The author at a group of six card translators.

The 4A Crossbar Toll System for Nationwide Dialing

O. MYERS
Switching Engineering

Increased customer dialing in various local areas and operator dialing on toll calls between these areas are bringing nearer the long-range Bell System plan for nationwide customer dialing. To extend the provisions of this plan economically, about 70 key offices in different parts of the country are being provided with 4A crossbar toll equipment. These offices — called Control Switching Points — are being integrated by the Telephone Companies into the existing plant to serve as nerve centers of a nationwide toll network.

Operator toll dialing, already in extensive use throughout the country, is based on the division of the United States and Canada into 90 (ultimately 92 or 93) numbering plan areas* interconnected by a national toll network through some 70 Control Switching Points (CSP's). These CSP's will be the key points in the nationwide automatic switching network, initially for operator dialing, but ultimately for dialing by customers, and it is for use at these points that the 4A crossbar toll system was developed. The primary objective of its development was to incorporate certain ar-

* RECORD, May, 1951, page 197.

rangements commonly referred to as CSP features. These are automatic alternate routing, the ability to store and spill forward the digits as needed, code conversion, and six digit translation. Without the first two, nationwide dialing would not be economically possible. The other two make the 4A system more economical to operate, pro-

play in the automatic selection of alternate routes. In the order of decreasing rank the CSP's are: national center, regional centers, sectional centers, and primary outlets. There is only one national center, in St. Louis, but there are eight regional centers and a larger number of sectional centers and primary outlets. All of the CSP's which

Fig. 1 — Part of the general arrangement of CSP's including tandem outlets and ordinary toll centers.

KEY

TYPES OF TOLL CENTERS

■	NC – NATIONAL CENTER	●	TO – TANDEM OUTLET
□	RC – REGIONAL CENTER	•	OTC – ORDINARY TOLL CENTER
△	SC – SECTIONAL CENTER	---	HIGH USAGE TRUNKS
○	PO – PRIMARY OUTLET	—	FINAL TRUNKS

ducing savings of such magnitude as to justify their inclusion.

The control switching points of the nationwide toll network are classified into four types which differ not in the switching equipment and circuits employed but in the size and importance of the area served, and in the part the switching equipments

are themselves toll centers, will serve a surrounding group of toll centers of lower rank, including non-CSP's known as tandem outlets and ordinary toll centers. The tandem outlets act as traffic concentrating units, and may handle calls to and from a number of ordinary toll centers. Part of this general arrangement is shown in Figure 1.

This diagram includes the national center and eight regional centers, but there are many more sectional centers and primary outlets than are indicated. In the complete network, the ramification from the regional centers, sectional centers, and primary outlets is also much greater than shown. Each toll center, of course, serves a number of local offices.

The solid-line paths shown connecting the various toll centers in the diagram form the backbone of the national toll network. Each such line represents a group of trunks large enough to handle, with substantially no delay, all the traffic likely to be offered to it under ordinary conditions. These liberally engineered backbone routes form the last choice in the selection of an idle channel. In addition to these final groups, shown by the solid lines, there are less liberally engineered, high-usage groups which may connect any two toll centers where the traffic warrants it. A few such groups are indicated by dashed lines at the right of Figure 1. They are used for the first choice and all the other choices up to the final one.

The photograph at the beginning of this article and those in Figures 2 and 3 illustrate part of the equipment used in the 4A system. Card translators which supply information required for alternate routing, code conversion, and six-digit translation are shown on page 369 and in Figure 3.

As already mentioned, alternate routing is one of the essential features of a CSP. This ability enables the equipment to select alternate routes automatically when no circuits are available in the first choice route. Besides providing protection against complete interruption of service when all circuits on certain routes are out of service, alternate routing contributes greatly to the economy of the toll plant. Peaks of traffic are sporadic and usually do not affect all trunk groups at the same time. By providing adequately for alternate routing, it is possible to load the trunks in the high-usage groups heavily. The likelihood is small that all groups, first choice and alternates, out of a single CSP, over which a distant point might be reached, would all be busy at the same time. With liberal provisions for alternate routing it is therefore possible to

use the trunks more efficiently, that is, to have about the same total number of trunks as are required for delayed service, and at the same time, to give substantially no-delay service.

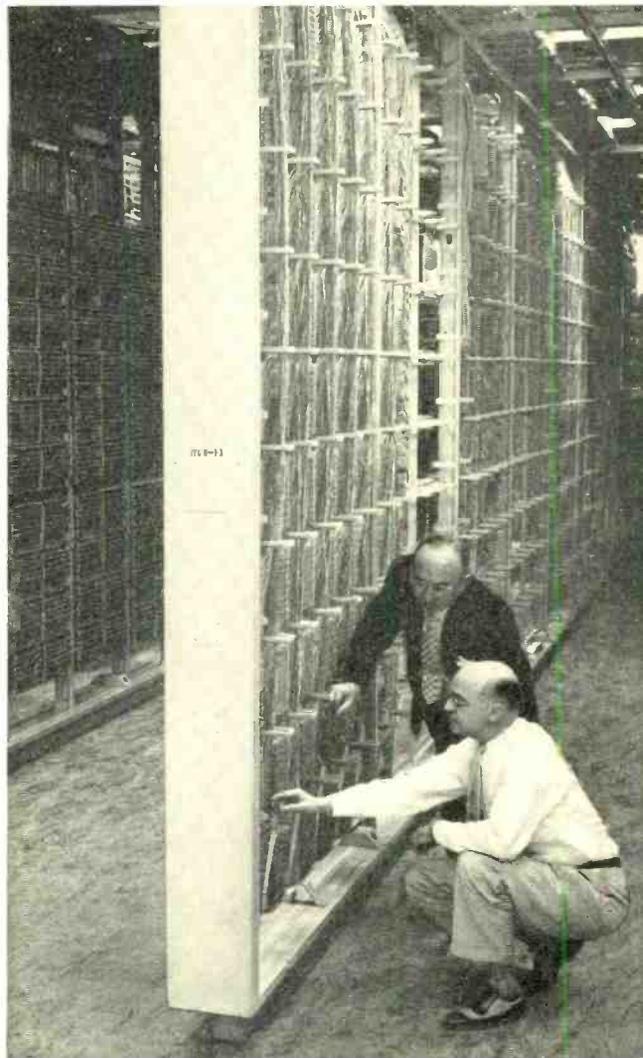This provision of high-usage first choice trunk groups and liberally engineered final

Fig. 2 — E. P. Krausche (front) and the author at a 4A junctor grouping frame.

groups that are selected on an alternate routing basis makes it essential to establish a definite order in selecting the alternate routes. The order employed is called "far-to-near" rotation. This might be more aptly described as a rotation from more direct to less direct, that is, from routes having fewer

Fig. 3—Part of a 4A sectional center showing a group of card translators in the foreground and another in the background (left) with the maintenance center between them.

to those having more switching points. Suppose, for example, a call comes into Columbus, Ohio, for completion to Harrisburg, Pa. This call could be completed over the final choice circuits of the national network via Cincinnati, Pittsburgh, St. Louis, New York, Philadelphia to Harrisburg. However, Columbus has high-usage trunks direct to Harrisburg, Philadelphia, New York, and Pittsburgh. In seeking an idle channel, the switching equipment at Columbus first tries the direct trunks to Harrisburg. If these are busy, it tries the high-usage trunks to Philadelphia, where the call would be completed over the final group to Harrisburg. Should the group to Philadelphia also be busy, Columbus would try New York. Finding these trunks also busy, it would try Pittsburgh, and on its last attempt it would test the final group to Cincinnati. This rotation thus begins with a route through the fewest switching points, Harrisburg, and rotates in substantially far-to-near order — ending at Cincinnati as the final choice. At each intermediate switching point reached, a similar search for trunks is carried out in the same order of rotation.

The final choice is always that of the liberally engineered "backbone" toll network. Should the trunks in the last group be busy, no further attempt to complete the call would be made. This is obviously the most economical procedure since it results in employing the most direct routes with fewer switches when they are available. The requirement that the order of selection always be in the same direction, however, has other very important advantages.

Using another example, suppose that the selection could proceed in either direction; that a call arrives at New York for completion to Harrisburg; and that all direct trunks between New York and Harrisburg are busy. Under these conditions, New York would select a trunk to Philadelphia. If, in attempting to complete this call, Philadelphia found all its direct trunks to Harrisburg busy, and the circuits were not arranged so that when a final group was found busy attempts to connect would cease, Philadelphia might select one of the trunks to New York so as to complete via that route. The switching system at New York, again finding all direct trunks to Harrisburg busy, would select a trunk to Philadelphia. This cycle would continue until

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all trunks between New York and Philadelphia were busy — just because of a single call to Harrisburg. Such situations are avoided by designing the circuits to rotate their selection in only one direction.

The second feature essential to nationwide dialing is the ability to store all digits received, and to spill forward as many digits, and only as many, as are needed to complete a call. A foreign area call starts out with a three-digit area code prefixed to the office code and station number. All ten or eleven digits must be spilled forward to the next switching point until the switching point next preceding the called area is reached. Here the area code is dropped. Only the office code and station number are spilled forward to that switching point.

The third CSP feature, code conversion, permits the substitution of one, two or three arbitrary digits in place of the area code or the office code or both. There are many step-by-step offices around the country that reach other offices by the use of codes that do not conform to the nationwide plan. Extensive changes and additional equipment would be needed in many places to make these offices respond properly to the nationwide codes. Code conversion makes this unnecessary. A switching system in a CSP equipped for code conversion takes care of such situations automatically. If a call coming into such a switching point is to a step-by-step office requiring special codes, the CSP ahead of the step-by-step equipment decodes the first three or six digits and substitutes the one, two, or three arbitrary digits required to reach the called office over the step-by-step trunks.

Useful by-products of this code conversion feature are the ability to use step-by-step type concentrating switches on calls to certain remote operators, thus saving trunks, and the ability to use a common trunk group to two No. 1 crossbar offices provided with multifrequency senders, and to step-by-step offices under some conditions.

Six digit translation is another feature of the 4A system. The ability to translate six digits effects economy by permitting the selection of the most direct trunk routes in many places where without it a more round-

about path would be selected. If only three digits could be translated, it would be necessary to direct all calls for a given area over the same route. This is illustrated in Figure 4 showing Scranton and Harrisburg in toll area 717 and Philadelphia in the nearby 215 area. An economical trunking plan calls for direct circuits from Philadelphia to both points. With only three-digit translation, however, the route to both places would be selected as a result of translating the area code 717 alone, and therefore calls for Harrisburg, for example, would have to be routed via Scranton. This means not only the expense of extra mileage, but also the introduction of an extra switch. With six-digit translation, the combination of area code and central office code is analyzed making it possible to select the most economical route in all cases.

Six-digit translation in combination with the code conversion feature also makes it possible to enter a toll center served by
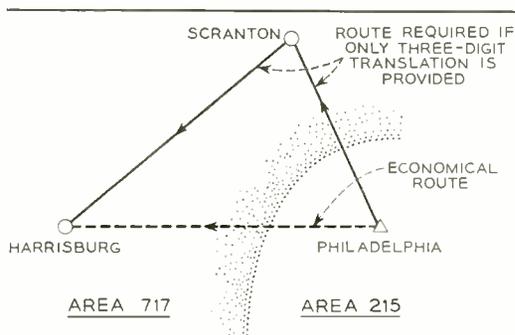

Fig. 4 — *Economical routing made possible by the six-digit translation feature of the 4A crossbar toll system.*

step-by-step equipment and substitute the arbitrary route codes for the complete area served by it in place of the nationwide dialing type of destination codes. This is illustrated in Figure 5, which shows three typical digit combinations as they might be dialed by an operator under the nationwide dialing plan and as they might be converted by a 4A system to fit the arrangement of a step-by-step toll center serving several tributary offices.

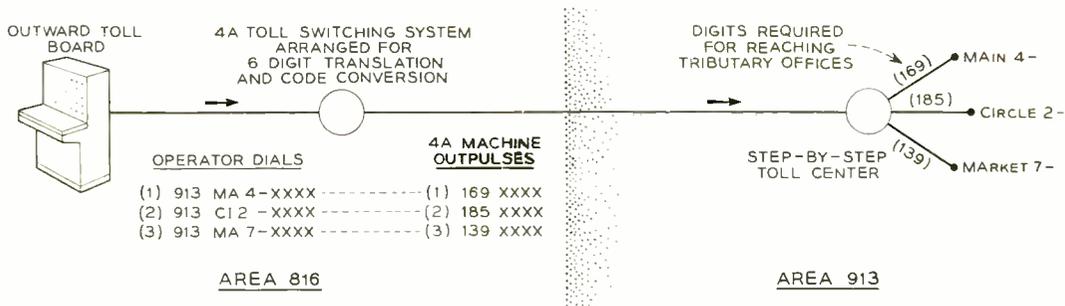Prior to the development of the 4A system, the No. 4 toll crossbar system was

Fig. 5 — *Typical three-digit combinations as they might be dialed by an operator and as they might be converted by a 4A system.*

placed in service in six cities. The A4A, in service in 13 cities, followed the No. 4 but preceded the 4A. This A4A system includes limited alternate routing features, and the ability to store and spill forward digits as needed. Similarly, with minor modifications already made or projected, the No. 4 cross-bar system will include these same features. Both A4A and No. 4 provide for a maximum of three alternate routes with up to 40 trunks per alternate, whereas the 4A provides for five alternate routes with up to 160 trunks per alternate.

The features of automatic alternate routing and the ability to spill forward the required digits are economically essential to a nationwide dialing plan. However, by pro-

viding all the CSP features, including code conversion and six-digit translation with which the 4A system is endowed, the resulting switching network will be considerably less costly to operate. Consequently, information is being made available to permit all the described 4A features to be added to either the A4A or No. 4 systems in the field. After this is done the A4A will be identical to the 4A and the No. 4 will be similar to the 4A except in certain details. The converted 4's will be coded 4M.

As planned at present, the 4A will be used at about 50 CSP's. At the remaining potential CSP's, the existing A4A or No. 4 systems will be converted to become the equivalent of the No. 4A.

THE AUTHOR: OSCAR MYERS spent three years with the Installation Department of the Western Electric Company before joining the Laboratories in 1924. Until 1929 he was a member of the circuit laboratory, engaged in testing circuits including the panel decoder sender and the toll key-pulsing system. Transferring to the sender design group, he worked on senders, decoders, markers and test circuits. In connection with common-control circuits for both local and toll crossbar systems, he became interested in crossbar development, participating in the fundamental design work of crossbar systems. More recently he has been associated with the Switching Engineering Department, concerned with fundamental planning for nationwide dialing. He is currently engaged in engineering study and planning work for toll systems. Mr. Myers received the B.S. degree in chemistry from Cornell University in 1921. He is a member of the A.I.E.E.

Bell Laboratories Record

Color Control in the Bell System

W. J. KIERNAN
Chemical and Metallurgical Research

The author and Mrs. G. Z. Dyer calibrating a color difference meter with a Bell System light-gray porcelain standard.

To help provide better maintenance and upkeep practices by controlling variations in the colors used on apparatus and equipment in the Bell System to within prescribed tolerances, some means of measuring a color must be devised. A simple physical measurement is not sufficient for this purpose since the sensation of color is actually a combination of the physical nature of light reflected by the colored surface, the physiological response to that light by the observer's eye, and the psychological interpretation of that response in the observer's brain. Methods have been developed, however, to insure that uniform colors are used throughout the Bell System.

As recently as twenty-five years ago, most of the apparatus and equipment used in Bell System central offices was painted black. This made these offices appear dark and somber, and together with the limited amount of reflected light from artificial or natural sources of illumination, made them difficult to maintain since dust and lint that might interfere with relay operation were not readily visible. Later, to improve maintenance, it was decided to replace the black by aluminum finishes. At the beginning of World War II, however, the use of aluminum pigment was greatly restricted and light gray finishes were adopted as a temporary replacement. These lighter finishes so enhanced the appearance of the central offices and were so widely favored, that it was decided a few years later to continue their use on a permanent basis.

Since the adoption of these light gray finishes, the use of color in the Bell System has expanded rapidly. Color has been used on station apparatus, mobile radio equip-
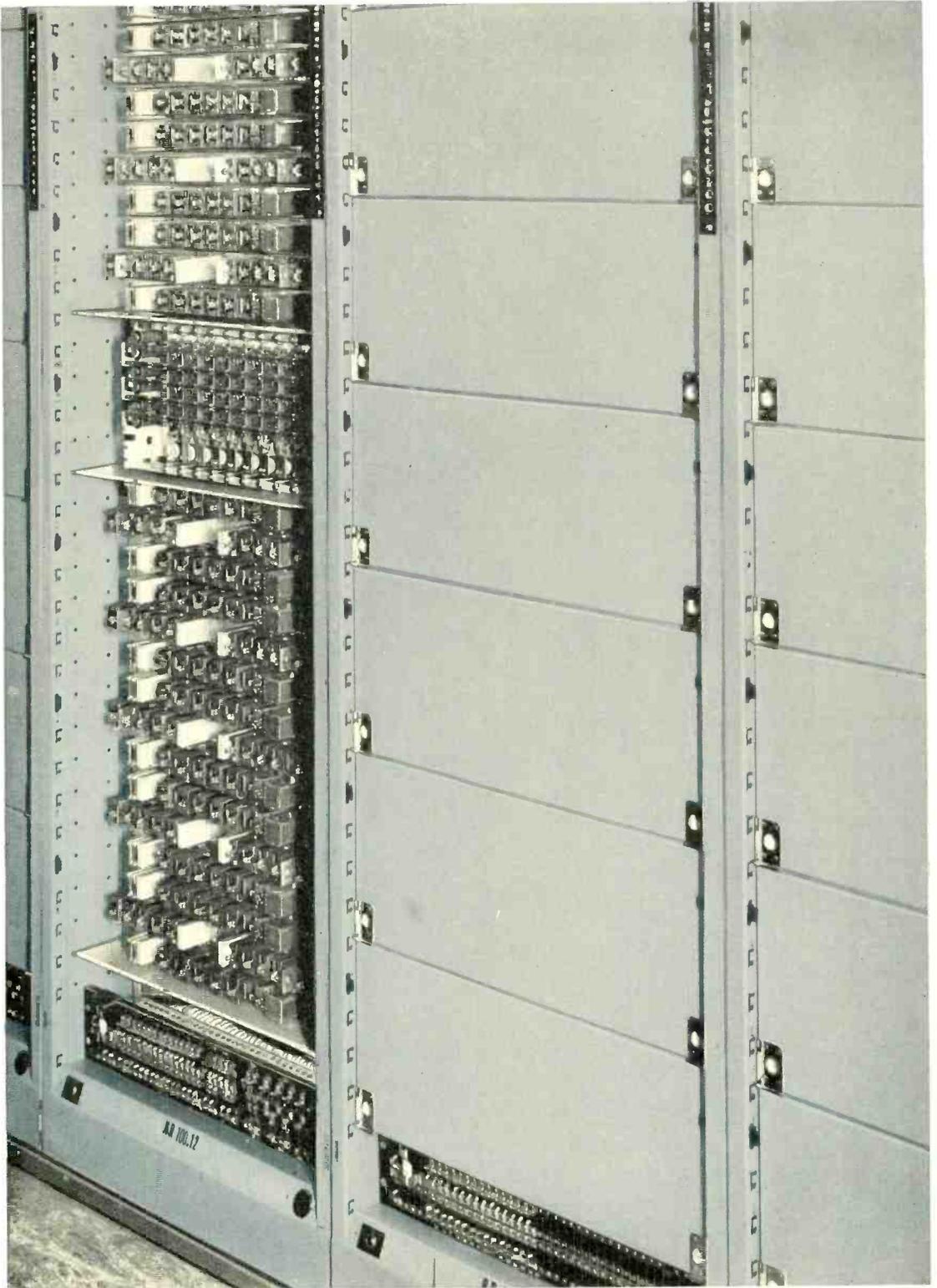
Fig. 1 – Part of the No. 5, crossbar office at Towson, Maryland, showing standard Bell System central office light gray color.

ment, and microwave apparatus. Even telephones themselves have been colored to harmonize with customers' furnishings. The increased use of color led to problems in color control that did not exist when black or aluminum finishes were used. It was found necessary to insure that successive lots of a particular paint or finish were actually the same color to within predetermined tolerance limits. Adequate color control is always difficult to obtain, and this difficulty is increased in the Bell System since individual pieces of its apparatus and equipment are manufactured and finished in many widely separated plants and factories. The effect of good color control is primarily esthetic, but as experience has shown, uniformity of color leads to good housekeeping, and is an evidence of pride in good workmanship.

The first attempts to control color in the Bell System were based on visual methods of matching colors and also their gloss and texture, to an appearance standard. In some applications, a single standard of the desired color was employed; in others, the single standard was supplemented by additional standards establishing light and dark limits. Visual methods of control have never proved to be entirely satisfactory, however, since the standards are never permanent, and judgments as to whether a commercial match to a standard exists depends upon the past training and physiological characteristics of the observer.

All surfaces finished with organic pigments change color with time to a varying extent, depending upon their age, exposure to light and weather, and on the conditions under which they have been handled. Moreover, the way one individual sees a color may be quite different from the way another sees it depending upon their previous training, the existing lighting and viewing conditions, and their relative color perception. Frequently, a number of observers can examine several finished objects, and although some may see them as matching acceptably, to others the match may appear entirely unsatisfactory. At first it might seem that the mere matter of matching paint should not be such a difficult problem, but when it is realized that the normal human eye can distinguish about 100-million shades and tints under ordinary conditions, it affords some idea of the scope of this work.

One basic difficulty in color control by visual methods is the fundamental process of describing a color. To say that most modern central office equipment is painted light gray does not convey a restricted meaning since at least 90,000 shades of gray can be distinguished. The actual color referred to, however, is shown in Figure 1 as it is used in a modern crossbar central office and this particular shade of gray must be duplicated time after time in many widely separated places.

To aid in describing color differences and mismatches in visual control, a method of describing a color more precisely through the use of three mental variables or sensations has been devised. In this system, a particular color can be thought of as occupying a unique point in a special three-dimensional color space, identified by three coordinates called hue, value, and chroma. Hue is the essential quality that primarily determines the name of the color; thus, whether it is called red or green. Value is a measure of how light or dark a particular hue may be; and chroma is the degree of strength or saturation in a color, the quality usually described by the terms, "pale" or "deep."

There are two problems that must be solved to achieve more adequate color control: first, a permanent, master standard must be established against which all other standards can be checked; and second, an instrumental means of measuring color must be devised that can easily be applied to shop inspection and control practices. The permanent standards for colors used in the Bell System consist of physical measurements made with a spectrophotometer. This instrument records the amount of light of each wavelength in the visible portion of the spectrum reflected from the sample as compared to the amount of the same wavelength that would be reflected from a surface coated with magnesium oxide. Magnesium oxide or some similar substance is used in this application since the amount of light it reflects is relatively independent of wavelength. Since the resulting curve of intensity
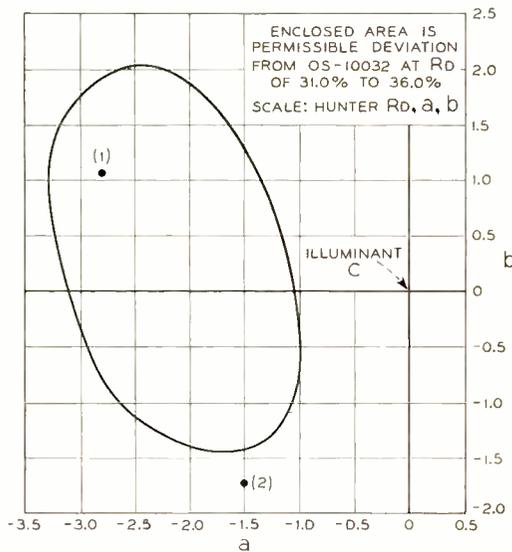
Fig. 2 — *Tolerance graph for Bell System central office light gray.*

versus wavelength is a physical measurement, however, it does not describe a color as a light sensation in customary terms such as light gray or dark brown.

To obtain the equivalent hue, value, and chroma from a particular spectrophotometric curve, the data must first be transformed to chromaticity coordinates in a special CIE coordinate system by a rather involved mathematical process. (This CIE system, adopted by the International Congress of Illumination at Cambridge, England, in 1931, provides a standardized way of describing a color.) Subsequently, the CIE chromaticity coordinates are converted to the equivalent hue, value and chroma. Although this spectrophotometric method is used to obtain a curve representing a permanent standard for a particular color, the process is not adaptable to general use in color control since the instrument is relatively expensive and difficult to operate, and the resulting data require extensive mathematical treatment before they are directly usable.

Color control has been made easier and more precise by the introduction of commercially available instruments that directly measure three attributes of color that are

reasonable equivalents of hue, value, and chroma. Actually, the instrument indicates three coordinates that define a particular color as a unique point in color space. These coordinates are determined directly from the instrument reading as contrasted to the involved calculations necessary to fix the point in space when a spectrophotometric reflectance curve is employed for color control. When properly used, this "color difference meter" is capable of detecting very small variations in color, even those falling well within established allowable tolerances. Essentially, the instrument duplicates a standard observer viewing the color under standard illumination and viewing conditions.

The operation of this instrument is based on the fact that light of almost any color can be produced by mixing selected amounts of the three primary colors — red, green, and blue. A sample of the color to be tested is illuminated by a single white source at an angle of 45 degrees, and the light reflected perpendicular to the surface of the sample is collected in a diffusing chamber. Part of this reflected light passes through windows in the diffusing chamber to each of 3 filters, one corresponding to each primary color. The intensity of the light transmitted through each filter is then measured by an associated photoelectric cell, and the resulting three intensities uniquely describe the color of the sample.

As compared to a spectrophotometer, these instruments are inexpensive and can be operated by relatively untrained shop personnel. Since there are variations from one instrument to another, and since any one instrument may vary from time to time as a result of temperature changes, the condition of the light source, and the age of the photo cells, it is necessary to use them as color difference meters rather than as accurate color meters. To obtain maximum precision, the instrument must be recalibrated before each color measurement with a relatively permanent porcelain color standard similar to the color to be measured. This standard is placed in the proper measuring position on the instrument as shown on page 375. Three instrument dials labeled Rᴅ, a, and b are then set to pre-

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viously assigned values recorded on the standard and adjustments are then made so that the galvanometer at the right of the instrument shows a null point for each one of these settings. The standard is then replaced by the specimen to be measured and the three dials of R_D, a, and b, are adjusted to bring the galvanometer back to the null point. The three new settings of the dials represent the actual color of the sample being measured. It is then necessary to determine whether or not these values fall within predetermined tolerance limits from the appropriate color standard.

Specifications are provided with each Bell System color standard describing that color in terms of a master-standard spectrophotometric reflection curve. A tolerance graph is also included with these specifications, and a typical example, for the same central office light gray used in Figure 1, is illustrated in Figure 2. To determine whether or not the sample tested lies within the tolerance limits, the operator first notes the final setting on the R_D scale and checks to see that it lies within the allowed limits as shown at the top of the graph. For the central office light gray, the R_D setting must be between 31 and 36. If the setting lies outside these limits, the sample is rejected as an unsatisfactory match, since it is either too dark or too light. If this condition is satisfied, however, the "a" and "b" scale

setting must also be checked. As shown in Figure 2, these values are plotted on a set of rectangular coordinates labeled "a" and "b," with the origin representing average daylight or neutral gray. The tolerance limits for the Bell System light gray are indicated by the area enclosed in the heavy line on the graph. All that is required then is to plot the final setting of the "a" and "b" scale on this chart and observe whether the resulting point falls within the indicated area. A point such as that labeled (1) in the figure, represents an acceptable match since it lies within the tolerance boundary. The point (2) however, indicates an unacceptable match, and the color can be described as being "too blue" since —b values represent the degree of prominence of blue in the sample while +b indicates yellow; —a, green; and +a, red.

In addition, gloss and texture must be controlled to insure a uniformly finished product; coincidentally with the establishment of instrumental color control as described, gloss control by instrumental means was adopted. Texture control, however, must still be accomplished by visual inspection. These methods of appearance control have been put into effect on all of the extensively used organic finishes in the Bell System, and have been successfully employed in the various plants of the Western Electric Company.

THE AUTHOR: WILLIAM J. KIERNAN joined the Laboratories in 1925 as a technical assistant concerned with paper and textiles, and other organic insulating materials. His work included the preparation of specifications, development of test methods, and evaluation and recommendation of materials. In the finishes group, which he joined in 1940, he has since been engaged in the development of protective coatings, working on moisture and fungus proofing, color control of materials, and methods of testing and evaluating. Studies of solvents and cleaning compounds are among his recent projects. Mr. Kiernan received the A.B. degree in chemistry from New York University in 1935. He is a member of the American Chemical Society and the Optical Society of America.

Auroras —
What They Mean to Us

O. B. JACOBS
Transmission Systems Development

The Aurora Borealis means much more to us than it did to the ancients. Associated with sun spot activity, disturbances in electrical communication that occur at the same time as the Aurora may be so severe as to interfere with, or to completely interrupt, electrical communication in many areas of the world.

Centuries ago, our ancestors probably looked upon displays of the Aurora Borealis, or the "Northern Lights," as they are more commonly called, as manifestations of the power of the gods. In those days, they had no effect except to awe the viewers, and, along with other celestial phenomena, may have been considered as portending momentous events.

Soon after the first commercial electromagnetic telegraph system was put in operation, however, there were periods of a day or more when electrical interference became so frequent and intense that transmission of messages became practically impossible. Studies of this problem by a British scientist, W. H. Barlow, led to his conclusion in 1847 that this interference came from the earth — from what came to be called "earth current storms." Subsequently, it was noticed that these occasions of severe interference with telegraph transmission coincided with auroral displays.

Records show that during the seven-day period, from August 29 to September 4, 1859, all the grounded telegraph lines in the world were apparently affected, and it was impossible to transmit any messages. On a 373-mile span in France the current was said to be "equal to that produced by a battery of 800 volts."

Naturally, as more and more telegraph circuits were established, these earth current storms (now called magnetic storms) received more attention. Although circuits that are completely metallic — that is, not depending on a ground return path — are less likely to be affected by magnetic storms, there still is the danger that a difference in ground potential between the two ends of a long circuit may exceed the breakdown voltage of the central office protectors, the normal function of which is to guard the equipment from damage by lightning and power line faults. Carbon block protectors, indicated in Figure 2, are designed to have a lower breakdown voltage to ground than the equipment connected to the circuits, and are provided at all equipment locations. If a voltage is built up between the wires and ground due to lightning or surges on adjacent power lines, it breaks down the small gaps at the protector blocks and thus prevents the potential difference from exceeding the breakdown voltage of the central office equipment. Breakdown voltages of the protector blocks average about 400 volts and may vary from about 300 to 600 volts. When high earth potentials exist, the protector blocks operate in a reverse manner. In this case, a high potential between points A and B, which may be represented by a battery connected between the two grounded blocks, as shown in Figure 2, will break across to the blocks connected to the line wires.

On the night of March 24, 1940, brilliant auroral displays were visible as far south as Tucson, Arizona, during an extremely severe magnetic storm that began suddenly
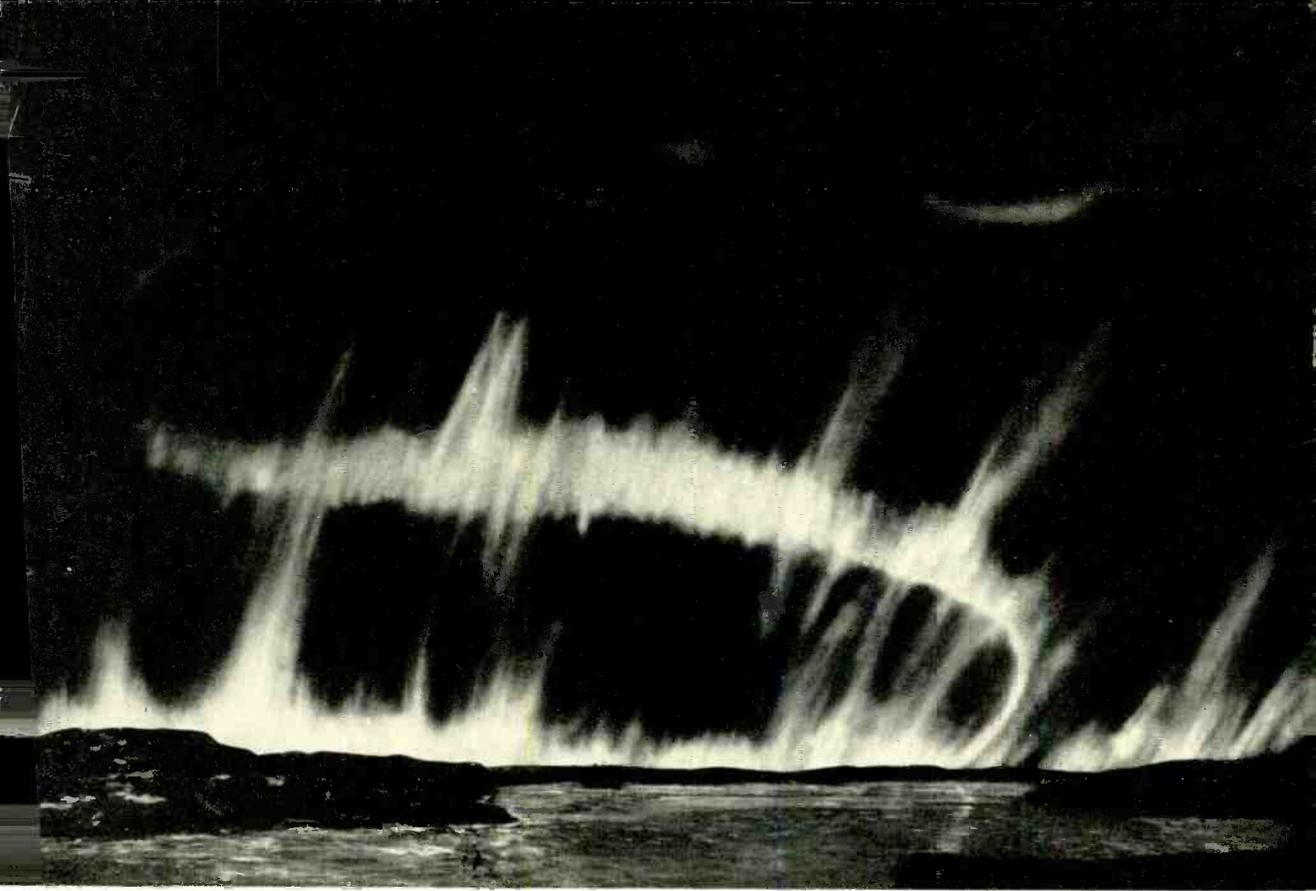
A rare display of the Aurora Borealis.

earlier in the day. Long distance communication of all kinds in areas north of the sixtieth parallel of latitude were disrupted to a great extent; voltmeters connected between ground and wires leading to distant grounded points indicated potential differences exceeding 600 volts. Gradients along the surface of the earth were believed to reach as much as 10 volts per mile for brief periods in some areas. Protectors operated on many wire lines, heat coils opened grounded telegraph circuits, submarine telegraph cable signals were scrambled, and overseas short wave radio circuits were rendered unusable.

A portion of a record made on an ocean cable between Long Island, N. Y., and Newfoundland is shown in Figure 1. At about 113 volts the recorder scale changes to a much larger one for higher voltages, which accounts for the compressing of the traces above that value. This cable has earth return conductors extending far out to sea; the distance between the grounding

points is about 990 nautical miles. Over this distance, the average potential difference per nautical mile was only about half a volt, but presumably it was much greater than this over portions of the route.

Magnetic storms are believed to result from enormous streams of electrified particles ejected from the sun at velocities considerably less than that of light. These particles strike the earth's atmosphere and are deflected by the earth's magnetic field, so that part of them travel in a wide band latitudinally at a height of several hundred miles. The stream of charged particles along the northern part of this country during a severe storm may be of the order of a million amperes for several hours, with changes exceeding 100,000 amperes within one minute. Differences in potential between points on the earth's surface are induced by the resulting changes in the magnetic field, causing huge earth currents, as well as currents in wire line circuits that use ground as a return path.
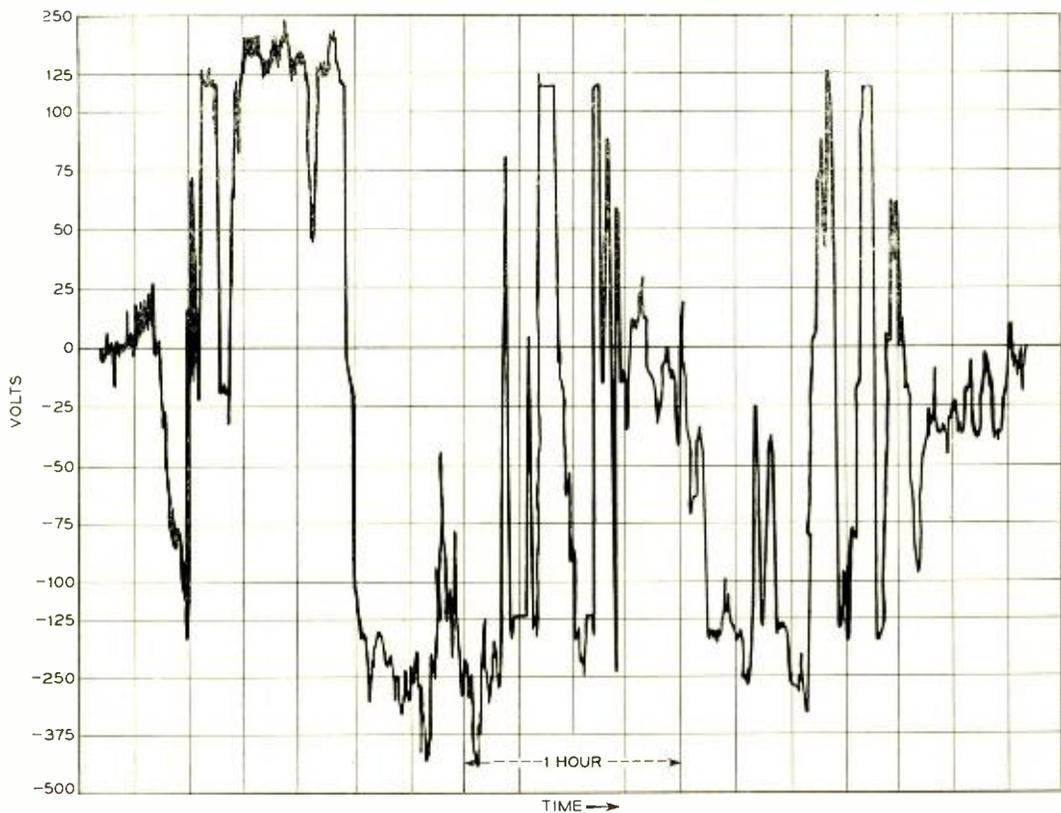
Fig. 1 — Portion of a record made on an ocean cable between Long Island, N. Y., and New-foundland, showing the wide swings in voltage on the cable during the magnetic storm of March 24, 1940.

Altogether, the total stream of particles reaching the earth's atmosphere may be equal to a current of several billion amperes. For example, during another great magnetic storm that occurred in April, 1938, calculations based on records obtained by the Department of Terrestrial Magnetism, Carnegie Institution of Washington, indicated that energy was expended in the earth at the rate of two billion kilowatts in a two-hour interval! This is about 100 times the capacity of all the hydroelectric developments in this country, and more than could be produced by all the power plants in the world. The magnetic storm of March, 1940, seems to have been even greater than that of April, 1938 — possibly the greatest magnetic storm yet recorded.

As mentioned previously, these magnetic storms probably result from disturbances in solar activity; one manifestation of this appears in the form of sun spots. There is some evidence that these disturbances are stimulated by certain relative positions of the planets, with resulting effects on the tides in the sun's atmosphere. However, efforts to predict the occurrence of severe magnetic storms on the earth have not been successful, although some correlation between planetary positions and radio disturbances has been found.

Records of magnetic intensity are made continuously at more than seventy observation stations located in many parts of the world. Many organizations record the occurrence of auroras, sun spots, and radio disturbances. For various periods, continuous records of voltages have been made on wire lines connecting certain points in the Bell System and special meters have

www.americanradiohistory.com

been provided for use during severe magnetic storms. Records were made for several years on a number of the Western Union Telegraph Company's submarine cables.

Magnetic storms are world-wide, as borne out by comparisons of all sources of information. Large differences in earth potentials and serious radio disturbances, however, are confined to latitudes within about 60 degrees from the poles. Radio and wire line transmission between about 30 degrees north latitude and 30 degrees south are affected very little.

The question arises as to why communication over coaxial cables is not interrupted by earth potentials, since the outer conductor of each cable is grounded at each end. This question can be answered by the fact that because of the relatively short distance between grounded repeater points the potential differences that are built up are insufficient to damage the outer conductor of the coaxial pair. Besides, dc potentials do not affect the signaling frequencies employed.

Although interference in some areas in the northern part of this hemisphere occurs quite frequently, it seldom is experienced in most parts of the United States. In Minnesota, however, these effects occur frequently enough to justify using metallic telegraph circuits where grounded telegraph circuits otherwise would be used.
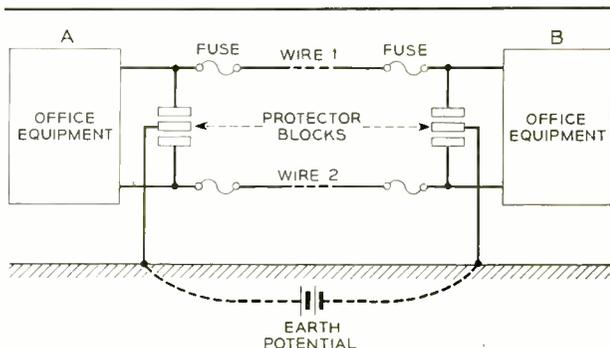

Fig. 2 — Schematic representation of a simple telephone circuit, with protective arrangements and a high earth potential difference.

Mild storms often interrupt short-wave radio telephone and telegraph service, or make such service much less satisfactory than under normal conditions. Operation of transatlantic submarine telegraph cables is frequently subject to interruption during mild storms. However, the existence of high speed (loaded) cables routed via the Azores Islands does enable service to be maintained to a considerable extent at such times. These cables are provided with loading so as to permit high speed transmission of telegraph signals under normal conditions. During magnetic storms, transmission can be at lower speeds, so that the received signals will be much stronger than the corresponding ones on the non-loaded cables, and

THE AUTHOR: OLIVER B. JACOBS received the B.S. degree in 1910 from Worcester Polytechnic Institute, and spent seventeen years with A T & T before joining the Laboratories. He was first concerned with equipment maintenance, specifications, and transmission maintenance, and later joined the Operation and Engineering Department. In World War I he served with the Signal Corps, assisting J. J. Carty in the assignment of communications personnel in France, and later directing the engineering of Signal Corps installations at Tours. In 1929, at the Laboratories, he engaged in the development of the submarine cable and assisted with the installation of the first coaxial cable. In World War II he participated in the development of communication systems for the Signal Corps, and then turned to studies of speech and recording apparatus. Since 1945 he has worked on the submarine cable, with particular attention to long deep sea cable systems, and system design of the 1950 Key West-Havana cable system. More recently he has been concerned with a submarine cable system for the Long Range Proving Ground of the Air Force. Mr. Jacobs is a member of the A.I.E.E. and an associate of the I.R.E.

therefore can be received through much more interference than is possible on the non-loaded cables.

A submarine telephone cable system of the type recently installed between Key West and Havana[*] would be affected very little by large differences in potential between the shore stations, even though the return path of the current for energizing the sea-bottom repeaters is by way of the station ground leads. The current supply is regulated to keep it within a very small range in the presence of potentials tending to increase it, and of potentials of opposite polarity reaching 20 to 25 per cent of the normally applied voltage. Should the opposing polarity reach excessive values, the energizing current would fall below normal only for very short intervals. At those times, the decrease would not be expected to change the gains of the repeaters enough to make service unsatisfactory.

[*] RECORD, *April*, 1951, *page* 149.

Regardless of the causes of magnetic storms, and what we have learned about their effects, there is nothing we can do to control them. The comparative rarity and short duration of great magnetic storms, such as the one that occurred on March 24, 1940, probably makes it impracticable to guard completely against them. For some reason, not yet explained, sun spot activity and magnetic activity show definite maxima at intervals of about eleven years, but definite prediction of individual great magnetic storms is not now possible, and there seems little hope of accomplishing it in the future. In spite of many temporary interruptions to communication, actual physical damage to equipment is small, and protective apparatus functions quite effectively. Bell System engineers, however, continue to study the records and effects of these storms with a view to reducing or preventing these interruptions, and thus further increase the dependability of Bell System communication services.

New Book of Binomial Tables

Highly valuable as a tool in sampling techniques, the recently published book *50-100 Binomial Tables*, by H. G. Romig, is the result of work done by Dr. Romig while a member of the Laboratories. The foreword by G. D. Edwards, Director of Quality Assurance at the Laboratories, states, "Effective inspection plans . . . can be determined only after evaluation of the probabilities connected with the various sampling procedures used. In making such evaluations, it has been necessary in the past to use approximate values of the p binomial. The exact values in these tables will afford a welcome substitute for such approximate values." The exact values were calculated on a Bell Laboratories general purpose computer built for the U. S. Government and later installed at the Ballistic Research Laboratory at Aberdeen, Maryland.

Originally collated and prepared in draft form in a copyrighted *Memorandum*, dated

June 4, 1947, the tables have been rearranged for publication in a handier and more useful form. Dr. Romig, in a preface to the book, acknowledges the help he received from many people at the Laboratories, and others from whom he received suggestions. Published by John Wiley and Sons, Inc., New York City, the volume is priced at $4.00 per copy.

The book not only sets forth the values of the p binomial in an easy-to-use form, but includes an explanation of the binomial, its uses and methods of interpolating values not in the tables. In general, if p is the probability of an occurrence, then q is the probability of "not-occurrence," and their total is unity. The general form of the binomial is, then $(p+q)^n$ where n is the sample size for a particular study. Heretofore approximations have been used; with the tables, exact values are immediately available for use in many problems involving probability.

The Cushion Body Belt

No single piece of personal safety equipment is more closely associated with the work of Bell System linemen than the body belt. This stout leather belt carries the lineman's frequently needed tools distributed in loops and other fittings. It has two large D-shaped rings for engaging the snap hooks of the safety strap, to support the lineman and prevent his falling when working aerially. The D-rings and buckles are thoroughly tested to insure adequate strength. The belt and safety strap are worn constantly while working aloft, and often on the ground if frequent aerial work is necessary.

The body belt used generally throughout the System is shown in Figs. 1 and 2. This belt is strong, relatively inexpensive, durable, simply constructed, light in weight and

On the ground, the cushion body belt worn by the man on the left rides easily and comfortably. The name comes from the five-inch wide "cushion" of leather next to the workman's body.

Aloft, the cushion body belt provides a soft cushion about the hips, preventing chafing or abrasions possible under extreme weather conditions or during long working periods. The man at the left wears the body belt normally provided.

generally satisfactory to the majority of the System's linemen. There is, however, the need for a more comfortable belt in some relatively few cases; in the southern states, for example, where during the summer months linemen are lightly clad, or whenever the work involved requires linemen to remain aloft more or less continuously for long periods of time. To prevent workmen from becoming bruised and chafed about the hips under these conditions, a cushion body belt has been provided.

The name comes from the 5-inch wide cushion next to the worker's body. This is a single strip of flexible leather, folded and sewn to give rolled edges to the body cushion. An additional comfort feature of the cushion body belt permits the D-rings to slide to the right or left over a range of about four inches. The strap connecting the D-rings fits loosely in two leather keepers or loops. When the lineman working on a pole turns his body, the D-rings and their connecting strap slide so that the belt does not bind on his body or twist his clothing.

W. H. S. YOURY
Outside Plant Development

The New Message Register

The author compares the old and new registers.

W. G. LASKEY
Switching Apparatus Development

Early in the century, the practice of charging by the call for telephone service made necessary some means of counting customer calls. An electromagnetic counter, known as a message register, was developed for this purpose and has been used for nearly fifty years. In the 1930's, these registers were also put to use in counting the number of calls on a trunk or trunk group, for traffic studies. New materials and manufacturing techniques available in recent years gave promise of improvements in register design. The 14-type register, developed to replace eventually the older type, is smaller, lighter, faster, and has a much greater life expectancy.

In the early 1900's, "metering" of customer telephone calls was made necessary by the practice of charging by the call as well as on a flat-rate basis. An electromagnetic counter, the 5-type message register, was designed for this service and became standard equipment. Some six million of them are in use today. These message registers consist of a counting mechanism driven by an electromagnet. Although small, such a device contains about 70 parts. Since the design of this register many years ago, new materials and manufacturing techniques have become available. It seemed likely that a smaller and less expensive register could be developed. As a result, the new 14-type register was designed and is now being used in the No. 5 crossbar system. Eventually all existing registers of the older type will be replaced by the 14-type, now in manufacture.

This new register is externally very similar to the 5-type, but is considerably smaller, as may be seen in Figure 1. The

height of both units is the same, but the 14-type register is slightly narrower and over an inch shorter. It weighs just eight ounces, half as much as its predecessor. Many parts have been eliminated through the use of molded black nylon for the number wheels and drive gears, and others through the use of simpler armature assemblies. Several parts have been eliminated in the change from the forward-drive pawl system in the 5-type to the back-drive system of the 14-type register. Only about 40 parts, Figure 2, little more than half the previous number, are required in the new register. Moreover, the arrangement of the drive-pawl plus the light weight of the number wheels permits much faster operation than before, and the lighter mechanism and simpler design give the 14-type register a much longer operating life. Other advantages of the new unit are: easier reading of the redesigned numerals, and elimination of glare, Figure 3, from brass parts through the use of black nylon. This is a great help to those who must read these registers regularly.

In the earlier registers, each number wheel was made up of several parts riveted together. This composite wheel has been replaced by a single molded piece that includes all the former parts, such as gears and bearings. Changes and improvements in the frame assembly and coil have also reduced the number of parts. One advantage of the new registers is that mounting plates, Figure 4, may be of lighter, thinner, and therefore less expensive materials. A further advantage is that the new registers may be conveniently used in test sets. Space considerations in such sets make it desirable to mount the registers vertically. The gravity operated pawls of the older units prevent this, since they will not operate at an angle greater than 45 degrees. The 14-type, using spring-operated pawls, may be mounted in any position.

The forward-drive system used in the 5-type, Figure 5, consists of a weighted drive-pawl pivoted to the armature, a stop-pawl, and a ratchet attached to the first number wheel. The stop-pawl is weighted on one end so that it is held against the ratchet at all times. When the ratchet moves, it simply slips over one tooth to the next

and gravity brings it back into position. The magnet pulls the armature toward it and at the same time pulls the driving pawl horizontally. The hook on this pawl, engaging a tooth of the ratchet, rotates it one digit on this forward stroke. Gravity also holds the drive-pawl in position. Release of the magnet permits the armature and pawl to return to normal, while the stop-pawl prevents backward motion of the ratchet. There is no stop-pawl to prevent unwanted forward motion, but this is prevented by a fixed overthrow stop and the shape of the drive-pawl.

Contrasted with this arrangement is the back-drive system, Figure 6, used in the 14-type register. Instead of a standard ratchet wheel, the drive wheel has square teeth,

Fig. 1 — Comparison of the 5AH and 14B registers. Metal sides have been replaced by plastic to show mechanisms.
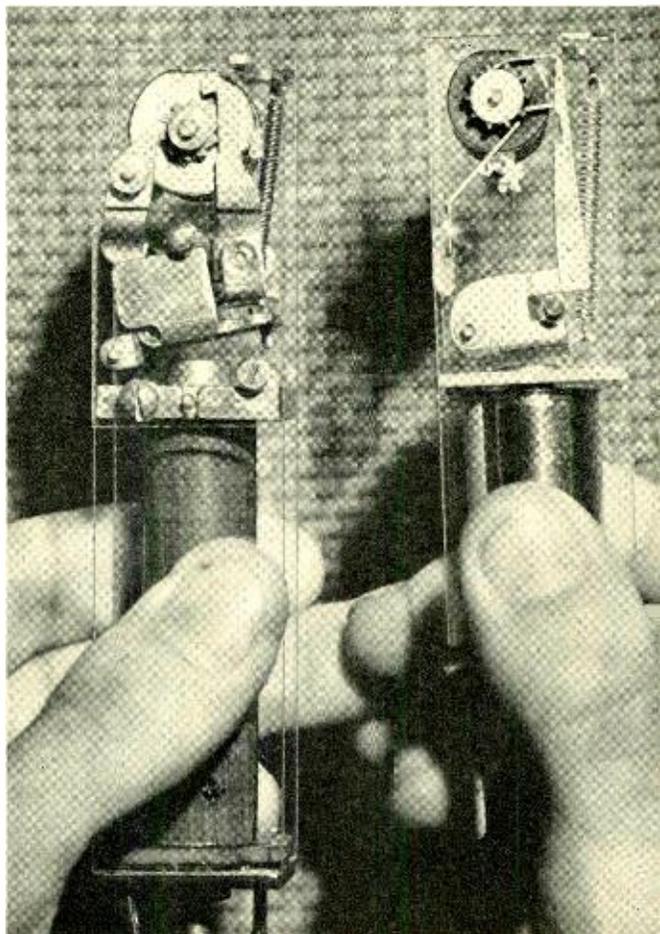
somewhat like a gear. The armature carries an extension as before, but it is rigidly attached instead of being pivoted. Attached to this extension are two pawls. Motion of the armature tilts this extension upward rather than pulling it horizontally, thus raising the two pawls. The shorter of these is an overthrow stop-pawl. Its job is to

Message registers are not reset; instead, the information desired is determined by the difference between successive readings. This permits the use in both the old and new units of a simple, straightforward carry mechanism known as a Geneva movement. "Carrying" is the process of advancing the next higher number wheel one digit
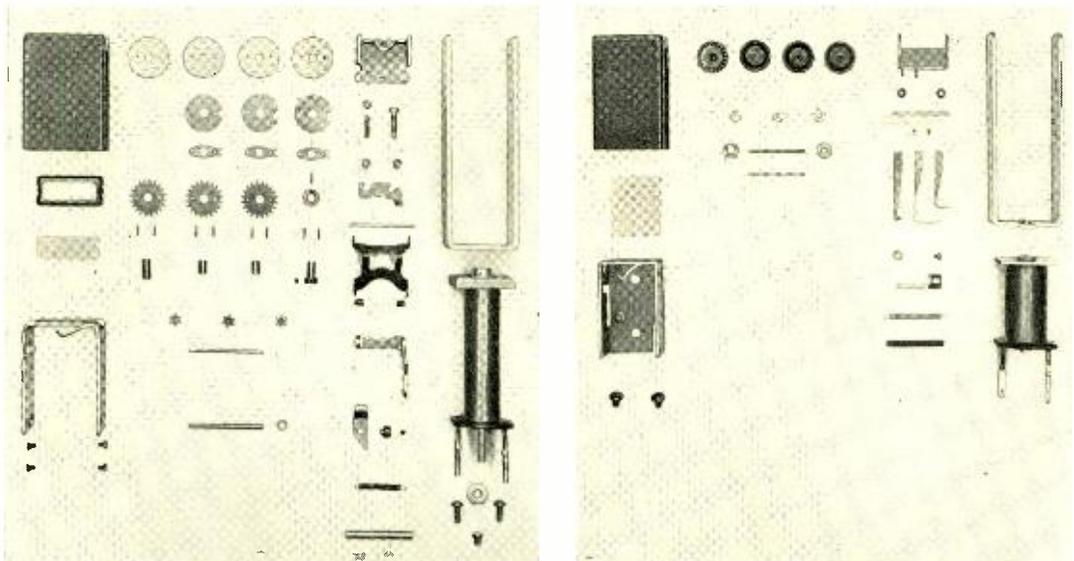
Fig. 2 — Two registers disassembled show the difference in the number of parts. The new register, on the right, has about forty parts. This is about half the number required for the one shown on the left.

stop rotation of the number wheel after it has advanced one digit. The second pawl is a moderately stiff spring, slightly curved at its lower end, which partially overhangs the gear. In its normal position it hooks over one tooth and its end rests against the next lower tooth. Operation of the magnet tilts the extension and raises the two pawls into a "cocked" position, but does not drive the gear. An auxiliary spring pawl is fastened to the frame of the counter and prevents backward rotation when the drive-pawl is raised on the operating stroke. The drive-pawl slips past the tooth it overhung and springs in to rest behind it. Release of the magnet permits the extension to return to normal. On this back stroke, the spring pawl drives the tooth it rests against downward, rotating the gear. After rotation through one digit, the overthrow stop-pawl intercepts a tooth and stops the action.

whenever a given number wheel rotates through ten digits, just as a digit is carried to the next column in ordinary addition. Three small gears on a separate shaft, in conjunction with gear teeth and notches molded into the number wheels, accomplish this carry.

One of the design features of the 14-type register is the reduction of eye fatigue on the part of the person reading the figures. In some offices readings are taken directly from the registers in their cabinets, while in others the registers are photographed in groups of twenty-five and the information is later taken from the picture. In either case, eye fatigue tends to blur the figures after many readings. This effect has been reduced in the new register in two ways. Since the number wheels are molded of black nylon, glare from brass parts between the number wheels, Figure 3, has been
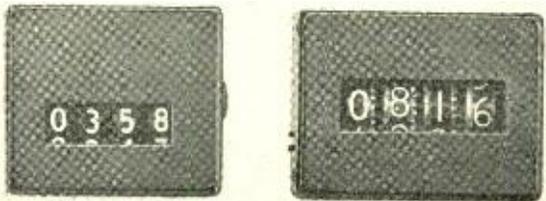
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Fig. 3 — *Improvement in readability of new register is shown by comparison.*

eliminated. In addition, the figures have been redesigned for easier reading. The body of the numerals is thicker, and such curved figures as 3, 5, 6, and 9 have been opened somewhat. The "tails" of these figures do not curl around as far as before, making them more easily distinguishable from each other and from the 8 figure.
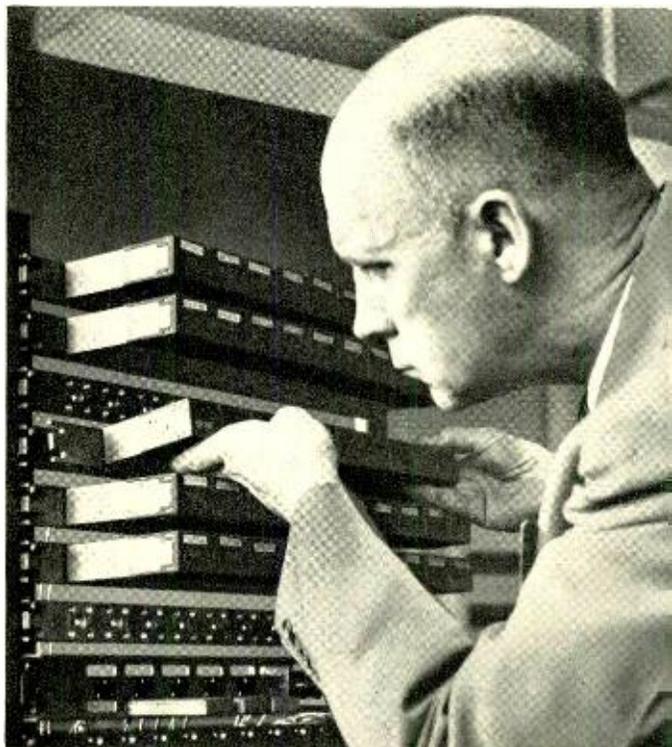
After the designing of the figures, they were cast into standard printers' type. This metal type is kept as the reference set, or standard, for making future dies. Actual size of the cast figures is shown in Figure 7. The type is set in a vertical row and a proof is printed. This is reduced photographically to the proper size for the lithographing stamps. These are rubber-stamps that are arranged on the periphery of a small wheel. Instead of a positive stamp, however, with the figures raised from the background, they are negative stamps with the figures recessed into the background. The nylon number wheel is painted white and the black inked rubber-stamp negative is rolled against it. The resultant white figures showing through the black background are much sharper than they would be if a positive stamp were used. In addition, the greater surface area of the negative stamps permits them to be used for many more printings before they wear out.

Registers used to count the number of calls on a subscriber line do not have to operate rapidly, but must give accurate counts as long as they are in service. Reliability is a prime requisite. The life expectancy of the 5-type is about half a million operations without a miscount. The lighter mechanism of the 14 units gives them a life expectancy far in excess of this figure —

a total of over two million operations without a miscount.

In the early 1930's, traffic studies required "traffic" counts on several trunks of a trunk group at one time. Since a call on one trunk may occur at practically the same time as that on another, the use of a single register to count all calls requires very rapid operation over long periods of time. Minor modifications in the 5-type, chiefly lubrication, resulted in a register with increased life expectancy. This is known as the 12-type. Over five million operations may be expected from this register. In some instances, it was necessary to use pulse-help relays to assist the traffic registers. This combination of relay and register could then operate on extremely short pulses encountered in counting certain traffic. Since the life expectancy of a lubricated 14 register is double that of the 12, or ten million counts, it is suitable for such service. Moreover, it is about five times as fast as the 12 and may therefore be used directly, ordinarily eliminating the need for the pulse-help relay. This represents a considerable
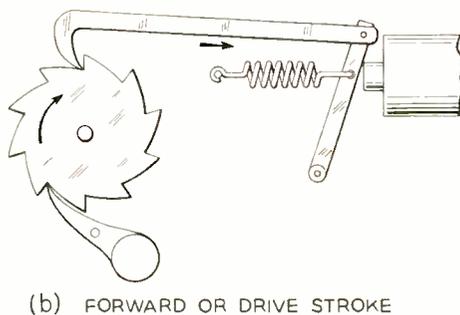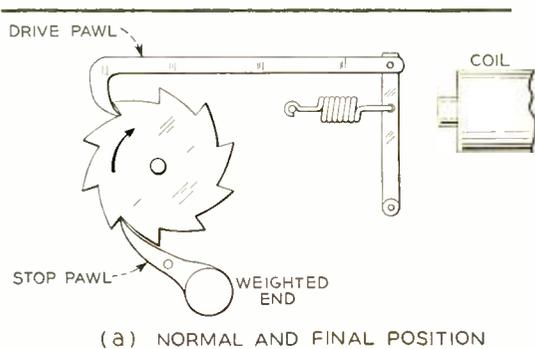
Fig. 4 — *Thickness of mounting plates is cut in half.*

(a) NORMAL AND FINAL POSITION

(b) FORWARD OR DRIVE STROKE

Fig. 5 — *Forward-drive arrangement of 5-type register.*

(a) NORMAL AND FINAL POSITION

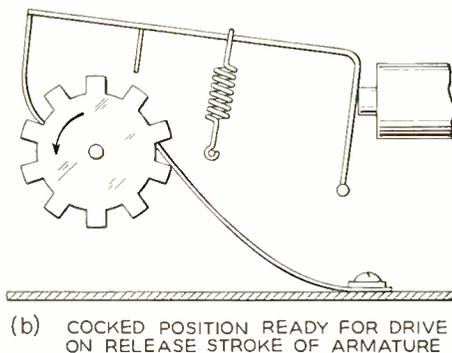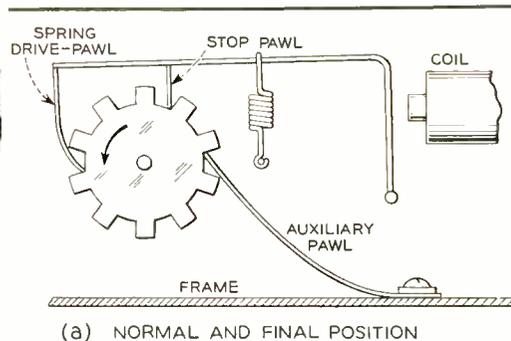(b) COCKED POSITION READY FOR DRIVE ON RELEASE STROKE OF ARMATURE

Fig. 6 — *Back-drive arrangement of 14-type register.*

saving in amount of equipment necessary.

Since the new register will eventually supplant all existing 5-type and 12-type, it is being furnished as a replacement unit, but its shorter length requires an extension to permit its use in racks designed for the older types. A complete series of 14-type registers is available with these extensions, and is called the "L" series. Certain of the older registers included a set of make or break contacts inside the unit, operated by the motion of the armature. These contacts

THE AUTHOR: WILLIAM G. LASKEY left his electrical engineering studies at M.I.T. in World War I to supervise the installation of radio-telephone equipment in naval aircraft. Immediately after the war he joined the Laboratories, working on the development of tungsten-filament lamps for switchboards until 1925. For the next seven years he was associated with the development of filters and special circuits and then transferred to work on the application of quartz crystals to telephone uses. He worked with electro-magnetic devices in 1936 and shortly afterward became interested in message registers. Except for time given to the development of electrical meters for the military services during World War II, he has since devoted most of his effort to this field, with particular attention to the completion of the 14-type message register.

were used in operator supervisory circuits and in other ways. The 14-type registers including similar contacts are also available. New installations using only the 14 registers utilize a new cabinet which is much more modern in appearance and fits in with present office appointments. It has been designed with the circuits available from the front, inside the door, and eliminates the need for an auxiliary traffic register distributing frame that was formerly used.

In addition to the better operating characteristics of the new registers, several savings have resulted from the design. Manufacture of the new units is less expensive, maintenance and replacement have been reduced, mounting plates are less expensive, and the need for pulse-help relays has been substantially reduced. At present, about 90% of production has been changed
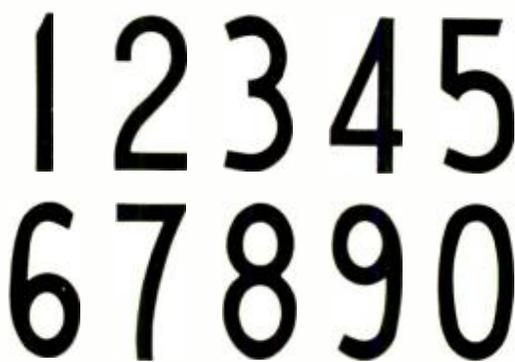
12345
67890

Fig. 7 — Actual printer's proof of new numerals. Type was cast to be used as permanent standard.

over to the new units. Manufacture of the old units is expected to be discontinued by 1956, when models of the 14 registers will be available for all replacements.

Air Traffic Control System Studies

As part of a program to develop communication facilities and services for improved air traffic control, the Bell System will help the Civil Aeronautics Administration evaluate the use of certain proposed new control equipment. The arrangement consists of magnetic drum storage equipment which the CAA has, operating in conjunction with an 81-D-1 automatic teletypewriter switching system modified for this use. A pilot may file his flight plan over the 81-D-1 system on punched tape, and this is then recorded in the drum storage equipment. Acting as a sort of "supervisor," the drum utilizes its stored information as to flight plans, available take-off and landing times, and other conditions from other sources, and returns a checked flight plan, corrected to be consistent with the stored information.

Bell Telephone Laboratories is developing the required equipment modifications, supervising the experimental installation, and will assist in evaluating the 81-D-1

teletypewriter switching system in this application. Initially, there will be fifteen "outlying" stations plus the system switching center, all located at Indianapolis.

Largest Business PBX Installed

Surpassed in size only by the Federal government's switchboard serving the Pentagon Building in Washington, D. C., a new forty-position PBX switchboard was recently cut into service at the J. L. Hudson Company store in Detroit, Michigan, after three years of planning and construction and a year of installation.

Engineered to handle 40,000 incoming calls a day over 330 incoming lines, the new switchboard distributes calls to more than 2,000 telephones throughout the store and warehouse. There are 178 outgoing lines. Also cut into service at the same time was Hudson's new telephone order board. Staffed by 196 order operators at a time, it handles customers' orders after the calls have been channeled through the main PBX switchboard.

A New General Purpose

Polarized Relay

J. S. GARVIN (retired)

Switching Apparatus Development

Polarized relays, because of their directional characteristics, high operating speed, and sensitivity, are important elements in many switching systems. These advantages are not obtained cost-free, however, and efforts are constantly being made to reduce the manufacturing and maintenance expense. Newer magnetic materials, improved manufacturing procedures, and design improvements for greater stability of adjustment have made possible a new design that is interchangeable with the old, but costs less, is more stable, and is even more sensitive.

Most of the relays used in the Bell System are of the so-called "neutral" type, that is, they will move the armature in one direction, regardless of the direction of current flow through the winding. There is, however, a small group of relays in each central office that is fundamentally different from the neutral type in that the movement of the armature depends upon the direction of the operating current. If the current flows in one direction, the armature will move toward one side; if the current is reversed, the direction of movement of the armature is reversed.

"Polarized relays," as these relays are called, have very important functions to perform — such as that, in machine switching systems, of telling when the called subscriber answers, and also in controlling many other switching operations. They are extremely sensitive — some of them are adjusted to operate on as little as 0.2 milliwatt. Polarized relays are fast operating, and, of course, advantages can be taken of their directional operating characteristics. They are of particular value where marginal conditions of release current and non-operate current are required, and are frequently used in pulsing or accurately timed circuits. Intervals of 0.010 second to 0.300 second or longer are measured to an accuracy of ± 10 per cent.

The advantages of polarized relays, however, have not been obtained without appreciable cost, and they have always been more expensive than neutral types. In the past, the 206-type relay, illustrated in Figure 1, and the 239-type, Figure 2, have been used to perform the desired functions. With

Otto Mohr adjusts the pole pieces of the 280 AN relay.

recent developments in magnetic materials, improved manufacture procedures, and new insulating materials, it has been possible to develop an improved relay that is interchangeable both electrically and physically with the older types, costs less, is more stable, and is even more sensitive. This new relay has been designated as the 280-type. Figure 3 shows the new relay with shell removed.

The operation of a polarized relay depends upon the interaction of two magnetic fields, one fixed, and one variable; the relative direction of movement of the armature depends upon the relative directions of the flux in the working air gaps and ϕ_c being the flux produced by the current in the coil, adding in one direction and subtracting for the other direction in the working air gaps.

Then the force may be expressed as:

$$F = K\phi^2 = K(\phi_s \pm \phi_c)^2, \text{ or}$$
$$F = K(\phi_s^2 \pm 2\phi_s \phi_c + \phi_c^2)$$

The first term, ϕ_s^2, is the polarizing component and is the force exerted on the armature by the permanent magnet. This force is present with or without current in the operating winding. In this relay, the polarizing component is used to counteract the
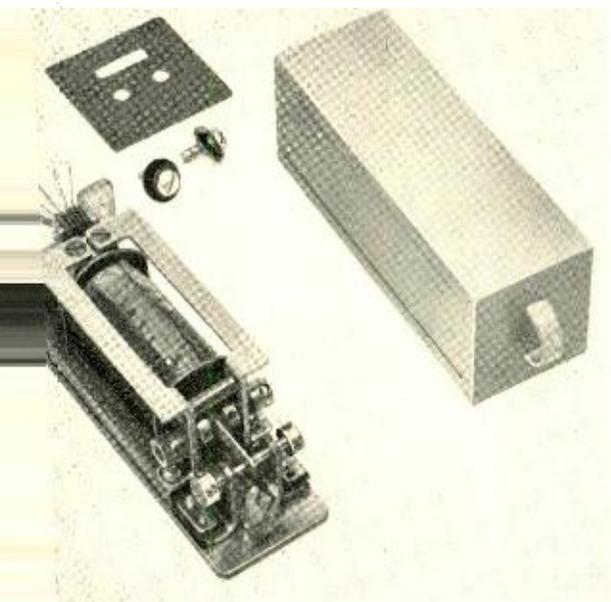
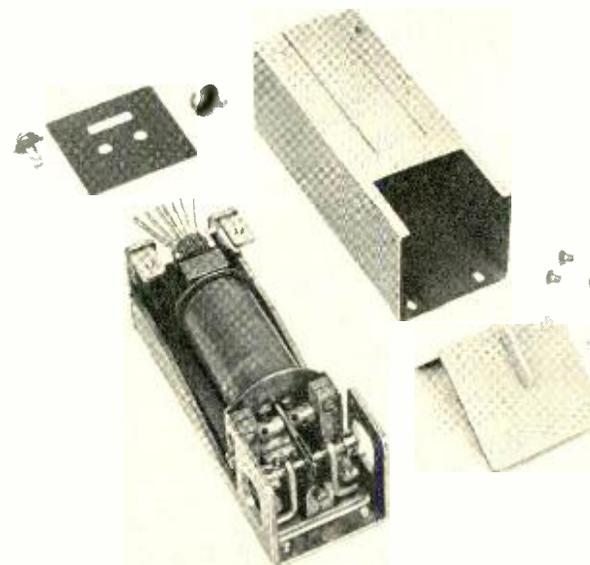

Fig. 1 — The 206-type relay.

Fig. 2 — The 239-type relay.

two magnetic fields. Both fields may be produced by current through windings, but the more common practice is to produce the fixed field by means of a permanent magnet.

Mathematically, the force between magnetic bodies can be expressed as $F = K\phi^2$, where F = force between bodies, ϕ = Flux passing between the bodies, K = Constant depending upon the size of areas occupied by the flux and upon the units used.

In a polarized relay, $\phi = \phi_s \pm \phi_c$, with ϕ_s being the steady (permanent magnet)

mechanical stiffness of the cantilever beam type armature; when the relay is in sensitive adjustment, these two forces are in substantial balance and very little force is required to move the armature from one relay contact to the other. The middle term is the important component, as it is the force that operates the relay — and it is this component that makes the relay selective to the polarity of the operating current because its direction is dependent upon the sign of ϕ_c. Since the magnitude of the middle term,

$2\phi_s\ \phi_c$, is proportional to the product of the steady, or polarizing flux, and the flux generated by the operating current, a high polarizing flux ϕ_s is effective in obtaining a highly sensitive relay.

This is what has been done in the 280-type relay. Instead of a relatively long chromium steel magnet, as used on the 206-type and 239-type relays, the new relay uses a short remalloy bar magnet, which has a great deal more magnetomotive force to provide the polarizing flux in the working air gap of the relay. This advantage can be used in either of two ways — to furnish greater pulling power for a given armature motion, or to provide the same pull but at larger air gaps. The latter is of particular advantage in obtaining greater stability. In addition, the remalloy magnet used in the new relay is stabilized against external magnetic fields. The stabilization is obtained by partial demagnetization of the magnet; this provides added stability in the adjustment of the relay.

In adjusting a 280-type relay the usual procedure is first, to back off the adjustable pole piece screws, so that they will not exert an attracting force on the armature, and then set the contact travel by means of the adjustable contact screws. The pole pieces are then brought into posi-
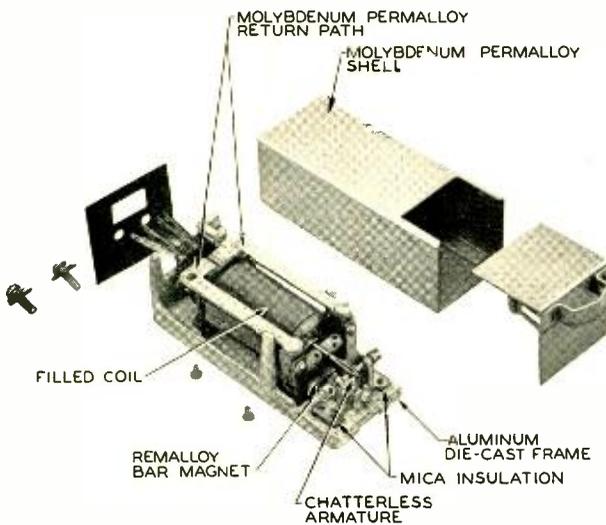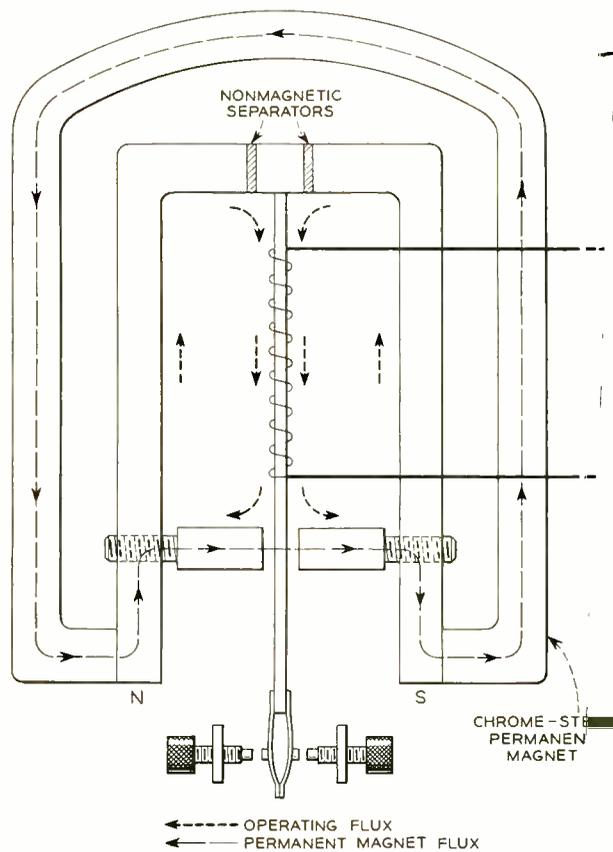

Fig. 4 — Schematic magnetic circuit of the 206-type

tion so that, following the momentary application of a relatively high operating current in one direction, the relay will operate in the opposite direction on three ampere turns, when the current flow through the winding is reversed, but will not operate on 2.2 ampere turns. This balances the stiffness of the armature against the polarizing magnetic force and results in polarized relays of high sensitivity and uniform adjustment.

In making this adjustment on the older relays, it has been necessary to bring the pole piece screws to within a few thousandths of an inch of the armature. Wear at the contacts is such that in a short while, the armature may touch the pole piece screws and the relay must be readjusted.

On the new relay, however, the improvement in pulling capability makes it possible to increase considerably the total air gap
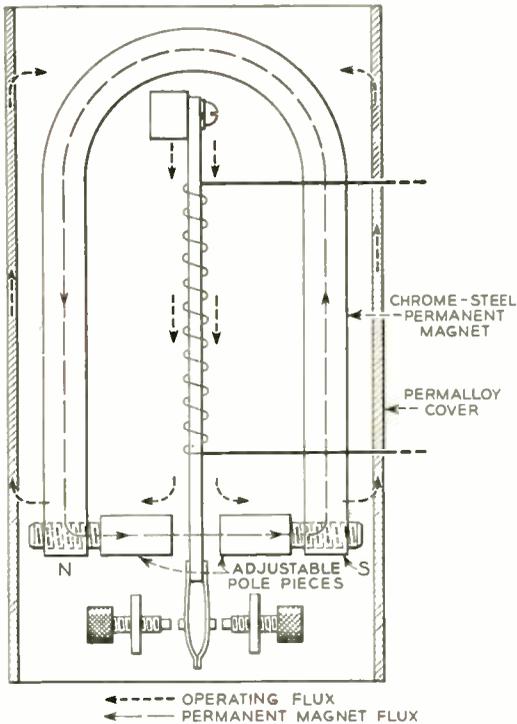
280 TYPE POLARIZED RELAY

Fig. 3 — The 280-type relay.

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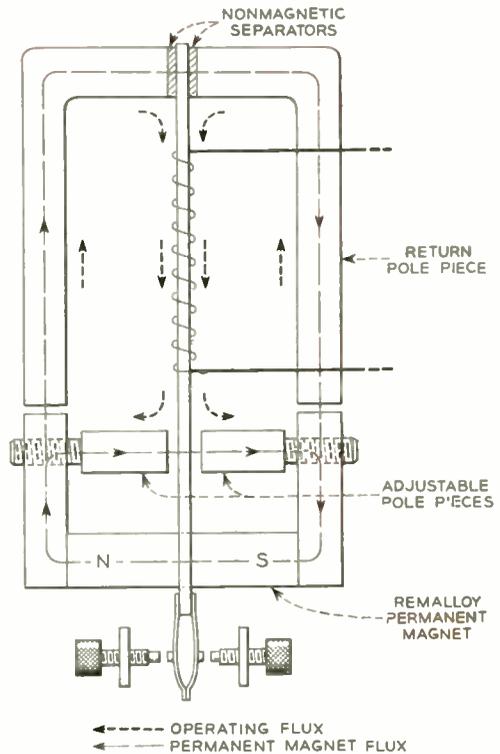Fig. 5 — *Schematic magnetic circuit of the 239-type relay.*

Fig. 6 — *Schematic magnetic circuit of the 280-type relay.*

between the armature and pole piece screws. This improvement makes the relay not only easier and cheaper to adjust, but provides greater stability in the adjustment when the relay is shipped and installed, as well as longer service before readjustment is necessary.

Schematic magnetic circuits of the 206-type and 239-type relays are shown in Figures 4 and 5, respectively. In the 206-type relay, Figure 4, the return magnetic circuit for the operating winding flux is through a pair of brackets that also carry the adjustable pole piece screws at the front end of the coil. Very little coil flux passes through the permanent magnet. The armature may be of silicon steel or 78.5 per cent permalloy, and the brackets and pole piece screws may be of magnetic iron or 78.5 per cent permalloy. The rear post that supports the

armature is formed from cold rolled steel.

In the 239-type relay, Figure 5, the magnetic return circuit is through the cover, which is made of 78.5 per cent permalloy. Armature, pole piece screws and pole piece screw posts are also of 78.5 per cent permalloy. The rear post that supports the armature is of magnetic iron.

For the new 280-type relay, the permanent magnet flux path has been shortened to the front end of the relay, as indicated in Figure 6. Molybdenum permalloy is used for the coil flux return paths and the pole piece screw posts are of hydrogen annealed magnetic iron. Hydrogen annealed magnetic iron is fully satisfactory for this purpose, besides being more machinable and less costly. The armature and pole piece screws are of 78.5 per cent permalloy as in the 239-type relay. Molybdenum permalloy

THE AUTHOR: J. S. GARVIN was graduated from the University of Kentucky in 1910 with a B.M.E. degree. Shortly afterward he joined Western Electric Company in Chicago. A few months later he transferred to Western's Engineering Department in New York. For six years he participated in the development of telephone apparatus. In 1917 he joined the relay development group of the Apparatus Design Department, where he remained until his retirement in April of last year. As designer and supervisor, Mr. Garvin left his mark on nearly every type of telephone relay in use today.

is used for the shell. This provides better shielding, thereby making the new relay freer from mounting restrictions with respect to adjacent relays or other apparatus that might cause magnetic interference. The shell is also of heavier construction, which adds to the stability of the relay.

An aluminum die cast base is used for improved rigidity and lowered cost. Filled coil construction*, in addition to being lower in cost, provides more uniform impedance and speed characteristics. Because mica has very little change in dimensions with humidity changes, this material is

* RECORD, *November*, 1951, *page*, 514.

used to insulate the contact brackets. This, in addition, adds to the stability of the contact adjustment.

Introduced into manufacture in 1950, the 280-type relay has replaced the 206-type and 239-type relays and manufacture of these older relays has been discontinued.

In the development of the new 280-type relay, generous and valuable aid was given by the chemical, materials and systems engineers of the Laboratories, the manufacturing engineers of the Western Electric Company, and by O. Mohr of the switching apparatus group, who was associated with the author in this work.

Patents Issued to Members of Bell Telephone Laboratories During July

Barry, J. F. and Ruggles D. M. — *Crystal Unit* — 2,644,904.

Callaway, W. B. — *Polar Relay Biasing Circuit* — 2,646,464.

Davis, K. H. and Norwine, A. C. — *Voice-Operated System* — 2,646,465.

Feldman, C. B. H. — *Antenna System* — 2,647,212.

Green, E. I. — *Telephone Equalizer Circuit* — 2,645,681.

Heising, R. A. — *Communication System* — Re 23,686 — (Orig. Pat. 2,539,623).

Kircher, R. J. — *Multicontact Semiconductor Translating Device* — 2,644,914.

Morin, F. J. — *Semiconductor of Mixed Nickel, Manganese and Iron Oxides* — 2,645,700.

Norwine, A. C., See K. H. Davis.

Ruggles, D. M., See J. F. Barry.

Thurber, E. A. and Wooten, L. A. — *Selenium Rectifier and Method of its Production* — 2,644,915.

Von Gugelberg, H. L. — *Multicathode Gaseous Discharge Device* — 2,646,523.

Willard, G. W. — *Focusing Ultrasonic Radiator* — 2,645,727.

Wooten, L. A., See E. A. Thurber.

Pole Mounted N1 Carrier Repeaters

J. A. WATTERS
Transmission Systems Development

Ray Oudine (right) of the New Jersey Bell is showing the author how he makes an "in service" filament activity test on the tubes of an N1 repeater, using the 2P tube test set.
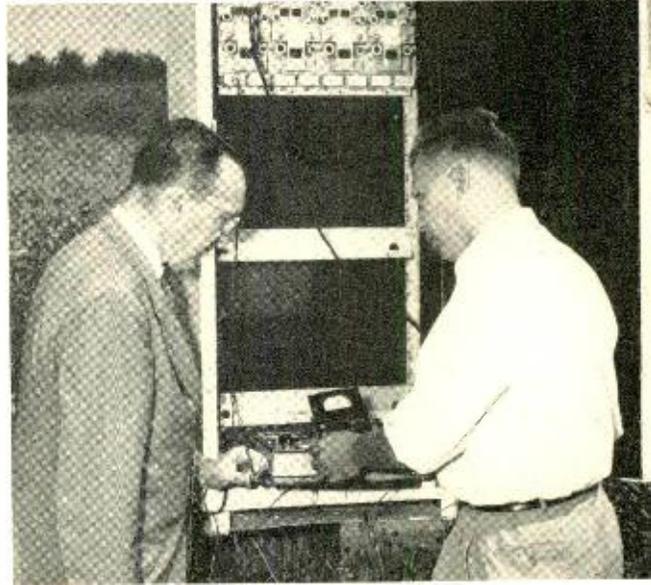
The principal objective of the type-N carrier telephone systems is to supply economical carrier facilities, over cable, for short transmission distances — circuits between 15 and 200 miles in length. On many of these routes, only a single cable is available, whereas on the earlier type-K system, two cables are employed, one for each direction of transmission.

Transmission studies indicated that a twelve-channel carrier system*, designed to operate over a single cable, would be possible. Band width, crosstalk, and noise requirements, however, made necessary relatively short cable spans between terminals and repeaters, and between adjacent repeaters, with distances not exceeding approximately eight miles. Consequently, to make the new system economically feasible for many routes, it was necessary to provide inexpensive power supply arrangements

> Locating repeaters along telephone lines at regular intervals is not new; for many years they have been installed in structures ranging from small huts to sizable buildings. With the smaller and more compact equipment used in the type N carrier system, however, it is possible to install the repeaters in cabinets that can be mounted on poles. The flexibility thus gained has made it possible to meet economically requirements of relatively short cable spans between repeaters and between terminals and repeaters.

and shelters for repeaters at locations out along the cable, away from central offices or the usual repeater station buildings.

Studies of various means of furnishing power showed that a repeater could be supplied from an adjacent station over the simplex circuits on the two associated transmission pairs of each system. Figure 1 shows a simplified schematic of the arrangement for supplying power over the cable from the power station to a pole-mounted repeater location. With this arrangement, power can be furnished from existing central office locations to the repeaters installed in inexpensive cabinets on poles between central office buildings. Three repeater points are supplied from power furnished to the middle repeater.

To maintain a voltage of 140 volts at the power receiving repeaters, both positive and negative 130-volt supplies are furnished at the power supplying offices. The higher
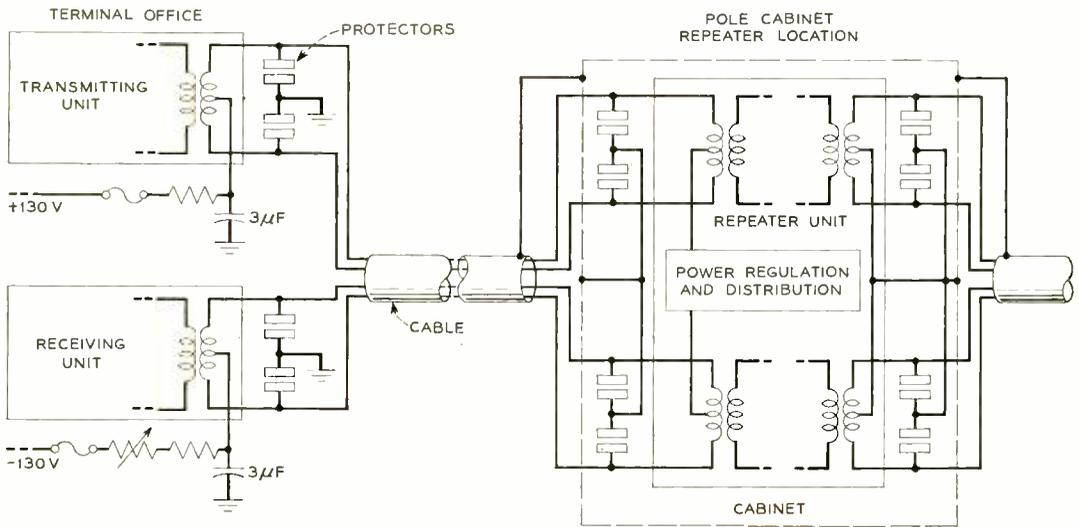
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* RECORD, JULY 1952, *page* 277.

Fig. 1 — Simplified schematic showing arrangement for supplying power over the cable to a pole-mounted N1 carrier repeater.

voltage (260 volts total) is required to compensate for voltage drop through the cable pairs, including flat loss pads for building out cable loss where this is required, and through the associated protective equipment. A voltage regulating tube at the repeater maintains constant voltage there.

Where power is supplied over the cable pairs to pole-mounted repeaters, voltage surges resulting from electrical storms add to the positive or negative potentials supplied. This condition, if it were not corrected, would increase the number of line protector breakdowns, increase the duration of breakdowns, and result in excessive fuse failures in the power feeding circuit. Capacitors, connected from the simplex circuits to ground, as shown in Figure 1, effectively reduce the surge peaks and, together with a new and improved slow-acting fuse, provide a satisfactory solution for this problem.

Pole-mounted cabinets, such as used on rural power line carrier and for some mobile radio installations, offered an attractive solution to the problem of shelter for the repeaters between the central office locations supplying power. Twelve of the compactly designed N1 carrier (plug-in) repeater units can be mounted in such a cabinet within reach of a maintenance man
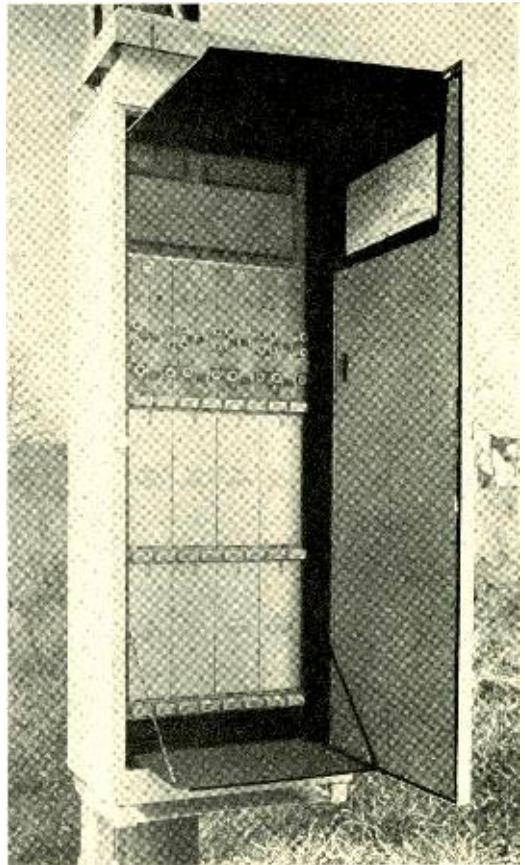

Fig. 2 — A pole-type repeater cabinet equipped with four repeaters.

standing in front of the cabinet. However, if cabinets were to be used, it was essential that some practicable and economical means of controlling temperature extremes within the cabinets be devised. Power for operating blowers and heaters could not be sent out over the cables, and it would not be economical to provide a local power source in an attempt to maintain the temperature inside the cabinet within a reasonable range. The cabinet has therefore been lined with thermal insulation, and is provided with a vent damper, operated by a specially designed bellows-type thermostat and linkage mechanism. Although such measures substantially reduce temperature variations, the temperature extremes expected in some climates required careful selection of potting compounds for apparatus components.

All cabinets are painted white to reduce heat absorption in hot sunny weather. Tests made by Laboratories' engineers disclosed that the use of darker finishes resulted in cabinet surface temperatures up to 30 degrees F higher than those measured on white surfaces. Although the effect of outside color on temperatures within the insulated cabinet was, of course, much less, the margin gained by the use of a white finish is definitely advantageous. The cabinets are so arranged that cable stubs may enter the cabinet at either the top or bottom as may be most convenient at the location where the cabinet is in-
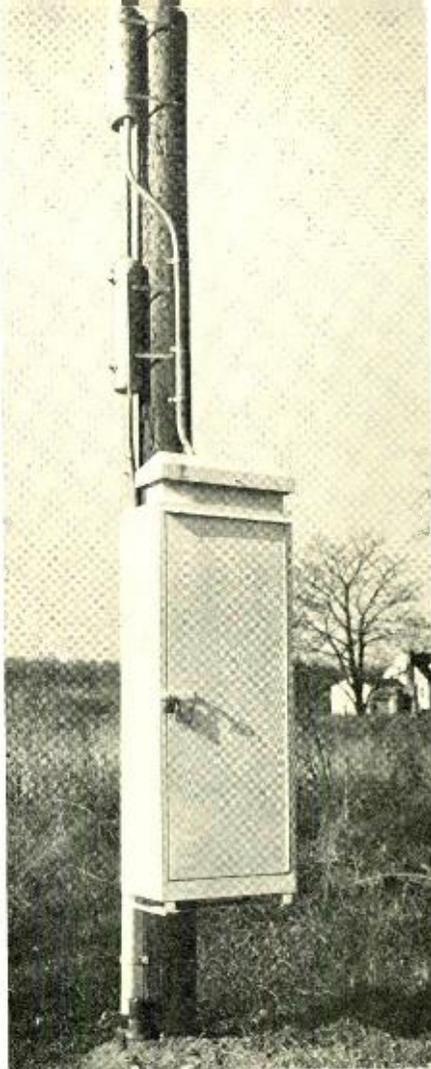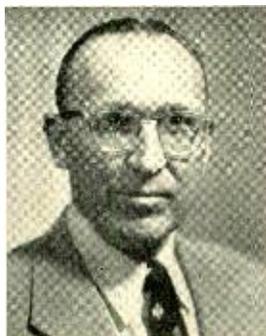

Fig. 3 — A repeater mounted on a stub pole on an underground cable route.

THE AUTHOR: A member of a transmission systems development group for the past sixteen years, JAMES A. WATTERS had previously spent two years at the Laboratories working on test equipment and trials of the telephone voice repeater, and early telephone transmission of radio programs. For a short time he was concerned with dial switching equipment before turning to the development of multi-channel carrier telephone systems for open wire lines. During World War II he did similar work on multi-channel communication equipment for the military services. He continued in this field after 1942 working on multi-channel carrier telephone systems for both open wire and cable circuits. He is currently concerned with the E-type voice frequency repeater, radio control terminal equipment, and carrier program equipment. Mr. Watters received his B.S. in M.E. (1930) from Montana State College.

stalled. Test equipment, designed for use with the repeaters, is of the light-weight portable type since the cabinets cannot always be conveniently located and test gear may, therefore, have to be carried to the location. Handy carrying cases, which protect the equipment from weather and handling damage, are available for carrying spare repeaters.

Provision is made at each cabinet for connecting a lineman's test set to the telephone order wire. Test power jacks are provided through which power is fed over the order wire and alarm cable pairs for operation of a repeater switching set at the cabinet. A cable terminal, designed to terminate all cable pairs associated with equipment located in the cabinet, is also included. Additional cabinets are installed, as required, to accommodate added repeaters. Figure 2 shows a pole-type cabinet, and Figure 3 shows such a cabinet mounted on a stub pole on an underground cable route.

Talks by Members of the Laboratories

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

Calbick, C. J., Surface Studies with the Electron Microscope, American Chemical Society and American Society for Metals Local Chapters, Richland, Wash.

Campbell, W. E., Unusual Analytical Methods in the Solution of Problems in the Communications Industry, Gordon Research Conference on Current Trends in Analytical Chemistry, New Hampton, N. H.

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

Ebers, J. J., Digital Computers, Summer Course in Digital Computers, Wayne University, Detroit.

Felker, J. H., Future Developments in Semiconductor Computers, Argonne National Laboratory, Chicago, Ill.

Fox, A. G., Non-Reciprocal Ferrite Devices in Round Waveguides, I.R.E. West Coast Convention, San Francisco, Cal.

Harris, J. R., TRADIC – A Transistor Digital Computer, Argonne National Laboratory, Chicago.

Lozier, J. C., and D. D. Cherry, A Transistor Feedback Amplifier for Carrier Frequency Applications, I.R.E. West Coast Conference, San Francisco.

Matthias, B. T., Survey of Ferro-Electrics, Argonne National Laboratory, Chicago.

Miller, S. E., Non-Reciprocal Ferrite Devices in Rectangular Waveguides, I.R.E. West Coast Convention, San Francisco.

Riesz, R. R., Human Engineering, Human Engineering Institute, Stamford, Conn.

Slepian, D., Estimation of Signal Parameters in the Presence of Noise, Symposium on Statistical Methods in Communications Engineering, I.R.E. Professional Group on Information Theory, Office of Naval Research, and the Departments of Engineering, University of California, Berkeley, Cal.

Stansel, F. R., An Improved Method for Measuring the Current Amplification Factor of Junction Type Transistors, I.R.E. West Coast Convention, San Francisco.

Terry, M. E., The Problem of Paired Comparisons Using Mosteller or Bradley-Terry Analysis, Statistical Summer Session, Sponsored by the University of Connecticut, Yale University, and Princeton University, Storrs, Conn.

Thomas, D. E., Point Contact Transistor VHF FM Transmitter, I.R.E. West Coast Convention, San Francisco.

Vogelsong, J. H., Transistor Circuitry for a 3-mc Serial Computer, Argonne National Laboratory, Chicago. Presented by W. A. Cornell.

Weiss, M. T., see A. G. Fox.

New Interrupter for No.5 Crossbar

R. B. REYNOLDS
Switching Systems Development
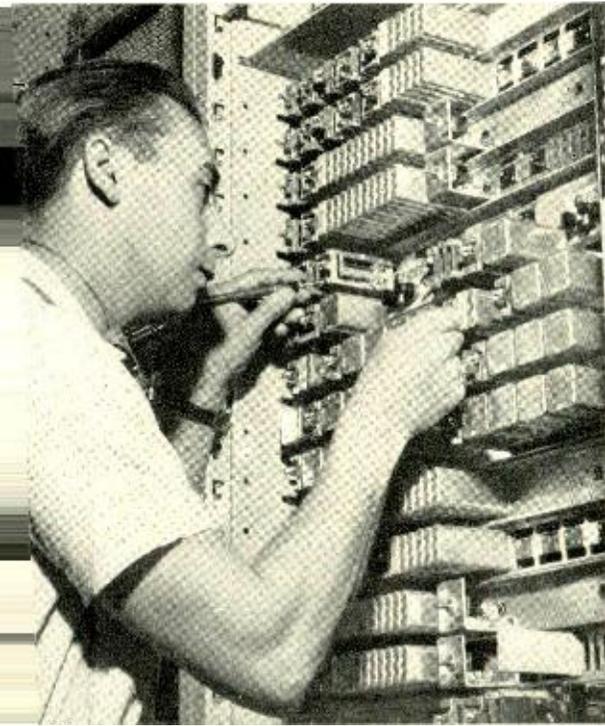
R. H. Granger holds a relay from operating while checking the alarm circuit.

Signaling is an important function in telephone service, since operators and customers alike must be apprised of conditions on the line. One of the requirements for "busy" signals is that a source of interrupted ground, tone, or both be available. These signals are produced by an interrupter capable of supplying the signals to many pieces of apparatus. An all-relay interrupter has recently been developed for use in No. 5 crossbar and other systems. This interrupter can supply a large number of signals, includes protective alarm circuits, and takes up only a small portion of a bay.

Interrupters are used throughout the telephone plant to supply interrupted ground, tone, or both to various equipments. These signals are used principally to indicate busy conditions, either by flashing operators' supervisory lamps or by supplying audible indications to operators and subscribers. Since a central office includes hundreds of circuits requiring these signals, it is not practicable to have each circuit supply its own signal. It is preferable to have a single source of interrupted ground control the action of an interrupter, which then dis-tributes the proper signals. This interrupter is basically an all relay interrupter which provides a highly adaptable distribution system with protective alarm circuits.

A cam-operated switch in the ringing machine supplies interrupted ground to the interrupter proper at either 60 or 120 IPM (impulses per minute). The path of this interrupted ground is shown in Fig. 1; from the ringing machine through a manual transfer key, through automatic transfer contacts on the alarm relay, and on to the coil of one or the other of primary relays
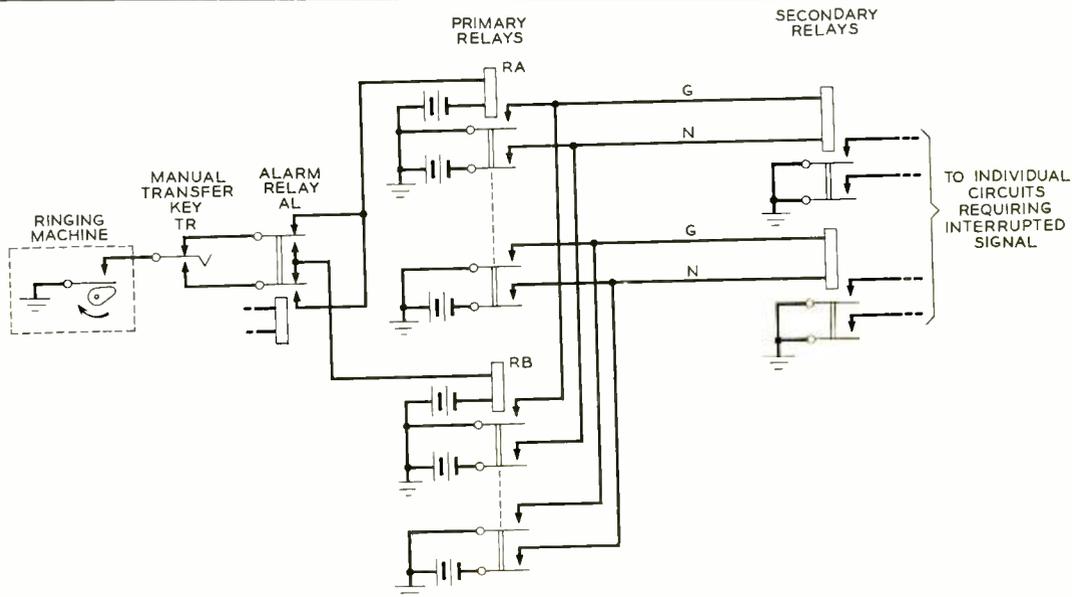
Fig. 1 — Signal path from ringing machine through interrupter to associated circuits.

RA or RB. Each of these primary relays is actually a group of several relays in multiple to increase the number of contacts available, but they are treated as individual units in this article for simplicity of explanation. Contacts on these primary relays control the operation of several secondary relays which form the distribution system. Each secondary relay supplies a large number of individual circuits either with interrupted ground, interrupted tone, or both as required.

The manual transfer key is included for two purposes. To maintain approximately equal wear on the two primary relays the key is operated manually at regular inter-
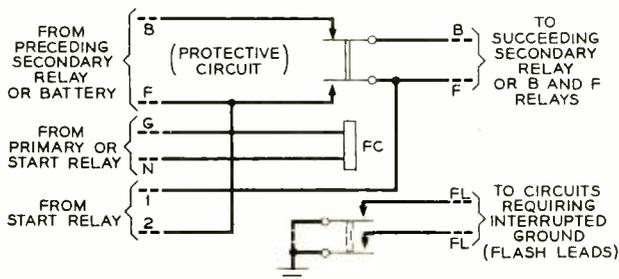

Fig. 2 — The FC secondary relay supplies interrupted ground only.

Fig. 3 — A test is made on one of the relays by R. Granger.
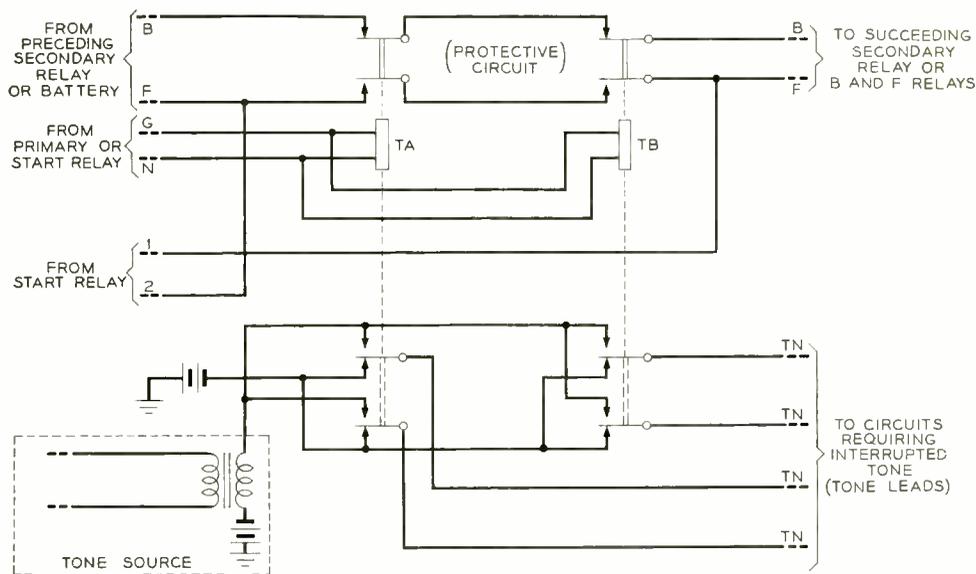
www.americanradiohistory.com

Fig. 4 — The TA-TB *secondary relay supplies interrupted tone only.*

vals, interchanging the relays. At the same time, a check on the operating condition of the idle relay is available at all times through the use of this key. The automatic transfer contacts on the alarm relay are operated when an alarm is given for any reason. If the alarm is the result of trouble in the operating primary relay, the transfer to the idle relay restores operation of the interrupter automatically, but maintains the alarm to indicate that trouble exists in some part of the equipment. When trouble occurs anywhere in the interrupter the alarm relay is operated, a lamp is lighted on the interrupter panel, and the office major alarm is sounded. This is augmented by annunciator lamps to indicate the physical location of the equipment in trouble.

Secondary relays are used in three different circuit arrangements as shown in Figs. 2, 4, and 5. In Fig. 2, the FC relay supplies only interrupted ground to its associated circuits. Relays TA and TB, shown in Fig. 4, supply only interrupted tone, and two relays are used here to increase the number of circuits that may be handled. Fig. 5 shows a third arrangement that supplies both types of signal and includes a ground detection circuit. If a permanent or trouble ground appears on any flash lead

supplied by the interrupted ground, the common connection through the secondary relay contacts will apply the trouble ground to all the circuits connected to the relay, blanking their indications. The external trouble ground operates relay GT which has hold contacts connected to the operate winding of relay G. The GT relay, however, may operate momentarily on a surge when the FL relay releases to close the flash leads to the GT relay. To prevent this possible momentary operation of the GT relay from operating the G relay and bringing in an alarm, the circuit for operating the G relay is effective only if the GT relay remains operated until the end of the open period. This is accomplished by using the pulsing contacts of the primary relay to control both the hold circuit of the GT relay and the operate circuit of the G relay. This latter relay also holds, removing regular local ground supply from the flash leads and sounding an alarm. Each secondary relay, regardless of its circuit arrangement, also has front and back contacts which are used in the internal self-checking protective circuits.

When used in conjunction with the primary relays only, the secondary relays supply signals at all times to their associated circuits. It is often desirable to have the

signal available only when needed by the external circuit to reduce wear of the contacts. To accomplish this, each secondary relay may be operated on a "call-operate" basis by including a start relay such as is shown in Figure 6. The circuit requiring the interrupted signal "calls" the interrupter by connecting ground to the start relay, which then connects the secondary relay associated with the calling circuit to the

second in both units. The protective circuits that have been designed to utilize these slow-release relays have several functions. Relay GP, in conjunction with a normal relay R, monitors the length of time the input from the ringing machine remains closed, to check for trouble grounds in the ringing machine circuit. When interrupted ground is supplied to the interrupter from the ringing machine, relay R operates and removes
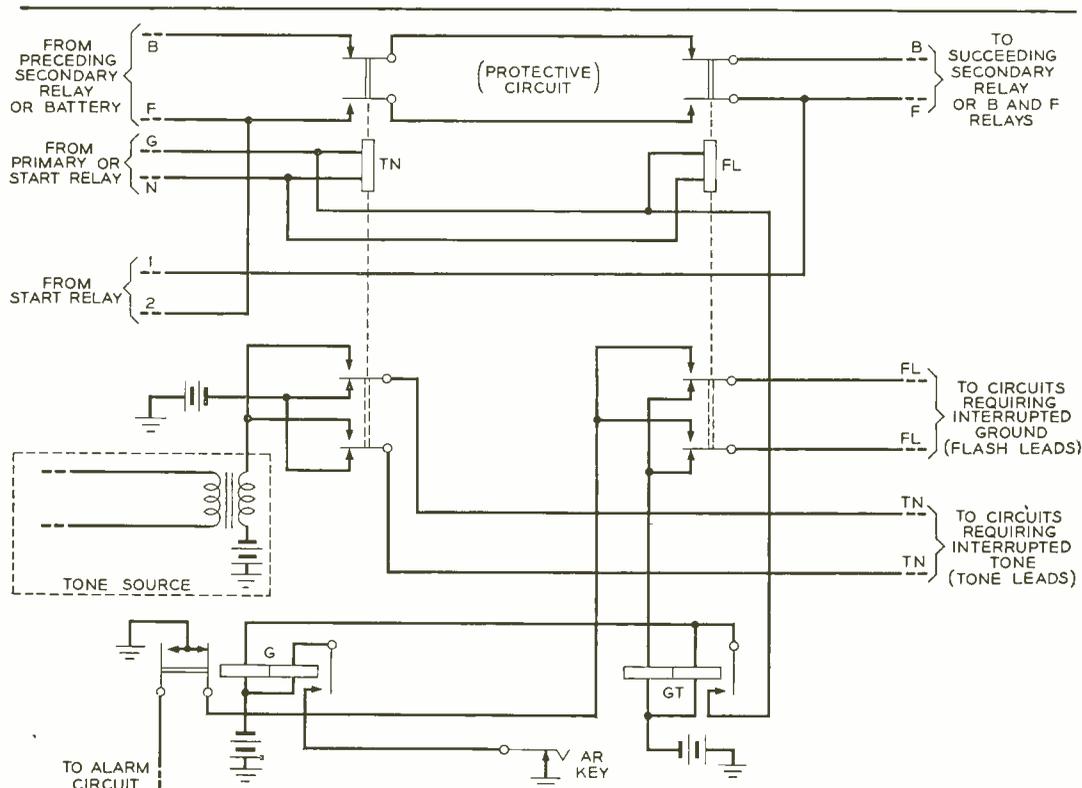

Fig. 5 — *The* TN-FL *secondary relay supplies both interrupted ground and interrupted tone.*

primary relay. When the circuit no longer requires the signal, it releases the start relay which in turn disconnects the secondary relay from the primary relay.

To protect service signals by sounding an alarm when trouble develops in the interrupter, three slow-release relays are used as shown in Fig. 7. These relays are timed so that they will release after a specified delay period has elapsed. For relays B and F, this time is 0.5 second in the 120 IPM interrupter and 0.7 second in the 60 IPM unit. Relay GP is timed to release after 0.75

battery from relay GP. If the ground is removed within the normal time limit, relay GP will not release before it is again energized through relay R. A permanent or trouble ground will not permit relay R to release and, after 0.75 seconds, relay GP will release, removing battery from the primary relays RA and RB and sounding an alarm.

Duration of both the open and closed periods of the secondary relays during interruption is continuously checked by relays B and F. Equipment which is supplied

with an interrupted tone or ground is affected by appreciable changes in the duration of the open and closed periods, and these two slow-release relays assure that the periods will be correct. Relay B is normally in the operated condition, and releases only when any of the series of back contacts on the secondary relays fails to close after 0.5 or 0.7 second has elapsed, depending on the interruption rate. Release of relay B grounds the alarm relay, sounding an alarm.

Relay F is also normally in the operated condition, and releases only when any of the series of front contacts on the secondary relays fails to close after the specified length of time. Thus the open period of the secondary relays is monitored by relay F and the closed time is checked by relay B. An open in the ringing machine circuit or failure of relay RA or RB to operate will release relay F and sound an alarm. The alarm relay itself has hold contacts to maintain the alarm once it has operated, and must be released manually by the alarm release key AR or by the alarm sending circuit of the No. 5 crossbar system.

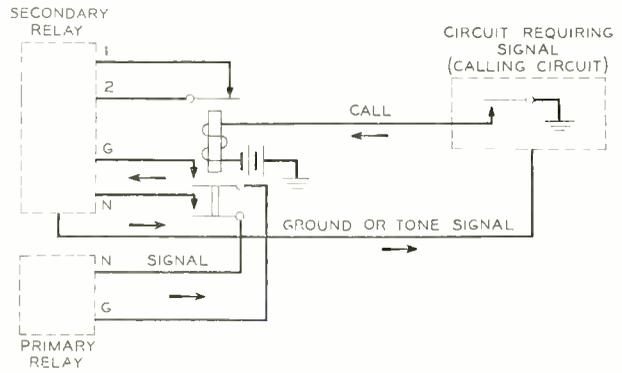The usual type of slow-release relay is

Fig. 6 — The start relay connects primary and secondary relays when called by associated circuit. Leads 1 and 2 are normally closed to prevent the idle secondary relay from operating the protective circuits.

a relay with a copper sleeve for the production of eddy currents that will slow the release action. The delay time of such relays is not sufficient for the protective circuits of the interrupter and they cannot be timed accurately. The release time of these relays depends upon the applied voltage and adjustment of the relay, and the re-cycling time is too long. Other more expensive tim-
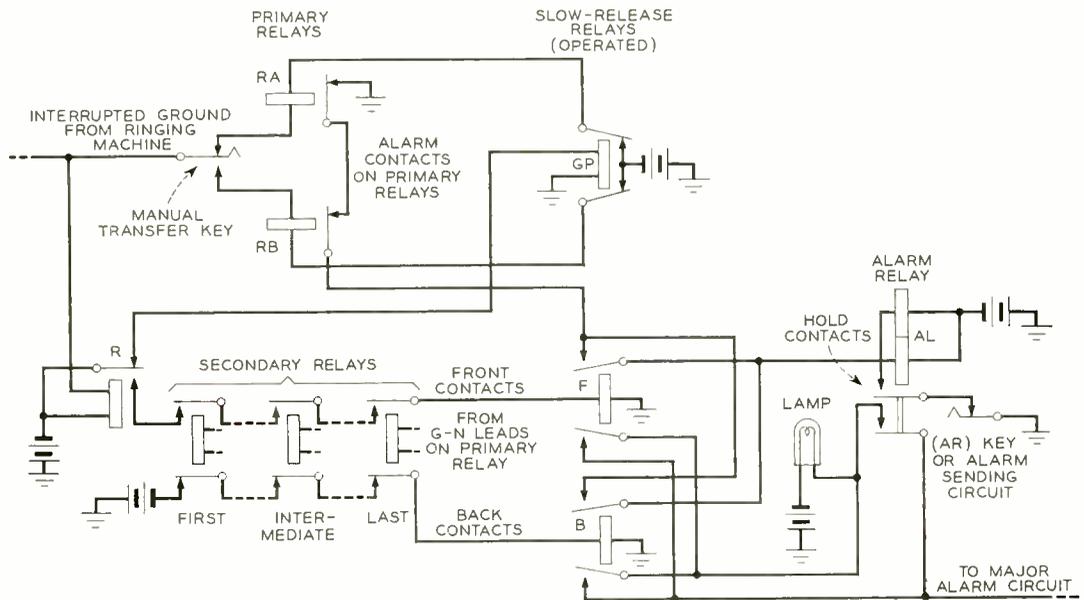

Fig. 7 — Simplified alarm circuits showing inter-relation of all parts of circuit. Secondary relays shown are operated by the primary relays. The slow-release relays stay operated until trouble develops, while primary and secondary relays are being pulsed continually.
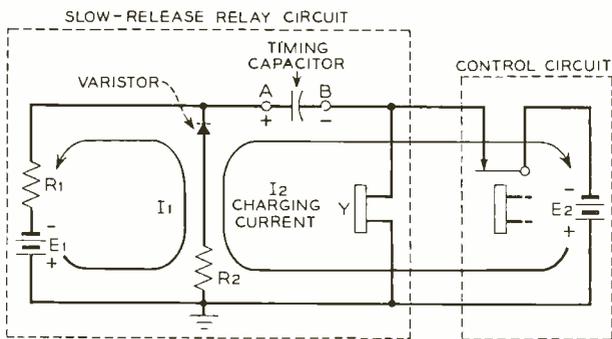
Fig. 8 — *Timing circuit for slow-release relays showing path of charging current. Operating current for relay Y from voltage E_2 is not shown.*

ing devices using polarized relays and cold-cathode tubes are available but a new type of timing circuit has been developed which is simple and inexpensive.

The slow-release feature in this circuit is a novel arrangement invented by M. E. Krom of the Switching Systems Development Department. Each slow-release relay (B, F, and GP) in the interrupter is a standard Y-type relay without the copper sleeve, timed by a combination of a resistance, a capacitance, and a varistor. Fig. 8 shows the circuit arrangement. When the external circuit is closed, the varistor conducts through the two resistors as shown by the I_1 current path. Since the resistance of the varistor in the forward or conducting direction is very low, and since R_2 has a very

low value, the voltage drop across these elements is small and point A is nearly at ground potential. The battery E_2 of the associated circuit will charge the capacitor rapidly through R_2 and the varistor with current flowing as shown by the I_2 current path. It is this rapid charging which permits rapid recycling. When the voltage across the capacitor reaches the value of the drop across R_1, the voltage at point A is stabilized at the same value it had before the external circuit was closed.

When the external circuit is opened, the potential at point B is made more positive by changing from the negative voltage E_2 to ground. This results in making the potential at the opposite side of the capacitor, at point A, more positive by an amount equal to E_2. The capacitor will discharge and cause a current, which decreases exponentially, to flow through the coil of relay Y and the R_1 resistor in the same direction as the relay operate current. As long as the potential at a point A is positive with respect to ground, no current will flow through the varistor. When the positive potential at point A decreases to zero, the varistor starts to conduct and the discharge current is cut off suddenly. The capacitor starts to charge in the opposite direction but the low resistance path provided by the varistor and resistor R_2 limits this charge to a low negative value equal to the voltage drop across the varistor and R_2. If the varistor were not

THE AUTHOR: R. B. REYNOLDS came to the Laboratories in 1951 as a technical assistant in the switching development group, where his assignments were in connection with the wire spring relay development. He also wrote Bell System Practices for No. 5 crossbar circuits. This was not his first Bell System experience, however; he had been a central office repairman for Southwestern Bell in Pampa, Texas, before finishing high school. After high school and a year at the University of Chicago, he enlisted in the Army in 1946 and later was a regimental radio repairman in Korea, supervising the installation of common battery telephone systems in Taejon and Chongju. After he was discharged from the Army, he entered the University of Texas to study electrical engineering. He has recently returned to the University, but works at night as a frameman for Southwestern Bell in Austin.

included, the capacitor would reach a negative charge approximately equal to the voltage of E_1, which is the same as that of E_2. Fig. 9 shows the discharge curve, where the dotted portion is the charging voltage which would occur if it were not halted by the varistor. Just after the charge on the capacitor has passed zero, the voltage at point A will be nearly zero, but will have changed polarity. This small voltage is in such a direction that the varistor conducts as at the beginning of the cycle, maintaining point A at nearly ground potential. With the potential at point A stabilized at slightly below ground, the charging of the capacitor is suddenly cut off. It is this sudden cutting off of the current through the relay that permits accurate timing of the circuit.

Although the current in the capacitor is suddenly cut off, the inductance of the Y-relay coil will maintain a short transient current. The duration of this transient current is determined by the values of the inductance of the coil and the capacitance of 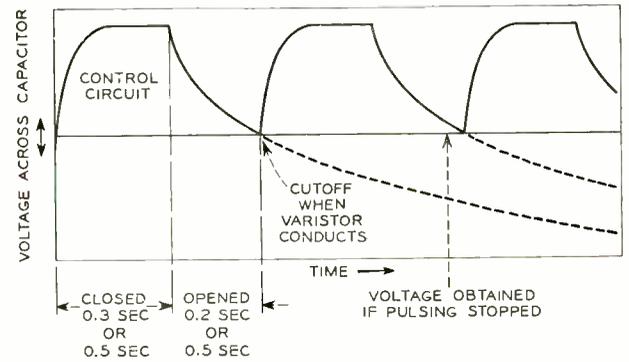the capacitor, but is relatively short and has little effect on the accuracy of the timing. The most accurate timing is obtained when the value of the capacitor current at cut-off is equal to the hold current required by the relay. Only a slight change of current is then required for the relay to release.

Fig. 9 — *Graph of voltage across capacitor. Dotted line is charging curve if varistor did not conduct. Relay will not release during interruptions.*

Three-in-one Machine for Making Telephone Cords

Changing from hand operations to machine operations is one of the most important functions in Western Electric production methods. A typical example is this "3 in 1" machine which does three jobs formerly done by hand on neoprene-jacketed telephone cords. Two machines now do the same jobs as several hands — and do them ten times as fast. The machines automatically cut telephone cordage to a predetermined length, strip the neoprene jacket from the conductors at each end, and count the cords into bundles of fifty, all in a single continuous operation. More than one million cords of the neoprene-jacketed type are produced each month at Western's Point Breeze plant, to supply the demands of the Bell System.
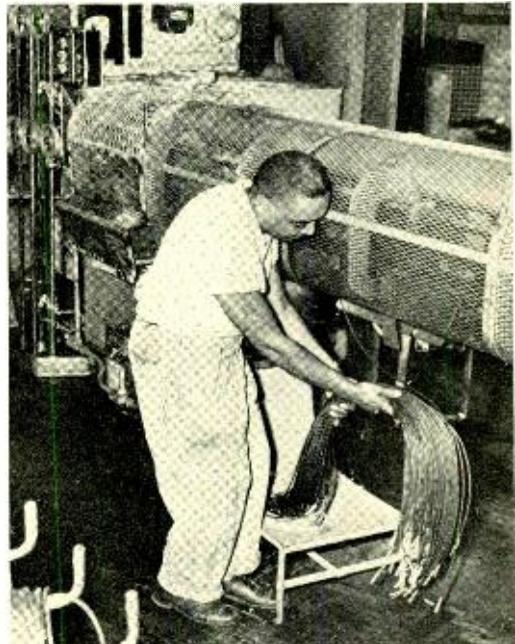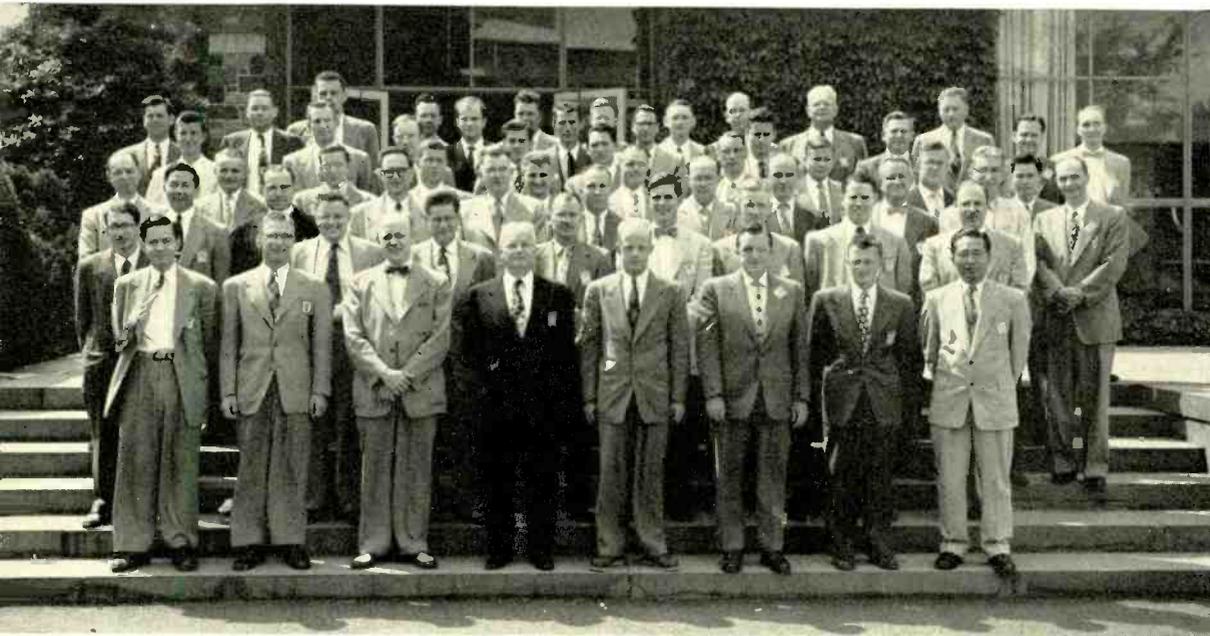
College Professors Study At Murray Hill

A *Short Course in the Design of Digital Control Circuits* was given at Murray Hill from August 24 through September 4, in response to many requests for detailed information on such circuits. Forty-one professors, representing thirty-four colleges and universities throughout the country, heard lectures on the fundamental theory and techniques of switching circuit design, on the types of components used in digital control circuits, and on the many different types of such control circuits.

Staff members of the Laboratories conducted the lectures and demonstrations of the course. Most of the lectures were held in the Arnold Auditorium at Murray Hill, but one day was spent at West Street with lectures, demonstrations, and a tour of the switching laboratories. A tour of the Murray Hill Laboratories was included, and a field trip to Englewood gave the "students" a chance to see the Englewood central office in action.

Demonstrations of typical computers and switching systems were given, including the general purpose relay computer, the general purpose analog computer, an I.B.M. computer and an experimental magnetic drum storage telephone switching system.

Additional displays embodying switching system principles were also shown to the class. They included the "Tower of Hanoi," a tic-tac-toe machine, a switching circuit synthesizer, a penny matching game, a Roman numeral computer and the maze solver.

All the lectures and demonstrations placed the emphasis on basic design methods for integrating discrete-valued components into systems for automatic control. These principles are applicable to designs using relays, electron tubes, transistors, or other components acting as discrete-valued devices.

Members of the technical staff who took part in the course include: H. A. Affel, J. Reid Anderson, J. J. Ebers, J. H. Felker, W. O. Fleckenstein, R. W. Hamming, C. M. Hebbert, R. E. Hersey, B. D. Holbrook, M. Karnaugh, W. Keister, R. W. Ketchledge, W. D. Lewis, W. Malthaner, G. H. Mealy, J. Meszar, E. F. Moore, J. P. Runyon, H. N. Seckler, C. E. Shannon, R. H. Van Horn, H. E. Vaughan, S. H. Washburn, and V. M. Wolontis.

Those attending the course included E. J. Smith and Shih-pai Tung, Polytechnic Insti-

tute of Brooklyn; Raymond H. Young, Bucknell University; Louis G. Walters, Univ. of California at Los Angeles; William P. Caywood, Jr., Carnegie Inst. of Technology; Irving Lefkowitz, Case Inst. of Technology; A. B. Bereskin, University of Cincinnati; Mario Tchou, Columbia University; Charles R. Burrows, A. B. Credle and Raymond A. Elliott, Cornell University; Wayne Chen, University of Florida.

Also W. B. Jones, Jr., Georgia Inst. of Technology; L. O. Brown, University of Illinois; L. A. Ware, State University of Iowa; J. Edmond Wolfe, Kansas State College; E. L. Jordan, University of Kansas; John J. Kelly, Manhattan College; T. W. Culpepper, Michigan State College; Norman R. Scott, University of Michigan; Joseph Seton Smith, New York University; R. E. Anderson, Donald W. Dickey and Robert H. Rose, Newark College of Engineering; David L. Johnson, Oklahoma A. & M. College; Carl Volz, John A. Warfield and H. I. Tarpley, Pennsylvania State College.

Also Harry J. Gray, Jr., University of Pennsylvania; Hans Belck, Rensselaer Poly. Institute; F. W. Tatum, Southern Methodist University; Carl Barus, Swarthmore College; John D. Tillman, Jr., University of Tennessee; Rubin W. Ludwig, University of Texas; John L. Warner, Tufts College; Rev. John A. Klekotka, Villanova College; W. H. Bixby, Wayne University; C. H. Davidson, University of Wisconsin; William B. Wadsworth, Worcester Poly. Institute; V. O. Long, University of Wyoming; and Conrad A. Wogrin, Yale University.

TV Football Coverage Expands

Expansion of the Bell System's coaxial cable and microwave network facilities throughout the nation will result in a large television audience this fall for football games. Orders have been received from the National Broadcasting Company for televising football games over a network of some eighty stations. On October 24 and November 7, the network will carry a "football panorama"; on each of these days, portions of four games will be shown.

Dr. Kelly Honored

M. J. Kelly, President of the Laboratories, received the Science Award of the Air Force Association at the seventh annual convention recently held in Washington, D. C. The award, comprising a certificate and a handsome silver trophy, was pre-

Air Force Association

SCIENCE AWARD

DR. MERVIN J. KELLY

In this Air-Atomic Age our security is increasingly dependent upon the men of science.

DR. MERVIN J. KELLY, President of Bell Telephone Laboratories, one of the world's great research establishments, is a scientist and administrator of rare ability who has demonstrated selfless devotion to the National Welfare.

As a Vice-Chairman of the Scientific Advisory Board of the United States Air Force, and as Chairman of the Defense Department Committee which brilliantly analyzed our Continental Air Defenses, he has displayed wise and vigorous leadership in dealing with our most vexing security problems.

To DR. MERVIN J. KELLY the Air Force Association awards its 1953 TROPHY FOR DISTINGUISHED SERVICE TO AIRPOWER IN THE FIELD OF SCIENCE.

sented by James A. Doolittle, famous airman and Medal of Honor winner, at the closing banquet of the convention. Dr. Kelly's award was specifically for "distinguished service to air power in the field of science." Dr. Kelly was unable to be present due to previous commitments, and the award was accepted for him by J. B. Fisk, Director of Research in Physical Sciences, of the Laboratories.

Past recipients of this award include Dr. Edward Teller, University of California; Dr. George E. Valley, Massachusetts Institute of Technology; Dr. Theodore von Karman, USAF Scientific Advisory Board; R. C. Sebold, R. H. Widmer and R. O. Ryan, who contributed to the development of the B-36; and John Stack, National Advisory Committee for Aeronautics.

Communications at the New Newark Airport Terminal

An ultra-modern and intricate nerve system of telephone and public address communications now serves the $8,500,000 new air passenger terminal at Newark Airport. The terminal will have a communications network equivalent to the size of a small-town central office. There are only 300 telephones at the Port of New York Authority's new building, but the over-all equipment is equivalent to a small office serving about 7,000 stations.

Approximately 8,000 pairs of wires terminate in the building's second-floor equipment room, including special weather, radio and teletype and traffic control circuits for the Civil Aeronautics Administration. A 711-A intercommunicating dial system enables each telephone extension to dial any other extension directly without calling an operator. Forty-one public telephone booths have been located at fourteen points. So extensive is the communications system, the terminal has its own directory.

More than 200 loud speakers are located around the building to broadcast announcements and background music. Speakers are

The new Port of New York Authority building as seen from the Newark Airport control tower. Even here in the control tower there are two switchboards and considerable other telephone equipment.

also placed along the observation level; through them an announcer describes important arrivals and departures, interesting sidelights and unusual events. These speakers are not tied in with the dial paging system, but can be seized by the airport superintendent through the public address switchboard for urgent announcements.

Some of the forty-one coin-telephone booths are installed at one of fourteen locations in the Port of Authority Building. Paneling of the booths is in blond oak, to match the building's decor.
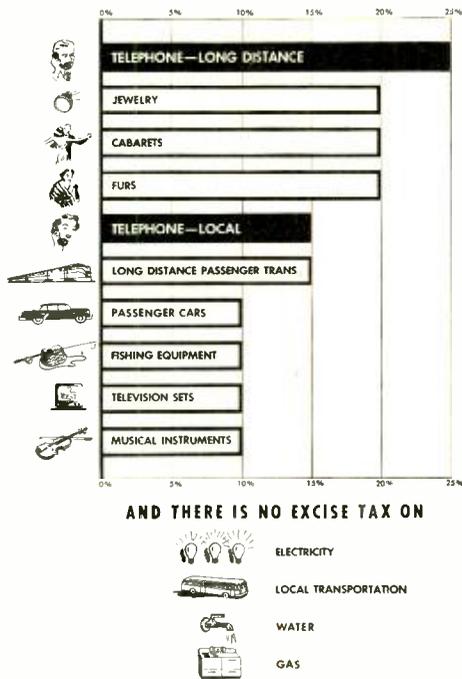
Testimony on Phone Taxes

Mark R. Sullivan, President of The Pacific Telephone and Telegraph Company, speaking for the Bell Telephone System, testified during a recent review by the House Ways and Means Committee of the existing excise tax structure. He characterized excise taxes on telephone service as "unreasonably high and burdensome." Long distance calls and leased wire facilities carry an excise tax of 25 per cent, and local service is taxed at 15 per cent.

Making it clear that, since the tax is paid by the telephone customers, any reduction would accrue directly and immediately to telephone users, not to the telephone companies, Mr. Sullivan stated:

"Telephone service is a necessity to our modern way of life, yet it bears an unreasonably high and burdensome Federal excise tax. Of the four essential household utility services — water, gas, electricity, and telephone — only telephone service is subject to any Federal excise tax. The objectionable discriminatory aspects of telephone excises are more sharply revealed in light of the fact that they are at a higher level even than those imposed on most luxuries. The present Federal excise tax rates were enacted under conditions which no longer prevail and should not be continued under present conditions."

Only liquor and tobacco bear higher tax rates than telephone service, Mr. Sullivan pointed out, and many luxury items bear less tax. Jewelry, furs, luggage, and cabaret charges are taxed 20 per cent. Many other items such as musical instruments, radios, sports equipment and wagers such as betting on races, are taxed at 10 per cent.

The present high excise taxes on telephone service are the outgrowth of conditions prevailing prior to World War II and during the war, he said, when steps were taken to discourage civilian telephone usage.

State regulatory bodies have taken a strong stand against the imposition of the high telephone excise taxes. The National Association of Railroad and Utilities Commissioners passed a resolution citing objections as have various state regulatory groups. Mr. Sullivan also referred to independent polls made by the American Institute of Public Opinion and Opinion Research Corporation on over-all tax questions which not only indicated public dissatisfaction with the telephone tax but ranked it at the top of the list of those most disliked. One of the polls, Mr. Sullivan added, summarized its findings by stating that in a nutshell, people say: "Lower the taxes on things we have to have."

COMPARISON OF VARIOUS EXCISE TAX RATES -- 1953

AND THERE IS NO EXCISE TAX ON

Network TV Cities Pass 100 Mark

Additions to the Bell System television network are rapidly being made. Among those TV stations recently added are WTVI, Belleville, Ill., WEEK-TV, Peoria, Ill.; WBPF-TV, Buffalo, N. Y.; KEDD, Wichita, Kan.; WETV, Macon, Ga., WPMT, Portland, Me.; KHSL-TV, Chico, Cal.; and WENS, Pittsburgh, Pa.

WTVI, the second station in the St. Louis area, is fed from the transcontinental radio-relay at Chicago through Terre Haute, Ind. WEEK-TV gets its network programs from a newly completed leg of a second radio-relay system being constructed from Chi-

cago to St. Louis. Buffalo's second station is fed from New York via Albany, over a new microwave link. The Kansas City-Dallas radio-relay system supplies programs to Wichita, and Macon can draw upon either Atlanta or Jacksonville for programs.

The stations in Portland and Chico provide the first opportunity for residents of these cities to view live network programs, while station WENS in Pittsburgh is another outlet in an area already covered by network facilities. Portland uses a temporary radio-relay route terminating at the Eastland Hotel there, and then carried by video link to the station in the Columbia Hotel. Chico's programs are beamed from Sacramento over a new microwave link. Network programs are now available to 157 stations in 105 cities.

New York-Boston Microwave

American Telephone and Telegraph Company's Long Lines Department has completed installation of additional microwave channels on the New York-Boston radio-relay system for use in long distance telephone message service. With the additional facilities, the system now provides a total of eight microwave channels. Four channels — two in each direction — are carrying telephone message service, while two north-bound channels are being used for network television transmission. The two remaining channels will be used for maintenance and protection purposes. The microwave facilities originally used on the New York-Boston route have been replaced with the latest type of equipment, greatly increasing its telephone message circuit capacity.

Upon completion of work now in progress, more than 600 message circuits will have been added to the New York-Boston radio-relay system. Of this total, about 350 will be transferred from paralleling cables. This rearrangement of facilities permits the termination of several hundred additional telephone circuits at intermediate points on the cable route.

The 220-mile microwave route, in operation since 1947, was the first link in the present Bell Telephone System's radio-relay network, which now extends more than 8,500 miles. As of June 30, this nationwide network carried more than 3,000,000 miles of telephone message circuits and almost two thirds of the 34,000 miles of intercity television channels.

Papers Published by Members of the Laboratories

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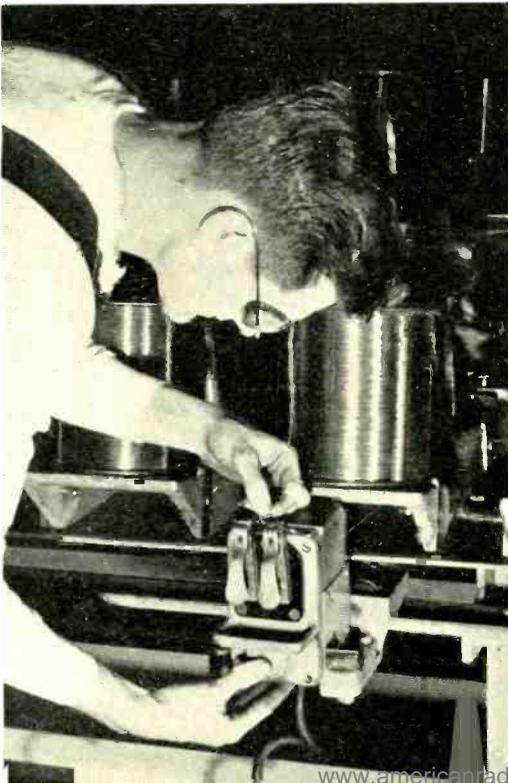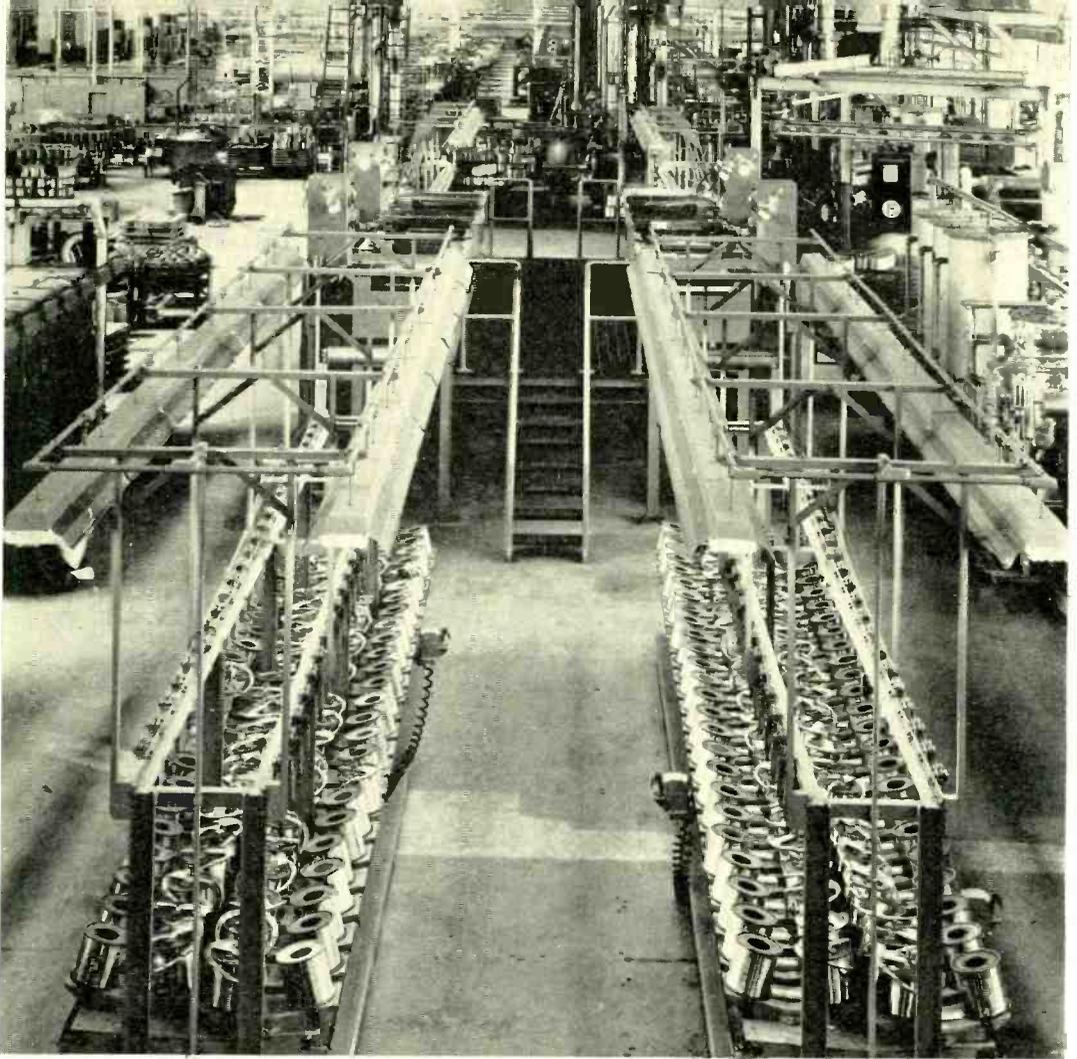
Electro-Tinning Wire

Fifty strands of wire speed simultaneously through each of these two electro-tinning machines at Western Electric's Tonawanda Plant to receive their coating of tin. Supply strands are in the foreground, washing and plating tanks on the "mezzanine" above.

At the supply end of the electro-tinning unit, an operator brazes one end of the wire from a full spool to the inside end of a spool about to run out, making a continuous wire for feeding into the plating tanks.

Bell Laboratories Record

Here, an operator strings wire through the plating tanks. Tin will dissolve from solid tin slabs and be deposited on the wires when current is passed through the plating solution.

Tinning A Million Miles Of Wire

It takes millions of wire connections to produce and install a large telephone central office, and whenever a soldered connection is made, tin on the wire makes soldering easier and more reliable. Engineers don't know where a switchboard cable, with its maze of rainbow-wrapped wire, will eventually be soldered. It's much more economical to give all switchboard wire a coating of tin. That involves a lot of switchboard wire. In fact, at Western Electric's Tonawanda Plant, more than a million miles a year glide through the tinning tanks.

Wire tinning is not a new process. In fact, it's been going on for years. But the method now in use, called electro-tinning, has been adapted for wire as the best possible way of doing the job. Wire is electroplated in much the same manner as auto bumpers and bathroom fixtures, with one important difference.

In plating something like a chrome ashtray, the object is dipped into a solution for a specified time, then lifted out. Switchboard wire, however, moves endlessly from supply spools, through the plating tanks and a scalding water rinse, to take-up spools at the end of the line. A coating of tin is applied by passing an electric current through the plating solution. The tin dissolves from a tin slab and is deposited

evenly on the wire during the few seconds it runs through the liquid.

Originally, the valuable tin coating was applied by passing wire through a bath of molten tin. This method had its disadvantages, among them the necessity of removing, or "wiping off," the excess metal. Western production men tried many ways to do this — string, hard rubber, metal dies and finally, superheated steam teamed up with these dies, to literally melt away the excess tin. But, no matter what was tried, the process never succeeded in producing a tin coating of consistently uniform thickness. Persistence on the production line finally paid off, however, when engineers came up with their own adaptation of electroplating. In addition to its other advantages, the new method used two-thirds less tin.

Recently, another improvement was added to the method. Wire produced at Tonawanda for use in winding coils, receives a covering of enamel in addition to its coating of tin. Why not, thought the engineers, team up these two separate processes? They did just that by linking the enameling and tinning so that both these operations are combined in one continuous process. Now, more than a mile a minute of tinned wire is fed directly into the enameling ovens, and enameling capacity has increased 25 per cent.

Members of Laboratories on A.I.E.E. Committees

A number of Laboratories' people have been appointed to general and technical committees of the A.I.E.E. for the fiscal year 1953-54. General Committees: *Board of Examiners*, R. A. Heising, C. E. Molina, F. J. Scudder, and H. M. Trueblood (all retired). *Edison Medal*, R. I. Wilkinson and O. B. Blackwell (retired). *Membership Committee*, C. Clos, Chairman. *Prize Awards*, E. I. Green, Chairman, L. G. Abraham, and W. H. MacWilliams, Jr. *Publication*, J. D. Tebo. *Public Relations*, R. K. Honaman. *Safety*, L. S. Inskip. *Standards*, R. D. de Kay. *Student Branches*, R. A. Deller. *Technical Operations*, J. D. Tebo, Vice-Chairman, H. A. Affel and E. I. Green.

Technical Committees include: *Communication Division Committee*, H. A. Affel, Chairman, John Meszar, Secretary, L. G. Abraham, A. C. Dickieson, P. G. Edwards, and E. F. Watson. *Committee on Communication Switching Systems*, W. Keister, Vice-Chairman, R. C. Davis, and J. Meszar. *Radio Communication Systems*, A. C. Dickieson, Chairman. *Telegraph Systems*, E. F. Watson, Chairman, and R. B. Shanck, Secretary. *Wire Communication Systems*, P. G. Edwards, Chairman and L. R. Montfort, Secretary. *Feedback Control Systems*, J. G. Ferguson. *Protective Devices*, P. A. Jeanne. *Science and Electronics Division Committee*, R. M. Bozorth and E. I. Green. *Committee on Basic Sciences*, R. M. Bozorth, Chairman, V. E. Legg, Secretary, and J. D. Tebo. *Computing Devices*, W. H. MacWilliams, Jr. *Electronic Power Converters*, D. H. Smith. *Electronics*, D. E. Trucksess. *Instruments and Measurements*, J. G. Ferguson. *Magnetic Amplifiers*, A. B. Haines. *Metallic Rectifiers*, D. E. Trucksess, Vice-Chairman, and J. Gramels.

Subcommittee members are: *Fault Limiting Devices Subcommittee (of the Protective Devices Committee) and General Systems (Transmission and Distribution) Subcommittee*, P. A. Jeanne. *Basic Sciences Subcommittees — Electrical Properties of Gases*, L. H. Germer and H. Hagstrom; *Electric Circuit Theory*, R. L. Dietzold; *Magnetics*, R. M. Bozorth, Chairman. *Dielectrics*, G. T. Kohman; *Semi-Conductors and Transistors*, J. N. Shive; and *Basic Concepts*, R. M. Bozorth and V. E. Legg. *Electronic Power Converter Subcommittees — Hot Cathode Power Converters*, D. E. Trucksess; and *Mechanical Rectifiers*, D. H. Smith.

Electronics Subcommittees — Electron Tubes, D. S. Peck, Secretary; and *High Frequency Conductors, Cables and Connectors*, W. J. King, *Instruments and Measurements Subcommittees — General Activities*, E. I. Green; *Recording and Controlling Instruments*, J. G. Ferguson; and *Special Instruments and Auxiliary Apparatus*, E. K. Jaycox, *Magnetic Amplifiers—Applications, Definitions, and Theory Subcommittee*, A. B. Haines. *Metallic Rectifiers Subcommittee on Definitions*, D. E. Trucksess.

R. D. de Kay is an alternate appointee by the Standards Committee to the Electrical Standards Board of A.S.A. and U. S. National Committee of the International Electrotechnical Commission.

High Seas Telephone Service

Twenty-six major passenger vessels are now participating in high seas telephone service, with traffic to and from these ships averaging nearly 2,000 messages per month. In addition, the high seas service is used by more than 300 ships (private and commercial, U. S. Navy, and Coast Guard) and private aircraft.