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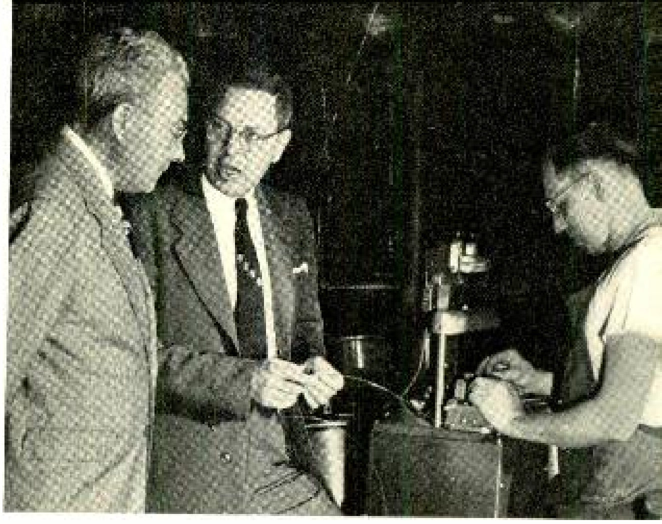


Aluminum Conductors in Telephone Cable

C. KREISHER
Outside Plant Development

Expansion of telephone service can be accomplished only if an adequate supply of cable, among many other items, is available. Until recently, cable production was completely dependent upon the availability of lead and copper. Development of alpeth and stalpeth sheath freed the Bell System from dependence upon lead, and more recently, the development of aluminum conductor cable by Bell Laboratories and Western Electric has moved far toward affording the Bell System the alternatives of aluminum and copper for cable conductors, the choice depending upon relative availability and cost in place. Many problems inherent in the use of aluminum wire have been solved, and Western Electric is producing a limited amount of the new cable to maintain and improve manufacturing techniques, and to supply cable to provide installation and service experience in the field.

Although conductors in telephone cables traditionally have been been made of copper, the Bell System for many years has been constantly alert to the possibilities of aluminum for this use. Aluminum has been used abroad to some extent for cable conductor purposes, particularly in Germany, at times when copper was unavailable, but such usage was prompted by conditions of expediency or necessity which have not applied in this hemisphere.

Among the properties of aluminum which make it attractive for cable conductor applications are its natural abundance (in recoverable form, it is one of the most plentiful metallic elements in the earth's crust), its good conductivity (about 60 per cent that of pure copper), its lightness (specific gravity less than one-third that of copper), and its low cost (currently about three-fourths that of copper in billet form). In

In the photograph at the top of the page the author and A. C. Nystrom, Assistant Superintendent of Manufacturing Engineering, Western Electric, discuss the special welding technique used to splice aluminum wire on a Micro products welder. The wire ends of the reels are being welded together by V. P. Buczynski of Western Electric to permit continuous feed to a pulp insulating machine.

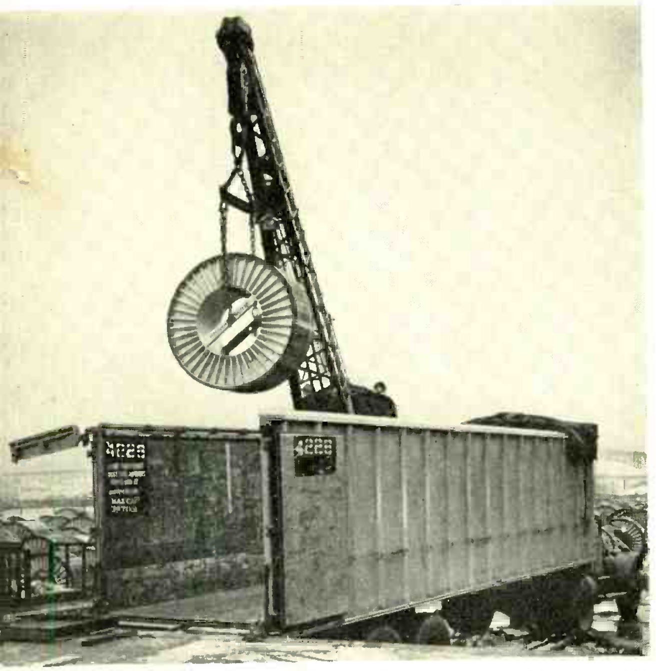


Fig. 1 – The first reels of aluminum conductor cable being loaded at the Western Electric Company Kearny Plant. These were shipped to Baltimore for an initial field trial installation.

the light of these desirable characteristics it is abundantly evident why the Laboratories has long maintained an exploratory program looking into the possible exploitation of aluminum as a conductor material. What is not so evident is why there has not been actual use of aluminum conductors in telephone cables until recently, since at present metal prices, conductivity can be obtained in aluminum wire at about half the cost of the same conductivity in copper. Principally the explanation is found, strangely enough, not in the aluminum conductors themselves, but in the cable sheathing.

To have approximately the same resistance as copper, an aluminum wire must be two sizes (American Wire Gauge) larger, or about sixty per cent larger in cross sectional area. Since the cross section of the insulation increases in direct proportion to the increase in the size of the conductor, the cross section of the entire cable will increase by about the same amount. This increase in cross section, in turn, will require about thirty-five per cent more sheathing material for the aluminum conductor cable. Until late in 1947, the only satisfactory sheathing material available was lead alloyed with small amounts of other metals. The cost of the additional lead required to cover the larger core of aluminum conductors more than nullified the saving in the conductors themselves. However, the much less expensive alpeth* and stalpeth† sheaths introduced at that time suggested new possibilities of utilizing aluminum conductors. As soon as these sheaths had sufficient field use to establish their position as strong competitors with lead sheaths in most applications, an active cooperative program of aluminum conductor development was undertaken by the Western Electric Company and the Laboratories. This proved to have been most timely because in less than a year this program was accelerated greatly to meet what threatened to be a very serious shortage of copper. The earlier work that had been done was invaluable in shortening the schedule for development and manufacturing preparation. Actually the anticipated copper shortage did not develop to the extent expected, and the production of aluminum conductors has been limited to the amount required to promote orderly development of manufacturing processes and to permit studies of field utilization.

* Record, *January*, 1948, *Page* 35; and *November*, 1948, *Page* 441.

† Record, *August*, 1951, *Page* 353; and *November*, 1951, *Page* 521.

Fig. 2 – L. C. Graham and J. L. O'Toole testing aluminum conductor cable for capacitance in the Bell Laboratories laboratory at Kearny.

Many factors have required special consideration in the course of this development. For example, the largest cables are ordinarily used in underground ducts, and their diameter is limited by the duct dimensions. For equal resistance, the number of pairs of aluminum conductors obtainable in a full diameter cable is only about sixty per cent of the number of copper pairs. This means that in most cases the larger cables will continue to be made with copper conductors. The important field for aluminum conductors will therefore be in aerial installations, although a substantial mileage may be used in ducts for projects where less than the maximum number of pairs is required. Also aluminum of the composition and temper suitable for cable conductors has less tensile strength than copper, and requires different techniques in processing.

The present phase of the aluminum conductor development began early in 1951 when the Western Electric Company obtained a small supply of aluminum rod for experimental purposes, and drew this material into 22- and 24-gauge aluminum wire. The 22-gauge aluminum wire would be the electrical equivalent of 24-gauge copper, and the 24-gauge aluminum would be the equivalent of 26-gauge copper. By agreement with the Western Electric Company, this wire was used to make two experimental cables for the Laboratories. These were so designed that the space occupied by each pair and the insulation on the wires were the same as for 22- and 24-gauge copper cables, and the capacitance would therefore be expected to be the same. Electrical measurements proved that the weaker aluminum conductors had not been stretched appreciably in processing, since both resistance and capacitance were as anticipated. The capacitance unbalances were also of about the same magnitude as in copper conductor cables.

To get these results in the experimental cables required a number of modifications in Western's manufacturing equipment and techniques. Their machines and processes – specially developed for reduced costs and high quality in large scale production, and unique in the industry – are designed for use with copper. Their high speed drawing, twisting, and stranding equipment called for some modification for most effective results in using the lower strength aluminum wire. Fully annealed aluminum wire is weaker than copper wire by a factor of about three for wire of the same diameter or about two for wire of equal resistance. Stronger wire can be produced by annealing at a lower temperature or by a final draw after a complete anneal, but such operations must be carefully controlled to obtain wire of reasonably uniform temper. An intensive study of annealing techniques and optimum wire hardness has been under way for some time, and at present, a minimum elongation of aluminum wire of ten per cent is specified as compared to twenty per cent for copper conductors.

Fig. 3 – Miss Mary Dempsey of Western Electric performing the "ring out" test for continuity of aluminum conductors in a cable prior to the sheathing operation.

Among the other difficulties encountered was that of splicing wire in the factory. Because the brazing process used to splice copper wire is unsatisfactory for aluminum, it is necessary to weld aluminum conductors. Special welding equipment, of the sort shown in the headpiece, had to be obtained

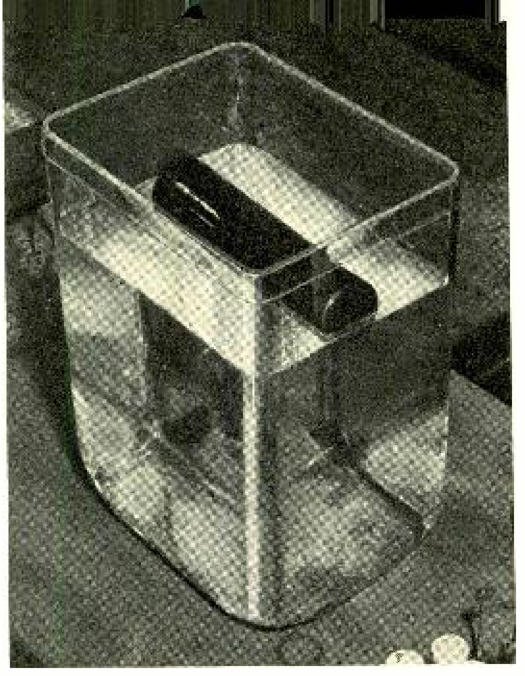


Fig. 4 — The lightness of 400-pair aluminum conductor cable with alpeth sheathing is illustrated by its ability to float on water.

to make the joint where aluminum wire from one reel is being spliced to permit continuous feeding into the pulp insulating machine. While this special equipment has aided the production of aluminum cable, the defect rate due to weld failures is greater than for copper, and development work is continuing on this problem.

One of the interesting features of the aluminum conductor cable is its light weight, the specific gravity being less than that of water. Its ability to float is illustrated in Fig. 4, where a sample of 400-pair 22-gauge aluminum cable with sealed ends is shown floating in a battery jar. Actually the aluminum conductor cable with alpeth sheath weighs about three-quarters as much as the equivalent smaller diameter cable with copper conductors, and about half as much as same diameter copper cable.

From the service standpoint, the low tensile strength of aluminum was of some concern at first because of the loads the cable is subjected to during installation. Figure 5 shows the load versus elongation characteristic for a 400-pair 22-gauge aluminum cable and a 400-pair 24-gauge copper cable, both with alpeth sheaths. It will be noticed that although the tensile strength of the aluminum wire is considerably less than that of copper, the aluminum cable itself is somewhat stronger than the equivalent copper cable within the range of loads ordinarily encountered in "pulling-in" operations. This greater strength is due mostly to the greater cross section of the insulating material, which in turn is due to the larger diameter of the conductors. The sheath of polyethylene and corrugated metals does not contribute appreciably to the modulus at very small elongations. The reversal of the load-elongation curves of Figure 6 between 0.4 and 0.5 per cent elongation is due to tensile failure of the insulation.

An elongation of 0.25 per cent is considered the maximum to which a cable can be subjected without impairment of the electrical properties. A 2,000 pound load is required to produce this elongation in the 400-pair aluminum cable, but only 1,500 pounds is needed to elongate the equivalent copper cable to the same extent. In addition to this advantage, less pulling force should be required to install the aluminum cable because of its lighter weight.

The most radical change that will be introduced because of this new kind of cable is the method of conductor splicing in the field. The thin film of oxide that is always present on aluminum exposed to the air is non-conducting, and wire joints of the twisted, or "pigtail," type commonly used in joining copper cable conductors, are us-

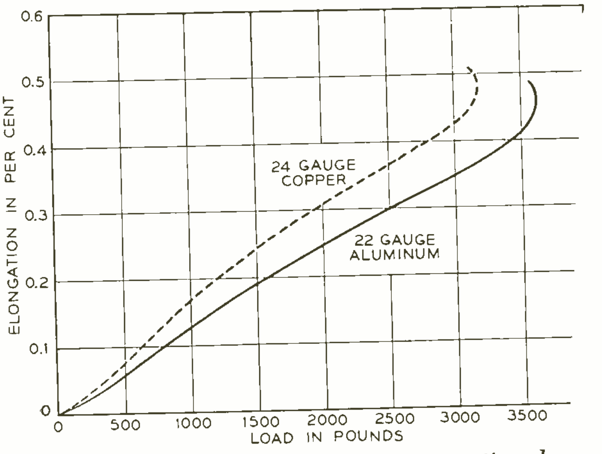


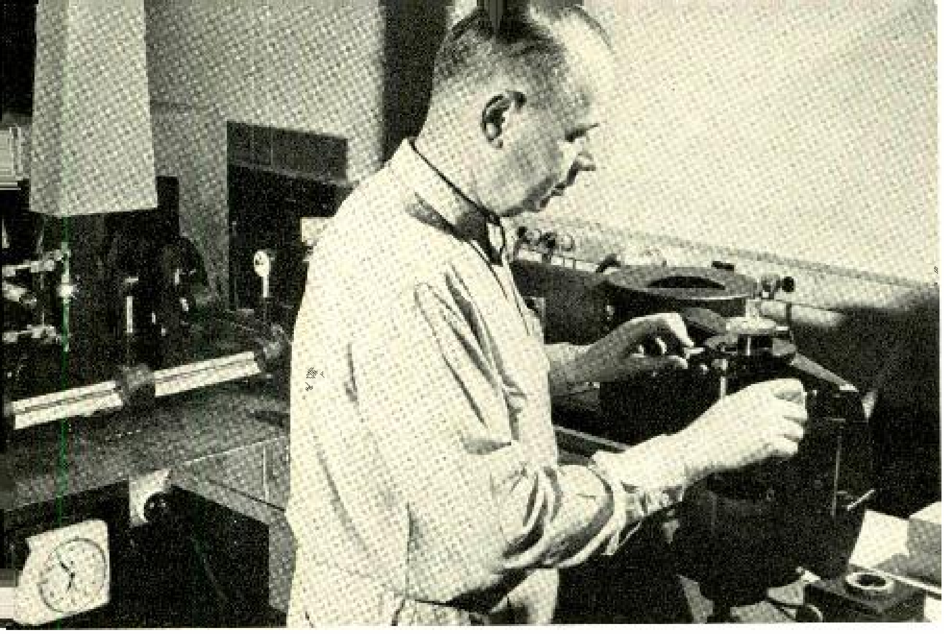
Fig. 5 — Curves illustrating the comparative loa versus elongation characteristics of copper and alı minum conductor cables.

ually high and variable in resistance when applied to aluminum. To produce low-resistance, electrically stable joints in aluminum, reliable metal-to-metal contact must be established and maintained. In Germany and elsewhere, aluminum wires have been joined by welding or soldering. These methods are not excluded from consideration for Bell System cables, but it is desired to develop cheaper techniques than those used abroad. An extensive study of aluminum wire joining techniques has been undertaken, and an adequate type of joint has been developed for use during the period of initial production of cable. This joint consists of a short tubular aluminum sleeve pressed tightly by means of the standard sleeve pressing tool over the end of the customary twisted pigtail. The twisted wires and compressed metal tube are then insulated with a waxed cotton sleeve in conventional fashion. This method of splicing required a minimum of personnel training, since it employs tools and techniques that are familiar to the splicing forces. Work directed toward development of less expensive joints of low and stable resistance is being prosecuted actively.

It is estimated that at present metal prices, the use of aluminum conductors will result in an actual saving in the cost of the materials which go to make the cable. The light weight of the aluminum conductor cable will also effect some saving in placing cost. On the other hand, some of these savings may be offset, initially at least, by increased conductor splicing costs and possibly by increased manufacturing costs.

This cable can be used by the telephone companies in any exchange area application where copper conductor cable would ordinarily be used. The first field trial of aluminum conductor cable was made in March, 1952, when about two miles of 303-pair 22-gauge aerial cable was installed by the Chesapeake and Potomac Telephone Company at Baltimore. Since that time, about 1,700 miles of aluminum conductor cable with 22-gauge, 20-gauge or 17-gauge conductors have been produced. The Western Electric Company is continuing to produce a limited amount of this cable to develop means of controlling the quality of the supply rod and of making a factory joint having a defect rate comparable to copper, and the Operating Companies are installing this cable to gain service experience. The Laboratories' program of conductor splicing methods development is being pushed very actively and with increasingly encouraging results. Upon completion of these Western and Laboratories developments, and with the accumulation of a substantial background of service experience, it is anticipated that the Bell System will have free choice between the two metals, aluminum and copper, for cable conductor purposes, so that usage of either or both can be elected on the basis of price and availability.

THE AUTHOR: Claude Kreisher received the B.S. E.E. degree from the State College of Washington in 1921, just prior to joining the Western Electric Company in Chicago with an assignment to what is now the cable branch of the Laboratories' Outside Plant Development Department. His work was concentrated on the development of paper insulated cables, cable sheath, and sheath protections. In 1929 he was in charge of a group engaged in the development of voice-frequency toll cable. Transferred to the Point Breeze factory, Baltimore, in 1932, he continued his previous work and became interested in the development of the coaxial cable, playing a prominent part in work leading to the design of the experimental New York-Chicago cable. Two years ago he was transferred to Kearny as Cable Design Engineer in charge of a group concerned with exchange area cable studies. Mr. Kreisher is a member of the A.I.E.E., Phi Kappa Phi, and Sigma Tau.



The author at the Zeiss prism-type spectrograph. The arc in which the sample is burned can be seen to the left.

Qualitative Spectrochemical Analysis

W. HARTMANN
Analytical Chemistry

A wide range of materials, containing almost every known chemical element, is used in the Bell System, and the search continues to find and apply others still more durable, economical and suitable. As a result, the analytical chemistry group of the Laboratories must determine the composition of many substances, quickly and accurately, often with only a small sample to examine. In most cases, the first analysis is done spectrochemically. The technique is so sensitive that in many cases, mere traces of an element—perhaps only one part in a million—can be positively detected and an approximation made of its relative abundance.

Qualitative spectrochemical analysis consists of the detection and identification of the constituent elements of a sample by means of a spectrograph. It supplies the answer to the question, "What elements are present (or absent) in this material?" and at the same time provides information on the approximate composition of the material. Its greatest asset is speed, since an analysis that might require several days for completion by chemical methods can usually be carried out in a few hours by spectrochemical procedure. Figure 1 is a schematic sketch of a prism spectrograph and illustrates its operating principles.

The chief advantages of qualitative spectrochemical analysis, in addition to its rapidity, are its accuracy and its ability to produce results with a minimum amount of sample. It is of value in many instances: the ascertaining of the purity of a sample; the comparison of two seemingly identical materials, one of which shows satisfactory characteristics and the other unsatisfactory; the identification of a stain, a deposit, or a corroded area on a piece of apparatus; the step-by-step control of chemical composition during a series of purifications; and the detection of the components of a sample as a guide for quantitative chemical or spectrochemical work.

The basis upon which qualitative spectrochemical analysis rests is the fact that each chemical element, when properly excited, as for instance in an electric arc or spark, emits a set of unique and characteristic radiations, and that these radiations are, for all practical purposes, fixed and immutable. This immutability obtains whether the source of the radiations is the individual element, a physical mixture containing it, or a chemical compound thereof. By means of a spectrograph, the radiations are recorded photographically to form the spectrum of the element or elements present in the source. The identification of the lines comprising such a spectrum constitutes qualitative spectrochemical analysis.

The identification is, theoretically, a series of measurements of the wavelengths of the spectral lines, with reference either to the primary standard of wavelength (the red line of cadmium located at 6432.-4696A*) or to one or more of the secondary standards based on it. This, however, is an intricate and time-consuming procedure, and is usually employed only in connection with the isolation and identification of an unknown element or isotope. For practical purposes, the "reference plate" method of identification is in common use; this is described in detail below.

As indicated in Figure 2, the working range of the spectrum used for qualitative analysis is that portion lying between 6000 and 2200A, with approximately three-fourths of the most commonly used lines in the 3600-2200A region. For a few elements, such as potassium, lithium, and rubidium, it is necessary to cover the 6000-8000A range, and for these, specially sensitized plates must be used. It might be of interest to point out that the visible region of the spectrum (roughly 6600-4300A) embraces comparatively few of the most sensitive lines: that is, those lines that are the last to disappear with vanishing quantities of the elements.

The equipment of the spectrochemical laboratory includes a medium-sized Zeiss prism spectrograph shown on the first page of this article, and a large, twenty-one foot Jarrell-Ash grating instrument (Figure 3). The former is used for the analysis of elements with simple spectra, such as aluminum, copper, magnesium, or lead. Since it is able to cover the entire 6000-2200A range in one exposure, it is also used in those instances where an amount of sample sufficient for only one exposure is available. The Jarrell-Ash, with its 200 microns per angstrom linear dispersion, is used for the

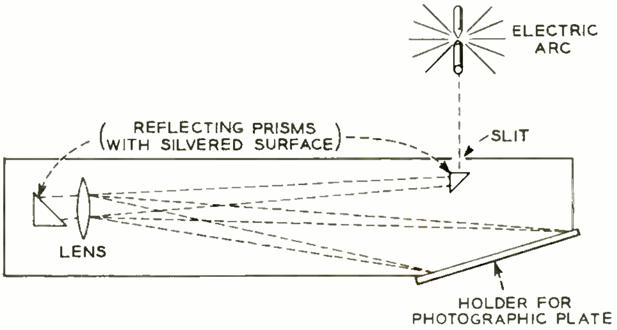


Fig. 1 — Schematic drawing of a prism spectrograph illustrating its operating principles. Light from sample is dispersed by prisms into identifying lines that are recorded on photographic plate.

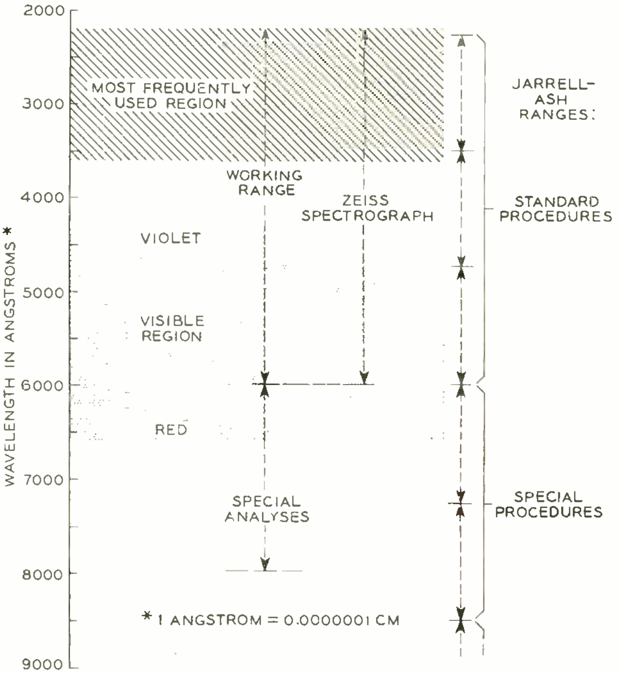


Fig. 2 — Range of wavelengths used in spectrochemical analysis.

* The symbol "A" denotes the angstrom unit, the length of which is one one-hundred-millionth of a centimeter or about four billionths of an inch.

Fig. 3 — E. K. Jaycox at the large Jarrell-Ash spectrograph.

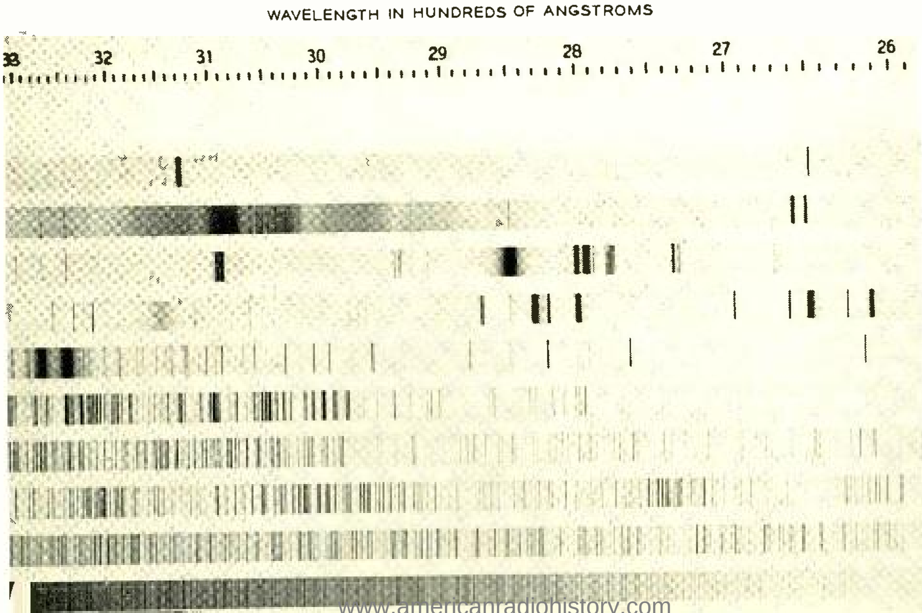
more complex spectra, such as cobalt, iron, molybdenum, or tungsten. However, due to the fact that its range per exposure, when a single plate is used, is only 1250A, the usual qualitative analysis requires three exposures: 6000-4750A, 4750-3500A, and 3500-2250A. Figure 4 illustrates the varying complexity of the spectra of several different elements.

The techniques employed in producing spectra for qualitative analysis vary in accordance with the nature of the particular sample. Many metals can be arced directly in graphite electrodes; others must be converted to their oxides and intermixed with graphite powder in order to produce a satisfactory spectrum. An illustration of the latter case is the analysis of aluminum, where if the metal is arced, an envelope of the oxide is almost immediately formed around the sample, which inhibits the emission of radiations. Another technique, often used for small amounts of sample, is to dissolve the sample and to transfer the solution to waterproofed electrodes. The solution is evaporated to dryness, and the residue is arced. A 220-volt direct-current arc is used exclusively for all qualitative work, at currents varying from five to fifteen amperes.

In this laboratory, as already stated, the elements in an analytical sample are detected and identified by the "reference plate" method. This method, illustrated in Figure 5, requires the preliminary preparation of a library of plates on which appear the spectra of one or more of the elements to be identified. On the same plate, but below and in juxtaposition with each spectrum, is placed the spectrum of iron or copper. These two elements are used because, due to their availability in pure form and their richness in spectral lines in the desired regions, elaborate tables and charts of their spectra have been published to facilitate their use as secondary standards of wavelength. Copper, with a relatively simple spectrum, is used for Zeiss work, while iron, with a more complex spectrum, is used with the Jarrell-Ash.

In making an analysis, the spectrum of iron or copper is also placed in juxtaposition with, but above, the spectrum of the sample. To carry out the analysis it is then merely necessary to line up the two iron or

Fig. 4 — Sample spectra of several elements as photographed in the Zeiss prism spectrograph.



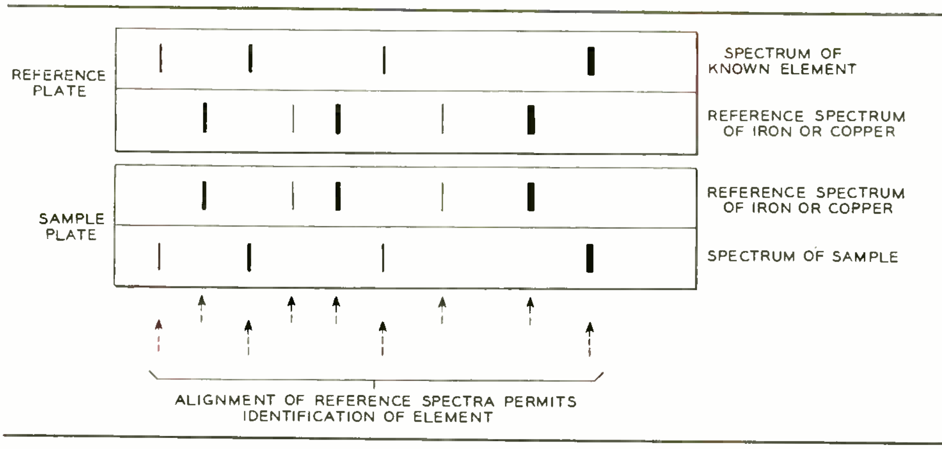


Fig. 5 — Drawing illustrating reference plate method of identifying elements. Actual photographs are seen in Fig. 6.

copper spectra, and to ascertain if any, or how many, lines of the element sought appear in the spectrum of the sample. Taking various factors into consideration, the number and the opacity of the lines of an element serve not only to identify the element, but also to offer an approximation of the amount of the element present in the sample. Conversely, the absence of the most sensitive line (the *raie ultime*) of the element from the sample spectrum denotes the absence of the element to the limit of its detectability.

An illustration of the "reference plate" method as applied to the detection of impurities in aluminum is shown in Figure 6. The "sample" in this case is a synthetic mixture of aluminum with 1 per cent phosphorous, 0.1 per cent of beryllium, 0.01 per cent of magnesium, and 0.001 per cent of copper. Each of the four sets of spectra shows, in effect, the alignment of the "sample" with simulated reference plates for the four elements mentioned. The two upper spectra in each set are, respectively, that of the specified element and that of iron. The two lower spectra are, respectively, that of iron and that of the "sample." With the iron spectra in alignment, the coincidence of the phosphorous, beryllium, magnesium, and copper lines is apparent. This type of analysis is frequently used to identify a particular aluminum alloy without the need of quantitative work. For example: type 2-S alloy may not contain more than a trace of magnesium, while type 52-S must contain between 2.2 and 2.8 per cent. It requires but a glance at the spectrum to ascertain to which type it belongs.

Figure 6 also illustrates one of the chief factors in evaluating the approximate amount of an element in a sample, namely that element's inherent sensitivity. Compare in Figure 6, for example, the opacities of the copper lines in the sample (produced by only 0.001 per cent) with those of the phosphorous lines produced by 1 per cent. Because of the high sensitivity of copper, as little as 0.00005 per cent can be detected, whereas the low sensitivity of phosphorous makes it difficult to detect even at 0.03 per cent.

A request for a qualitative analysis may require the identification of only one or of a few elements, or it may call for a general qualitative analysis. In the latter case a form, shown as Figure 8, is used. The elements listed in the first two columns are regularly sought, while those in the third (right-hand) column are sought if requested or if the nature of the sample indicates the possibility of their presence. Other elements that can be identified are hafnium, uranium, and the rare earths. Still others such as carbon, sulphur, chlorine, bromine, and iodine, cannot be detected with the equipment presently available in this laboratory and are usually detected by different methods.

Although a qualitative analysis is primarily for the purpose of determining what elements are present in a sample, it is of little value unless it carries with it some indication of the relative amounts of the

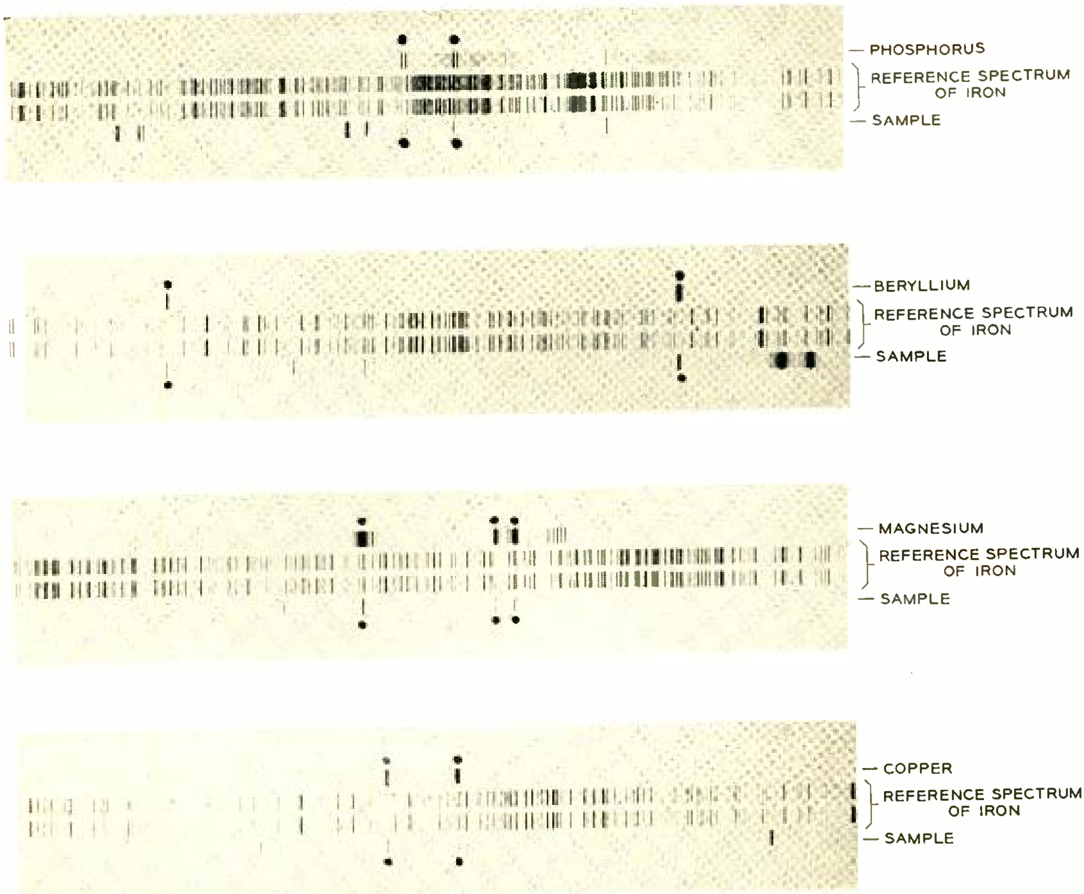


Fig. 6 — Reference-plate photographs of phosphorus, beryllium, magnesium, and copper in a mixture with aluminum. As reference spectra for these Jarrell-Ash photographs, iron is used in the middle two of each group of four. Dots mark identifying lines.

elements found. For this purpose, the results of an analysis are usually reported in accordance with a schedule of "Estimated Ranges" shown in Table I.

It is to be emphasized that this type of analysis is in no wise a quantitative determination, as is evidenced by the overlapping of the several categories. The inclusion of an element in one or another category depends entirely on the operator's judgment, based on the inherent sensitivities of the respective elements, on the nature of the sample being analyzed, and on the amount of sample available for the analysis. Each of these factors is essential, but since the third one (amount of sample) has occasionally led to a misconception of the potentialities of spectrographic technique, it merits elaboration.

There is a prevailing belief that the spectrograph is able to detect all of the component elements in any sample. Provided that sufficient sample is available, and subject to the limitations already discussed, this is generally true. However, in the case of very small amounts of sample, the radiations of the trace elements are so weak that they fall below the detectable limit, and in such

Table I — Schedule of Estimated Ranges

	Per Cent
Principal component	$>10.$
Major components	$>1.$
Minor components	0.1 – 3.
Impurities	0.01 – 0.3
Traces	<0.03
Slight traces	<0.005
Very slight traces	<0.001

cases only the chief constituents of the sample can be identified.

The scope of the qualitative work done in this laboratory is best described by a list of the metals, alloys, and compounds analyzed during the first five months of 1953:

Silver, silver solder, aluminum, aluminum oxide, arsenic, gold, gold-gallium, barium carbonate, barium titanate, beryllium, beryllium-bronze, bismuth, cadmium, cadmium bronze, copper, iron, iron oxides, iron-silicon, ferrites, ferro-magnetic alloys, gallium, germanium, germanium oxide, mercury, indium, magnesium, magnesium oxide, molybdenum, niobium pentoxide, nickel, palladium, platinum, lead, antimony, tin, selenium, silicon, silica, tantalum, titanium oxide, tungsten, zinc, and zirconium hydride.

These were submitted in various forms, either directly as a sample or as part of a piece of equipment or apparatus, e.g., mercury switches or precious metal contacts from relays. Other instances are the analyses of the component parts of electron tubes: grids, grid supports, cathodes, cathode coatings, and deposits on the bulbs. Organic samples are also occasionally submitted for an analysis of their inorganic constituents; included in this group are resins, alpeth cable sheath, rubber insulation, glazes, and telephone handset housings. Finally, there are miscellaneous analyses, such as water residues and samples that were labeled only as "deposit from the walls of a muffle (a type of oven) or "an unknown fragment."

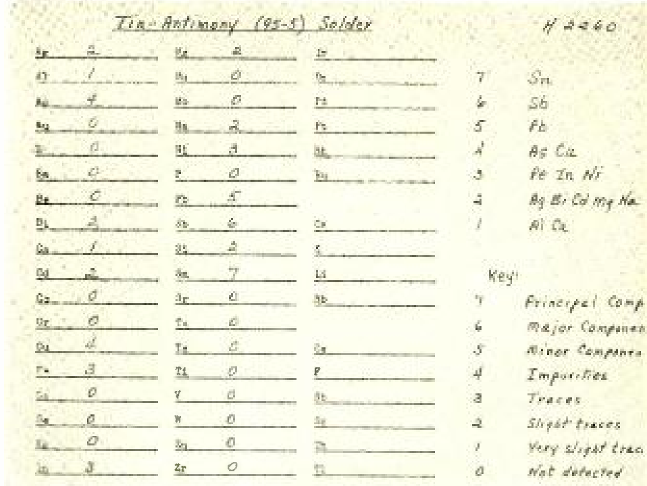
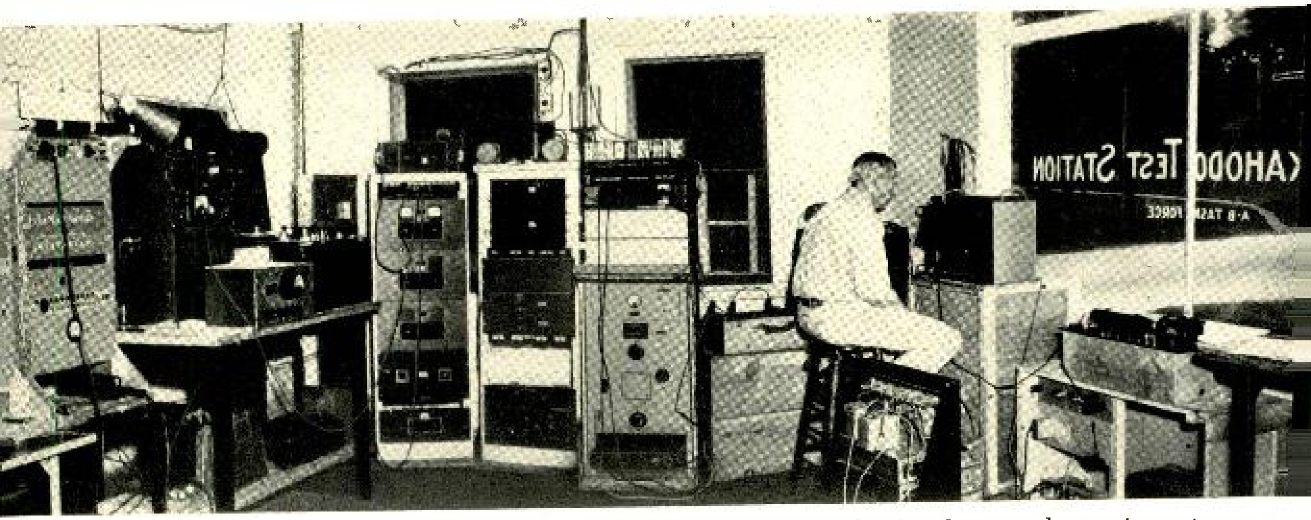


Fig. 7 — Form used for reporting results of analysis in spectrochemical laboratory. Elements in first two columns are regularly sought; those in last column only under special circumstances.

Spectrochemical analysis was inaugurated at the West Street laboratories about thirty years ago. During the intervening time it has become a major analytical tool in the quantitative, and particularly in the qualitative field, with the result that over ninety-five per cent of all qualitative analysis is now done spectrochemically.

THE AUTHOR: With the Western Electric Company from 1917 to 1925, Werner Hartmann was first concerned with general analytical chemistry, and then, as a member of the rubber group, with investigations of the water absorption of various compounds for the development of the Catalina cable. In 1925 he transferred to a Laboratories group concerned with vacuum tube research, to spend the next ten years in the refining of platinum and allied metals for vacuum tube filaments. Following this he was associated with studies of magnetic powder insulation in connection with the development of permalloy. Since 1941 he has worked on general spectrochemical analysis. Mr. Hartmann received his B.A. degree from the City College of New York in 1927. He is a member of the Optical Society of America, the Society for Applied Spectroscopy, and Phi Beta Kappa.



Panoramic view of the Hamokahodo test station in Madison, Florida, showing the equipment used for making tape recordings of open-wire line noise caused by thunderstorms. The author is seen examining oscilloscope patterns of noise bursts.

Thunderhunting

R. M. HAWEKOTTE
Transmission Engineering

"Thunderhunting" is the glamorous name given to one of the recent activities of the Transmission Engineering Department – the recording on magnetic tapes of the noise induced on open-wire telephone circuits by atmospheric static. Thunderstorms can therefore be simulated merely by playing back the tapes in the laboratory or on other lines. Because it is so readily reproducible, recorded noise is particularly valuable for comparison of different types of circuits and equipment.

During thunderstorms, lightning discharges induce extraneous voltages into telephone circuits. These voltages, if not controlled, would appear to a telephone subscriber as bursts of noise that sometimes interfere with the transmission of speech. Such noise bursts might also interfere with telegraph transmission or signaling. Interference with signaling is becoming more important with the increased use of toll line dialing. Furthermore, noise caused by atmospheric static discharges is particularly bad on telephone circuits operating on open-wire lines. By contrast, the static noise on circuits carried in a lead-sheathed cable is severe only when there are open-wire pairs extending from the cable.

The performance of the new open-wire type-O carrier telephone system* under severe static conditions was one of the major problems that faced design engineers. The need for the type-O system was so urgent, however, that there was no time for exten-

* The new type-O carrier system will be described in a future series of RECORD articles.

sive field tests. A new technique was therefore developed for recording the static noise to permit the testing of new equipment in the laboratory as it is developed, and for the testing of new or improved equipment in the field in the absence of natural static.

Early in 1950 a group of "thunderhunters"* was organized to go into an operating company plant and, during thunderstorms, "can," with a tape recorder, the noise that was induced on open-wire telephone circuits of the type to be used for type-O transmission. The thunderhunters set up their test station in the northern part of Florida, a region of high thunderstorm activity. A pair of open-wire conductors was taken out of use, but was otherwise left in its original condition, strung along poles beside other pairs in service.

The headpiece is a panoramic view of the inside of the "Hamokahodo" station in Madison where static noise was actually recorded. Its title was derived from the first two letters of the last name of each of the five thunderhunters who set up the station: HAwekotte, MOntfort, KAhl, HOchgraf, and DOncourt. The test leads from the open-wire circuit, which terminated just outside of the station, shown in Figure 2, were brought in through the left of the two windows seen in the rear. In the center are three frames of equipment. On the top of the right frame is a high pass line filter, which passed the carrier frequency noise in the type-O band, but excluded noise and interfering tones in the lower frequency bands. On the center and left frames are the demodulator and associated amplifiers and attenuators employed to transfer the carrier frequency noise to audio frequency noise for recording. At the bottom of the right frame is a carrier frequency calibrating oscillator. The high fidelity magnetic tape recorder, having a 50 to 20,000-cycle pass band, is seen on the table to the left of center. A tone from the calibrating oscillator was introduced at the line terminals of the filter and recorded on the beginning of each of the tapes. The known levels of carrier frequency tone impressed and of audio tone recorded on the tape thus gave an over-all calibration for the recording equipment. On playback of the "canned" noise, the calibrating tone at the audio output of the recorder is adjusted to the same level at which it was recorded, and the carrier frequency tone at the output of the modulator-amplifier arrangement may be adjusted to the calibrated level or varied as desired. The carrier frequency noise will, of course, be proportional to the carrier frequency calibrating tone.

To the far left of the headpiece are the wideband level distribution recorders, commonly referred to as LDR's. The LDR has a bank of message registers arranged in steps

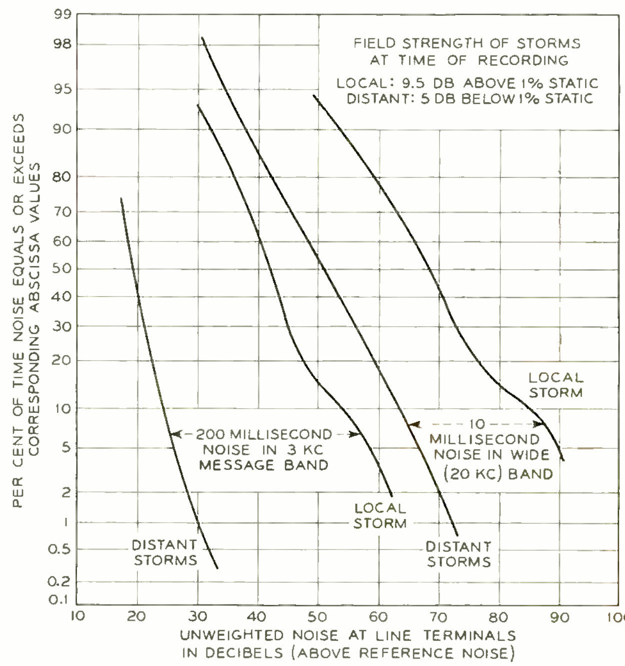


Fig. 1 — Distribution curves of atmospheric static, used to check the accuracy of the tape recordings and to supply other information of use to the thunderhunters.

of five decibels so that each register indicates the number of seconds the noise exceeded a particular level while the static noise was being recorded. The information obtained from the LDR's was used to plot statistical distributions of the noise. These distributions were used later as a check on the accuracy of the tape recordings, since the recordings themselves, when played

* RECORD, *September*, 1950, *page* 409; *March*, 1951, *page* 137.

Fig. 2 — Outside view of the Hamokahodo test station. The pole in front of the station carries a pair of conductors from which noise was recorded during some of the thunderstorm periods.

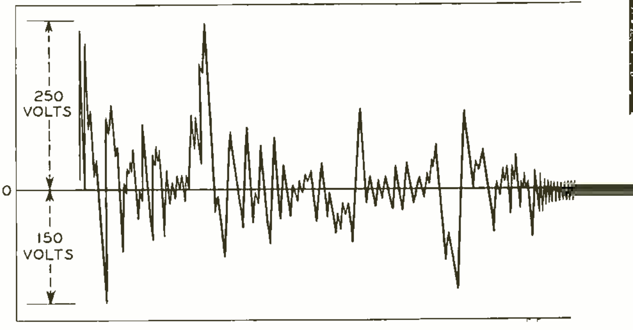
back into the LDR's, gave resultant distribution curves that coincide with the originals. The LDR's and the tape recorder can also be seen in Figure 4.

Distribution curves of static noise during a particular local storm, and during a period of static from distant storms, are shown in Figure 1. In addition to their use as checks on the accuracy of the tape recordings, curves such as these show the magnitudes of noise that can be expected from the various types of storms, and also give important information on the noise that occurs within different time intervals. This time element is important in transmission studies of telephone systems. For voice communication, bursts of noise lasting less than 200 milliseconds are not troublesome, but for the signaling and telegraph pulses, bursts as brief as five milliseconds can cause errors, particularly if the burst occurs at either the rising or the falling edge of a signal pulse. The oscilloscope seen to the right of center of the headpiece permitted the thunderhunters to view many bursts of high magnitude voltage lasting from five to ten milliseconds.

To the far right of the headpiece is an automatic oscilloscope that photographed the wave form of all noise bursts on the line that exceeded a preselected value. The wave form of a particular burst is shown in Figure 3. It appears to be a composition of many frequencies, with the outstanding components at about three, thirty, and sixty kilocycles. Other noise bursts due to static discharges resulted in somewhat different wave forms, different both in frequency and in magnitude. During local storms there would often be a chain of such bursts lasting at times as long as a half second, with the form of each burst differing from the others. An accurate knowledge of these induced voltages is of importance to design engineers in their efforts to provide error-free telephone and telegraph service.

It was not sufficient merely to record the noise induced on a pair of conductors. Care had to be taken that this noise was accurately calibrated so that it could be used in other areas where thunderstorm conditions were different from those in Madison. In earlier studies by Laboratories people it had been found that, on the average, the noise in a three kilocycle message circuit on a given type of open-wire line varied al-

Fig. 3 — Automatic oscillograph record of the metallic circuit voltage induced into open-wire lines by a lightning discharge.



most directly with the intensity of the static field. It was also found that there existed an empirical relationship between the average number of thunderstorm days during the static season in any particular locality and the particular intensity of the static field that is equaled or exceeded for one per cent, or about thirty-seven hours, of the five months static season. In engineering studies, it has been found useful to refer to this intensity by the term "one per cent static."

The average number of thunderstorm days for any location can be determined from meteorological records, but to measure the static field intensity, the thunderhunters set up an auxiliary test station in a truck in the center of an open field about five miles east of Madison. During the time that static noise was being recorded in Madison, measurements of field intensity were made simultaneously in the truck. These measurements of intensity, referred to as deviations from one per cent static, thus established a reference for the particular recording. By knowing the average number of thunderstorms for any other area, engineers can compute its one per cent static, and can then use the tape recordings made in Madison as a representative source of noise for testing purposes.

After the closing of the Hamokahodo test station at the end of the static season, a model of the OB system (one of the type-O carrier systems) was brought to the area, and a field study was made, with line terminals at Lake City, Florida, and Thomasville, Georgia. The static noise recordings were played back through a modulator and introduced into the line at the Lake City terminal. Thus, during December, 1950, and January, 1951, when there were practically no natural static storms in the area, the effects of actual summertime static were obtained by using the tape recordings.

Again in November and December, 1951, when there was practically no natural static, the recordings made in Madison were used to introduce static noise at carrier frequencies into the line of the trial OB system installed between Thomasville and Macon, Georgia.

The results of the thunderhunting operation have also been applied to the use of voice frequency carrier telegraph systems over channels of the OB system. During the 1952 static season, tests were made with 40C1 and 43A1 telegraph systems operating over channels of the Macon-Thomasville OB system using natural static when available and the Florida static recordings during periods of low static. These test results showed that the number of telegraph errors was essentially the same for natural and "canned" static when the distribution of the

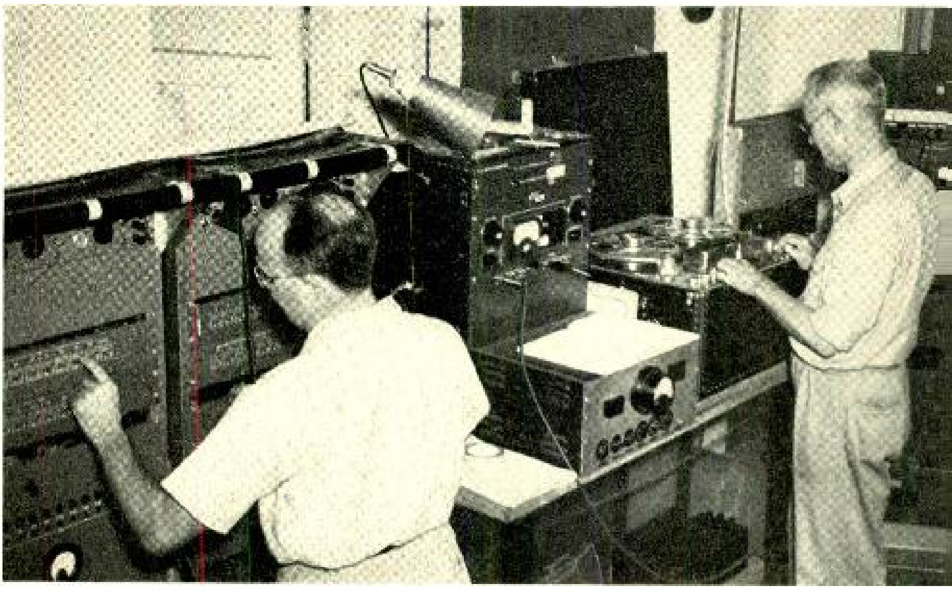


Fig. 4 — C. W. Irby checking the level distribution recorders as M. T. Dow adjusts the tape recorder.

noise from the two sources was the same.

Thunderhunting by the recording method has proven its merit. It has provided not only a laboratory source of static noise, but more important, a source that is reproducible. Comparison of performances of different types of circuits under similar static noise conditions, heretofore unobtainable except by a complete field trial using natural static, is now readily obtainable. The recording method, moreover, is not restricted to the voice and type-O carrier frequency ranges, for which tape recordings are now available, but may be employed for any frequency band by the use of appropriate demodulating equipment to bring the line frequencies down to the recorder frequency band of 50-20,000 cycles.

THE AUTHOR: ROBERT M. HAWEKOTTE came to the D & R Department of A T & T Co. in 1924 after he was graduated from Purdue University with a B.S. in E.E. degree. His early assignments in the field of transmission included the development of apparatus for tests on inductive interference, inductive coordination studies of voice-frequency noise, and the correction of wave shape distortion on power circuits. Transferring to the Laboratories in 1934, he continued his work on inductive coordination, devoting a considerable amount of time to the Joint Subcommittee on Development and Research of the Bell System and Edison Electric Institute. During World War II he was concerned with military projects and subsequently was associated with studies of atmospheric static noise on voice and carrier systems. Recently he again became associated with projects for the military. Mr. Hawekotte is a member of Eta Kappa Nu and Tau Beta Pi.

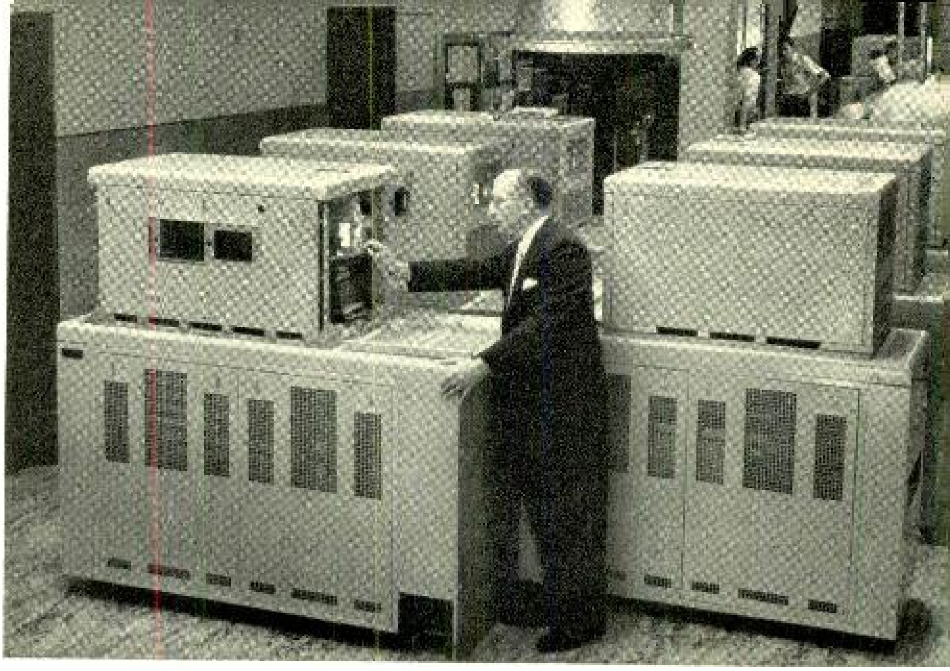
Out-of-Hours Courses

A program of Out-of-Hours Courses for the fall term of 1953 was recently announced. The purpose of these courses is to provide educational opportunities in the field of communications technology; they are presented by specialists well qualified in their respective fields through years of experience. The program has been arranged by the Personnel Department in cooperation with the Technical Departments. As the need arises or as requests develop from members of the Laboratories, new courses are added each year.

The size of the classes will be limited so as to permit class members to participate actively in classroom discussions. A high standard of scholastic effort and achievement will be expected of each individual. Consequently, applications will be carefully reviewed to insure that those enrolled are adequately prepared by training and experience to profit from the course.

As in the past, the Out-of-Hours Courses are offered without charge to members of the organization, and enrollment is on a voluntary basis. Members are expected to use their own time for preparation.

Supplementing the Out-of-Hours Courses program, a series of informative lectures which will deal with selected phases of the Laboratories' work that are of timely and general interest is being arranged for presentation in New York, Murray Hill, and Whippany during the coming months. Announcements of these lectures will be made at a later date.



O. Myers of the Laboratories inspects a card translator at the Newark, N. J., 4A installation.

Common-Control Features In Nationwide Dialing

J. B. Newsom
Switching Systems Development II

For nationwide toll dialing, there will be about seventy strategically located automatic switching offices, known as control switching points (CSP's). The switching system for these CSP's requires features such as automatic alternate routing, six-digit translation, code conversion, and the storing and sending forward of variable numbers of digits. These features are made possible by the common-control equipment used in the 4A system, each piece of equipment contributing its particular share as determined by nationwide dialing requirements. This article gives a general description of the various items of common-control equipment and the integration of this equipment into a fast, comprehensive switching system capable of handling both operator and customer nationwide dialing.

To provide those features essential at key offices – control switching points (CSP's) – in the nationwide dialing plan, the 4A toll crossbar system has been developed. Nationwide dialing is based on each customer's telephone number, consisting of the local office code and the individual line number, and these are preceded where necessary by three additional code digits representing the area in which his local office is located. This nationwide dialing numbering plan, together with the CSP offices, provides the basic toll switching facilities for direct dialing by operators, and eventually by customers, of toll calls to the entire country and Canada.

For these CSP offices to meet nationwide dialing requirements, the common-control circuits of the 4A system, such as senders, decoders, translators, and markers, incorporate many new features and circuit arrangements. Among these features are six-digit translation, extensive automatic alternate routing, control of the number of digits to be pulsed forward, code conversion, improved trouble-recording arrangements and additional testing and maintenance facilities. The block diagram, Figure 1, shows, the basic interconnecting arrangement of the common-control circuits in the 4A system.

One of the new features of the 4A system is known as "variable spill," and this feature is incorporated in the senders. The number of digits to be "spilled forward" to the next office may vary from call to call, and the senders are arranged to spill forward from one to eleven digits as the call requires, by information from the card translator. This results in the sender spilling forward all digits as received, or in omitting, substituting, or prefixing digits as necessary. The earlier No. 4 toll system used three types of incoming senders and two types of outgoing senders to receive and trans-

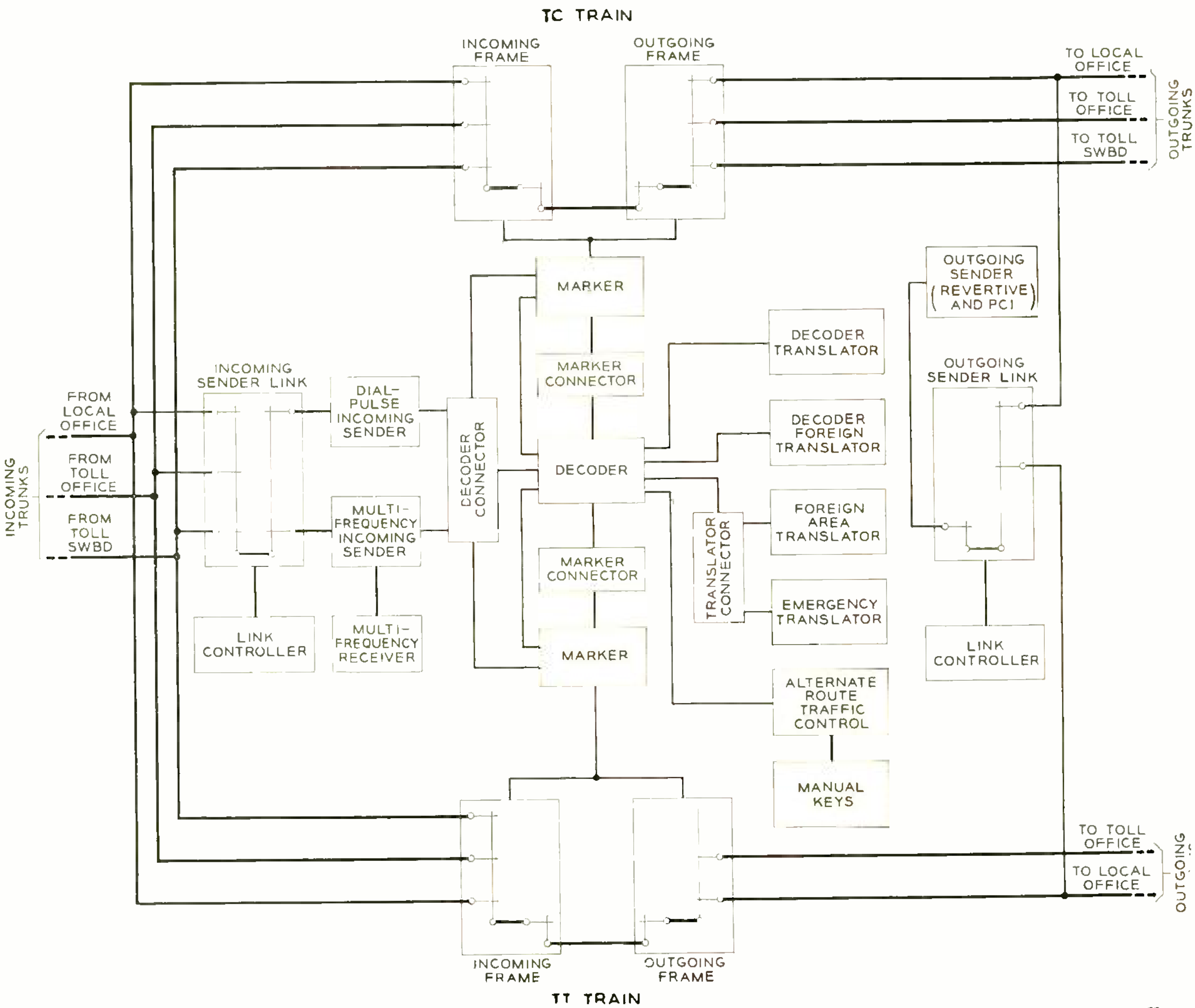


Fig. 1 – Simplified block diagram of a 4A system. The trouble recorder, not shown, connects to all items and will drop a punched trouble record card whenever trouble occurs.

mit all the necessary signals. In the 4A system, these same functions have been integrated into only two incoming and one outgoing sender.

Another important factor in nationwide dialing influenced decoder-marker arrangements. On some types of calls, the first three digits are sufficient to provide for the selection of an outgoing trunk. On other calls, however, more than three digits are needed. Because of the diversity of the codes used, it was not economical for the sender to predetermine whether to present three digits for translation or to wait for more than this number. The senders therefore always make a request for translation after the first three digits are received.

On those calls where more than three digits are needed, decoding and translation facilities are used only to signal the sender to release the decoder and wait for the rest of the code digits. On such calls the marker is not needed until the proper number of code digits is presented. Also, the marker is not needed on any call until the decoding and translating functions are complete. The number of markers necessary, therefore, could be reduced if the markers were separated from the decoding and translating facilities, and brought into service only when and if needed. In the 4A system the decoding, translating, and marker functions have been separated so that a decoder selects a translator and a marker as may be needed by a particular call. This separation also permits early release of the decoder and translator, while the marker is still engaged in setting up a connection between the incoming and outgoing trunks. The number of each of these important common-control circuits required in a 4A office is thus reduced to a minimum.

Six-digit translation was needed for economical use of toll lines or trunks because in many instances there are two or more routes or trunk groups from a particular CSP office into other numbering areas. For calls to such areas, both the area code and office code are used to determine the route. The need for six-digit translation means that there are a great many more codes to be translated than previously, and this required considerable extension and revision of translating facilities in the 4A system. Another important translating feature needed was a flexible and rapid means of changing and adding to the translating routing information. This was needed for adjusting the translating and trunking arrangements to meet the frequent changes in toll and local plants.

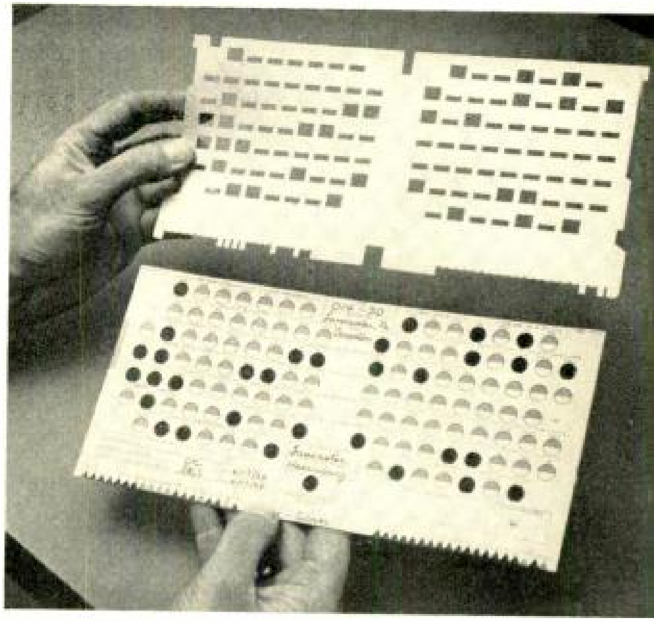


Fig. 2 — A punched metal code card, top, and the template used as a punching guide. The cardboard template is punched as desired and inserted into a card-punching machine. This machine then enlarges the holes in the metal card to agree with the template.

These translation problems encountered in nationwide dialing were solved by the development of the card translator.* In designing the translator, it was not feasible to design a single machine capable of accommodating the many thousands of code-cards needed in nationwide dialing. In a 4A office, therefore, several translators are used, each capable of holding about 1,000 cards. The headpiece of this article shows a group of card translators. The translator cards, Figure 2, representing the codes to be translated, fall into four general groups or classes. These are: (1) three-digit code cards for local offices within the home numbering area, (2) three-digit area code cards,

* A more complete description of the card translator will be given in a forthcoming issue of the Record.

(3) six-digit foreign-area code cards, and (4) alternate-route cards.

Because some of these cards are used more than others, they are placed in groups in particular translators. Those translators that contain low-usage card groups can be used in common, with only one or two translators per office for each 1,000 such cards. The translators are grouped, therefore, according to the cards they contain, as follows:

Decoder translators contain cards for local three-digit office codes, three-digit area codes, alternate-route codes and, where each decoder with an individual foreign-area translator.

The emergency translator is for emergency use. It can be used as a substitute for any other translator, by transferring the cards.

In nationwide dialing, the diversity of routings requires the use of several different types of outpulsing. Also, the number of digits to be sent ahead is often either more or less than the number of digits received. Moreover, the received digits themselves must sometimes be changed to other digits in order to reach the called destination.

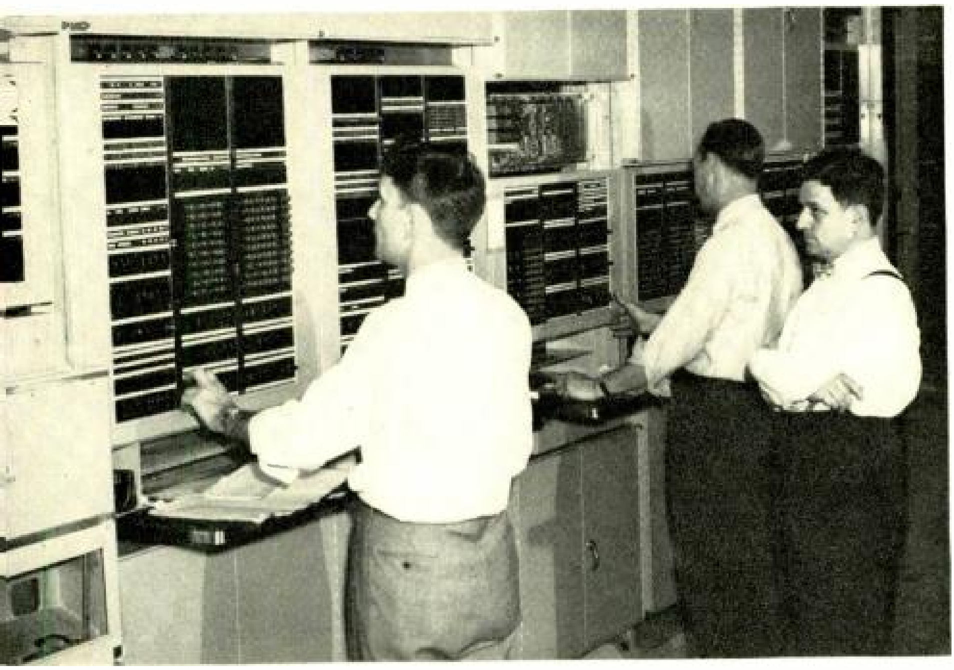


Fig. 3 — The maintenance center at Newark. Western Electric installers are testing the system prior to cutover.

space permits, some high-usage six-digit foreign-area codes. One of these translators is provided per decoder and connection to it is made by connector relays in the decoder.

In foreign-area translators are placed most of the six-digit foreign area code cards. One of these translators is provided per office for each 1,000 cards. They are in a common pool and are selected by a single-ended translator-connector circuit. Arrangements are such that a maximum of nineteen of these translators may be used.

In some CSP's there may be enough high-usage six-digit cards to warrant providing In addition to this, even on a single call these items of information change as shifts are made among the various alternate routes possible. These and many other similar conditions require a flexible and diverse translator output to meet the needs for automatic alternate routing, code deletion, code conversion, code substitution and the various types of outpulsing to be used. This rather complex but interesting problem will be discussed in detail in future articles.

From a particular CSP, there are many points to which calls are completed. Most of these points have alternate routes and the particular alternate-routing pattern used to some destinations is different from those to other points or destinations. Under heavy traffic loads or cable failure conditions, it is often necessary or desirable to control the alternate-route pattern to certain destinations, and sometimes to change or cancel all of the alternate-routing patterns. The inclusion of extensive automatic alternate routing in the 4A system creates the need for some means of changing or cancelling the alternate route patterns, either individually or collectively. An alternate-route traffic control circuit is provided for this purpose. Keys give the traffic force control of the decoder circuit, causing it to cancel either part or all of its tests for alternate routes.

To facilitate the rapid detection of troubles, a card-punching type of trouble recorder is used in the 4A system. This trouble recorder, Figure 3, in the event of failure of a decoder, translator, marker, or controller, automatically punches and drops a properly designated trouble card. This materially aids in locating the cause of the failure. Necessary keys and connecting relays are also provided so that test calls can be made on decoders, translators, and marker circuits, as desired by the maintenance force. Such test calls can be made using any working code on any combination of these circuits. This is very useful in setting up and checking out new codes and routings, and also in re-establishing code and circuit combinations on which trouble records have been occurring, to isolate the cause of failure. The trouble recorder also provides key control for obtaining trouble record cards of stuck senders. For traffic study purposes, records may also be obtained of calls routed to "reorder," "delay quote," "master busy," or "no circuit." Separate automatic test circuits for senders, controllers and trunk circuits are also provided. A tea-wagon type test set is used for bench testing the selector unit of the card translator. This test set is also used for adding and removing translator cards, and for making adjustments and timing tests on the translators.

New features of the common-control circuits of the 4A system will be discussed individually in future issues of the RECORD. There will be articles on senders, decoder-connectors, decoders, translators, markers, and trouble recorder circuits. Articles will also appear on translation by means of the card translator, on code conversion, on automatic alternate routing, and on traffic usage equipment. These and other articles will aid the reader in achieving a better understanding and appreciation of the 4A toll crossbar system and many of the CSP features and requirements of nationwide dialing.

THE AUTHOR: After four years of military service in World War I, JAMES B. NEWSOM joined the Western Electric Company in 1920, directing his attention to the development of manual telephone systems and the panel telephone system. Since the incorporation of the Laboratories in 1925, he has been a member of Switching Systems Development II and has devoted time to the design of panel and crossbar systems, crossbar tandem and toll crossbar systems. During World War II he was a lieutenant commander in the U. S. Navy, assigned to the Naval Research Laboratory in Washington, D. C. Since 1946, Mr. Newsom has been in charge of a group concerned with the development of toll crossbar senders, decoders, translators and markers.

Pulse-Testing TD-2 Antennas

W. C. WARMAN
Transmission Engineering

Regardless of the excellence of a microwave radio system, its operating performance will be determined in great part by the effective directivity of the antennas used. Measurements of TD-2 antennas in the field gave an apparent directivity different from the design value, and tests were made to discover the reason. Radar pulse techniques were used in these tests, and it was found that objects near the antennas, such as trees, buildings, and mountain ranges, caused unwanted reflected signals to enter the front of the antennas. The presence of these reflections reduced the effective directivity of the antennas below the actual value for the antenna alone. This pulse-testing technique will be a valuable aid in selecting future locations for TD-2 antennas.

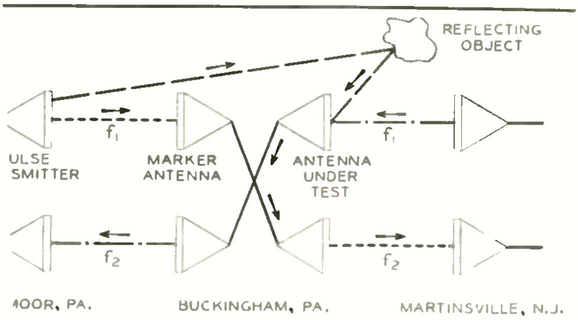
One of the more important factors in the design of microwave radio relay systems is the directional characteristic of antennas. Good antenna directivity provides a maximum radio signal over the radio path between repeater stations, and also provides discrimination against unwanted signals arriving at the receiving antenna from various directions. In the TD-2 radio system, a two-way radio channel utilizes one pair of frequencies throughout a microwave route. At each repeater station, as in Figure 1, incoming signals are received on one of the frequencies and outgoing signals are transmitted on the other frequency. In adjacent sections of the route, these same two fre-

← *A caravan of two station wagons, a large truck, and a small pickup truck were required to move the equipment and personnel.*

quencies are employed in the opposite direction to minimize RF feedback. It is apparent that signals from opposite directions must be separated by directivity of their respective antennas. The unwanted signal, received from the rear of the antenna, results in unintelligible crosstalk or noise.

The relationship between the forward and rearward responses of an antenna is known as the front-to-back ratio, and may be expressed in decibels. A high value of front-to-back ratio for a given antenna results in less unwanted signals entering from the rear. An increase in transmitter power, or improving the receiver selectivity, has no effect on this type of interference; antenna directivity is the sole determining factor.

To check the front-to-back ratio of TD-2 antennas installed and in service, nineteen antennas on the New York-Chicago microwave radio route were measured, using continuous-wave signals. Values measured in the field ranged from 54 to 74 decibels, as compared with a value of 68 decibels obtained in laboratory tests. It was conjectured that this wide variation in front-to-back ratio was a result of foreground reflections. For example, signals arriving from the rear of a receiving antenna could travel beyond the antenna and be reflected from objects in the foreground, back into the front of the antenna. Tests were made to eliminate the possibility of unwanted signals entering through mechanical faults in the antenna



'ig. 1 — *Diagram of the Buckingham station, showıg normal and reflected transmission paths.*

system, such as improper mating of wave guide flanges, deformation of the antennas, or weathering of the sealing putty* on the horns. It was decided that further tests of the effective front-to-back ratio should be made, using radar pulse technique.

Test equipment was selected that permitted the measurement not only of the amplitude of the signals, but the time delay of their arrival. This arrangement would then show the presence or absence of reflections. The assembled equipment used portions of a standard radar unit, and TD-2 microwave radio receiver equipment. A radar pulse transmitter with a peak power of 500 kilowatts was mounted in a truck

Fig. 2 — The pulse transmitter mounted in the truck is inspected by J. A. Smith.

as shown in Figure 2. It was equipped with 100 feet of solid-dielectric coaxial cable and a transducer to permit connection to the regular TD-2 waveguide. Field tests could then be made without hoisting the transmitter up to the equipment floor of a microwave station. The pulse receiver consisted principally of portions of TD-2 receiver equipment and the test bay in the repeater stations, and a radar oscilloscope.

It was decided that the pulse tests would

* RECORD, *December,* 1952, *page* 470.

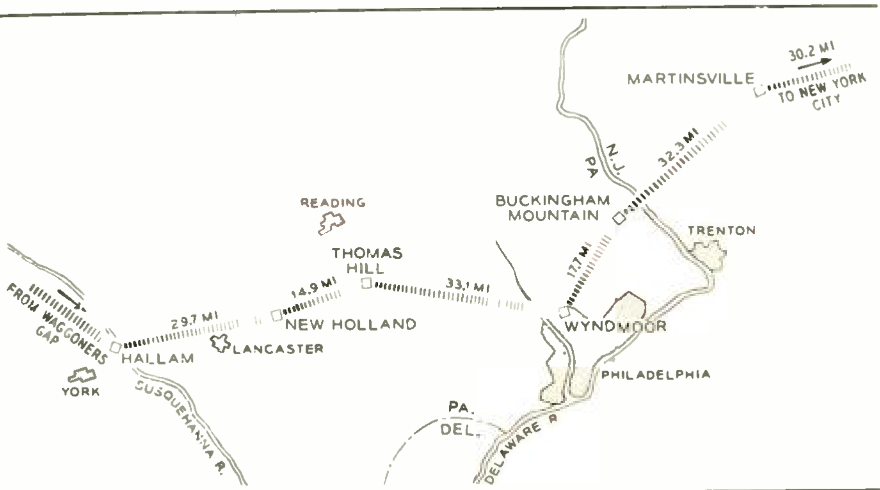


Fig. 3 – A simplified map of the area involved and the microwave stations tested.

be made on those antennas that had previously shown the lowest front-to-back ratios. These antennas were located at repeater stations in Pennsylvania, near Buckingham, Wyndmoor, and New Holland. Figure 3 shows a map of the area.

This section of the TD-2 microwave route carried both message and television service, and it was necessary for the Long Lines Department of the American Telephone and Telegraph Company to transfer the message channels to other broad band facilities during each test period. The tests were scheduled to start after daily television network transmissions were concluded, and to finish about one hour before the daily television network line-up.

Tests were conducted during the first two nights at microwave radio stations near Buckingham and Wyndmoor, Pennsylvania. Pulse signals transmitted to Buckingham from the TD-2 antenna at Wyndmoor were received directly on the Buckingham antenna facing Wyndmoor, for calibrating and synchronizing purposes. This is shown in Figure 1. The same signal was also measured on the Buckingham antenna facing the Martinsville, N. J., station. Thus, the effective front-to-back ratio of the Buckingham antenna facing Martinsville was the difference in amplitude of the signals received on the two antennas.

The results of these measurements are shown on an oscillogram, Figure 4. The amplitude of the "pips" indicates the strength of reflected signals, and the time delay of the "pips" indicates the excess travel time of reflected signals. One microsecond is equal to approximately 1,000 feet of radio transmission, and a one microsecond delay indicates the presence of a reflecting object 500 feet in front of the antenna. An analysis of this oscillogram, combined with a map-study of the terrain, showed that pips occurring in the first few microseconds, and varying greatly in amplitude, were reflections from nearby trees. Pips occurring around ten microseconds on the oscillogram were reflections from a tree covered ridge, about one mile in front of the antenna. A

BUCKINGHAM EAST RECEIVING ANTENNA

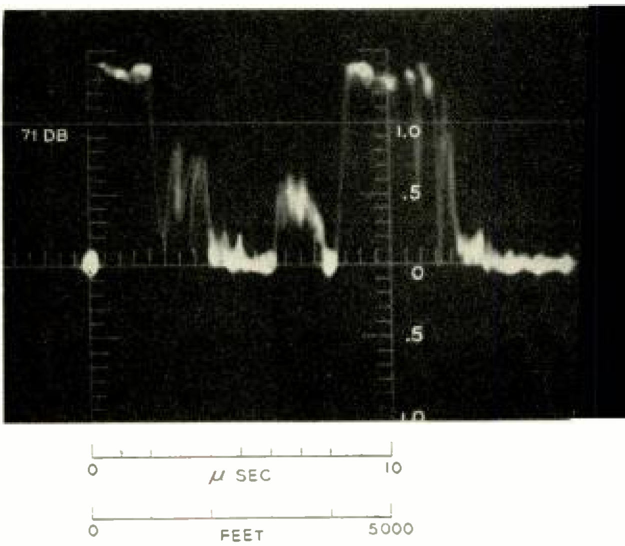


Fig. 4 – Oscillogram for the Buckingham receiving antenna facing East toward Martinsville, N. J.

weak reflection coming from a ridge about two miles away was also observed. The sources of these reflections are shown in Figure 5. The combined amplitude of the various pips indicated an effective front-to-back ratio of 54 db. This value checked that previously obtained using the continuous-wave method.

To meet a rather tight schedule, the test team was divided into two groups. One group moved and set up the test equipment during the day, and another group made the tests during the night. Tests were made during the third night at Wyndmoor and Thomas Hill repeater stations to determine the front-to-back ratio of the Wyndmoor transmitting antenna facing Buckingham. In this case the pulse transmitter was connected to the Wyndmoor transmitting antenna and measurements were made at Thomas Hill. This meant that signals transmitted from Wyndmoor toward Buckingham were reflected from objects in the foreground and bounced back to the receiving antenna located at Thomas Hill as shown in Figure 6. While the test set-up here was slightly different, the same general measuring techniques were used to obtain the effective front-to-back ratio. The results of these measurements are shown on the oscillogram of Figure 7. The pips shown in this figure remained relatively constant in amplitude as compared to tree reflections which vary continually. Visual inspection showed that these reflected signals came from buildings and towers located near the Wyndmoor station. The effective front-to-back ratio of this antenna was 57 db as compared to 58 db obtained with continuous-wave measurements.

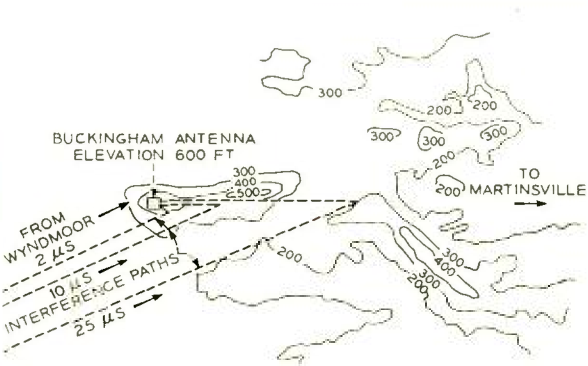


Fig. 5 – Simplified topographical map of the terrain around the station at Buckingham.

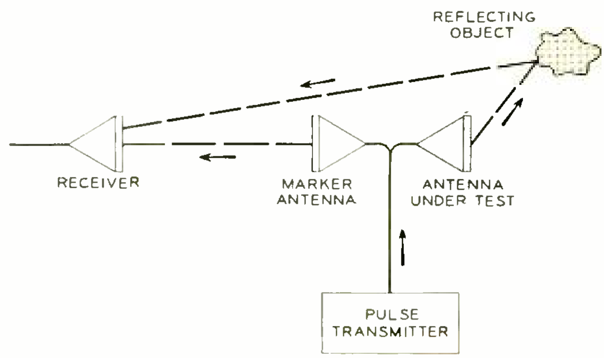


Fig. 6 – Arrangement used to test the Wyndmoor transmitting antenna.

The following day the transmitting equipment was moved to the Hallam station, and the receiving equipment was moved to the New Holland station, Figure 3. The Buckingham-Wyndmoor test arrangement was again set up and measurements were made during the following night. Figure 8 is a photograph of the receiver arrangement at New Holland. Here, again, the front-to-back ratio was similar to that obtained at Buckingham, as shown in Figure 9, but resulted from a different type of terrain. The New Holland station is located in cleared farming land, with wide sweeping cultivated fields on either side. The controlling reflected signal, 56 db down, came from a mountain located approximately 9,000 feet to the right of the regular transmission path.

This location afforded an opportunity to measure the actual front-to-back ratio of the antenna, since there were no important reflections contributed by nearby objects. By reducing the time scale on the oscilloscope to eliminate reflections from the mountain it was possible to measure the contributions of the antenna itself to the front-to-back ratio. A value of 75 db was measured, as shown in Figure 10, corroborating the maximum front-to-back ratio obtained using the continuous-wave method.

Subsequent to the measurements made in Southern Pennsylvania, similar tests were made at the New York terminal to determine the reflections from tall buildings at a location having converging routes. The pulse transmitter was set up at the Atlantic microwave station, near Tinton Falls, N. J. This is the first station south of New York on the direct New York-Washington, D. C., route. Test signals were transmitted to antennas on top of the Long Lines building at 32 Avenue of the Americas, and measurements were made on the New York transmitting and receiving antennas facing Martinsville and the transmitting antenna facing the Jackie Jones Mountain station, using them as receiving antennas. The oscillogram of Figure 11 shows the principal reflection obtained. The principal pip, 62 db down, is probably a reflection from the Empire State building.

Tests to determine the effect of cross-polarization on the front-to-back ratio were made in conjunction with the other tests at Buckingham and at New Holland. The TD-2 delay lens antenna* is designed for vertical polarization and cannot be conveniently rotated on its side for horizontal polarization. Parabolic antennas, however, can be readily cross-polarized. A fifty-seven

Fig. 8 – The author, facing the camera, and E. J. Henley making one of the tests.

inch TE-type parabolic antenna was mounted alongside the regular TD-2 transmitting antenna and aligned to the transmission path. The pulse transmitter was connected to this parabolic antenna and vertically and horizontally polarized signals were then transmitted and measured in the same manner as for TD-2 antennas. The comparative values of the two measurements revealed the effect of cross-polari-

* RECORD, *February*, 1952, *page* 49.

WYNDMOOR EAST TRANSMITTING ANTENNA

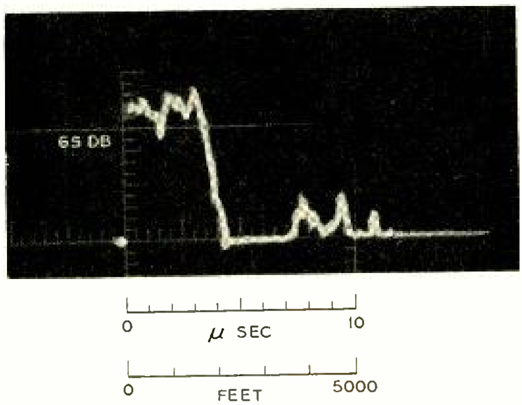


Fig. 7 – Oscillogram for the Wyndmoor transmitting antenna. Reflected signals came from buildings and towers near the station.

NEW HOLLAND EAST RECEIVING ANTENNA

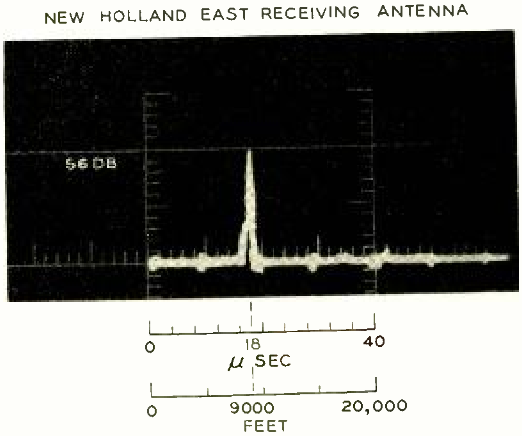


Fig. 9 – Oscillogram for the New Holland receiving antenna showing a single strong reflection from a nearby mountain.

NEW HOLLAND EAST RECEIVING ANTENNA

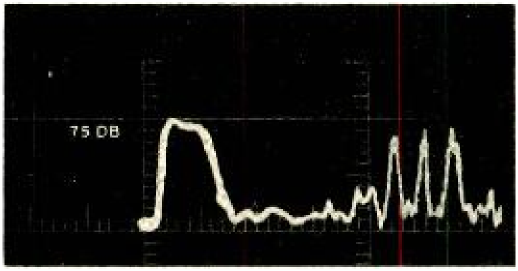


Fig. 10 – Changing the scale on the oscilloscope and increasing the amplification used gives this oscillogram. This is the same as the first five microseconds of Figure 9.

NEW YORK – JACKIE JONES TRANSMITTING ANTENNA

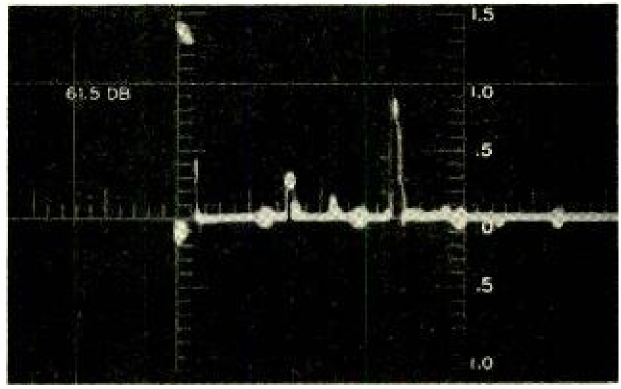


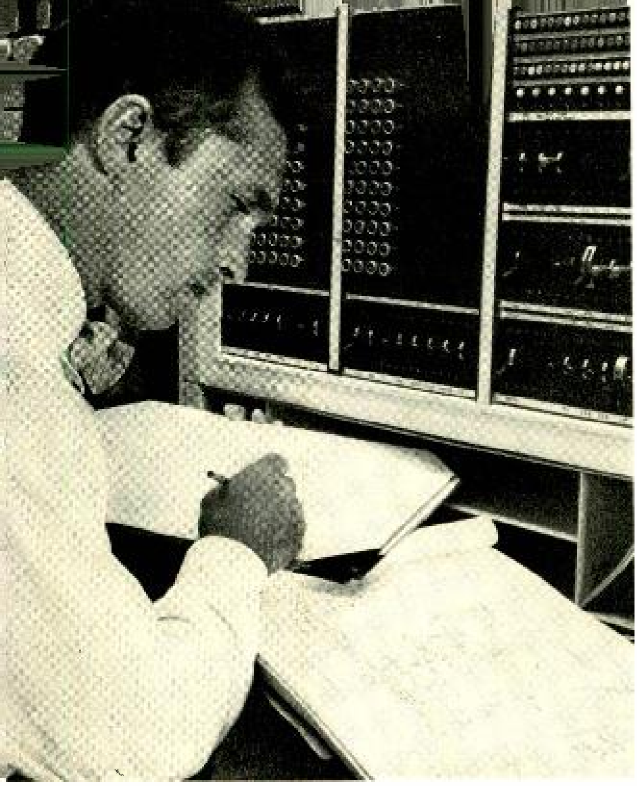
Fig. 11 – Oscillogram of the New York transmitting antenna facing Jackie Jones Mountain. The large pip is probably a reflection from the Empire State building.

zation on the front-to-back ratio. An improvement of about 3 db was measured on nearby reflections and 8 to 10 db on remote reflections.

All tests were conducted under the direction of the author, with N. F. Schlaack responsible for the procurement and adaptation of equipment used in the test. Other Laboratories personnel participating were L. G. Young, J. A. Smith, P. O. Sadenwater, E. J. Henley, R. Zarouni and J. J. Keilsohn, and Nelson Trusler of the Long Lines Department was a helpful observer.

The results of these tests show that pulse-testing will be valuable as an aid to the normal procedure in selecting future sites for antennas to be used on TD-2 and other contemplated microwave systems.

THE AUTHOR: William C. Warman joined the Laboratories in 1951 after twenty years in the Engineering Department of the Chesapeake and Potomac Telephone Company in Washington, D. C. While associated with the Chesapeake and Potomac he had worked with toll circuit layout, transmission, maintenance, and outside plant groups. His work included the design of local and long distance circuits, mobile radio systems and television circuits, and later the application of engineering standards to outside plant. As a member of the Laboratories he was particularly concerned with the development of microwave radio relay systems. He returned to the Chesapeake and Potomac Company of Baltimore City, Md., on October 1. Mr. Warman received his B.S. in E.E. degree in 1930 from West Virginia University. He is a member of the A.I.E.E. and Tau Beta Pi.



Sequence Charts for Switching Circuits

J. W. GORGAS
Switching Systems Development II

N. P. DeLuca, equipment maintenance man, using a sequence chart in conjunction with a trouble indicator at the Long Lines No. 4 crossbar office in New York City.

Modern telephone switching systems not only direct calls to thousands of customers in local areas, but, under control of the operator's or customer's dial, are reaching out across the nation. As these systems extend the direct dialing range, new intricate circuits must be developed. The problem of describing the operation of these circuits so that adequate preventive maintenance can be applied by skilled personnel becomes more difficult as the circuits increase in complexity. Sequence charts, using compact symbolic notation, aid greatly in solving this problem by making it possible to understand these operations more quickly and easily.

A chart that greatly simplifies the task of describing the operation of complex modern switching circuits has been adopted as a Bell System standard. These sequence charts, as they are called, explain circuit actions through the use of a compact graphical method that is so efficient that the order of circuit operation and the cause-effect relationships of hundreds of events can be shown on a single 11- by 17-inch page. Each chart is to take the place of many pages of text material which have heretofore been used to describe circuit operations and which have proved to be increasingly cumbersome for normal use. Experience of associated companies and of Bell Telephone Laboratories in training Bell System personnel has shown that the use of sequence charts makes it possible to understand the operations of particular circuits more quickly and easily. Training, maintenance, and, in fact, all the phases of communication work that require a detailed knowledge of switching circuits are benefited by the use of these charts. The time and effort required to obtain specific circuit information is also reduced and this results in lower training and maintenance costs.

Sequence charts are drawn in such a way that the time order of the various operations in a circuit, or the direction from cause to effect, is from top to bottom on the page. Each event on the chart is represented by a symbol; an "X" indicates the operation of a relay, or magnet, or the activation of an electronic element, and the symbol "—" indicates a release or deactivation. Each event on a chart is shown to be the result of a previous event or a combination of events by connecting the appropriate symbols with lines similar to those used on "family trees" or organization charts. The designation for each element on the chart is shown beside the symbol representing its action. Unless otherwise specified, these symbols represent the actions of relay contacts. When they are used to represent elements other than relays, such as electron tubes or magnets, additional designations are included on the sequence charts to indicate the nature of those elements.

Each sequence chart is provided with coordinates similar to those used on road maps. These consist of capital letters across the top and bottom of a page and numbers along both sides. Such coordinates are useful in locating an action symbol which is referred to in a descriptive text or on other sequence charts. When more than one page is required for the chart describing the entire operation of a circuit, a page number is prefixed to these coordinates to specify the page that describes a particular phase of the operation.

The basic form of a typical sequence chart is illustrated in Figure 1 which shows the operation of a 4A toll system marker in selecting a trunk. In this figure, lines connecting the operation symbol for the MC1-3 relays at coordinates C2, with that for the TC- relay at C3, and RCD relay at D3 illustrate how one action is shown to cause several succeeding events; operation of MC1-3 results in the operation of both TC and RCD. On the other hand, there are many instances when a particular event will not occur unless several preceding actions have taken place. To illustrate this situation, the TBA- relay at C6 (Figure 1) cannot operate unless both the MCA (C5) and TB2K (D5) relays have first operated.

Another important characteristic of sequence charts is that the lines indicating the link from cause to effect are directed horizontally or downward and never include any upward steps. For example, operation of the TB2K relay at D on line 5 of Figure 1 is required for the operation of TBA- at C on line 6 but not for MCB at B on the same level since there is an upward step in the line connecting TB2K and MCB.

In complex switching systems, the individual circuits do not operate independently, but rather actions in one circuit lead to actions and events in associated circuits, and vice versa. The actions of the 4A marker in establishing a call, for example, are closely related to actions in a number of other circuits. These "foreign" actions are differentiated from the actions of the primary circuit on a sequence chart by adding abbreviations enclosed in parentheses to

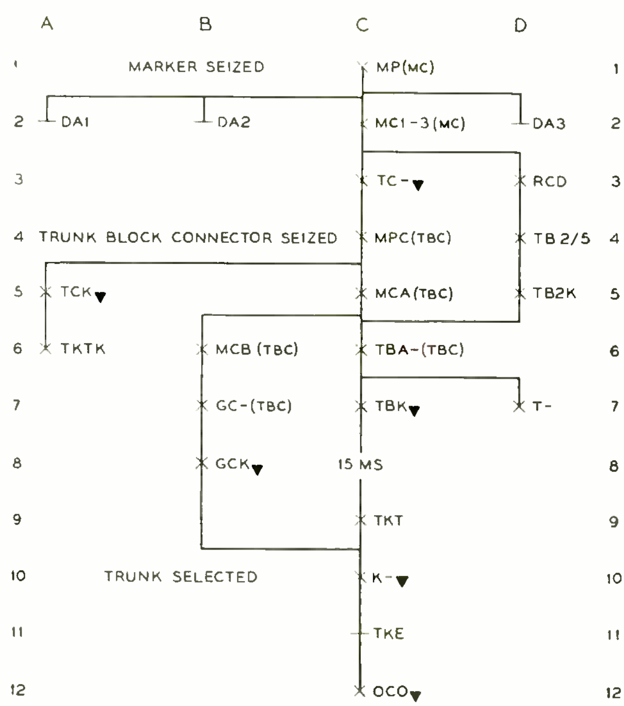


Fig. 1 — Basic form of a typical sequence chart. The symbol "X" represents the operation of the designated relay, and "—" indicates its release.

represent the name of the foreign circuit. In Figure 1, the abbreviation (MC) following the MP and MC1-3 designations (coordinates C1 and C2) shows that these actions take place in the marker connector circuit, rather than in the marker itself. Similarly, actions in the trunk block connector circuit are shown by the abbreviation (TBC) at coordinates B6, B7, and C4, C5, C6.

It is sometimes necessary to delay particular circuit actions to provide sufficient time for other actions to be completed. These delays are indicated on the charts by skipping a space on the vertical line between the action symbols. This is illustrated in Figure 1 by the delayed operation of the TKT relay at C9 as a result of the TBK operation at C7. The specified delay for the TKT relay, which is accurately controlled to a time of 15 milliseconds, is shown in the interval on line 8. When ordinary slow operate or slow release relays are used to obtain delays, the abbreviation SO for slow operate or SR for slow release is shown in the interval instead of a specified time.

Figure 2 illustrates a sequence chart typical of those in wide use in the field. This particular chart shows all the operations of a 4A marker in establishing a call under ordinary conditions. Inter-related events that take place in a definite sequence in about four-tenths of a second are included. If sequence charts were not available, dozens of pages of written description would be required to explain this complicated process, and the text would be much more difficult to interpret.

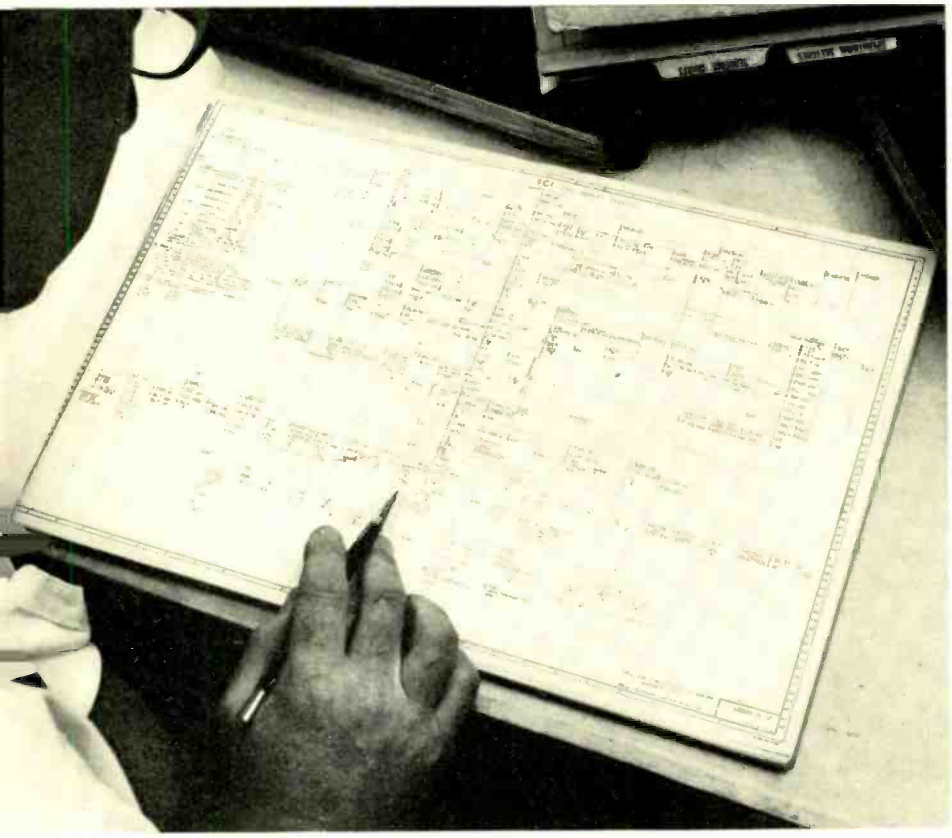


Fig. 2 — The author consulting a sequence chart that describes the action of a 4A marker in establishing a trunk.

The operations indicated by a sequence chart of the type shown in Figure 2 are based on a set of assumptions which make it useful under the most general conditions. This chart, for example, is based on the supposition that a call does not encounter trouble or overloaded circuits. Occasionally, however, traffic congestions or trouble conditions cause the marker to vary its sequence of operations, and, these variations are described in supplementary sequence charts.

One of these supplementary charts, shown in Figure 3, illustrates the operation of a 4A marker when it encounters two subgroups of channels that are busy. The action of a marker under these conditions does not vary from the normal sequence until after relay CHT operates. Accordingly, the supplementary chart begins by repeating this event and giving its location by coordinates on the over-all chart. Similarly, when the action returns to an event on the over-all chart, this event is repeated at the end of the supplementary chart and coordinates are again supplied to identify the location.

One sequence chart may include alternative assumptions. The upper part of Figure 3 – lines 1 through 9 – for example, shows the action of the marker when it finds one entire subgroup of channels busy. Since the chart is based on the assumption that there is more than one subgroup of channels, the marker then connects to a second subgroup. From line 14, the action of the marker takes either of two courses depending upon what further assumptions are made. If it is assumed that a channel is available on the second subgroup the CH- relay (coordinates A15) operates and the action proceeds to the "hold magnet test" on the over-all chart. If it is assumed that a channel is not available, however, the CHB relay at D15 operates, and the action continues to the "trouble release" function. A dot is placed at the point where the action may take one course or the other (B14 on Figure 3). The branching lines of action are separated and labeled with the alternative assumptions, "Idle Channel" and "All Channels Busy."

Natural shorthand methods make sequence charts even more compact. This is illustrated by the fraction 2/5 following the TB designation at coordinates D4 in Figure 1. This notation indicates that two and only two of five TB relays provided in the marker should operate. An associated schematic drawing shows that these TB relays are designated TB0, TB1, TB2, TB4 and TB7. Zero, one, two, four, and seven are the digits used in the self checking additive two-out-of-five code. Since this code is widely known, it is convenient to indicate such circuit actions by the abbreviated notation.

In addition to their widespread use in training personnel, sequence charts have proved to be valuable for central office maintenance. They show what events should take place and the order in which they should occur. Therefore, these charts form a basis for recognizing mal-operation in a circuit. A typical mal-operation, for example, is the failure of a circuit to complete its operations. Major circuits recognize this

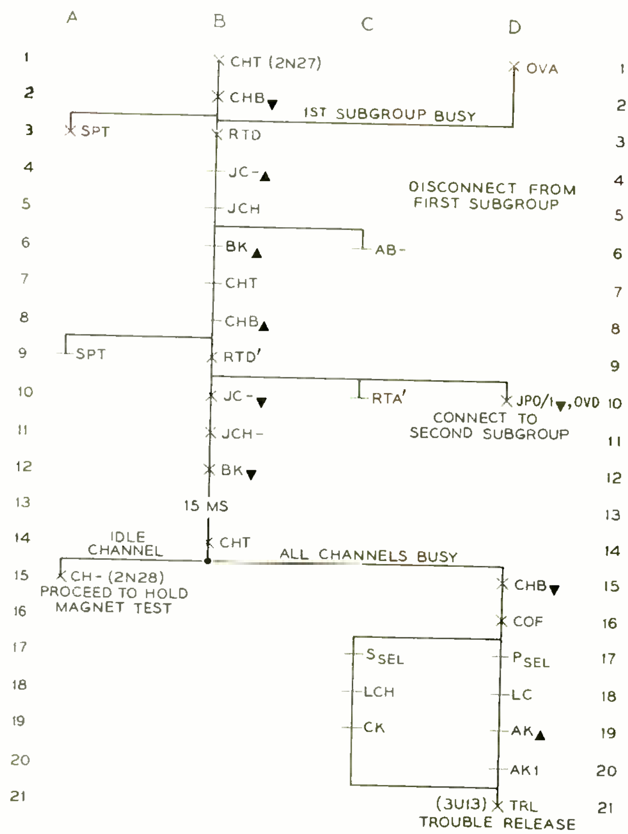


Fig. 3 – Supplementary sequence chart showing the operation of a 4A marker that encounters one or two subgroups in which all channels are busy.

failure by "timing out" and leaving a trouble record. This identifies the circuits that encounter the trouble and indicates their progress at the time of failure by showing whether key circuit elements were operated. On the sequence charts, these key or "milestone" elements are identified by solid triangular symbols near the circuit action symbols as shown in Figures 1 and 3. Reference to these symbols from the indi-

THE AUTHOR: John W. Gorgas' twenty-two years' experience with the Bell Telephone Company of Pennsylvania included dial system maintenance, maintenance engineering, and plant training. He transferred to the Laboratories in 1946 to help in planning the No. 5 crossbar training literature and school. He was subsequently concerned with the design of the 4A toll system decoder-marker test and trouble recorder circuit, and later was responsible for the development of new circuit description and schematic methods. Currently, he is engaged in the design of sender test circuits in the various No. 4 systems. Mr. Gorgas' electrical engineering training included two years at Drexel Institute of Technology.

cations on a trouble record shows how many milestones on the chart were reached by the circuit before the trouble was encountered. This greatly assists trouble analysis since the actions immediately following the last indicated milestone are apparent, and their failure can be investigated.

The CHB relay of the marker is one of these key elements. A solid triangle drawn with its apex downward near the symbol showing the operation of this relay (B2, Figure 3) indicates that a failure after this operation would cause a CHB trouble indication. A triangle with its apex upward near the CHB release symbol (B8, Figure 3) indicates that a failure after that operation would not cause a CHB trouble indication.

The number of symbols used on sequence charts has been kept to a minimum. This avoids congestion and makes the notation easy to learn. No symbols have been used, for example, to show that a relay is provided with a holding path subsequent to its operation since no action is involved. Circuit details of this type are shown better and more completely on a schematic drawing. As a result, sequence charts are free to depict circuit actions in concise symbolic notation. The simple form of these charts has been an important factor contributing to their marked success. They have been provided for most of the common control systems including No. 5 crossbar, No. 4 toll, AMA and CAMA, and are being widely used both for training classes and on the job in the Bell Syetem.

TWA Installs New Teletype System

Keeping ahead of its present 300-mile an hour aircraft fleet, Trans World Airlines has installed the new 81-D-1 Teletype system to streamline its communication operations. The fourth installation of this fully automatic Teletype system, it links 110 automatic units in 45 cities to switching centers in New York City and Kansas City, Missouri. Daily transmission of 1,250,000 originated words is possible with the system.

Designed by Bell Laboratories, the system is a fully automatic teletypewriter network that replaces the former manual network. In originating a message, the operator merely types in the proper address and "directing" code ahead of the message. The switching center then automatically routes it to the proper destination with no further attention. Messages that are temporarily undeliverable are stored on special machines in the switching center and later automatically transmitted to their destination when the circuit is free. Messages are sent only to the station or stations addressed, replacing the former manual practice of sending all messages to all stations.

The author (left) discusses the wiring of the 1031-type crystal filter unit with W. J. Carroll.

A New Crystal Unit for Broadband Carrier Systems

A. W. ZIEGLER
Transmission Networks Engineering

A quartz crystal plate is inherently an efficient resonator; its internal damping is very small, and, when properly mounted, its ratio of inductive reactance to effective resistance, "Q", ranges from 10,000 to over 1,000,000. The chief problem has been that of mounting the crystal plate to preserve its valuable characteristics and at the same time producing a crystal unit that is reliable, economical to manufacture, capable of withstanding reasonably rough handling, and small in size. Recent design improvements have made considerable progress toward these objectives.

Demands for more and more telephone circuits have made it necessary to expand the use of broadband carrier systems – type J on open-wire lines, Type K on paper insulated cables, and type L on coaxial cables. Thus, requirements for copper are minimized, and line costs are shared by a number of channels.

Broadband carrier telephone systems are designed to operate in groups of 12 channels. Two such groups, one comprising the transmitting channels and the other the corresponding receiving channels, provide 12 two-way circuits. Between each modulator and the line in the transmitting group is a filter designed to pass only the lower side band resulting from the modulation; and between the line and each demodulator of the receiving group is an exactly similar filter which serves to select, from the fre-

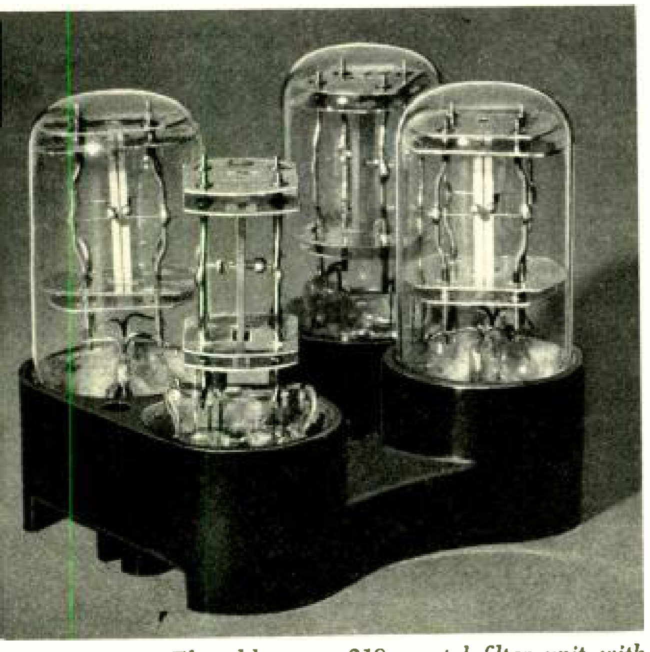


Fig. 1 — The older type-219 crystal filter unit with shielding removed and the glass envelope absent from the crystal unit in the foreground, so as to show the internal construction.

quency bands on the line, the particular one to be passed to the demodulator. These twenty-four filters, two for each assigned channel frequency range, are the channel filters.

Since the same type of channel filter is employed for all present broadband systems, joint efforts by the Western Electric Company and the Laboratories have been directed toward obtaining small, inexpensive filters without sacrificing performance.

Crystal units used in the first channel filters were of the mechanical clamp type* which, together with other filter components of that time, required a panel mounting space approximately 3½ inches by 14½ inches. Design improvements in filter components, including the development of wire supported quartz crystal units† produced the electrically superior and more compact 219 type crystal filter.

In the earlier model of the 219-type filter, the four crystal units were of the glass-enclosed dry air type, each containing a quartz crystal plate supported by fine wires, and protected against mechanical damage or displacement by a system of mica spacers or bumpers. These four units were mounted on a molded phenolic base that carried all inter-unit wiring. Figure 1 shows this assembly with electrical shielding removed and the glass enevelope absent from the crystal in the foreground to show the internal construction.

Engineering analysis of cost and size of the earlier 219 type channel filter showed two major contributing factors. One was the large air core inductors; the other was the crystal units themselves. By using the newly developed ferrite materials in the design of the inductors, a considerable saving in panel mounting area was gained, and such inductors are used in the new 536 type channel filter. The crystal units, however, represent approximately 70 per cent of the cost of each channel filter. Therefore, any appreciable direct cost saving emphasized the need for developing less expensive crystal units, whether used as components of the 219-type filter or the more recent 536 type. A redesign of the crystal unit has recently been accomplished, in which a considerable saving in manufacturing cost has been attained.

One simplification of crystal unit construction that appeared promising was the elimination of the bumper spacers used to limit the displacement of the lightly supported crystal plates under impact or acceleration. Experience in mounting small, high frequency quartz crystals without bumpers indicated that the same procedure could be used for the larger and heavier quartz plates of the channel filter. Mounting wires for the quartz plates had to be heavier, however, and this necessitated studies of not only the size of the wire itself but the effect of the wires on the frequency stability and on the ratio "Q" of inductive reactance to effective resistance of the crystal plate. These studies showed that 0.0126 inch diameter phosphor bronze wire was adequate to support the heaviest crystal plate used in any of the twelve different filters and that the electrical performance of the crystal plates required for the 60-kc to 108-kc frequency range, was completely satisfactory. The new crystal plate mounting system is shown in Figure 2.

* Record, *October*, 1938, *pages* 62 *and* 66.
† Record, *April*, 1945, *page* 140.

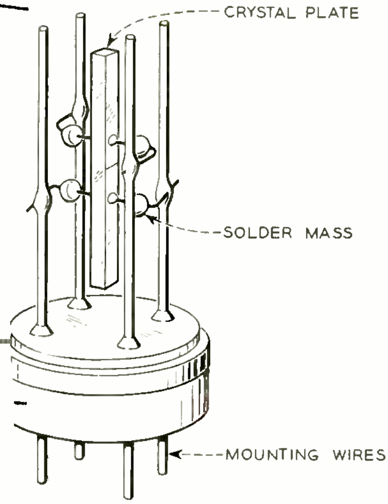


Fig. 2 – The new crystal plate mounting system.

As mentioned in an earlier article,* even when the wires are fastened to the crystal at a node, the finite attachment area extending into the region of quartz movement may cause a slight damping, some of the energy of the vibrating crystal being transmitted to the support system. To prevent transmission of this vibration to the support wires, a ball of solder of proper mass is placed on the mount wires at a point that effectively clamps the wire and allows the end attached to the crystal to vibrate freely.

In contrast to earlier crystal unit designs, in which the crystal plate electrode is equally divided by a lengthwise insulating line, in the present design, the plate electrode is equally divided by a shorter crosswise line at the center of the plate. As illustrated by Figures 2 and 3, the wire attachments are displaced farther from the crystal plate node than in the former design. The proper positioning of the solder balls controls, to a low value, the energy transmitted to the support system.

New techniques in the application of silver paste and burnishing of the silver spot on the crystal have resulted in increased strength of mount-wire attachment of the crystal plate. As described in the earlier article, the mount wires are headed and soldered to the fired-on and burnished silver spots. With the improved techniques, a force of more than 12 pounds is required to pull a mount wire from its associated silver spot – and the solder joint fails rather than the silver spot itself. These several design improvements have made it possible for the units, when mounted in experimental filters, to withstand repeated shocks in severe dropping tests.

Channel filters in which these crystal units are housed are designed for hermetic sealing to assure stability of other components. Consequently, the vacuum tight glass enclosure used on the earlier wire-supported crystal units is unnecessary, and an enclosure of simple construction can be used. Actually, the container is an extruded aluminum can ⅞ inch in diameter, which is standard in the capacitor industry. A partially cut-away view of the crystal unit, with the unit and its associated cover, is shown in Figure 4. The base of the unit is a

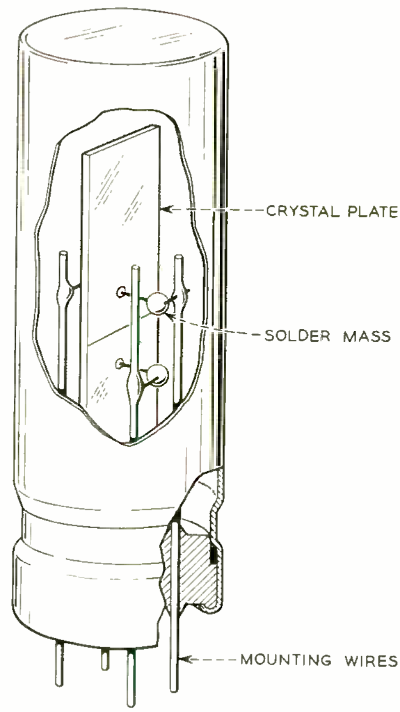


Fig. 3 – View of the new crystal plate mounting system with cover in place.

*Record, *April,* 1945, *page* 140.

molded plastic and carries the four straight spring-tempered, tinned brass support wires, each of which is identified by marks molded in the base. A neoprene gasket is placed over a reduced diameter base section and becomes squeezed into position during final assembly by crimping the mouth of the can in one operation over the rim of the base. This provides a satisfactory seal for the crystal unit prior to its assembly in the filter. A locking detent in the base prevents the base, and hence the crystal unit, from turning after installation.

This crystal unit, housed in the aluminum container, is known as the type-31 crystal unit. A group of four of these units, attached to a common base, pre-wired and tested for use in the redesigned 219 type filter, is designated the type-1031 crystal unit. Such a unit is shown in Figure 1.

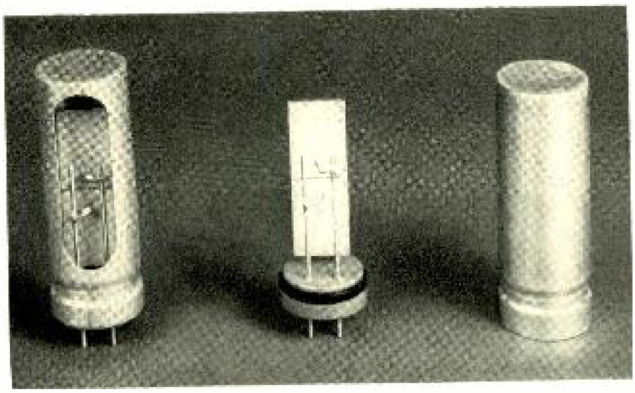


Fig. 4 — A partial cut-away view of the crystal unit (left), the crystal unit alone (center), and the container.

THE AUTHOR: A. W. ZIEGLER interrupted his engineering studies at the University of Illinois in 1918 to become a Naval Air Pilot during World War I, and then received his B.S. degree in Electrical Engineering in 1921. He joined the Engineering Department of Western Electric that year, transferring to the Laboratories upon its incorporation in 1925. His earliest work was on the development of switchboard lamps, vacuum thermocouples and ballast resistors; and later, the development of filters and networks for voice frequency and power line carrier circuits. His work on quartz crystal filters and later on synthetic EDT crystal filters for broadband carrier telephone circuits was primarily concerned with improvements in crystal plate mounting systems. Following his recent interests in the field of hermetic seal terminal design, he is currently engaged in the development of barium titanate storage devices. Mr. Ziegler is a member of Eta Kappa Nu and the I.R.E.

Freda Lutchko measures impedance of 400-type varistors while the author (left) and J. G. Whytock look on.

N1 Carrier—Selection of Varistors For Use in Compandors

F. R. STANSEL
Transmission Systems Development

With the advent of the electron tube, the telephone industry was provided with a circuit element that did not obey Ohm's law. Besides, the current through the tube depended upon the polarity of the applied voltage. These characteristics gave the tube wide usefulness as a modulator and as a rectifier. Solid non-ohmic conductors, such as copper oxide, silicon carbide and, more recently, germanium, gave rise to a new class of circuit elements which, because of their variable resistance, have become known as "varistors." These devices have replaced the electron tube in many of its non-linear and rectification uses.

In the development of the N carrier system, all of the existing carrier art, built up over a period of more than twenty years, was reviewed in the light of the new requirements. Probably the most important single feature that could be adapted to the new system was the compandor. This device, originally available only for use on the longer carrier systems, compresses speech amplitude at the transmitting end and then expands it to its original volume at the receiving end. An earlier article* describes the compandor used in the N1 System, and the advantages to be gained from it.

The heart of any compressor or expandor is an attenuator pad, called a "vario-losser,"

* Record, *November,* 1953, *page* 452.

in which transmission loss is controlled by a direct current derived from the speech currents. This pad consists of both fixed resistors and varistors, which are circuit elements whose resistance changes with the application of voltage. At the compressor end, the varistor elements form the shunt arm of the pad and the fixed resistors form the series arm, as indicated in Figure 1(a). Direct (control) current passed through the circuit causes the transmission loss to increase with increasing control current, as shown in Figure 1(b).

At the expandor, the vario-losser pad is the inverse of that at the compressor; that is, the varistors are now in the series arm and the resistors in the shunt arm, as shown in Figure 2(a). This causes the transmission loss to decrease with the dc control current, as illustrated by Figure 2(b). This action of the two vario-lossers tends to be complementary, so that after the signal has passed through the two vario-lossers in tandem, it is restored substantially to its original amplitude range.

Any one of several types of varistors can be used in a vario-losser. In early compandors, copper oxide varistors were used. In the N1 carrier system, the vario-lossers are made from selected germanium varistors of the 400 type.

For many engineering uses, the figure of merit of a varistor is the differenence in resistance in the forward and in the reverse direction, i.e., its rectifying properties. In contrast, here is an application in which the varistor never operates on the reverse, or high resistance portion of its characteristic curve. The desirable transmission in this application is the forward direction, and the curve of dc bias current versus ac resistance should be as uniform as possible from varistor to varistor.

Figure 3 shows the forward characteristic of a typical germanium varistor. At any point such as A, the resistance of the varistor

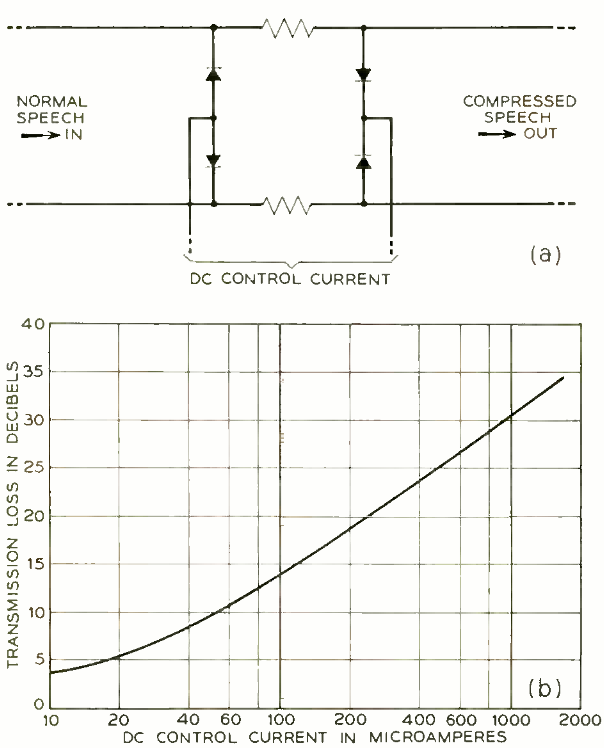


Fig. 1 — Above, (a) schematic circuit of vario-losser in the compressor. Below, (b), transmission characteristic of vario-losser of (a).

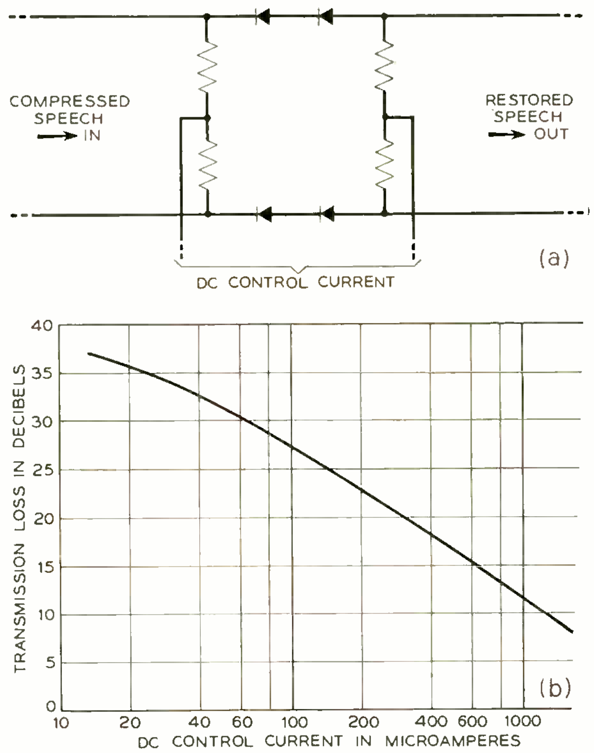


Fig. 2 — Above, (a) schematic circuit of vario-losse in the expandor. Below, (b) transmission character istic of vario-losser of (a).

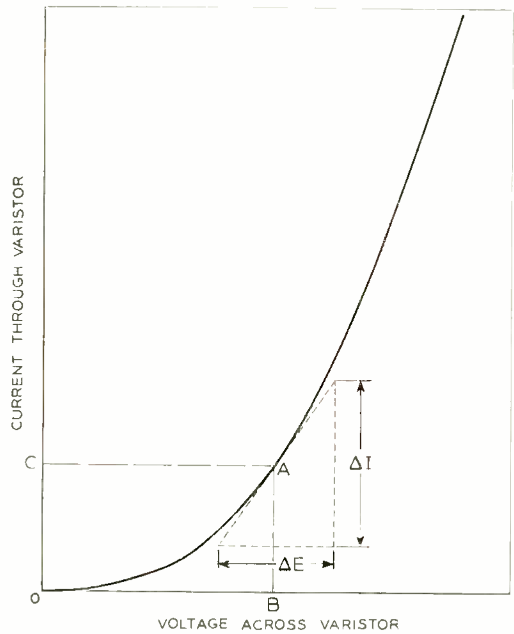


Fig. 3 — Volt-ampere characteristic of a typical germanium varistor.

may be considered as the voltage OB divided by the current OC. This resistance is usually referred to as the "dc resistance"; in some applications of varistors, such as rectifiers, this is the resistance that is of importance. If, however, a dc bias, such as OB, is applied along with with a small superimposed ac voltage, the current flow due to this small ac voltage is not proportional to the dc resistance. Instead, the alternating current produced by this small superimposed voltage is proportional to the slope of the characteristic curve at the point A. Hence the "dynamic" or "ac resistance" is the quantity $\Delta E/\Delta I$ as indicated in Figure 3.

This dynamic or ac resistance varies as the dc bias varies. The ac resistance of a typical germanium varistor, as a function of the superimposed dc through it, is shown in Figure 4. For low values of bias direct current, the ac resistance is high, and as the bias current is increased, the ac resistance drops. For small bias currents, this decrease is large, but as the bias current increases the rate of decrease diminishes. It is this decrease in ac resistance with increasing dc that makes possible vario-lossers having the characteristics of Figures 1(b) and 2(b).

Measurements of the ac resistance can be made on a bridge such as the one shown schematically in Figure 5. In place of the usual resistance ratio arms, two capacitors C1 and C2 are used. Use of capacitors instead of resistors simplifies the application of the superimposed bias current by limiting it to the varistor only. The bias current is obtained from a relatively high voltage source, through the series resistor R2 and one of the resistors R3, R4 or R5, depending upon the predetermined amount of the bias current desired. Capacitor C4 by-passes the ac away from the dc supply, and resistor R6 and capacitor C5 balance the resistor R2 and capacitor C4. Capacitor C3 blocks the bias dc from flowing through transformer T1 that connects to the detector circuit.

Ac resistance is measured by supplying a small ac voltage, of the order of 50 to 100 millivolts, from an oscillator, and adjusting the resistance standard R1 for minimum output of the detector. At this adjustment, the ac resistance of the varistor is equal to the value of R1.

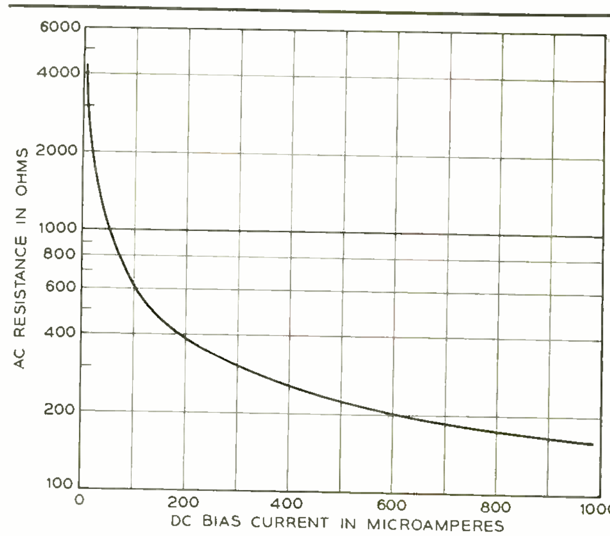


Fig. 4 — Dynamic, or ac resistance of a typical germanium varistor as a function of dc bias current through it.

From a manufacturing standpoint, it would be highly desirable to produce varistors so similar that any varistor selected at random could be used to form a vario-losser. Unfortunately, this degree of uniformity has not yet been obtained.

It does happen, however, that a good degree of correlation exists between the ac resistance versus bias current curve, Figure 4, and transmission curves of the types shown in Figures 1(b) and 2(b), that are used in manufacturing the units. This makes it practicable to select varistor units for the vario-losser pads on the basis of ac resistance measurements. Units are selected initially by measuring the ac resistance with 500-microamperes dc bias superimposed. Those having an ac resistance less than about 200 ohms and greater than about 250 ohms are rejected for use in vario-lossers, but these units can be made available for other varistor applications, such as modulators or rectifiers.

The uniformity required makes necessary a second screening of the varistors that passed the first test. This time, a 50-microampere dc bias is employed and varistors having ac resistances less than about 800 ohms and greater than about 1,100 ohms are rejected for use in vario-lossers. However, these rejected units can be used in other varistor applications.

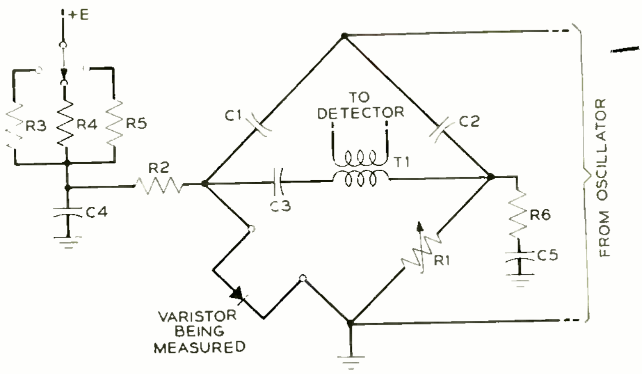


Fig. 5 – Schematic bridge circuit used to measure ac resistance of varistors.

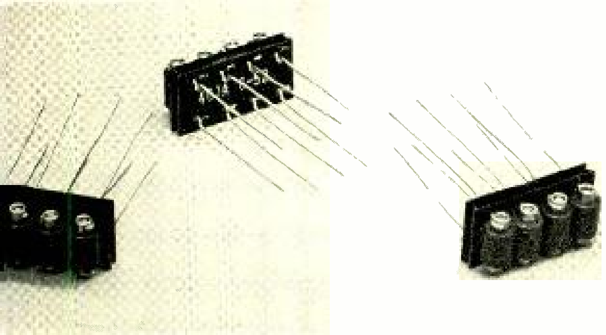


Fig. 6 – 407A varistors ready for mounting for use in vario-lossers.

In the case of the varistors used for the compressor, a further selection is made, in which the ac resistances at 5-microamperes dc bias for the two pairs do not differ by more than about 5 per cent. Such close agreement is necessary to insure that the compressor, Figure 1(a), is very closely balanced to avoid troublesome transients, or "thump," when the gain around the loop formed by the amplifier, control rectifier

THE AUTHOR: Frank R. Stansel's twenty-seven years at the Laboratories have been split between several departments at the three major locations. In 1926, with a B.S. degree in E.E. received that year from Union College, he became a member of the Whippany Radio Laboratory, engaged in the development of high-power radio transmitters for broadcast and transoceanic service. Ten years later he transferred to the Apparatus Development Department in New York City and worked on special testing equipment and wire tracing apparatus. During the same period he attended the Polytechnic Institute of Brooklyn to receive the M. E.E. (1934) and D. E.E. (1941) degrees. He was a member of a group associated with the design of radar equipment during World War II, and subsequently received a special assignment in filter development. He later transferred to Murray Hill for work on germanium varistor development. He is currently concerned with the application of transistors to new carrier telephone systems. Mr. Stansel is a member of the A.I.E.E., the I.R.E., Sigma Xi and Eta Kappa Nu.

and vario-losser is high. The balance requirements on the expandor vario-losser are less stringent and this type of matching of varistors is not required.

After this preliminary selection is completed, the varistor elements are mounted in molded plastic details, as shown in Figure 6. They are then measured for transmission loss as a complete pad in a standard transmission measuring circuit similar to those provided for measuring filters and other networks. An additional test is made to insure a high loss from the dc input to the ac output of the vario-losser, to prevent spurious oscillations, or "singing" around this circuit. Varistor assemblies meeting these requirements are then made available for the N1 channel units.

Telephones Aid Pipeline Installation

Telephones are being used to guide the longest pipeline in the world across Michigan, across the deepest waterway ever attempted, and across an International Boundary. When completed, it will carry crude oil from the rich fields of Alberta, Canada, to Sarnia, Ontario, Canada, a distance of 1,765 miles. The 643-mile section being constructed through Michigan is an extension of the pipeline already in existence from Alberta to Superior, Wisconsin.

Planning and engineering of the job were completed early last spring. Telephone installations by Michigan Bell were rushed at more than a dozen different places along the route, from Ironwood to Port Huron. These facilities served the contracting companies hired to construct separate segments of the line simultaneously. At Saginaw, where a team of seasoned pipeliners headquartered to direct the project, a seven-trunk switchboard with fifty stations was installed. In addition, Long Lines private line teletypewriter service was provided between the headquarters, twelve construction points in Michigan, and three in Wisconsin.

Laying the thirty-inch pipe, the "biggest-inch" pipe in North America, has posed many engineering problems. But the greatest was crossing the Straits of Mackinac, the deepest water crossing ever attempted in pipeline history.

The distance to be spanned, at that point, was 21,000 feet – about four miles. The pipe had to be pulled from St. Ignace to Mackinaw City in water to a depth of 243 feet. Construction crews were working on both shores, and on derrick barges between. Every operation was done with precision.

Deep in a forest near Mackinaw City, the largest winch ever built was embedded in cement for the big pull. A special two-inch steel pulling cable was stretched completely across the Straits from the winch to the first of eight 2,500-foot sections of pipe to be pulled into the water.

When the cable had been connected, word to start the pull was sent along to nine shore stations, the derrick barges, and a battery of walkie-talkies. Inch-by-inch the pipe started to move and the four-mile crossing was underway. But suddenly, a shaft snapped on the giant winch and telephone lines across the country began to hum. Arrangements were made to have a new shaft machined and delivered by airplane. A week later, the eight sections of pipe were successfully inched across the Straits without further mishaps.

When the pipeline is completed, nearly three million barrels of crude oil will be required to fill it. Engineers estimate that with necessary tests along the way, it will take about one month for the first drop of oil, traveling at three miles an hour, to reach Sarnia. From then on the pipeline will yield 120,000 barrels of oil per day.

Upon completion, telephone facilities will continue to have an important part in the operation of the line. Long Lines will provide private line teletypewriter service between the Alberta headquarters dispatching department, and all the pumping stations, and division maintenance offices located along the line. Michigan Bell, Northwestern Bell, and Bell Telephone Company of Canada will provide the normal telephone service needed to operate the system.

Stanley Bracken

Frederick R. Kappel

F. R. Kappel New Western Electric President

Frederick R. Kappel, vice-president of the American Telephone and Telegraph Company, has been elected president of the Western Electric Company to succeed Stanley Bracken, who becomes chairman of the board. These changes become effective on January 1. As president, Mr. Kappel will be chief executive officer of the company. He was also elected to the Board of Directors.

Mr. Kappel has been vice-president of A.T.&T. in charge of operation and engineering since 1949. His career typifies the traditional Bell System policy of developing executives from within the organization. Following graduation from the University of Minnesota in 1924 with the degree of Bachelor of Science in engineering, Mr. Kappel was employed by the Northwestern Bell Telephone Company as a groundman, and during the first six months worked successively as lineman, cable splicer's helper and frameman. Within ten years he became plant engineer for the Nebraska-South Dakota area. Thereafter, he held a number of positions of growing responsibility and in 1942 was elected a vice-president and director of Northwestern Bell. In 1949 Mr. Kappel transferred to the parent company in New York where he served as assistant vice-president in the operating and engineering department and as vice-president in charge of the Long Lines Department before moving to the post he now leaves. Mr. Kappel is the ninth president of the Western Electric Company. He was born at Albert Lea, Minn., on January 14, 1902.

Mr. Bracken, who becomes board chairman of Western Electric, has served as president since 1947. He joined the company in 1912 as a student engineer at Hawthorne, following graduation from the University of Nebraska with the degree of Bachelor of Science in Electrical Engineering. Mr. Bracken was assigned to development engineering and continued in various branches of this activity until 1922 when he was sent to Osaka, Japan, in a consulting capacity. There, he aided in the construction of a plant erected by the Sumitomo Electric Wire and Cable Works for the manufacture of toll cable. He returned to Hawthorne in 1925 in charge of the development of permalloy manufacture for loading transoceanic cable. After a number of engineering and manufacturing assignments and several years as executive vice-president and president of the Teletype Corporation, Mr. Bracken, in 1942, became vice-president in charge of the Company's manufacturing operations. Five years later he was elected executive vice-president and soon thereafter, president. Mr. Bracken was born in Blair, Nebr., on March 14, 1890.

Dr. Kelly to Receive the 1954 Industrial Research Medal

M. J. Kelly, President of the Laboratories, has been named to receive the Industrial Research Institute Medal for 1954. The medal, awarded annually since 1945, is given for "outstanding accomplishment in leadership in or management of industrial research which contributes broadly to the development of industry or the public welfare."

Announcement of the award was made by Dr. Allen Abrams, President of the Institute and Vice President of the Marathon Corporation, Rothschild, Wis., at the Institute's recent fall meeting in Detroit. Official presentation of the medal will be made at an Institute meeting to be held in San Francisco on April 22.

The Industrial Research Institute was organized in 1938 under the auspices of the National Research Council. It has a membership of 128 companies with research staffs totaling more than 50,000 persons. Its broad objectives include the promotion of improved management of industrial research, the development of an understanding of research as a force in the life of the nation, and the promotion of high standards in the field of industrial research.

Laboratories Men Become I.R.E. Fellows

Several members of the Laboratories were recently elected to Fellow Grade in the Institute of Radio Engineers, to become effective January 1, 1954. Their names and citations are:

J. G. Chaffee, Transmission Systems Development I, for his contributions to transmission and relay systems and frequency modulation.

E. P. Felch, Transmission Development, for his contributions in the field of precision measurement and instrumentation of communication circuits.

W. D. Lewis, Switching Research, for his contributions to research, particularly in the fields of microwave filters and switching systems.

J. R. Wilson, Electronic Apparatus Development, for his stimulating leadership in research on electron tubes and devices, and in their development and manufacture.

D. A. Quarles, formerly with the Laboratories, and now Assistant Secretary of Defense in charge of research and development, for his distinguished service in the administration of major technical programs in the fields of communications, military electronics, and atomic ordnance.

T. C. Fry Talks on Mathematics

T. C. Fry, Assistant to the President of Bell Laboratories, spoke on *Applied Mathematics as a Responsibility of the Mathematical Profession* at a recent joint conference of the American Mathematical Society and the National Research Council in New York. Mr. Fry's talk was the concluding summary of six other sessions on various aspects of mathematics. H. W. Bode of the Laboratories was one of the speakers in the session on *The Mathematician in Industrial Organizations.* The increasing complexity of the technical problems that must be solved in developing new things for either civilian or military needs has required an increasingly analytical approach. This, together with the expanded use of mathematics in the physical sciences, has led to an active demand for applied mathematicians that exceeds the supply. The conference was arranged by the National Science Foundation to enable representatives of university, industrial, and government laboratories to discuss the extent of this demand and the type of education required.

A. B. Clark Lectures

A. B. Clark, Vice-President of the Laboratories, presented the second in a series of Out-of-Hours lectures at the three principal Laboratories' locations during the week of November 16. The series, designed to acquaint employees with certain areas of the Laboratories' work, is given at intervals during the fall and spring.

Mr. Clark's subject was *Development Program Discussions with Operating Telephone Companies.* Under the joint direction of Mr. Clark and W. H. Nunn, Assistant

Chief Engineer in the Operation and Engineering Department of the American Telephone and Telegraph Company, various teams of five or six men have been visiting the Operating Companies during the past twelve months. These teams of O & E and Laboratories personnel held one or two-day meetings with each Operating Company. The meetings were attended by the company officers, department heads and usually many others.

The visits had two principal objectives: (1) To explain our development program to the Operating people and, if found desirable, revise it to better meet their needs, and (2) to assist the companies in their long range planning, particularly for nationwide automatic switching. Mr. Clark spoke on the highlights of these meetings.

Laboratories personnel accompanying Mr. Clark and Mr. Nunn on one or more of the visits included M. L. Almquist, G. H. Baker, A. F. Bennett, P. W. Blye, J. W. Emling, F. F. Farnsworth, G. W. Gilman, R. J. Nossaman, F. F. Shipley and F. J. Singer.

CAMA Placed in Service

The initial installation of the Centralized Automatic Message Accounting (CAMA) System was put into commercial service by the Chesapeake and Potomac Telephone Company early Sunday morning, November 8, 1953, at Washington, D. C. This system offers the most economical means for wider range customer dialing from existing panel and No. 1 crossbar central offices. Its availability represents a major step in long range plans for a nationwide customer dialing.

With CAMA, the equipment required to automatically record the message billing data is located at a centralized point – at present, a crossbar tandem office – rather than in each local office. After a customer dials the called number, an operator momentarily comes in on the connection to obtain the calling number and to key-pulse it into the associated AMA equipment. The connection is then automatically established, and the billing data are recorded by the centralized AMA machinery.

This first installation permits approximately 835,000 customers of the Washington Metropolitan Area to dial toll calls directly to certain offices in Maryland and Virginia, as well as their inter-zone local calls. On Monday, November 9, about 66,000 CAMA calls were dialed by these customers. Technical features of this CAMA system will be presented in a series of articles in later issues of the Record.

New Western Plant Begun

The first shovelful of earth was turned on November 2 to mark the start of a construction project which will transform 150 acres of farmland near North Andover, Mass., midway between Haverhill and Lawrence, into the site of a modern industrial plant employing about 3,000 men and women. Prominent public and business representatives from the three neighboring communities joined with executives of Western Electric and the New England Company in observing ground-breaking formalities.

The new Western Electric installation, to be known as the Merrimack Valley plant, will consist of a two-story administration building connected by passageway to a two-level factory building. The entire plant, with a service building which will be a combination garage-powerhouse, will aggregate approximately 875,000 square feet.

The new plant will produce systems and apparatus required in long distance telephony, and will furnish Western Electric with added manufacturing capacity with which to provide facilities to the Bell System for keeping pace with the nation's continuing demands for telephone service.

Long Lines in Color TV Tests

Long Lines played a major role recently in a demonstration of the color television system of the National Television System Committee. The demonstration, in New York, was ordered by the Federal Communications Commission in connection with the proposed adoption of new color specifications for TV. It involved the transmission of programs from the National Broadcasting Company's Colonial Theater in New York to the Waldorf-Astoria Hotel over local facilities and over intercity radio-relay and coaxial cable channels. In addition, programs were transmitted over local facilities by the Allen B. Du Mont Laboratories, Inc., and the Columbia Broadcasting System.

Among those present at the demonstration were the Commissioners and other representatives of the FCC, and a number of Bell System officials. Long Lines people participated in establishing and maintaining the test facilities along the intercity routes.

To demonstrate the capability of its intercity facilities for carrying color signals, Long Lines provided the following: a regular and alternate TD-2 radio relay channel from New York to Washington (Garden City) to Clark's Knob, Pa., and back to

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:

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

Biggs, B. S., and W. L. Hawkins, Oxidative Aging of Polyethylene, Modern Plastics, **31**, pp. 121-122, 124, Sept., 1953.

Bieling, D., see D. Edelson.

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

Brown, W. L., *n*-Type Surface Conductivity on *p*-Type Germanium, Phys. Rev., **91**, pp. 518-527, Aug. 1, 1953.

Edelson, D., C. A. Bieling, and G. T. Kohman, Electrical Decomposition of Sulfur Hexafluoride, Ind. and Eng. Chem., **45**, pp. 2094-2096, Sept., 1953.

Elmendorf, C. H., R. D. Ehrbar, R. H. Klie, and A. J. Grossman, L3 Coaxial System, A.I.E.E. Trans., Commun. and Electronics, **8**, pp. 395-413, Sept. 1953.

Fine, M. E., C_p-C_v in Silicon and Germanium, Letter to the Editor, J. Chem. Phys., **21**, p. 1427, Aug., 1953.

Goertz, M., see H. J. Williams.

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

Hagstrum, H. D., Electron Ejection from Tantalum by Helium, Phys. Rev., **91**, pp. 343-551, Aug. 1, 1953.

Hawkins, W. L., see B. S. Biggs.

Heffner, H., Backward-Wave Tube, Electronics, **26**, pp. 135-137, Oct., 1953.

Johnson, J. B. and K. G. McKay, Secondary Electron Emission of Crystalline MgO, Phys. Rev., **91**, pp. 582-587, Aug. 1, 1953.

Jones, T. A. and W. A. Phelps, Level Compensator for Tele-Photograph Systems, Elec. Eng., **72**, pp. 787-791, Sept., 1953.

Kohman, G. T., see D. Edelson.

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

Logan, R. A., Thermally Induced Acceptors in Single Crystals and for Fused Silica, J. Appl. Phys. Rev., **91**, p. 757, Aug. 1, 1953.

Maita, J. P., see M. Tanenbaum.

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

McAfee, K. B., see K. G. McKay.

McCarthy, R. H., Organization for Production Engineering, Mech. Eng., **75**, pp. 785-788, 793, Oct., 1953.

McKay, K. G., see J. B. Johnson.

McKay, K. G., and K. B. McAfee, Electron Multiplication in Silicon and Germanium, Phys. Rev., **91**, pp. 1079-1084, Sept. 1, 1953.

McSkimin, H. J., Measurement of Elastic Constant at Low Temperatures by Means of Ultrasonic Waves – Data for Silicon and Germanium Single Crystals and for Fused Silica, J. Appl. Phys., **24**, pp. 988-997, Aug., 1953.

Merz, W. J., Double Hysteresis Loop of $BaTiO_3$ at the Curie Point, Phys. Rev., **91**, pp. 513-517, Aug. 1, 1953.

Phelps, W. A., see T. A. Jones.

Robbins, R. L., Measurement of Path Loss Between Miami and Key West at 3675 mc., I.R.E., Trans., P.G.A.P.-1, pp. 5-8, July, 1953.

Tanenbaum, M., and J. P. Maita, Hall Effect and Conductivity of InSb Single Crystals, Letter to the Editor, Phys. Rev., **91**, pp. 1009-1010, Aug. 15, 1953.

Walker, L. R., Starting Currents in the Backward-Wave Oscillator, J. Appl. Phys., **24**, pp. 854-859, July, 1953.

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

Williams, H. J., R. M. Bozorth, and M. Goertz, Mechanism of Transition in Magnetite at Low Temperatures, Phys. Rev., **91**, pp. 1107-1115, Sept. 1, 1953.

New York; and a regular coaxial channel from New York to Washington and back to New York. An alternate channel was also provided over the coaxial route. The programs transmitted over these routes traveled via the television operating center at Long Lines Headquarters. The many special loops required were furnished by the New York Telephone Company.

Long Lines Engineering and Plant, and Bell Laboratories people cooperated in carrying out the preparations for the demonstration over intercity facilities. To ensure satisfactory transmission, the facilities had to be specially equipped and tested. Making its debut was a new type converter developed by Bell Laboratories to enable NTSC color signals to pass through coaxial cable which has a narrower band width than radio relay. In addition, special equalizers went to work for the first time. Used to make a circuit more capable of transmitting color signals, these equalizers were hand-tailored by Bell Laboratories, pending manufacture by Western Electric.

Long Lines has provided facilities for demonstrating NTSC's color system on a number of previous occasions, the most recent having occurred recently when a radio relay channel was furnished from New York to Los Angeles for the National Broadcasting Company in connection with the first transcontinental tryout of the National Television System Committee's color system. The program, consisting of two half-hour shows, was transmitted across the country over radio relay facilities.

Aerial Survey for Telephone Lines

When conventional methods of surveying a proposed path for telephone lines was found to be too difficult, the Michigan Bell Telephone Company used airplanes. The survey plane flew from a base airport in the vicinity – one-half day of general reconnaissance, and two days of aerial survey; followed by two days of ground survey checks of the aerial data.

The airplane used was equipped with pressure and radar altimeters and other instruments to improve accuracy. Data from these instruments were recorded photographically to provide permanent records.

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:

Baker, W. O., Electronic States in Polymer Solids, American Chemical Society, Princeton Section, Princeton, N. J.

Bangert, J. T., The Transistor as a Network Element, Radio Fall Meeting, Electron Devices Section, Sponsored by I.R.E., R.T.M.A. of Canada, and R.E.T.M.A. Engineering Department, Toronto, Canada.

Basseches, H., see D. A. McLean.

Biddulph, R., Short-Term Autocorrelation Analysis and Correlatograms of Spoken Digits, Acoustical Society of America, Cleveland.

Biondi, F. J., Corrosion Proofing Electronic Apparatus Parts Exposed to Ozone, National Conference on Tube Techniques, Sponsored by Research Development Board, Committee on Electronics, New York City.

Bode, H. W., Applied Mathematics, Conference on Training in Applied Mathematics, American Mathematical Society, New York City.

Bogert, B. P., The VOBANC—Voice Operated Compressor, Acoustical Society of America, Cleveland.

Bömmel, H. E., An Electromagnetic Method for Measuring the Amplitudes and Attenuation of Ultrasonic Waves, Acoustical Society of America, Cleveland.

Bown, R., The Transistor as an Industrial Research Episode, Industrial Research Institute, Detroit.

Campbell, W. E., Fretting Wear, Boston Section, American Society of Lubrication Engineers, Boston, and Solid Lubricants, American Society of Lubrication Engineers, Montreal and Toronto, Canada.

Carmichael, R. L., The Use of Transistors in Digital Computers, A.I.E.E.-I.R.E. Subsections Joint Meeting, Pennsylvania State College, State College, Pennsylvania.

Compton, K. G., Protective Coatings – Metal and Organic – Fundamentals and Selections, National Association of Corrosion Engineers, Milwaukee.

Crabtree, J., Stress Cracking of Rubber by Free Radicals, Electrical Insulation Conference, Pocono Manor, Pennsylvania.

Dodge, H. F., Experience in Sampling, Rochester Section of Society for Quality Control, Rochester, N. Y.

Egerton, L., Some Factors Affecting the Dielectric and Piezoelectric Properties of Barium Titanate Ceramics, Electrical Insulation Conference, Pocono Manor, Pa.

Egerton, L., and S. E. Koonce, The Structure of Barium Titanate Ceramics as Observed with the Electron Microscope, Basic Science Section, American Ceramic Society, Schenectady, N. Y.

Evans, H. W., Microwaves and Associated Relay and Terminal Equipment, A.I.E.E.-I.R.E. Joint Meeting, Cornell University, Ithaca, N. Y.

Ferrell, E. B., Analysis by Location of Extremes, American Society for Quality Control, N. Y. C.

Fisher, J. R., The Application of the Sink-Float Density Method to Steatite, Symposium on Ceramic Dielectrics, Rutgers University, New Brunswick, N. J.

Fisher, J. R., and J. F. Potter, Important Factors Affecting the Physical Structure of Dry Pressed Steatite, American Ceramic Society, Bedford, Pennsylvania.

Goss, A. J., Crystallization of Silicon from Solution in Tin, American Institute of Mining and Metallurgical Engineers, Cleveland.

Hagstrum, H. D., Reflection of Ions as Ions or as Metastable Atoms at a Metal Surface, Conference on Gaseous Electronics, Washington, D. C.

Hannay, N. B., Mass Spectrometry of Inorganic Compounds, American Chemical Society, Summit, N. J.

Harvey, F. K., see W. E. Kock.

Herbert, N. J., Transistors, A.I.E.E. Alabama Section, Birmingham.

Herring, C., Thermoelectric Power of Semiconductors, General Electric Physics Colloquium, Schenectady, N. Y.

Honaman, R. K., Frontiers of Communication, Instrument Society of America, Albuquerque, N. M., Rotary Club, Albuquerque, Cactus Club, Denver,, and Kiwanis Club, Denver.

Hornbeck, J. A., Trapping of Injected Carriers in Semiconductors, General Electric, Schenectady.

Keiper, C. J., Defining Some Basic Terms Used in Statistics, Metropolitan Section, American Society for Quality Control.

Keister, W., Mechanized Intelligence, Joint Meeting, Franklin Institute, and Communication Discussion Group, Philadelphia Section, A.I.E.E., Philadelphia.

Kircher, R. J., Transistor Applications, A.I.E.E., Erie, Pa., and Columbus, Ohio.

Kock, W. E., The Physics of Music and Hearing, A.I.E.E., Cincinnati, and Focusing Sound Waves with Microwave Lenses, I.R.E., Ithaca, Binghamton, and Syracuse Sub-Sections, Cornell University, Ithaca, N. Y.

Kock, W. E., and F. K. Harvey, Polarized Airborne Sound Waves, Acoustical Society of America, Cleveland.

Maggs, C., see R. L. Vance.

Mason, W. P., Ferroelectrics and the Dielectric Amplifier, I.R.E., N. Y. Section, New York City.

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

McLean, D. A., and H. Basseches, The Gassing of Liquid Dielectrics Under Electrical Stress, Two Parts, Electrical Insulation Conference, Pocono Manor, Pa.

McLean, D. A., see J. K. Werner.

McSkimin, H. J., Wedge Geometry for Ultrasonic Delay Lines, Acoustical Society of America, Cleveland.

Pierce, J. R., Some Recent Advances in Microwave Tubes, A.I.E.E.-I.R.E., Garden City, Long Island, N Y.

Potter, J. F., see J. R. Fisher.

Raisbeck, G., Transistors at Work, A.I.E.E., Syracuse Section, and the Technology Club, Syracuse, N. Y.

Reynolds, F. W., and G. R. Stilwell, Some Properties of Evaporated Metal Films, Optical Society of America, Rochester, N. Y.

Ross, I. M., Field Effect Transistors, Bristol University, University of Reading, and Cambridge University, England.

Sawyer, G., Job Evaluation, Merit Rating, Salary Administration, Technical Drawing Associates Meeting, Detroit.

Schnettler, F. J., The Ferromagnetic Properties of Ferrites in Relation to Their Structure, American Ceramic Society, Schenectady, N. Y.

Sherman, S., and E. Lakatos of Hughes Research and Development Laboratory, Noise Generation for Analog Simulation, Symposium on Simulation and Computing Techniques, University of Pennsylvania, Philadelphia.

Shive, J. N., Semiconductors, New Jersey Patent Law Association, Newark.

Spector, C. J., see J. K. Werner.

Stilwell, G. R., see F. W. Reynolds.

Terry, M. E., Inefficient Statistics, Metropolitan Section, American Society for Quality Control, New York City.

Vance, R. L., and C. Maggs, Magnetron Heater Design to Avoid Undesirable Magnetic Effects, Symposium on Tube Techniques, Western Union Telegraph Co. Auditorium, New York City.

Werner, J. K., C. J. Spector, and D. A. McLean, The Effect of Additives on the Strength of Insulating Oils, Electrical Insulation Conference, Pocono Manor, Pa.

White, A. H., The Chemistry and Physics of Electron-Hole Re-combination, Physics Department Seminar, Telecommunications Research Establishment, Great Malvern, England.

Long Lines Construction Plans

A $29,000,000 construction program, that would provide new telephone plant in every state in the Union except South Dakota, was submitted to the Federal Communications Commission for approval recently by the Long Lines Department of the A.T.&T. Company and thirteen Bell System Associated Companies. The proposed construction would be carried out in 1954 and would represent about one-fourth of the Company's program for the coming year.

Additional facilities proposed in the application are needed to meet the continuing demand for more Bell System communications services. The program would provide for 2,000,000 miles of telephone channels, 1,400,000 miles of private line telegraph and teletypewriter channels, and additions in audio facilities for television.

A projected West Palm Beach-Miami cable would supplement the existing coaxial cable now furnishing communications between these two cities. Four of the eight coaxial tubes in the cable would be developed initially, providing three southbound and one northbound video channels. At present, there are two TV channels – one in each direction – on the existing cable. These would be transferred to the new system. The two additional video channels provided by this rearrangement would be used for anticipated network TV expansion in this area. The four coaxials on the proposed cable would be equipped with the newest type of carrier system – L3. With this system, one pair of coaxials can transmit one TV program in each direction plus 600 telephone conversations.

The Company also plans to provide more telephone circuits in the Chicago-New York area by equipping two additional coaxial tubes between Chicago and Newark, N. J., with L3 carrier. Four coaxials on this route are currently being converted to L3.

Patents Issued to Members of Bell Telephone Laboratories During September

Bond, W. L., Sparks, M. and Teal, G. K. – *Semiconductor Translating Devices* – 2,651,831.

Brown, J. T. L. and Ellwood, W. B. – *Relay* – 2,653,199.

Coyne, H. L. and Mesch, O. S. A. – *Adjustable Potentiometer Termination* – 2,653,207.

Cutler, C. C. – *Expander for Microwave Signals* – 2,652,541.

Dietrich, A. F. – *Apparatus for Modifying the Amplitude Range of Microwave Signals* – 2,652,540.

Edwards, P. G. and Wurmser, A. V. – *Coding and Signaling System* – 2,651,678.

Ellwood, W. B., see J. T. L. Brown.

Graham, R. E. – *Motional Correlation in Reduced Band Width Television* – 2,652,449.

Harazim, S. J. – *Support Structure* – 2,652,307.

Hays, J. B., Jr., – *Fault Detector* – 2,651,021.

Heising, R. A. – *Amplifier Utilizing Deflection of an Electron Beam* – 2,650,956.

Hines, M. E. – *Channel Separation Light Filter* – 2,651,715.

Hollenberg, A. V. – *Electron Gun* – 2,652,512.

Hollenberg, A. V. – *Microwave Amplifier* – 2,652,-513.

Kernahan, J. J. J. – *Method of Mounting Apparatus* – 2,651,833.

Ketchledge, R. W. – *Accelerometer* – 2,650,991.

Kock, W. E. – *Unipolarized Wave Refractors* – 2,652,493.

Langabeer, H. T. – *Power Supply System* – 2,653,-253.

Mallina, R. F. and Melick, J. M. – *Perforating Systems* – 2,652,116.

Melick, J. M., see R. F. Mallina.

Mesch, O. S. A., see H. L. Coyne.

Ostendorf, B., Jr. – *Voltage Regulator* – 2,653,252.

Shockley, W. – *Semiconductor Signal Translating Devices* – 2,654,059.

Sparks, M., see W. L. Bond.

Stropnicky, J. F. – *Mounting for Telephone Apparatus* – 2,650,789.

Wallace, R. L., Jr. – *Transistor Amplifier Circuits* – 2,652,460.

Wurmser, A. V., see P. G. Edwards.