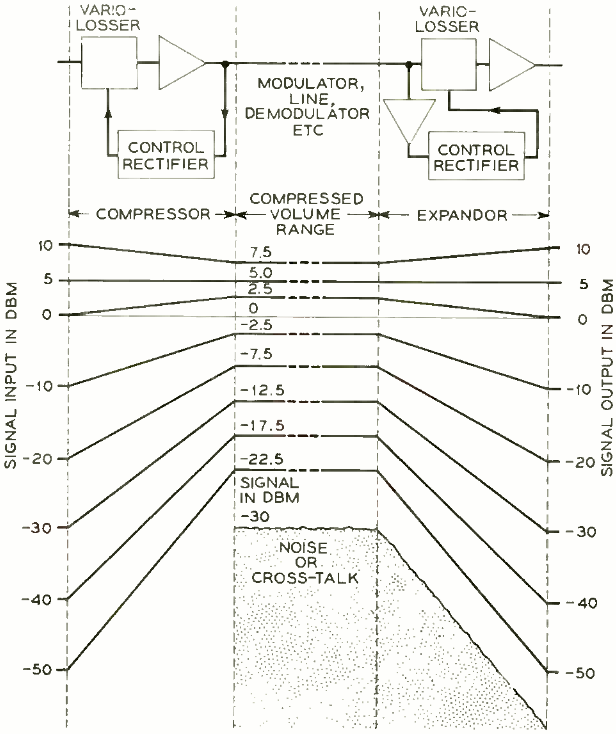


Fig. 1 — How a compandor works. The compressor raises the level of weak speech input, but strong speech is transmitted with little or no change in level. The expandor restores speech to its original level.

---

* RECORD, *December*, 1934, *page* 98.

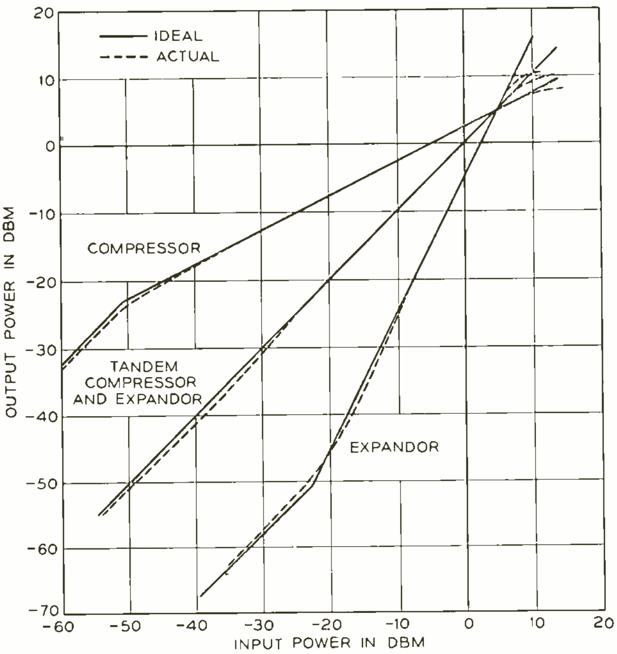


Fig. 2 — Typical input versus output characteristics of the compressor and expandor.

Figure 2. Referring to the compressor curve, from about +5 dbm input down to about —51 dbm, the so-called "knee" of the curve, the output change is 1 db for each 2 db change in input. Below —51 dbm input, the compressor acts as a linear circuit. Conversely, for the expandor, from about +5 dbm input down to about —23 dbm input the "knee" of its curve, the output change is about 2 db for each 1 db change in input. Below —23 dbm, the expandor acts as a linear circuit, similar to the compressor. Extending the ranges of the compandor below the indicated "knee" values provides little or no benefit, because of interference from noise currents normally existing in the transmission circuit.

The compressor circuit is shown schematically in Figure 3. The essential features of the circuit are contained in the three parts designated as the variolosser, amplifier, and control circuits. Speech signals applied to the input of the compressor pass first through the variolosser, which consists of a balanced attenuator circuit using germanium varistors in the shunt arms.* After passing through the two-stage voice frequency amplifier, the speech power is divided between the output circuit and the input to the control circuit. The part passing into the control circuit is rectified and the resultant direct current is passed through the variolosser in a logitudinal manner. Since the elements of the variolosser are arranged in a balanced bridge circuit, control current variations do not produce interference or "thump" in the transmission path. The balance requirements are an important part of the variolosser performance. The arrangement of Figure 3, where the power applied to the control circuit is obtained from the output of the device, is commonly referred to as a "backward acting" circuit.

In the amplifier circuit, two 408A electron tubes provide about 40 db gain. Stability is obtained through the use of nearly 20 db of feedback, a small part of which is under the control of the COMP potentiometer. This potentiometer is used for adjustment or line-up in the field, enabling the operating personnel to adjust the circuit at a single level with a single control similar to any ordinary amplifier gain adjustment.

Speech power applied to the control circuit through the transformer T3 first passes through a resistance network that serves both to establish the limiting point of the amplifier and to control the impedance presented to the full wave varistor rectifier. Capacitor C2 is connected across the output of the rectifier, and serves as one of the elements determing the action time of the variolosser; it also acts as a filter element. Resistor R1 controls the magnitude of the current applied to the variolosser. This direct current changes the impedance of the varistors, and hence the transmission loss, in accordance with the strength of the incoming speech.

The speed with which the variolosser changes its loss depends to some extent on the strength of the applied signal. Loss in the variolosser circuit changes from that of its idle condition to a steady-state operating condition value in 2 to 3 millisec-

---

* Earlier variolossers used electron tubes. See RECORD, 13, *December,* 1934, *page* 98.

onds after the application of the signal at the input to the compressor. The time required for the circuit to return to its idle condition value is 10 to 15 milliseconds after removal of the applied signal. The effect of these times, when speech is applied, is to produce a changing loss in the variolosser at a syllabic rate. The action is too slow to follow voice frequencies, but is sufficiently fast to follow the envelopes of syllables. The compression action of the compressor circuit on steady state tones is illustrated by the dashed curve of Figure 2.

Expandor action is the opposite of that provided by the compressor – loss is removed from the variolosser circuit with the application of a signal to the input. The simplest method of providing this action would be to use an arrangement of varistors in the series arms and resistors in the shunt arms, which is the inverse of the configuration used in the compressor variolosser. Such an arrangement, however, inherently introduces a "dead" loss, because the varistor impedance must always be large compared to the shunt resistor in order for the varistor to control the loss properly. To overcome this "dead" loss would require an additional stage of amplification in the output amplifier. The expandor circuit used is shown in Figure 5. It also consists of three major sections: variolosser, control circuit, and output amplifier. Unlike the amplifier in the compressor circuit, however, the expandor amplifier is not involved directly in the expandor operation. It provides gain to produce the desired output level, and, incidentally, provides more convenient test levels for expandor measurements. Broadly speaking, the output am-

Fig. 4 – The author describes the construction of the N1 compressor to A. H. Schuh.

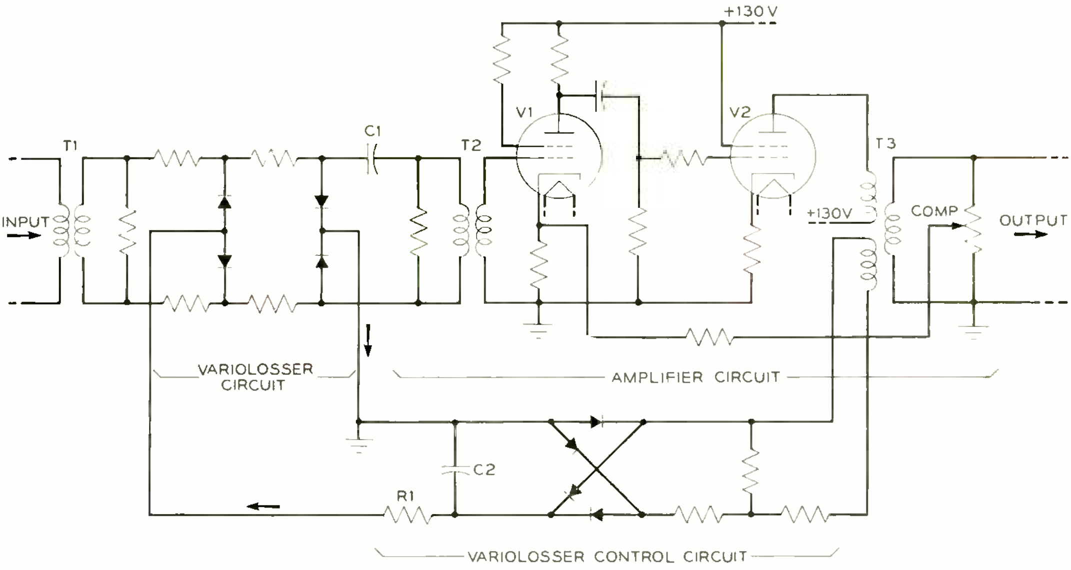


Fig. 3 – Schematic circuit of the compressor.

plifier is not an additional expense chargeable to the use of the compandor, because an amplification stage would be required even if the compandor were not used.

Like the compressor, the expandor requires but one operating adjustment in the field. This control is the potentiometer marked EXP in the input circuit. A second control, labeled R10 in Figure 5, is a factory adjustment resistor that shapes the expansion characteristic at high levels of applied signals.

As shown in Figure 5, a fixed bias current from the 130-volt power supply is passed through the shunt varistors VR1 and VR2 under control of resistors R3 and R4, to establish the desired ac impedance of these varistors for the idle condition. In the absence of an input signal, and consequently no dc control current, the varistors in the series arms, VR3, VR4, VR5, and VR6 have a high impedance and thus insert the desired high loss. Bridging resistors R7 and R8 control the idle condition loss to close limits.

With the application of low level signals to the input of the expandor, direct current from the control circuit passes along the parallel paths R5, VR4, VR3, R1, and R6, VR6, VR5, R2. No current goes through the varistor VR7 because of the blocking bias established by the voltage drop across R9 that results from the current supplied through resistor R10. As the control current increases with increased input signal, a point is reached when the voltage drop across R5, VR4, and VR1 exceeds the blocking voltage across R9 and some control current will start to flow along the paths VR7, R9, VR1, VR3, R1 and VR7, R9, VR2, VR5, R2.

The control current thus passing through the varistors VR1 and VR2 is of a polarity to reduce the initial bias current, and causes an increase in the ac impedance of the shunt varistors. This reduces the loss of the variolosser and supplements the action of the series varistors. When the input signal

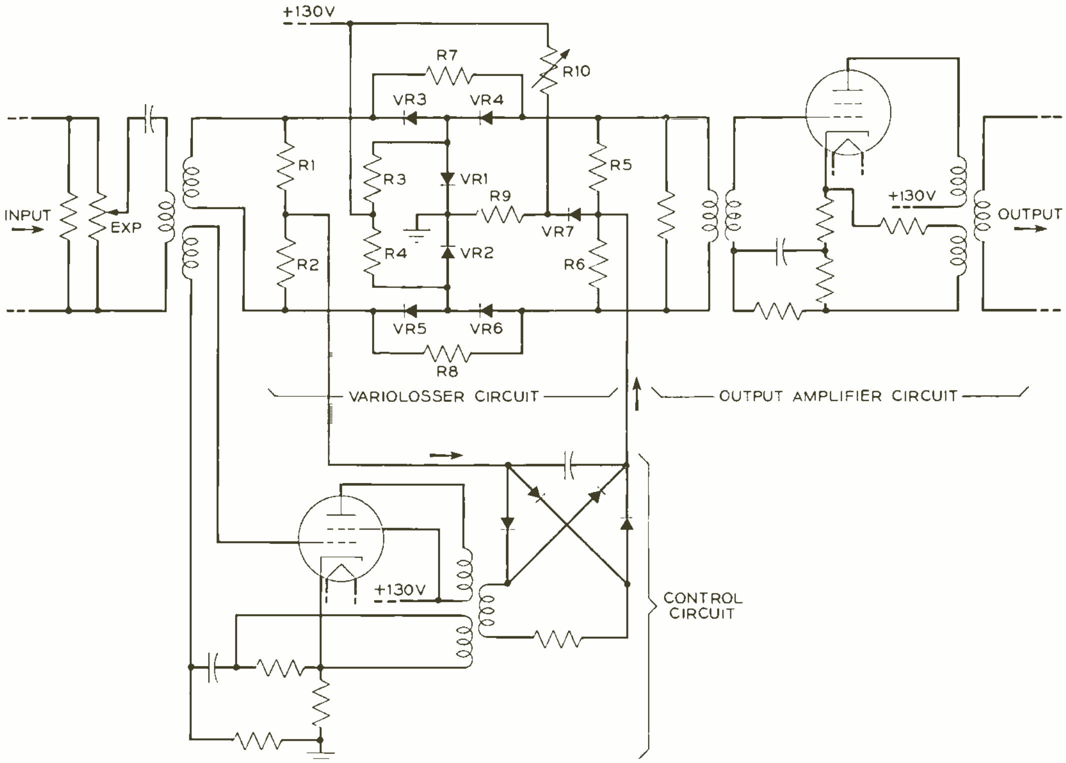


Fig. 5 — Schematic circuit of the expandor.

THE AUTHOR: R. D. FRACASSI had been engaged in system engineering in the American Telephone and Telegraph Company's Development and Research Department for four years when that department was transferred to the Laboratories in 1934. He became interested in thermistors and the stabilization of voice frequency cable pair losses as affected by temperature. He was also associated with the 15 kilocycle program circuit. During World War II his assignments were related to radar development, covering tubes for radar use and allied apparatus. More recently he has been a member of Transmission Systems Development, concerned with type-N, type-O, and type-ON carrier systems. Mr. Fracassi received both his B.S. and M.S. degrees in E.E. from M. I. T. in 1930.

is at its maximum level, the impedance of the shunt varistors is high and that of the series varistors low, thus virtually reducing to zero the loss in the variolosser.

The signal that provides the control current is taken from the input of the expandor in contrast to the output connection used in the compressor; hence the expandor may be looked upon as a "forward acting" circuit. The signal frequencies that energize the control circuit in the expandor are also those that energize the control circuit in the compressor, the only difference being that they are taken from the transmission circuit at the ends adjacent to the corresponding units.

The time required for the expandor to reach a steady state operating condition is about 5 milliseconds and the decay time is approximately 30 milliseconds. The dashed curve in Figure 2 adjacent to the expandor curve illustrates a typical input-output expansion characteristic obtained with steady state tones.

Early fundamental development of the compressor and expandor circuits was under the direction of S. Doba, with the assistance of J. W. Reike.

Customer Long-Distance Dialing

In November and December, the customers of two more No. 5 crossbar offices will be able to dial directly to some twelve million telephones in fourteen large cities throughout the country. The first such installation – Englewood, N. J. – went into operation late in 1951. The "Valley" exchange in East Pittsburgh, Pa., and the "Midwest" exchange in Birmingham, Mich., are the latest offices slated for cutover this year.

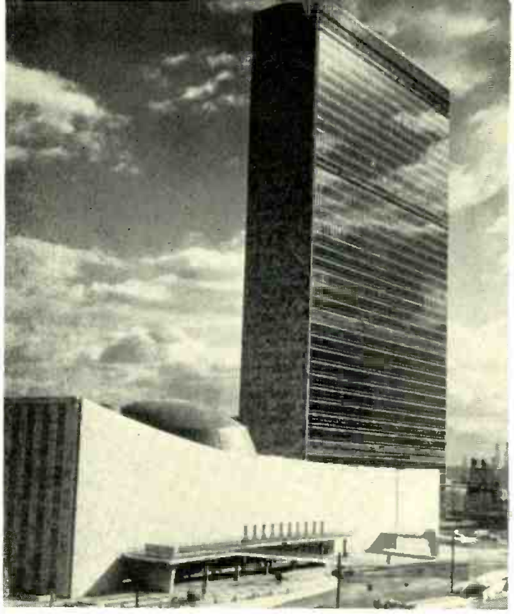
Operator toll dialing has been in operation for several years; direct long-distance dialing by customers is the ultimate goal. In addition to the Valley and Midwest exchanges, nine other exchanges will have been cut over for customer toll dialing by the end of this year. About twenty-five more will be added in 1954. With the exception of Englewood, Valley, and Midwest, these exchanges will at first have access by direct dialing to about five million telephones in extended local areas. As more 4A toll crossbar systems are installed and existing toll crossbar offices are converted, these and other exchanges will be added to the continent-wide network of the customer toll dialing system.

Communications at U.N. Headquarters

It would appear that the architects of the United Nations said to themselves, "There shall be no secrets here."

The vast glass sides of the famous main building of the U.N. headquarters in New York are, perhaps, symbolic of the desire that all the world should look in. The extensive facilities for coverage and dissemination of news and information – the most complete in the history of international affairs – are concrete evidence that the United Nations wants news and information to flow freely to the far corners of the globe.

Thanks to the superb communications system available, the reporters, translators, radio, television and film experts who look down upon the delegates from glass paneled booths in the assembly and council chambers, can do their jobs efficiently and with amazing speed. To help make this policy a reality, telephone instruments and a tremendous variety of the mechanical and electrical appurtenances of the art of modern communications, plus engineering skill and know-how, have been installed in the recording rooms, and in the master control room for the communications system serving



Above – The permanent home of the United Nations symbolizes the ideals and hopes of mankind. The building in the foreground houses the large auditorium for meetings of the general assembly and the tall structure is the office building for the Secretariat.

Left – The new main switchboard at the U.N. is always on twenty-four-hour duty, serving some 2,300 stations. In the foreground, Chief Operator Ethel Schnell chats with Doris Eastman, a visitor from Western Electric.

Below – In the Information Unit, girls speaking Chinese, Russian, Spanish, French, Arabic, and English supply telephone numbers and addresses of U.N. personnel and agenda of conferences and meetings. Multiple key turrets simplify their busy jobs.

the entire headquarters located on the lower level of the General Assembly building.

Delegates find telephones ready for action alongside their easy chairs in the delegates' lounge -- telephones which are served by a PBX switchboard whose operator speaks 11 languages fluently. Familiar Bell System identification is found on the handsome main switchboard on the seventh floor of the Secretariat building, the PBX serving Secretary-General Dag Hammarksjold's staff on the 39th floor, the multiple key turrets in the information center, the battery of machines in the Teletype room, the recording and sound equipment in the film laboratory.

It is clear that if there are any "secrets" at U.N. headquarters, they do not exist for lack of communications.

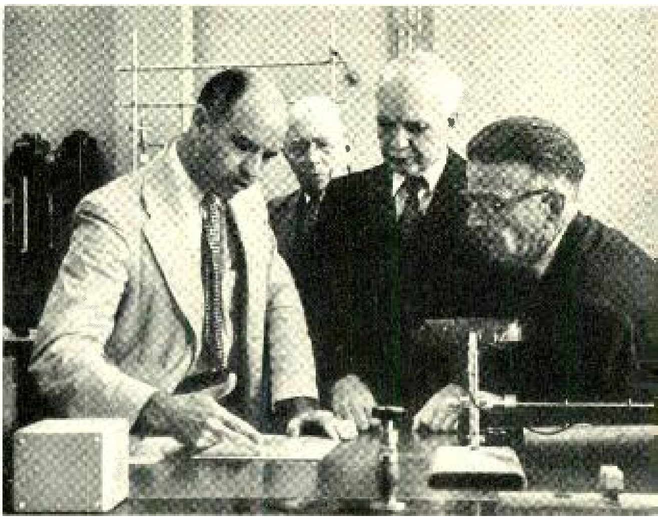
Dr. Kelly to Aid Air Force

Dr. Mervin J. Kelly, President of the Laboratories, has been named to a special five-man advisory group to assist in the development of ways of further improving cooperation and collaboration between the Air Materiel Command and the Air Research & Development Command, it was announced recently in Washington by Gen. N. F. Twining, U. S. Air Force Chief of Staff.

Audio Engineering Society Honors

In recognition of their outstanding achievements in audio engineering, Edward C. Wente of the Laboratories and Henry C. Harrison, who recently retired after nearly forty years of Bell System service, were honored by the Audio Engineering Society at its Fifth Annual Convention recently. Mr. Harrison received the Emile Berliner Award, while an honorary membership in the Society was conferred upon Dr. Wente.

The Berliner award, given for the first time this year, is to be awarded annually. The citation accompanying it reads, "The first Emile Berliner Award is given to Henry C. Harrison in recognition of his outstanding inventions and developments in audio engineering; for his application of transmission line principles and the lateral rubber line recorder used in making the first and many subsequent electrically cut records for phonograph and talking movie applications; and for his contributions to carbon-button microphones, the orthophonic victrola, wire-spring relays and a multi-reed selective signaling system used in mobile radio."



Sir W. Lawrence Bragg, O.B.E., F.R.S., Cavendish Professor of Experimental Physics and Director of the Cavendish Laboratory at the University of Cambridge, visited the Murray Hill Laboratories on September 8. A germanium sample in a low temperature measurement holder is being discussed by F. J. Morin, (left), while K. K. Darrow, Sir Lawrence, and Dr. Kelly, President of the Laboratories look on.

Mr. Harrison, whose many valuable inventive contributions to communications are attested by 109 issued patents, did his early work on fundamental studies of receivers, carbon-button microphones and submarine detecting devices, and later made valuable pioneer contributions in loud speakers, sound recording and reproducing devices. His concept of treating units such as loud speakers and recorders as transmission lines requiring impedance matching and proper termination led to the development of many of the devices listed in the citation.

For nearly forty years, Dr. Wente has been engaged in technical research relating primarily to acoustics and acoustical instruments with special reference to their application to the transmission, recording and reproduction of speech and music. Among his numerous developments, the condenser microphone was the first mechanism permitting sound reproduction with satisfactory naturalness. The Franklin Institute awarded him its John Price Wetherill medal for this work. His ribbon light valve for recording sound on films and his design of special microphones and loudspeakers were of fundamental importance in sound motion picture technology. For these contributions, he received the first Progress Award of the Society of Motion Picture Engineers. He also pioneered in stereophonic transmission and reproduction of sound, architectural acoustics, sound recording on magnetic tape, a very high-powered air-raid warning siren, and electrical anti-aircraft gun direction.

Modulation Theory Added to Bell Laboratories Series

Modulation Theory, by Harold S. Black of the Laboratories, is the latest title to be added to the Bell Laboratories series of books on technical subjects. The list now includes twenty-eight titles. Stemming from original material used in the Communications Development Training Program, the new book discusses modulation theory in terms of recent advances in communication theory.

Fundamental in its approach, and covering an area of communication where there is a real need for homogeneous and consistent treatment, *Modulation Theory* is presented on an engineering level for advanced students and practicing engineers. The first eight chapters concern the general philosophy and principles of modulation and communication theory, providing a framework on which to base comparisons of various systems of modulation. Such factors as the rate of receiving information, non-surpassable ideals, redundancy, bandwidth occupancy, threshold effects, signal-to-noise ratio, distortion, interchannel crosstalk, and probability of errors, are used for comparison.

Amplitude, phase, and frequency modulation principles and systems are treated in the next six chapters, with the last six chapters devoted to pulse-modulation principles and methods. Pulse-modulation systems are rapidly increasing in importance for many types of communications. Each chapter contains a list of references and most chapters include a group of typical problems. Review questions and exercises are also included in an Appendix. The book is suitable as a text for classroom use, valuable for home study without a teacher, and useful as a reference. Priced at $8.75, the book is published by D. Van Nostrand Company, Inc., New York City.

Lecture Series on Pulse Techniques

W. A. Malthaner of the Laboratories is one of six lecturers giving talks on pulses and pulse techniques in a series sponsored jointly by I.R.E. and A.I.E.E. at the Engineering Societies Building in New York City. Pulses and pulse techniques have become important in many electronic applications. Circuits and concepts associated with pulse work differ markedly from those of steady-state sinewave applications, and the more important aspects are covered in the series. Mr. Malthaner will discuss the basic building blocks of pulse circuitry, such as multivibrators, binary counters, diode logic circuits, and both tube and transistor decimal counters.

Dr. Shockley Lectures in Europe

As part of an extended tour of Europe and Great Britain, W. Shockley gave three lectures, September 30 through October 2, at the Sorbonne in Paris. He also gave lectures at the Summer School for Theoretical Physics, Les Houches, France, August 10-14 and 24-28 and at other stops in his trip. In Paris, the talks were on *Holes and Electrons in Semiconductors, Experiments and Concepts of Holes and Free Electrons*, and *Theoretical Physics of Transistors*. The talks at Les Houches were on the same general subjects, except that the last talk was on the mobility of holes and electrons in semiconductors.

The three-day series at Paris was under the sponsorship of the French Society of Physics, the Society of Radioelectricians, the Society of Video Engineers and Technicians, and the French Atomic Energy

Commission. Dr. Shockley left the United States on July 23 and visited much of Europe. After a short sojourn in England, he traveled through France, Switzerland, parts of Germany, The Netherlands, and back to Paris, visiting universities and laboratories in these countries. After his Paris lectures, he returned to Great Britain, visiting industrial laboratories and universities at Cambridge, Oxford, Bristol, and Reading before coming back to the Laboratories in the middle of October.

Papers Published by Members of the Laboratories

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

Anderson, J. R., Electrical Delay Lines for Digital Computer Application, I.R.E., Trans. P.G.E.C. – 2, pp. 5-13, June, 1953.

Bennett, W., Telephone System Applications of Recorded Machine Announcements, A.I.E.E. Trans., Communications and Electronics, **8**, pp. 478-483, Sept., 1953.

Bogert, B. P., On the Band Width of Vowel Formants, Letter to the Editor, J. Acoust. Soc. Am., **25**, pp. 791-792, July, 1953.

Campbell, W. E., Solid Lubricants, Lubrication Eng., **9**, pp. 195-200, Aug., 1953.

Dacey, G. C., and I. M. Ross, Unipolar "Field-Effect" Transistor, Proc. I.R.E., **41**, p. 970, Aug., 1953.

Ditzenberger J. A., see C. S. Fuller.

Fuller, C. S., and J. A. Ditzenberger, Diffusion of Lithium into Germanium and Silicon, Letter to the Editor, Phys. Rev., **91**, p. 193, July 1, 1953.

Gramels, J., Problems to Consider in Applying Selenium Rectifiers, A.I.E.E. Trans., Communication and Electronics, **8**, pp. 488-492, Sept., 1953.

Kuh, E. S., Potential Analog Network Synthesis for Arbitrary Loss Functions, J. Appl. Phys., **24**, pp. 897-902, July, 1953.

Lange, R. W., 40- to 4,000-Microwatt Power Meter, A.I.E.E. Trans., Communications and Electronics, **8**, pp. 492-494, Sept., 1953.

Lewis, W. D., Electronic Computers and Telephone Switching, Proc. I.R.E., **41**, p. 1242, Oct., 1953.

Mallery, P., Transistors and Their Circuits in the 4A Toll Crossbar Switching System, A.I.E.E. Trans., Communications and Electronics, **8**, pp. 388-392, Sept., 1953.

Malthaner, W. A., and H. E. Vaughan, An Automatic Telephone System Employing Magnetic Drum Memory, Proc. I.R.E., **41**, p. 1341, Oct., 1953.

Matthias, B. T., Superconducting Compounds, Letter to the Editor, Phys. Rev., **91**, p. 413, July 15, 1953.

McGuigan, J. H., Combined Reading and Writing on a Magnetic Drum, Proc. I.R.E., **41**, p. 1438, Oct., 1953.

Moore, E. F., see C. E. Shannon.

Morrison, J., Leak Control Tube, Rev. Sci. Instr., **24**, pp. 546-547, July, 1953.

Prince, M. B., Experimental Confirmation of Relation Between Pulse Drift Mobility and Charge Carrier Drift Mobility in Germanium, Phys. Rev., **91**, pp. 271-72, July 15, 1953.

Reiss, H., Chemical Effects Due to the Ionization of Impurities in Semiconductors, J. Chem. Phys., **21**, pp. 1209-1217, July, 1953.

Ross, I. M., see G. C. Dacey.

Shannon, C. E., Computers and Automata, Proc. I.R.E., **41**, p. 1234, Oct., 1953.

Shannon, C. E., and E. F. Moore, Machine Aid for Switching Circuit Design, Proc. I.R.E., **41**, p. 1348, Oct., 1953.

Stansel, F. R., The Common-Collector Transistor Amplifier at Carrier Frequencies, Proc. I.R.E., **41**, p. 1096, Sept., 1953.

Towsley, L. M., see E. A. Wood.

Turner, E. H., New Non-Reciprocal Waveguide Medium Using Ferrites, Letter to the Editor, Proc. I.R.E., **41**, p. 937, July, 1953.

Van Roosbroeck, W., Transport of Added Current Carrier in a Homogeneous Semiconductor, Phys. Rev., **91**, pp. 282-289, July 15, 1953.

Vaughan, H. E., see W. A. Malthaner.

Vogelsong, J. H., A Transistor Pulse Amplifier Using External Regeneration, Proc. I.R.E., **41**, p. 1444, Oct., 1953.

Walker, A. C., Hydrothermal Synthesis of Quartz Crystals, J. Am. Ceramic Soc., **36**, pp. 250-256, Aug., 1953.

Washburn, S. H., Application of Boolean Algebra to the Design of Electronic Switching Circuits, A.I.E.E. Trans., Communication and Electronics, **8**, pp. 380-388, Sept., 1953.

Willard, G. W., Ultrasonically Induced Cavitation in Water: a Step-by-Step Process, J. Acoust. Soc. Am., **25**, pp. 669-686, July, 1953.

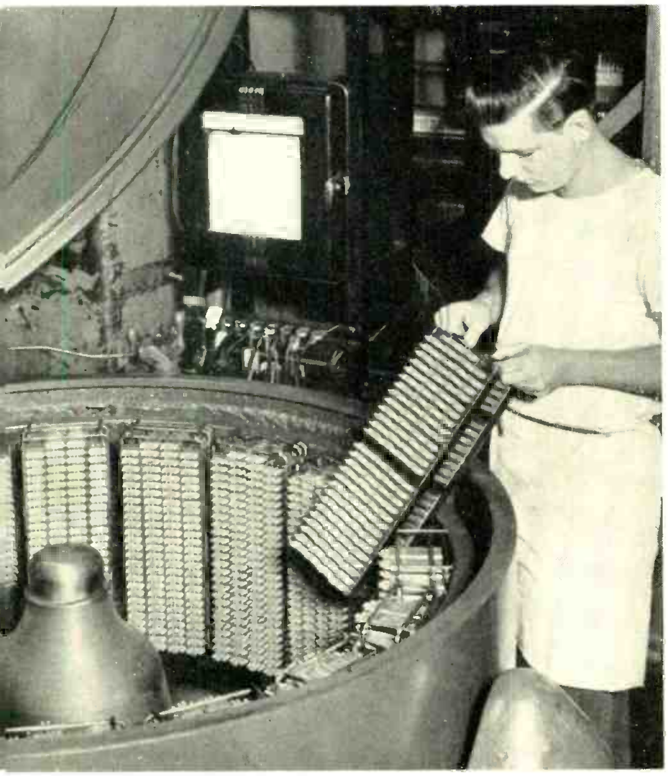
Wood, E. A. and L. M. Towsley, Manganese Film-Shield for FeKβ X-rays., Rev. Sci. Instr., **24**, p. 547, July, 1953.

Medical Devices Used in Telephone Manufacturing

Two machines used in the production of parts for telephone central offices are straight out of the medical laboratory. The fluoroscope, for instance, gives Western Electric inspectors a chance to look inside wax-filled metal cans containing networks of capacitors and resistors. It is much the same as the fluoroscope that a doctor uses and it works on the X-ray principle, except that the viewer gets a direct picture on a screen instead of on a photographic negative.

Another machine is the centrifuge, used in hospital laboratories to whirl blood samples around and around until various elements have been separated for testing. Western Electric's Hawthorne plant uses a centrifuge to spin cans containing apparatus after they have been filled with wax. The wax expands and contracts with heat and, as a result, shrinks after cooling. Until recently, considerable reprocessing has been necessary to eliminate what engineers call "voids," or cavities, that develop in the wax, creating potential moisture paths. Spinning the cans in a centrifuge under a blast of hot air accomplishes this purpose, eliminates reprocessing and provides more dependable apparatus components at an annual saving estimated to approach $100,000.

Thanks to the fluoroscope, this Western Electric worker can look inside the wax-filled metal cans used to protect resistors and capacitors from moisture. He uses the fluoroscope to make spot checks, insuring that Western's quality requirements are met. What he sees is shown at top right.



This is an industrial cousin of the small centrifuges found in most medical laboratories. Metal cans containing resistors and capacitors surrounded by potting wax are spun at high speed in this centrifuge at Western's Hawthorne plant. This binds the wax together, eliminates cavities, and results in more dependable and longer-lived electrical networks for central office equipment.

Deal Laboratories Close

October 14 marked the end of thirty-four years of occupancy by the Laboratories of facilities at Deal, N. J. A sales contract disposing of the buildings and the 208 acres of land at Deal was signed in January, 1953. According to the provisions of the contract the deed was transferred in April. At that time a one-year lease was signed subject to termination by the Laboratories on thirty days' notice. Notice of termination by October 14 was given and all Laboratories property was removed before October 1. All personnel formerly located at Deal have been transferred to other Laboratories locations.

The Deal property has been the site of many historic events in radio and radiotelephony. Deal was one of the first stations in the world to broadcast a musical program for entertainment. With the goal of extending telephone service to ships at sea, Deal engineers set up, in 1920, an experimental transmitter and put speech and music on the air. This experimental work led in the following year to successful tests with coastwise ships and in 1922 apparatus was installed on the transatlantic steamer *America*. Other significant advances born at Deal include the development of the short wave transmitter for the first transatlantic radio-telephone service. During World War II, a part of the Laboratories' work on radar research and development was carried on at Deal.

New Radio-Relay Between Chicago and St. Louis

A new radio-relay system between Chicago and St. Louis was opened on September 14 by the Long Lines Department of AT&T. When fully developed, the 283-mile microwave route will be capable of carrying more than 1,000 telephone conversations, plus a number of network television programs. Present plans call for eight microwave channels over the system, totalling about 2,300 channel miles. These will augment coaxial cable and other facilities serving the area.

Initially, four channels—two in each direction—were placed in operation for telephone message and private line service. Upon completion of work now in progress, more than 300 message circuits will have been placed in service. Connections at Chicago and St. Louis to existing cable and radio-relay systems will extend some of these circuits to more distant points, including the East and West Coasts. The remaining four channels will be added later to meet network television requirements. The proposed channels will be part of a "round robin" TV network of two channels in each direction, serving stations from New York to Chicago and back to New York via St. Louis and Washington. Such an arrangement adds considerably to the flexibility of intercity network facilities.

Nine radio-relay stations were constructed at intermediate points along the route. Towers, ranging from 137 to 275 feet in height, were erected at each station to support four microwave antennas each. A "line-of-sight" transmission path is provided between adjacent stations to transmit the radio frequencies in a straight line as they leave the antenna.

New Plant for Western

Before the end of the year, construction is expected to begin on the 150-acre tract in North Andover, Mass., recently purchased by Western Electric for the site of what will be its fifth largest manufacturing location. This expansion of operations was designed to meet the increased needs of the telephone companies of the Bell System. Among the products to be made at the new plant will be coils, resistances, transformers, filters, and networks.

The new plant will house activities now carried on in leased buildings at Haverhill, in addition to accommodating products presently manufactured at other Company locations. Western, which has been operating for ten years in leased space in the Haverhill-Lawrence area, recently purchased buildings in Lawrence to add to its space there. It is anticipated that the new location will employ from 2,500 to 3,000 people, an increase of from 500 to 1,000 over the number now working in Haverhill.

Network Color TV Planned

One transcontinental radio relay channel in each direction will be ready for transmitting color TV between Los Angeles and New York by January, 1954, and the National Broadcasting Company has announced plans to colorcast the Pasadena Tournament of Roses over the transcontinental TV network. NBC's plans, however, are subject to approval by the Federal Communications Commission of NTSC (National Television Service Committee) color standards.

Meanwhile, a closed circuit demonstration of color TV was made available by the Bell System between New York and Chicago on September 21 and 22. NBC programs were sent over Long Lines equipment, including TD-2 microwave, A-2 facilities, and a TE microwave leg. Representatives of the press and various advertising agencies saw color television programs lasting about twenty minutes each.

Pending approval of NTSC color standards by the FCC, a limited number of noncommercial color TV programs will be fed to the network, to provide experience and as tests of public reaction. Immediately following FCC approval, an "Introductory Year" is planned, when commercial shows will be transmitted at the rate of one or two a week. These plans are not contingent on the general availability of color receivers, but are expected to stimulate interest and provide practical experience in handling and transmitting color programs. NTSC standards require full compatability, and the programs, although broadcast in color, may be viewed on standard TV receivers in black-and-white.

First Holmdel Colloquium Meeting

With the closing of the Deal Laboratory, the 24-year-old Deal-Holmdel Colloquium has been changed to the Holmdel Colloquium, and the first meeting of the season took place on October 9. Originated as a result of a suggestion by J. C. Schelleng, the Colloquium had its first meeting in the fall of 1930. Except for three years during the last war, it has since been a continuous project on the part of personnel at the two locations. Each season runs for eight or nine months, with a break during the summer months when many members are on vacation.

Subjects chosen for discussion are usually outside the field of radio – the primary work at Deal and Holmdel – and often non-Laboratories people are invited as speakers. At the October 9 meeting, the guest speaker was Ralph Bown, Vice-President in charge of Research, who spoke on *Some Thoughts on Microwave and Transistor Research.*

Dr. Bown pointed out that the purpose of Bell Telephone Laboratories is, in general, twofold: to keep abreast of scientific progress and to provide the necessary tools to put these scientific developments to use. The present microwave radio relay was cited as an example of a research that took a long time to mature. As another example, he cited the development of the transistor as an incident in a deliberate program of investigation into solid state physics.

New Communications Glossary Now Available

A glossary of communication definitions, including contributions by a number of Laboratories engineers, is now available at the West Street library. In its present form the glossary is a final draft awaiting approval of an American Standards Association sectional committee.

Preparation of the draft was carried out over a period of several years by a subcommittee headed by Chairman E. I. Green, Director of Military Communication Systems, and Vice Chairman, J. C. Schelleng, Director of Radio Research at Holmdel. The glossary is designated as Group 65 of the A.S.A. C42 Standard Definitions of Electrical Terms.