Preference Research

J. E. KARLIN and R. K. POTTER *Transmission Research*

Technology offers more and more possibilities for improving the telephone system. What developments would be best from a user standpoint? To answer such questions reliably people must be given actual experience. Through simulation it is possible to provide experience now with systems that might ultimately be made available. In this way future customers' likely wants are being studied as a guide to present-day research.

The problem of developing the telephone system to fit its users' preferences becomes more complicated as technology creates more ways to provide new or improved services. From a user standpoint research can be aimed at the right objectives only to the extent that we know what future users are likely to prefer. It is especially important to be able to forecast future user wants in the case of costly developments which will require many years to complete. To help guide long-range research a small group was organized in the Research Department of Bell Telephone Laboratories in 1949 under the name "Preference Studies."

Though the term "Preference Problem" is comparatively new, the problem itself has long been encountered in all divisions of telephony, from research through development and engineering, to operation and maintenance. For example, such problems have been answered in the Station Apparatus Department during the development of handsets, ringers and other items that come into close contact with the user. They have also appeared elsewhere within the Laboratories – as in the Outside Plant Department in connection with such things as the development of tools.

The great amount of preference data gathered through the years by Laboratories engineers would provide a sizable and significant volume. In addition for almost a quarter of a century the American Telephone and Telegraph Company has regularly conducted large-scale surveys of telephone users throughout the country to keep the Bell System informed regarding user preference in terms of wants and attitudes.

At first the preference research group was concerned with transmission research problems and its activites were of little interest outside the Transmission Research Department. Gradually, however, the group has been asked to help with

Test subject Mary Lutz, shown at the top of this page, depresses key to record that she detects a flicker in a light she is observing. Flicker becomes less obvious as rate of flicker is speeded up, finally disappears. Test helps reveal eye's ability to receive information and transmit it to the brain.

preference problems that crop up in other phases of the telephone business; and the indications are that basic exploratory techniques now being studied and developed can be useful in a wide variety of problems involving human factors.

In transmission studies a typical problem is to determine which of two circuits performs more acceptably from a user's standpoint. This problem occurs for example where a transmission system can be made to reduce circuit noise at the cost of occasional distortion. The question is to determine to what extent less perfect transmission can be profitably traded for more thorough exclusion of noise. Dependable solutions to "Preference Problems" of this type require controlled tests in which users are given actual experience.

Richman Danl 70PkTerW ....LOrain 9-3991
Richman Dave 200W20 ....WAtkns 4-1280
Richman David lwyr 19W44......MUrryhil 2-2691
Richman David 2700GrndConc .....FOrdhm 7-9147
Richman Dorothy 97Suffolk ......ORegn 3-4463
Richman E Miss 65W54 ....CIrcle 6-3926
Richman Edith L Mrs 110W69 ....TRaflgr 4-6017

Richman Danl 70PkTerW 569-3991
Richman Dave 200W20 924-1280
Richman David lwyr 19W44...........682-2691
Richman David 2700GrndConc 367-9147
Richman Dorothy 97Suffolk 673-4463
Richman E Miss 65W54 246-3926
Richman Edith L Mrs 110W69 874-6017

Here are two dial-directory combinations. Which would users prefer? This is a typical preference problem. The answer is not as obvious as you might think.

One of the problems of preference study which is especially important to the Research Department is that of predicting preference *before* ways have been found to build the equipment involved. Here the wish is to determine whether you would prefer, for example, this or that type of telephone instrument *if* these items could be produced. Answers to such questions are of the greatest importance if research is to be most effective.

Now, these "if" questions cannot be answered reliably merely by questioning people. Asking them whether they would like something if it were available may get right answers concerning minor changes but it is likely to fail completely when the "something" is new. In other words, polling is not reliable when unsupported by actual experience with the new devices, systems, or services about which an opinion is desired. Early opinions without a background of actual experience, though frequently emphatic, are more often wrong than right. Even the most imaginative of us is likely to be wrong in long-range estimates of preference. This applies equally to expert and lay opinion. Pessimistic opinions confidently expressed in grandfather's day about those "new contraptions," the telephone and the horseless carriage, were forgotten long before they were refuted by the facts. Within our own generation doubts as to whether

Through measurement and a study of past experience Station Apparatus engineers designed a more comfortable and efficient type headset for operators.

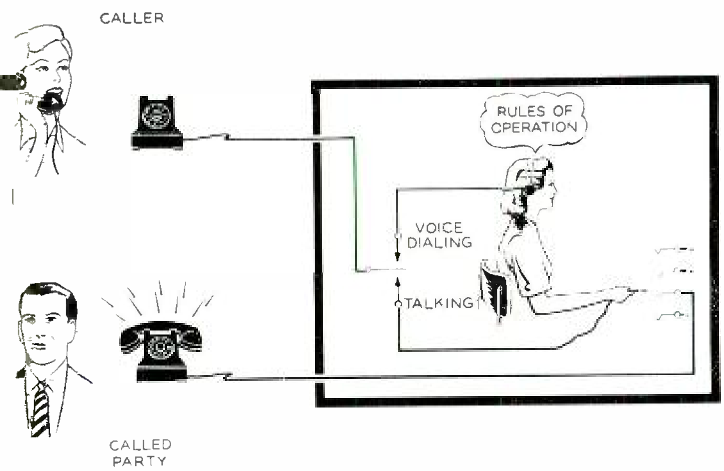
television would ever take hold were soon answered by soaring receiver sales.

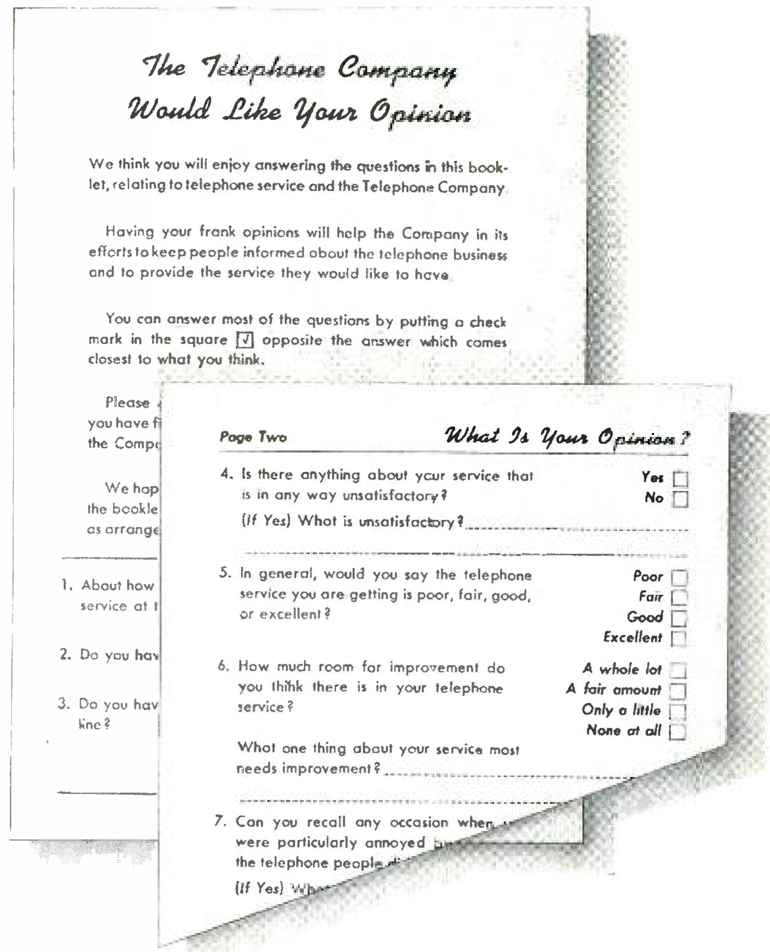
For such reasons a basic principle in preference testing says "potential users cannot make a dependable choice without actual experience." The first problem is to provide the experience – something easy to do when the equipment about which an opinion is desired already exists. If the equipment has not yet been built the necessary experience may be effectively supplied through "simulation" wherein the user is exposed to an experience which as far as he is able to tell is essentially the real thing.

Consider a recent example. Through simulation it was possible to test probable user reaction to a proposed transmission technique which would permit telephone conversations to share circuits economically on a time basis. We talk in spurts. In a telephone conversation the average user is actually talking only about one-quarter of the time. The rest of the time he is listening or thinking. These blank intervals represent wasted circuit time.

An arrangement was devised for permitting a large number of talkers to converse over a substantially smaller number of circuits by utilizing the blank intervals mentioned above. Paper studies and past experience with similar systems suggested the advantages might be sizable under some conditions

Would people like voice dialing—talking the telephone number to a machine that would change the speech into dialing pulses? In the absence of a suitable machine translator of spoken numbers, the problem was studied by simulation. The calling party talked his number into his telephone, and a silent operator in the central office connected him to the called party. By varying the "rules of operation" followed by the operator, it was possible to preference test a variety of voice dialing arrangements.





What do users all over the country think of their telephone? The A.T.&T. Co. has several ways of finding out. The questionnaire above is one way.

but could only provide rough estimates of performance in the case under consideration. Actual listening tests would be necessary for a dependable evaluation. The problem reduced to one of finding out, first, what degree of circuit sharing causes noticeable transmission impairment and, secondly, what degree is objectionable.

To build this system and cover a practical range of conditions for preference test would be a very large and expensive undertaking. So simulation methods were employed. In the first part of the experiment an arrangement of voice-operated relays, and start-stop magnetic recording was bridged on various tie line circuits between the Murray Hill and New York Laboratories. This equipment automatically recorded a tone whenever talkspurts coincided for a certain predetermined number of tie-line talkers such as 10. The significance of these tone intervals is that in a final circuit-sharing system with

At a television operating center an interval of only 20 seconds may be available between broadcasting periods for the switching of programs and circuits. Accuracy as well as speed is crucial. R. H. Galt (rear) and R. R. Riesz discuss methods of operating a simulation of a proposed switching panel designed to speed operations.

only 10 channels, any 11th talker could not get a channel while the tone was present. This would result in the initial part of his talkspurt being lost until a channel became available as signified by the cessation of the tone interval. In the second part of the experiment the magnetic tape was used to control a connection between two talkers in their offices in the Laboratories in such a way that transmission was interrupted whenever a tone interval appearing on the tape overlapped the beginning of a talkspurt. This resulted in loss of the speech until the end of the tone period. This made it possible to study user preference as realistically as though an actual circuit-sharing system had been available.

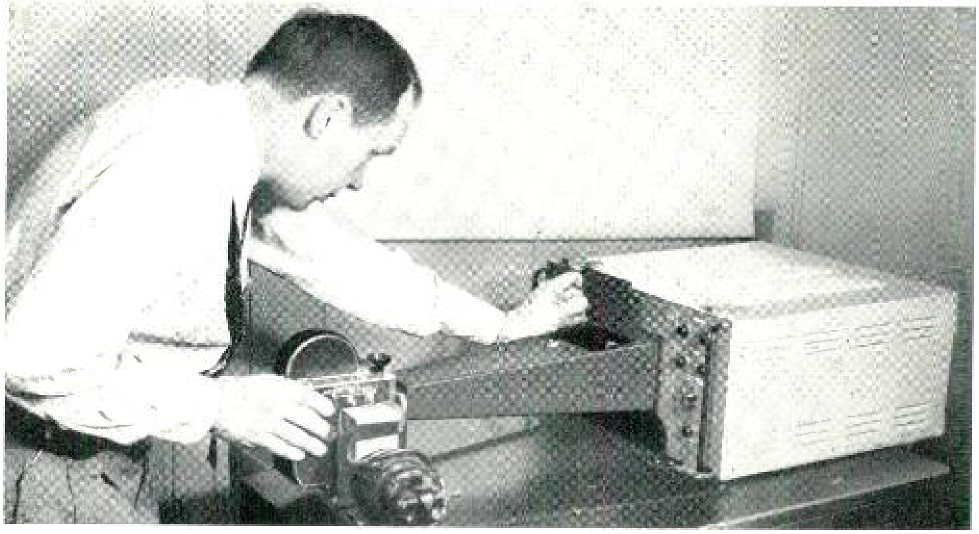
In a similar manner, simulation was used to determine user reaction to a variety of circuit-sharing conditions. Preference tests with this comparatively simple simulation scheme gave answers that would otherwise have required many bays of complicated circuits, some of which were still undeveloped.

Sometimes a possible future machine may be simulated by combining an existing machine and a human. For example, the Laboratories has a research interest in dialing mechanisms that can respond to the voice.* How would the telephone user feel about talking his number to a machine? Would

* Record, *February*, 1953, *page* 52.

Television techniques make it possible to observe and photograph such things as hand movements without disturbing the laboratory test subject. Above, Edythe Scales is working out a test problem involving an arrangement of numbers.

A. P. Winnicky monitors scene picked up in another room by the television camera. By deflecting a key with his left hand, he can switch in a movie camera to make a permanent record of significant sequences.



Movie camera operated by S. E. Michaels makes a permanent record of televised preference test.

it be desirable to have the machine say something in reply?

These questions were answered by simulation. The simulation was accomplished by a silent girl operator in the central office who listened to the spoken number and then performed the voice-to-dial-pulse translations exactly as they might be performed by a future machine. Trial users were given no indication of human intervention. As viewed by the user there was simply a "black box" containing a mechanism that could convert spoken numbers to dial operations. The silent operator followed certain rules and the "design" of the machine could, therefore, be altered at will simply by changing the rules.

Test results in the Laboratories showed that there are no worries about talking to a machine. On the contrary some users with speech difficulties got along better with the "machine" than they did with human operators. Apparently this improvement was due to the fact that some speech difficulties only arise when the speaker is talking to another person.

The reaction of a test group is found to depend on the way in which a situation, real or simulated, is presented. Not only do individuals differ in their wants but in addition their wants vary with conditions of use. Some for example favor subdued colors while others like their colors bright, but their feelings in this matter will depend upon the color environment. One objective of preference research is to learn more about how to select sample trial user groups and conditions of use which will represent the wide variations in individuals and environments.

Some ABC's of Preference Testing

Preference opinion without real experience is unreliable

☆

Initial preference is often revised with subsequent experience

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Experience with machines of the future can often be provided through simulation

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Your liking something is no guarantee others will like it

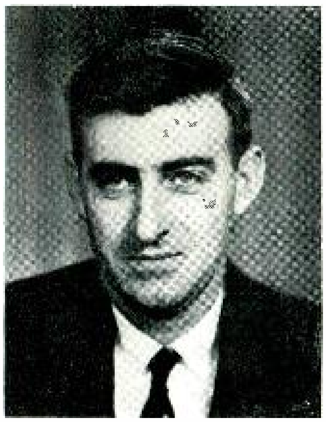
☆

The need for preference testing is unending since technical advance will bring new preference problems

We are conditioned to decimal numbering systems. How easily could people learn to read binary systems? Which would they prefer? By means of lighted lamps the box below displays the same five-digit numbers by a decimal system (left) and a binary system (right). Binary systems offer big economic and engineering advantages. Test subject Mary Lutz listens as M. P. Wilson discusses her score.

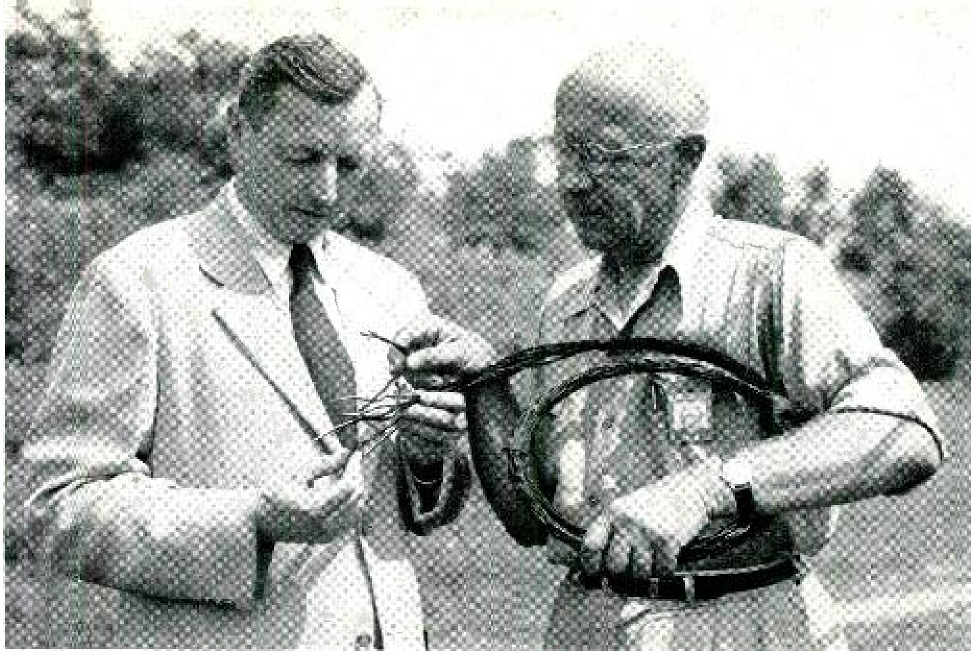
For reasons of convenience and accessibility, the studies have been conducted inside the Laboratories with Laboratories' personnel as trial users. Though this places some limits on the generality of the results, the indications are that in many cases these limitations are not serious in the evaluation of long-range research objectives. Even though test experience may not give final answers it will usually indicate preference trends, and desirable test procedures. In addition to these factors, the advantages of experimental control and flexibility are substantial.

THE AUTHORS



John E. Karlin received the B.A. (1938) and M.A. (1939) degrees in psychology from the University of Capetown, South Africa, and studying under a Commonwealth scholarship, received the Ph.D. degree (1942) from the University of Chicago. For the next three years he was engaged in military communications research at Harvard University's Psycho-Acoustic Laboratory, meanwhile taking night courses in electrical engineering at Harvard and Northeastern University. In 1945 he became the first research psychologist to join the Laboratories, and was engaged initially in studies of hearing. In 1949 he was part of a small group formed in the research department to look into questions of what telephone users are likely to want in the future. This work has been his primary concern ever since and he currently heads a group conducting preference studies. Mr. Karlin is a member of the Acoustical Society of America, the American Psychological Association, the American Statistical Association and Sigma Xi.

Ralph K. Potter joined the Development and Research Department of the American Telephone and Telegraph Company in 1923, with B.S. (1917) and E.E. (1923) degrees from Whitman College and Columbia University, respectively. A member of the Radio and Research group, he took part in pioneering investigations of radio transmission problems and has since become an authority in the field, continuing his work at the Laboratories after 1934. His studies of signal transmission effects led to an interest in the structure of speech and its portrayal, known as Visible Speech. In 1944 Mr. Potter became Director of Transmission Research. Between 1944 and 1951 Acoustics Research was also carried on in his department. He was associated with early work on spectrographic analysis of speech, selective voice control and other now familiar developments in the acoustics area. He also became interested in a better understanding of "human factors" that arise in many research problems and organized the user preference research group. Mr. Potter is a member of Phi Beta Kappa and Tau Beta Pi and a fellow of the I.R.E. and the Acoustical Society of America.



A. P. Jahn (left) and W. C. Sturzenegger inspecting a coil of rural distribution wire at the Chester, N. J., Laboratories.

Rural Distribution Wire

C. C. LAWSON *Outside Plant Development*

The twentieth-century American farmer is no longer the isolated man with a few acres, a horse, and a plow. Today he needs more machinery, power, and transportation than ever before. He also needs more telephones. Installation of lines over long distances in sparsely settled areas means relatively high wire costs per telephone, and constant attention is therefore being given to ways of lowering these costs. One step in this direction is a new distribution wire which is aiding the expansion of rural services.

Supplying telephone service to customers in rural areas presents problems quite different from those encountered in urban and suburban areas. The low population density means that long distances must be traversed with a single circuit or a small group of circuits. Many locations will be quite far from a central office. Under these circumstances, the design of distribution facilities for service at low installed cost has been, and remains, a real challenge to the Bell System. The problem is further complicated currently by the increasing demand by rural customers for a higher grade of service, such as two-party or individual lines instead of the multi-party lines often used in rural areas.

Many facilities for providing service in rural areas have been devised, and each finds a field of use under the specific circumstances favorable to its adoption. These include open wire lines, small cables, buried wires, and carrier circuits on power distribution lines. The need for the provision of several pairs of wires that could be installed cheaply was pointed up by the Michigan Bell Telephone Company, who cooperated closely in the early design of what came to be known as rural distribution wire.

This wire (Figure 1) consists of six twisted pairs of insulated copper conductors cabled around an insulated steel wire strong enough to support the structure in the spans normally encountered (up to 250 feet in heavy storm-loading areas). The conductors are No. 19 AWG (0.036 inch diameter) annealed copper. Each conductor is insulated with polyethylene followed by an extruded outer covering of semi-rigid or rigid polyvinyl chloride compound to provide added toughness. This outer covering protects the polyethylene insulation from injury during installation and service. The conductors, thus insulated, are twisted into pairs, each having a different twist length to reduce crosstalk between them. The pairs are cabled around the support wire with a lay of approximately nine inches and in a direction opposite to the pair twist. This "lay" (or distance for one pair to complete a turn around the support) is sufficiently long to facilitate spreading of the pairs for making attachments to the support wire.

The support wire is 0.109 inch diameter galvanized steel having a breaking strength of a little over 1800 lbs. It is insulated with polyethylene, which acts as a mechanical cushion and provides adequate electrical breakdown strength between the conductor jackets and the steel wire. This steel support wire is the standard 109E steel line wire used in long-span rural open wire lines, where spans up to 600 feet may be encountered.

Manufacture of rural distribution wire involves no new materials, and it is adapted to Western Electric Company extrusion, twisting, and cabling machinery. The polyethylene insulating compound

Fig. 1 — New rural distribution wire fanned out to show six pairs of conductors stranded around an insulated steel support wire.

is the same as that used for sheathing cables and is specially compounded for long life outdoors. The polyvinyl chloride outer, or secondary, insulation is a selected compound that will not affect the electrical characteristics of the primary polyethylene insulation. It is similarly compounded for long physical life under the exposure conditions to which this wire will be subjected in use. This outer jacket is extruded to fit snugly over the polyethylene. The wire is furnished in factory lengths of approximately three-fourths of a mile on reels from which it can be payed out directly.

This new wire incorporates some of the features of open wire and some of cable. Its attenuation when dry is intermediate between the usual low- and high-capacitance sheathed cables, but since this wire has no outer sheath, the attenuation increases in wet weather to a somewhat higher level than that of either type of cable. Like cable it may be loaded when used in long runs. It is more like open wire, however, in its susceptibility to noise pickup and in the need for protection of associated lines and equipment from damage by lightning and by accidental contact with high voltage power circuits. Protective equipment similar to that used on open-wire lines is therefore required.

In the short time that rural distribution wire has been available, it has found use in a variety of ways. It is particularly useful in adding circuits to existing pole lines which already have so many wires that they could not carry another crossarm of open wire without being extensively rebuilt. Use of the new wire under these conditions is shown in Figure 2, where it has been strung below the open wires.

The wire may also be used parallel to existing runs of small cables where additional pairs must be provided for making connections to open-wire facilities beyond the end of the existing cable route. This usage is illustrated in Figure 3, where the distribution wire is strung above a small cable. Finally, the wire can be used as branches off existing main lines of open wire and cable. Here, several circuits may be distributed to care for a few *ig. 2 — Installation f rural distribution ire on pole when ossarms above are lready carrying open ire lines to capacity.*

Fig. 3 — Rural distribution wire supplementing small distribution cable.

customers where the chances of further demands for service appear slight.

Rural distribution wire is designed for rapid and inexpensive installation. A simple type of supporting bracket, in the form of a "J" (Figure 4) fabricated from half oval steel stock, provides a saddle (the loop of the "J") over which the wire can be pulled during payout and to which the support wire may be attached after the line has been tensioned. For pole mounting, the long leg of the "J" is provided with two holes to accommodate either two lag screws, or one lag screw and a through bolt, to secure the hook to the pole. The short leg of the "J" has a single square hole to accommodate a short carriage bolt, on which is fastened half of a standard one-bolt clamp. All of these hardware items are galvanized.

Another type of bracket, similar in design, is provided for use where the bracket must be attached to a crossarm instead of to a pole. This arrangement is shown in Figure 5. In this bracket, the long leg of the "J" is made longer than in the bracket for pole mounting, and contains a twist which serves to properly orient the hook portion below the crossarm. In attaching the crossarm type bracket, the long leg of the "J" is placed against the side of the crossarm, with the end extending somewhat above the arm. The bracket is fastened in place with a "U" bolt which spans the arm. This method of fastening avoids having to drill the crossarm and prevents rotation of the bracket. A lag screw, driven into the side of the crossarm through a hole in the bracket, prevents lengthwise movement along the arm.

Fig. 4 — A. P. Jahn inspecting a "J" hook at the Chester, N. J., Laboratories. This "J" hook is placed out of line to simulate hook position at a corner pole.

During installation, the wire is payed out along the line either from a moving reel carried on a truck or trailer, or from a stationary reel. When installed from a stationary reel, wire is raised into the "J" supports on the poles as soon as possible to avoid excessive dragging along the ground. The support wire is permanently attached to the first pole, using a dead-end sleeve or clamp. The wire may be tensioned in several spans, the number of spans being determined by the severity and number of direction changes in the line. The proper tension is determined by sight-sagging. The wire is then fastened at the intermediate poles by separating the insulated conductors from the support wire and by clamping the latter in the brackets. A short length of split plastic tube is placed around the bunched conductors to protect them from abrasion by the fixture. Such tubes can be seen in Figures 4 and 5.

Occasionally, to permit passage of vehicles, it is necessary to raise the wire temporarily over roads or driveways before the entire length is pulled up to tension. This is accomplished readily by placing a wedge-type clamp over the complete wire, pulling the slack by hand, and then securing the clamp temporarily to the pole beyond the driveway.

Where heavy corner pulls are encountered, it is considered best to tension up to the corner pole,

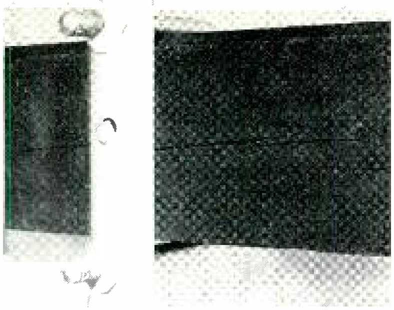


Fig. 5 — Crossarm mounted support bracket showing "U" bolt attachment.

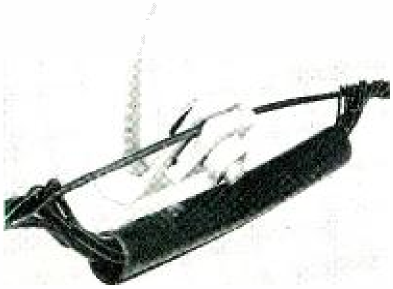


Fig. 6 — Telephone lineman placing new rural distribution wire using reinforcing strap for pole attachment.

dead-end the support wire both ways, and continue to tension the remainder of the run away from this pole.

The light weight of the wire and the design of the attachments are such that, for repairs, the wire may be disengaged readily at one or more points and lowered to a height convenient for working from the ground. At road crossings where the wire cannot be lowered for maintenance purposes because of vehicular traffic, a ladder platform truck is required, since the wire is not strong enough to support a workman on a ladder or in a cable car.

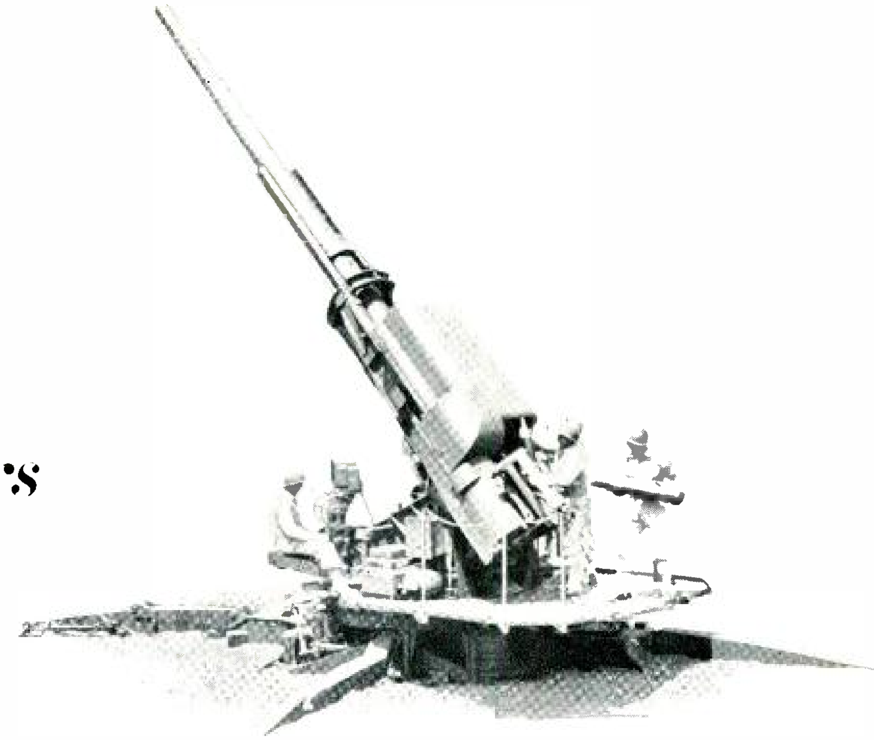
It is expected that this rural distribution wire will be relatively free from some of the difficulties encountered in the usual open-wire and cable constructions due to vibrations caused by wind. These vibrations are of two types, one a high frequency, low-amplitude vibration frequently observed on open wire lines and usually accompanied by audible "singing"; the other a low frequency, high-amplitude vibration in which the cable or wire whips up and down violently, is frequently referred to as "dancing." The damping effect of the insulated pairs on the support wire and the favorable cross-section of the wire, essentially round, both tend to minimize these two types of harmful vibration.

Rural distribution wire has found may applications for providing communication circuits to customers at lower cost than has been possible with previous standard facilities. The rural wire is used largely to supplement existing cable and open-wire lines and, under favorable conditions, is being used for extensions from such plant.

THE AUTHOR

C. C. Lawson received the B.S. degree in chemistry from the Sheffield Scientific School of Yale University in 1925. He joined the Outside Plant Development Department in 1929, working on such products as clay conduit and motor vehicle finishes, and participating in investigations which led to the elimination of "splicers' rash" and to the adoption of the desiccant method of drying cable splices. A member of the wire development group during World War II, he was associated with the design and development of special wires and cables for the armed forces. Following the war, he had charge of the group responsible for the development of insulated outside distributing and station wires and of line wires and strand. He is currently plant facilities engineer, concerned with the placing of wires and cables, and with the maintenance aspects of outside plant. Mr. Lawson is a member of the American Society for Testing Materials, the Wire Association and the American Standards Association.

Precision Potentiometers for Analog Computers



D. G. BLATTNER *Military Equipment Development*

From the detection of the target to the firing of the gun, the aiming process is slow and difficult if carried out manually. In modern fire control systems, however, analog computers solve complex mathematical problems almost instantaneously. Vital to these computers are potentiometers, which convert a large number of variables into the electrical potentials that control the system. Bell Telephone Laboratories and the Western Electric Company have worked together to design and produce these potentiometers to a very high degree of precision. As an example, the precision of one particular part is such that the error corresponds to only six yards in twenty miles.

During the late World War the Allied Forces were able to shoot down enemy targets flying at speeds as high as 400 miles per hour. At such a speed the target might travel four miles while the projectile is in flight to intercept it. Since for a kill the projectile must explode at a point within about fifty feet of the target, such marksmanship is a remarkable achievement. It was made possible by the antiaircraft fire control system developed by Bell Telephone Laboratories and manufactured by the Western Electric Company*, a system which predicts the future position of the target and fires the projectile at the proper time to intercept it at the predicted point. One of the vital components in this system is the precision potentiometer.

As a scientific instrument the potentiometer is old in the electrical art. Fundamentally it consists of means for obtaining any desired fractional part of the potential difference between two points in an electrical circuit. As used in the fire control system, the potentiometer consists of one or more wire-wound cards across which known voltages are impressed and one or more contacting brushes mounted on each. These brushes, sliding along the straight edge of the card, pick off fractional parts of known voltages according to their specific functions and according to the positions at which they are set. As fire control instruments, precision potentiometers have as many as twenty-seven such card and brush assemblies, and a fire control system may require a dozen or more such instruments.

Figure 2 shows a number of different precision potentiometer cards, each shaped to make the brush voltage the desired mathematical function of the brush position. These cards vary in length from five to ninety inches and are wound with insulated

*Record, *December*, 1943, *page* 157.

Fig. 1 — The author points out an improvement in the potentiometer indexing means to Marya Motowska.

high resistance wire specially selected for uniform resistance, low temperature coefficient, and high tensile strength. The turns of wire are uniformly spaced along the card, 200 to 300 turns per inch of length, depending upon the wire size. In some cases as much as one-third mile of wire is used per card. The cores of the cards are of stress-free hard rubber ground to uniform thickness.

After the wound card has been cleaned of enamel in the brush contacting area and has been provided with terminals as required, it is calibrated for resistance ratio at various brush positions throughout its length; it is then usually mounted on a drum for mechanical support as shown in Figure 3. In the photograph a single card spans the entire circumference of the drum. In many cases the circumference is shared by three or four cards. When maximum accuracy is required, the card is made slightly longer than the arc length to be spanned on the drum so that by scalloping, frequent calibration points throughout its length can be made to register with corresponding fiducial marks on the drum regardless of slight manufacturing deviations. These fiducial marks indicate precise points at which marked turns on the card are located.

The card and drum assembly is now ready to be mounted on a rigid base as shown in Figure 4. A shaft, coaxial with the card and drum, is also provided. At one end the shaft bears one or more arms, as required, on which the card brushes are secured so as to rotate with the shaft while making contact with the different cards. The other end of the shaft is arranged for coupling to whatever driving means are to be used. The shaft must be supported to rotate freely in its bearings with minimum clearance. Leads from the cards and brushes are brought out to connectors for convenience in wiring the potentiometer to the associated apparatus. In the case of the brushes, slip rings are provided between the brushes and the connectors.

When the assembly has been completed and a

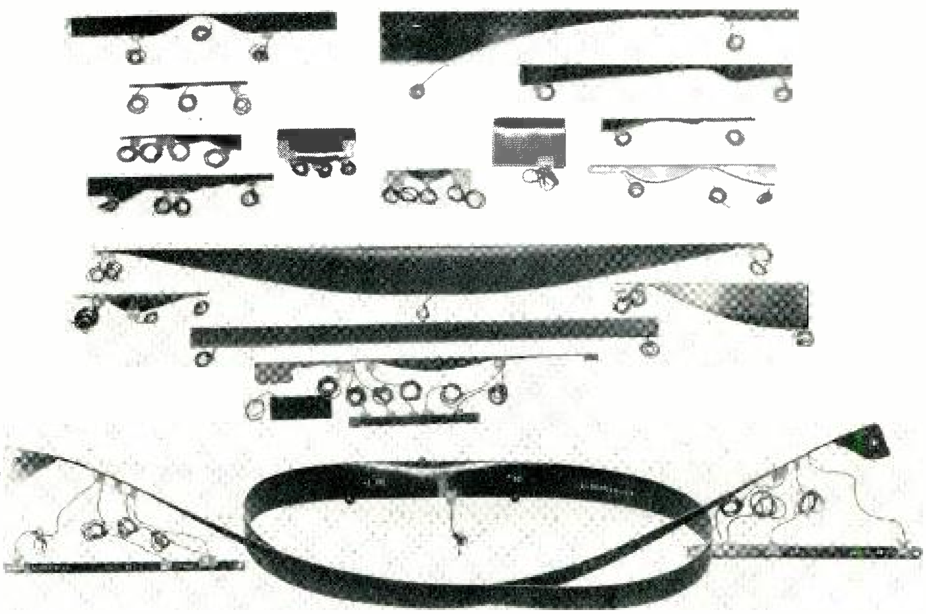


Fig. 2 — A number of typical potentiometer cards.

Fig. 3 — Miss Motowska here makes an adjustment on a card and drum assembly. Scallops in card permit accurate alignment of calibrated points on card with fiducial marks on drum. In many cases the circumference is shared by three or four cards.

check of the complete potentiometer has been made, the card and drum assemblies, brush arm assembly, and internal wiring are thoroughly cleaned by spraying with oil from jets in a rotating nozzle. Then a dust-tight cover is applied to exclude foreign material from the enclosed working parts. Where long life is required, the brushes and the contacting edges of the cards are immersed in oil. In other cases the oil remaining after washing provides sufficient lubrication.

Figures 4 to 6 show several precision potentiometers constructed in accordance with the above principles. Potentiometers vary in over-all diameter from three to twenty inches, have from one to twenty-seven cards and from one to twenty-five card brushes. They provide as many as twenty-five different functions of shaft position to as many different circuits. One may wonder if such a variety of sizes and arrangements is really necessary. The answer is that besides various numbers and arrangements of card and drum assemblies required, the circuits of which they are a part may be quite different in different cases. For example, cards for a given purpose in two different systems may be different in resistance or in accuracy requirements, or they may be different in granularity — a term used to express the degree of brush displacement for minimum change in potential. Also in many cases weight, rigidity, mounting space and inertia of moving parts are important considerations.

So far, the structures described have consisted of assemblies in which the cards are mounted on circular drums. Another type of structure adapted for the use of long cards is the spiral potentiometer. One such device is shown in Figure 8. In this case a ninety-inch card is used, mounted in the shape of a spiral of two and one-half turns about a foot across. The device is arranged to permit continuous rotation in either direction and provides sine and cosine functions of the shaft position. The purpose of the long card is to provide high precision and fine granularity. The device shown in the figure is equivalent in these respects to a conventional four quadrant potentiometer with a circular card five feet in diameter. Further refinements are possible by the use of still longer cards. Figure 7 is a photograph of another type of spiral potentiometer designed for large brush displacements in still further reduced over-all size. In this case a thirty-inch card is used in a five and one-half turn spiral two and one-half inches across.

Precision type potentiometers as components of fire control systems are used for either of two purposes: to generate data or to mark a shaft position.

As an example of the former use, suppose an available voltage E, applied across the card, is numerically equal to the ground distance to a target of interest and that the card is so shaped that the brush voltage varies as the sine of the angle of rotation of the shaft. Now if the potentiometer shaft is connected to a radar antenna or a telescope, free to

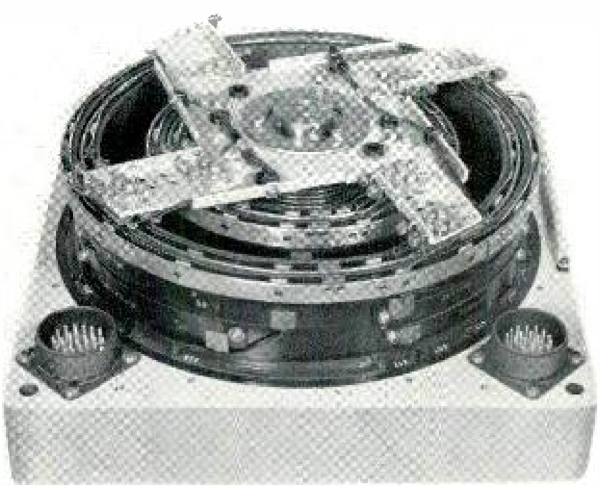


Fig. 4 — Drum type potentiometer with fourteen card brushes and drum assemblies.

Fig. 5 — R. G. Maines setting up potentiometer for calibrating. The potentiometer here is a small drum type with one card and drum assembly.

Fig. 6 — F. L. Sulpy examining a molded potentiometer having two cards and four slip rings mounted in three concentric slots.

rotate on a vertical axis as indicated in Figure 10, and if the whole assembly is oriented to give a brush voltage of zero when the telescope is pointed due north, the voltage for any direction $\theta°$ east of north will be

$$E \sin \theta.$$

This is the distance the target is east of the meridian through the point of observation (see Figure 9). In like manner the distance of the target north of the parallel through the observation point can be found by means of a second brush (Figure 10) to be

$$E \cos \theta.$$

These data completely define the ground position of the target and can be used in various ways, as for example to bring a gun to bear on the target. Suppose the gun is located known distances Px east and Py north of the observation point. Figure 9 shows the assumed locations of target and gun with respect to the observation point. It will be seen that with respect to the gun the target is north

$$E \cos \theta - Py$$

and east

$$E \sin \theta - Px.$$

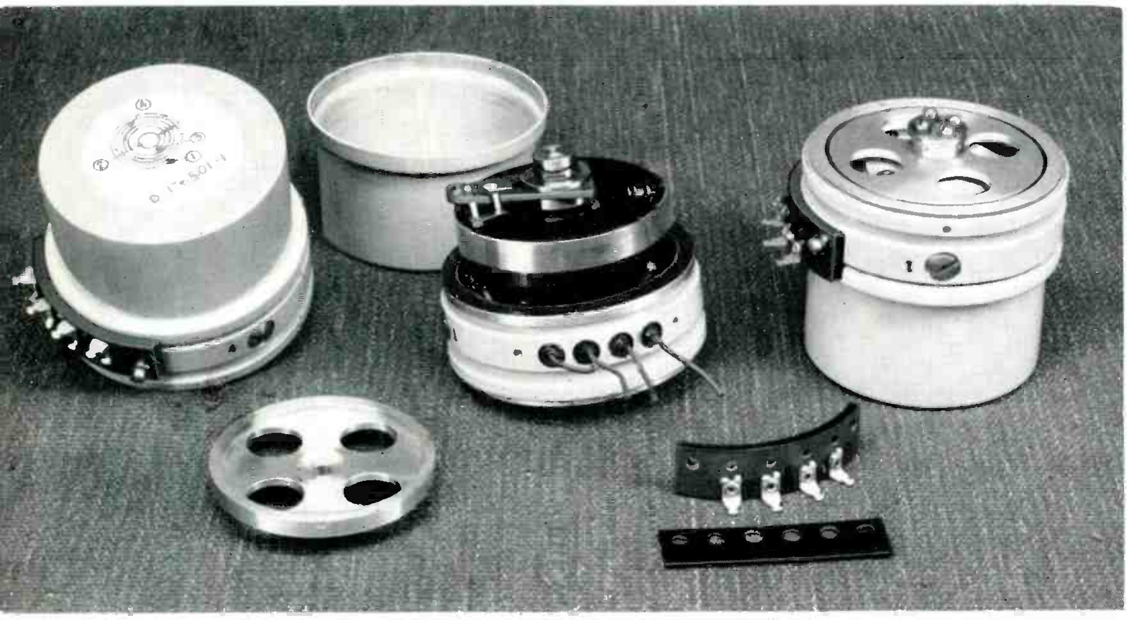


Fig. 7 — A small potentiometer of the spiral type. A thirty-inch card is wound into a five and one-half turn spiral, two and one-half inches across.

Hence the desired azimuth bearing of the gun, (angle Φ in Figure 9) is

$$\Phi = \tan^{-1} \frac{(E \sin \theta - Px)}{(E \cos \theta - Py)}$$

Presumably a gun crew could now set the gun to the proper azimuth and, with other information found similarly, could give it the proper elevation so that a projectile therefrom would hit the target. Such solutions however would be so time consuming

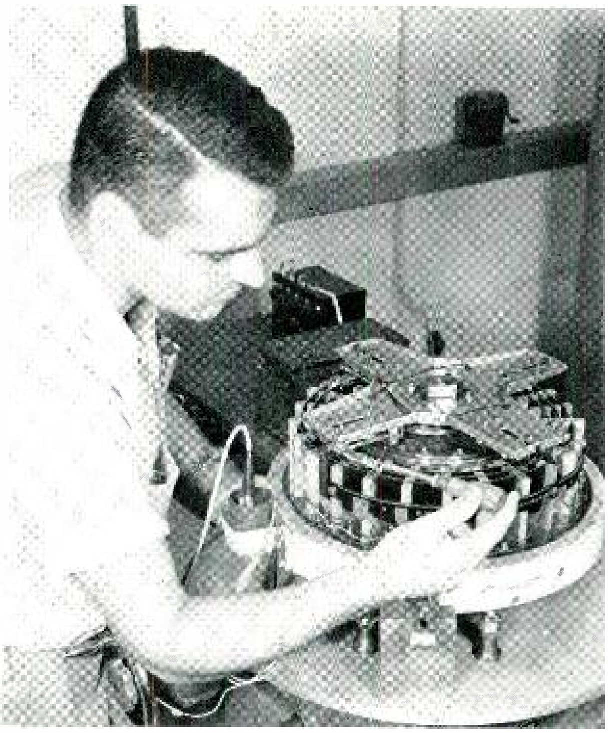


Fig. 8 — J. J. Moran at a dividing head for adjusting potentiometer brushes. Shown is a large spiral potentiometer, containing a ninety-inch card and brushes that move radially as mounting rotates.

that a mobile target might escape. Fortunately, the same solutions can be found and the gun automatically maneuvered to bear continuously on the target, even one in rapid motion, by means of a system illustrated in part by Figure 11.

Before proceeding further let it be noted that although precision potentiometers are used primarily as components of fire control systems against aircraft targets, the example cited in Figures 9 and 10 assume a stationary ground target. This choice of target was purely a matter of convenience. The purposes of the potentiometers are the same and are accomplished in the same way. In systems for use against aircraft, additional potentiometers are required because of the third dimension involved, and additional cards are used in certain potentiometers in conjunction with speed calculating circuits to determine how far the gun should lead the target and when the projectile should explode.

To return to the simplified system, then, Figure 11 is cited to show how precision potentiometers can accomplish their second type of use, namely to mark a shaft position. Suppose the target distance east, $E \sin \theta$, found by the data unit, Figure 10, and the known gun distance east, Px, be applied to the summation amplifier SA1 as indicated. The latter device, as the name implies, effectively connects the two input potentials in series in the amplifier input circuit so that for zero voltage gain the output is the algebraic sum of the two input voltages with negative sign. Let this output, indicated in the figure, be applied to potentiometer card C1 and also to inversion amplifier IA1, the latter, again as the name implies, serving merely to change the polarity without change in magnitude. Now let the output of IA1 be applied to C1 as indicated so that the potential of brush B1 on card C1 if set at any angle α with respect to its reference position will be

$$-[(E \sin \theta - Px)] \cos \alpha.$$

In similar fashion let the target distance north, $(E \cos \theta)$, found by the data unit, Figure 10, and the known gun distance north, Py, be applied to SA2, IA2, and C2 to produce a voltage at brush B2 of

$$[(E \cos \theta - Py)] \sin \alpha$$

as indicated in Figure 11.

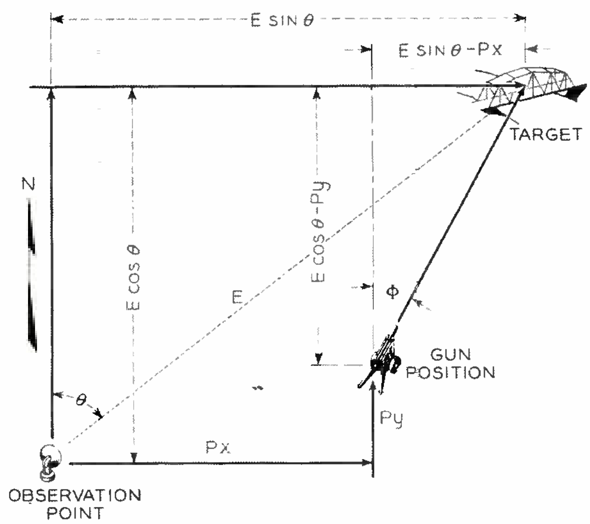


Fig. 9 — Trigonometric relationships between the observation point, gun position, and ground target.

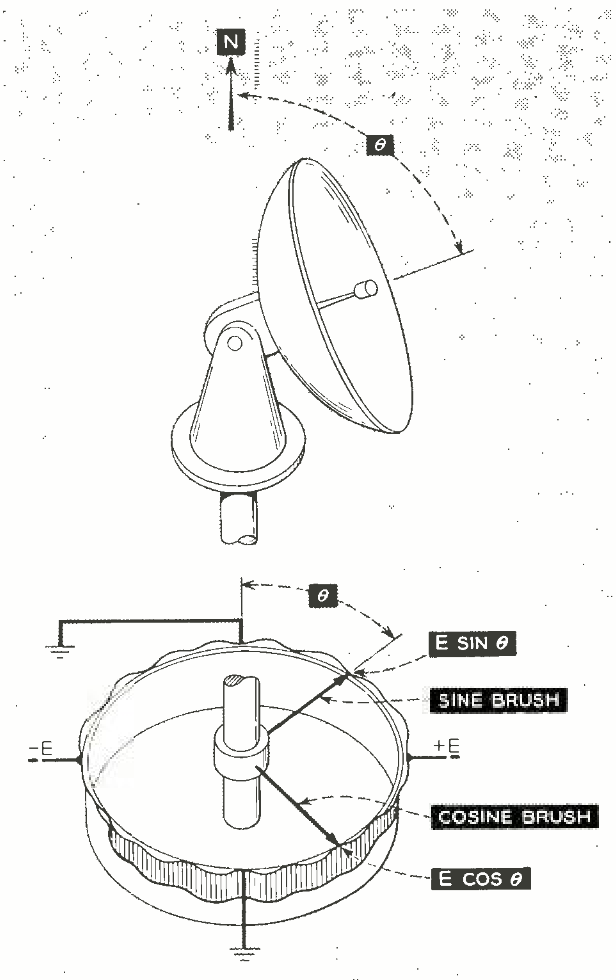


Fig. 10 — Drawing illustrating the function of a potentiometer in relation to radar antenna.

These brush voltages when applied to SA3, a device similar to SA1 but having a certain suitable voltage amplification, will cause an output to the motor control unit which then energizes the motor unless the two brush voltages are equal in magnitude as well as opposite in polarity. In the event of inequality the direction of rotation will be such as to move the brushes toward the position for equality when, of course, the motor will stop.

Thus the shaft position is marked for the one and only position where

$$(E \cos\theta - Py)\sin\alpha - (E \sin\theta - Px)\cos\alpha = 0.$$

By comparing this statement with the previous calculation, however, it will be seen that this condition can exist only when angle α is equal to angle Φ, the desired gun azimuth bearing. It is only necessary then to gear the gun to the motor shaft to fully accomplish the desired azimuth setting.

It is to be noted that the system shown in Figure 11 is only one of several problem solvers required in an antiaircraft fire control system. In the case discussed only two pieces of data are applied to the potentiometer which is provided with but two cards and two brushes. In others of the solvers the desired shaft setting is a function of a number of variables which the correspondingly more complex potentiometer handles with the same degree of facility.

The time-of-flight solver is one of the more complex varieties. In this case the solution depends upon such factors as the range and velocity of the target, the kind and amount of propellant behind the projectile, the trajectory of the projectile, the degree of wear of the gun barrel, the density of the air and a variety of other factors. In many cases these factors are of such nature that they can be quantized only on the basis of experiment. All together twenty-two different pieces of data are supplied to the time-of-flight potentiometer, each piece to its individual card. It is largely because of the adaptability of the potentiometer to handle any amount and kind of information with greater precision, all at reduced

THE AUTHOR

D. G. Blattner received the B.S.E.E. degree from the Kansas State Agricultural College in 1911 and two years later joined the Western Electric Company in Chicago. The next year he transferred to the Engineering Department in New York City where he concentrated on the development of loud speakers and public address systems and on special studies associated with the electric stethoscope. In 1927 he became responsible for development work on loud speakers and phonograph recorders and reproducers. His next assignments included the development of central office maintenance facilities and specifications for repaired apparatus. During World War II he was concerned with military projects and since 1949 he has been engaged in military apparatus development at Whippany. Mr. Blattner is a retired fellow of the Acoustical Society of America.

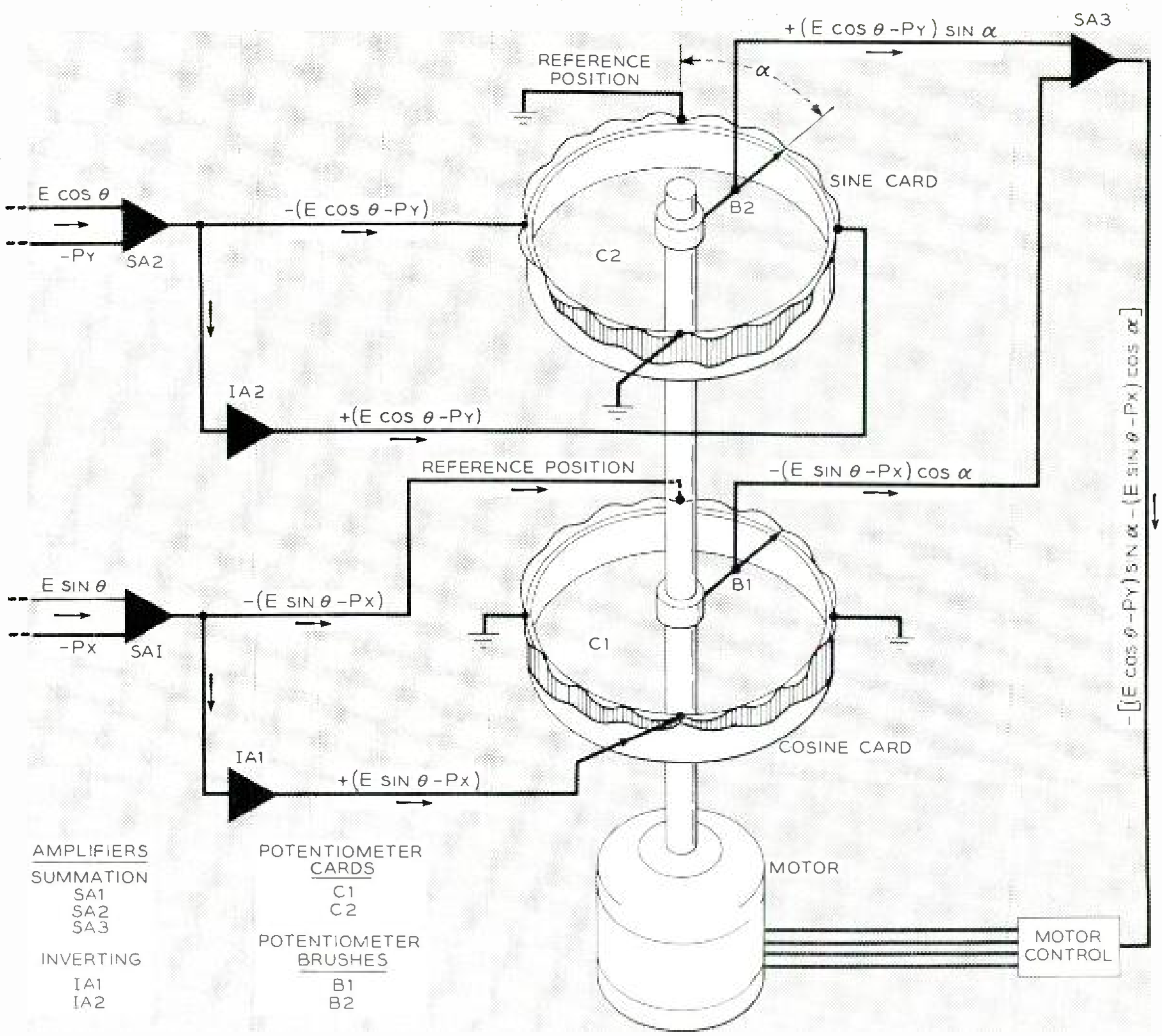


Fig. 11 — Potentiometers in an electrical circuit used to mark a shaft position and thus to aim a gun.

cost in plant and manpower, that the electrical antiaircraft fire control system has practically displaced all other types of such devices.

It will be apparent from the foregoing paragraphs that the precision potentiometer is a unique component of the electrical antiaircraft fire control system both as to purpose and adaptability. It is also unique in other ways. For example, due to the materials, methods and workmanship involved, potentiometers are made to function so precisely that for a given shaft position the brush voltage realized will be in error by an amount no greater than the drop across a single turn of the fine wire with which the card is wound. In an azimuth data unit, for example, this is equivalent to an error of approximately six yards in the indicated position of a target twenty miles away. Expressed as an angle this is one-third less than the human eye can resolve. From the standpoint of life expectancy the precision potentiometer is also unique.

The Western Electric Company has been manufacturing these potentiometers in considerable numbers for ten years, and these have withstood operating conditions in all quarters of the globe. It is expected that in fire control systems these potentiometers will still be serviceable when the systems of which they are a part will no longer be serviceable because of obsolescence. Truly the precision potentiometer is a remarkable achievement in conception, design and manufacture.

Dr. Kelly Surveys Military and Civilian Uses of Atomic Power at Centennial Science Forum

The civilian atomic age may be less than a decade away, predicted Dr. M. J. Kelly, President of the Laboratories, in an address given recently before the Centennial Science Forum in Omaha, Nebraska.

Some areas of the world which might be expected to make earliest use of peacetime atomic energy were listed by Dr. Kelly as the "arctic, the desert, and large areas in Asia, where fossil fuels are not available and their transport over great distances is necessary.

"England, with its dwindling coal supply, its coal mining labor difficulties, and its serious shortage of exchange for payment of fuel purchases abroad, will be another early candidate," he noted.

Dr. Kelly explained that until recently, atomic furnaces have been designed for maximum effectiveness in producing plutonium, not for efficient power production. When they are designed primarily for power, he pointed out, it is expected that they will become efficient enough to make atomic power competitive with oil, coal, and water power.

The A.E.C. has been giving increasing emphasis to the power furnace, or "reactor," in its research and development programs, according to Dr. Kelly. "It has already spent some tens of millions of dollars in its development, and huge expenditures must still be made and much must be learned before the day of commercial atomic power arrives," he observed.

Dr. Kelly also examined the part competitive industry must play in making atomic power a practical civilian utility:

"Realizing that developments directed at commercial and economic use of atomic fuels for power will move most rapidly and be most effective when American competitive industry is brought into the program, last year the Commission invited several industrial groups to make engineering studies of the problem.

"Before full participation by industry is possible there must be major changes in the Atomic Energy Act of 1946. The administration has recommended changes that will make such participation possible. With this participation we may well have power reactors economically employed in the generation of electric power for civilian use within a decade. The more optimistic talk of dates closer at hand."

Speaking of military uses of atomic power, Dr. Kelly observed that the atomic weapons project is perhaps the "largest single excursion into science and technology that a government has ever sponsored. Its contribution to the preservation, to this time, of the freedoms of Western man without war will stand in history as a monument to the determination of a people to maintain their freedom.

"For without doubt our atomic weapons potential has prevented the Russians from precipitating a hot war."

Concerning weapon development, Dr. Kelly said that "the TNT explosive equivalence of a single fission bomb has been raised from some 20,000 tons to some 500,000 tons" since World War II. In addition to such airborne weapons, he described the development of more versatile atomic weapons, ranging in explosive power down to a fraction of the Hiroshima bomb.

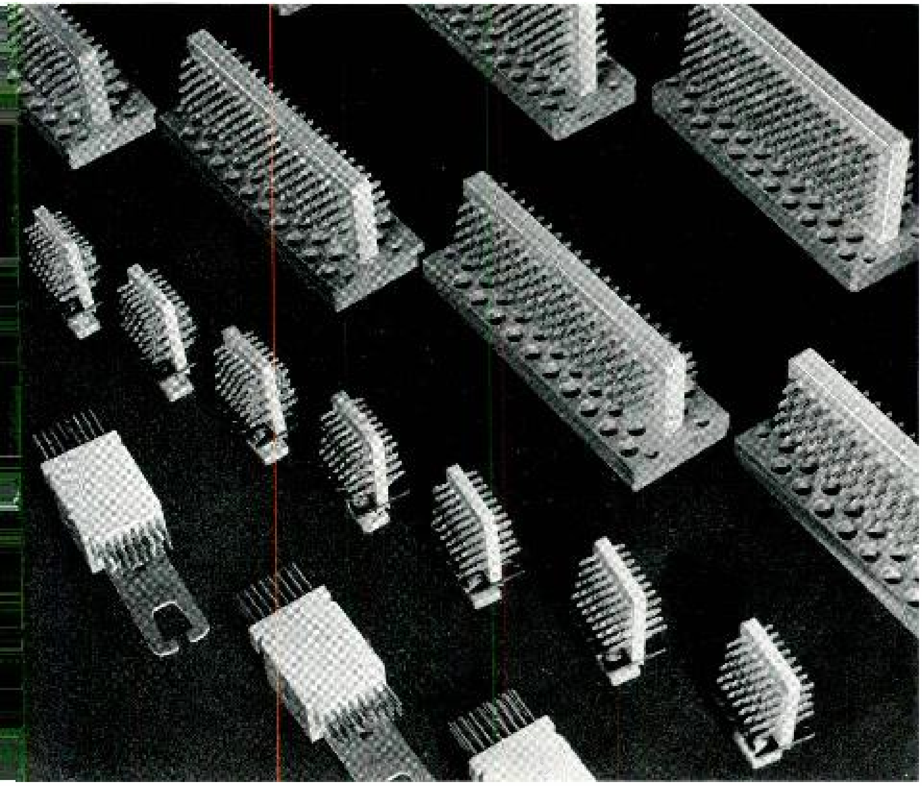
Dr. Kelly also described the organization of the nation's atomic energy program under the A.E.C.

"The contractors of the Commission in its operating tasks comprise a representative cross section of the nation's organized strength in science and industry. Of the Commission's fifteen major research and development installations, nine are operated by universities and six by major units of industry.

"Du Pont, Union Carbide, General Electric and the Bell System are typical of the industrial organizations that, under management contracts, operate huge industry-like plants owned by government," he reported. "Each plant performs an essential portion of the herculean task of converting uranium ore into the metals that are essential to bomb and atomic power, and then applying this metal in the construction of the atomic weapons that comprise our ever-increasing stockpile."

Dr. Kelly emphasized, however, that as a by-product to the weaponry program, "we are now in a position to vigorously pursue the peaceful applications of the atom's power.

"A source of primary power for generations to come is assured," he predicted; and "the time of its arrival depends on the vigor of our exploitation."



Cast Resin Terminal Strips

R. MORSE
Switching Apparatus Development

The complexity of modern telephone switching systems requires some convenient means of cross-connecting and multipling the various circuit elements, and this is provided by terminal strips. Since they are passive elements having neither sound nor motion, their development has not received so much attention as that of other less prosaic telephone apparatus. Nevertheless, several efforts have been made to improve them in the past. Recent progress in materials and manufacturing techniques has resulted in better, less costly, and more useful types made of cast resin.

Terminal strips, those groups of metallic terminals that permit easy changing of connections, probably have been among the most prosaic subjects in the telephone business. Yet, just imagine what a telephone central office would be without any terminal strips! Every wire would have to connect directly to each piece of apparatus associated with it, with no provision for changes or rearrangements. Wires coming into an office in an entrance cable would have to be spliced directly to office cables. Modern coordinate-type switching systems, such as crossbar, would be virtually impossible to construct because of the multiple appearances of circuit connections.

Thus, despite their prosaic nature, terminal strips are extremely important building blocks in the telephone system. There are over 300 different codes in use, and nearly 2.5 million were produced last year. Since they are passive elements, with no sound or motion, they are often taken for granted. Until recently, the basic design of terminal strips had not been changed in fifty years. As may be seen on the left in Figure 1, a terminal strip is simply a large number of metallic terminals insulated from each other. Wires are connected to each end of a terminal, and it then becomes an integral part of the circuit. If, for example, an entrance cable brings outside lines from customers to one side of the terminal strip, an office cable might connect the other side of the terminals to an incoming link

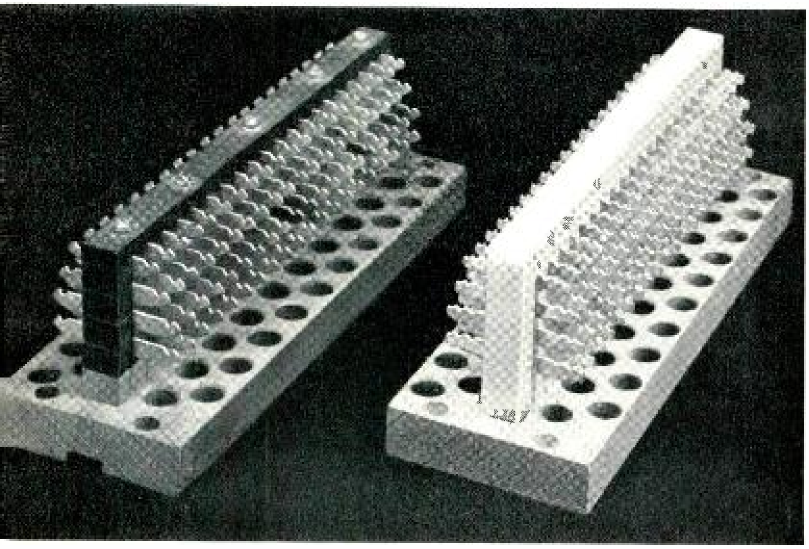


Fig. 1 — An older terminal strip of laminated construction shown with its cast resin replacement.

frame, or some other piece of equipment. It is a simple matter to interchange and rearrange connections on the terminals, and this permits incoming lines to appear in different places on the office equipment – as, for instance, when a telephone number is changed from one customer to another.

Terminals on these strips are short, usually flat, metallic pieces, with notched or perforated ends for easy connections. The insulating material has for years been arranged in long strips, with slots machined in one side to hold the terminals in place. Several of these insulating strips with their terminals are then bolted to a wooden base, called a fanning strip. Individual wires are inserted through the holes in the fanning strip and connected to the terminals; they are thus "fanned out" into small groups to facilitate identification and connection.

Various attempts have been made in the past to design a better terminal strip and thus eliminate some of the disadvantages of the fabricated type. However, for years it has been impossible to obtain anything as economical or as satisfactory as the standard fabricated design. From the designs considered, cast resin terminal strips, developed initially by the Western Electric Company at their Hawthorne plant, were chosen as most satisfactory. After intensive investigation by the Laboratories, a specific cast resin compound was found most suitable. Western Electric then proceeded to develop machines and methods at its Point Breeze plant to manufacture such cast terminal strips on a production-line basis. The casting compound uses a basic styrene-polyester copolymer resin; this is improved by including powdered silica and glass fibers, plus a coloring material. After continued exposure in a corrosive test atmosphere, cast resin strips measured 5,000 megohms resistance compared with two megohms for hard rubber.

In the manufacture of cast resin terminal strips, terminals are fitted into slots in the mold, Figure 2, and the mold is clamped together with wing nuts. The casting resin is poured, Figure 3, and the filled mold is placed on a conveyor that feeds it into an oven. It passes through three heating zones: 125°F for fifteen minutes, 140°F for five minutes, and 175°F for twenty-five minutes. After forty-five minutes in this oven, a stripping machine, Figure 4, strips the sides of the mold from the cast block over the projecting terminals. After the terminal strip has cooled, grinding operations on the poured surface assure smooth flat surfaces for mounting. Holes are molded into the bottom of the cast resin block and self-tapping screws are used to fasten it to a wooden fanning strip. A typical production line is shown in Figure 5.

Favorable reports from field trials of cast resin terminal strips early in 1948 indicated that this new insulating material should be utilized on all

Fig. 2 — Terminals are placed in slots in the mold by Violet M. Elkins at Western Electric's Point Breeze Plant.

terminal strips. Moreover, Western Electric estimated that the final cost would be less than for hard rubber strips, and this has since been realized. The introduction of cast resin terminal strips was delayed, however, and regular production did not begin until 1952. This was caused primarily by government control of resin supplies. In the meantime, design and development of the wire-spring relay* was undertaken and, along with this relay, the companion ideas of machine-wrapped connections† and solderless wrapped connections‡ were introduced. A whole new series of cast resin terminal strips has been designed to be used in conjunction with wire-spring relays.

Terminal strips of the "D" type are expected to be used in many crossbar switching applications. They are intended for association with the general purpose wire-spring relays and have replaced the 227A type in the newer offices where wiring space at the rear of the frames has been reduced. The terminals are square wires running completely through the terminal strips to provide for solderless wrapped connections. This permits

* RECORD, *November*, 1953, *page* 417. † RECORD, *July*, 1951, *page* 307. ‡ RECORD, *February*, 1954, *page* 41.

Fig. 3 — After the solid sides of the mold have been clamped on, the casting compound is poured in this way. The operator is Donald F. Beck.

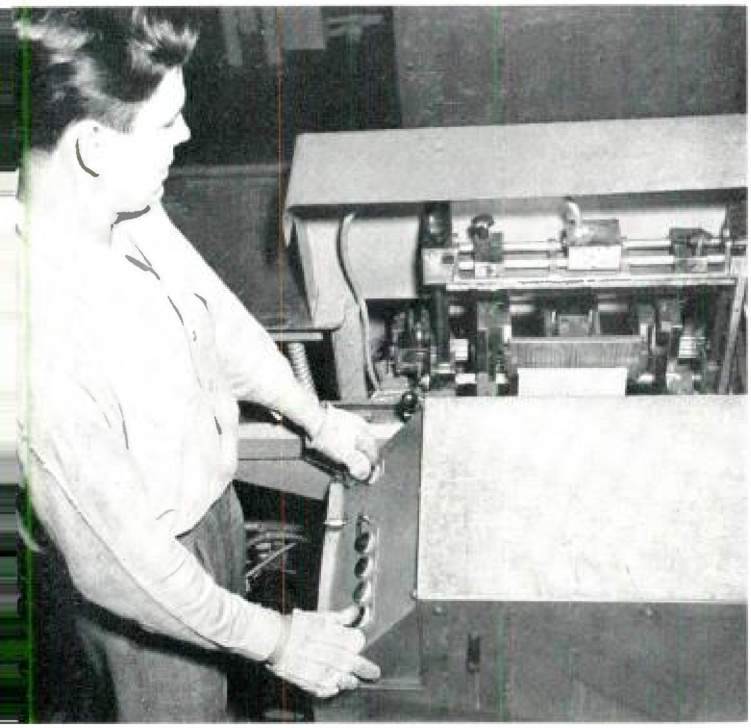
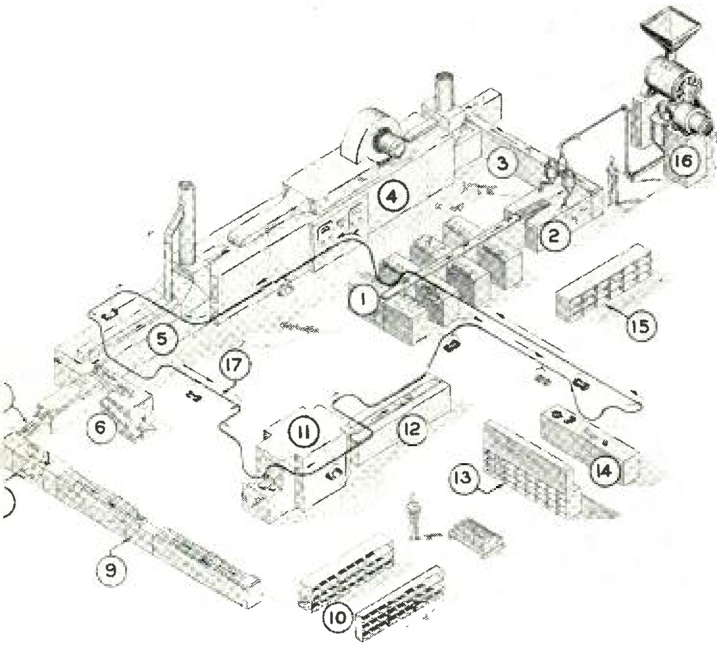


Fig. 4 — The molds are stripped from the cast terminal strip by this machine, operated by V. H. Cullum.

shop wiring to be done on the rear of the terminal strip and the installer makes his connections on the front where aisle space is greater. Molded styrene details will be fitted onto the ends of these tinned wires before the assembly is placed in a mold. The styrene details take the place of the faceplates of the regular mold and become an integral part of the terminal strip. This eliminates the need for stripping the sides of the mold from the terminals, since styrene "sides of the mold" become part of the casting. Design of the D-type strips is such that the only molds needed are for terminal strips having eight rows of five terminals each. Strips having fewer rows of terminals are produced by simply controlling the depth to which the molds are filled.

Insulating grommets and cable retainers, used with the older styles of terminal strips, are no longer necessary. The phenol-fiber wire guide is adjust-



1. TERMINAL LOADING BENCH
2. POURING BENCH
3. TRANSFER CONVEYOR
4. CURING OVEN
5. HEATED CONVEYOR
6. STRIPPING MACHINE
7. CASTING TRANSFER CONVEYOR
8. SURFACE GRINDER
9. EDGE GRINDER
10. CASTING SORTING RACKS
11. MOLD CLEANING
12. MOLD ASSEMBLY BENCH
13. MOLD STORAGE RACKS
14. MOLD SELECTION BENCH
15. TERMINAL STORAGE RACKS
16. COMPOUND MIXING & STORAGE
17. OVERHEAD TRANSFER CONVEYOR

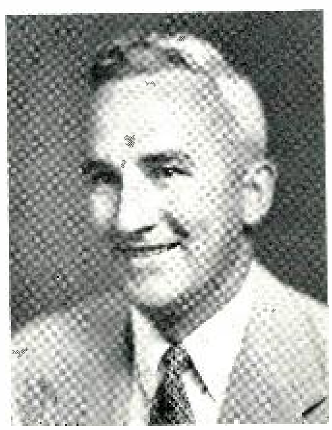
Fig. 5 — A typical production line for making cast resin terminal strips. The terminal strips follow the numbers through the various machines, and at the same time a conveyor belt takes the molds through cleaning, assembly, storage, and selection.

able. It may be moved close to the terminal strip, moved away from it, or completely removed. This gives flexibility in wiring arrangements. Furthermore, these new terminal strips can be mounted close together and on either end of the mounting plate. Provision has also been made in this type for temporary attachment of fanning strips and contact test fixtures on the front of the strip, for use during shop and installation testing, and for permanent attachment of a strip for equipment designations.

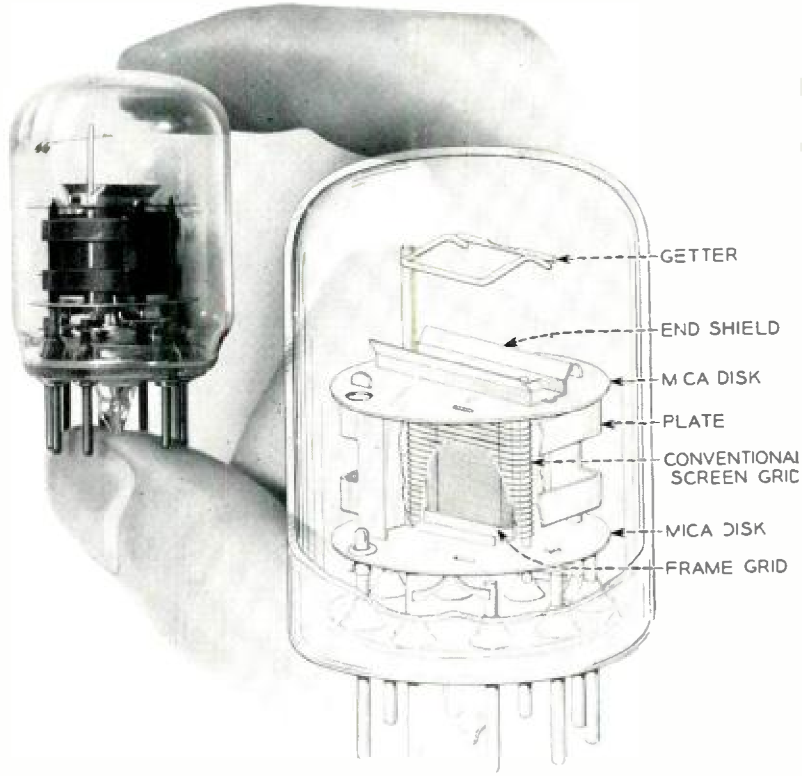
Problems such as routine tightening of the stacking bolts, and loose terminals, are eliminated by the one-piece molded terminal strips of today. Short-circuits, resulting from solder or wire-clippings becoming lodged in the slots of the older fabricated types, have also been eliminated.

THE AUTHOR

Reginald Morse received the B.S. degree in Industrial Engineering from Northeastern University in 1941. During World War II he was a member of Johns Hopkins University's Applied Physics Laboratory, engaged in the development and testing of the radio proximity fuse for the Navy's Bureau of Ordnance. He joined the Laboratories in 1946 and has since been concerned with development, design, and manufacturing preparations on electro-mechanical switching apparatus. For the past several years he has been engaged in the development of switching apparatus related to a telephone central office set for the Signal Corps. His current projects also include the development of new apparatus for association with the wire spring relay and particular attention to new apparatus related to solderless wrapped connections.



Mechanical Problems of Electron Tubes for L3 Carrier



E. J. WALSH *Electron Tube Development*

New electron tubes that have a greater bandwidth and operating stability than any previously available have helped make it possible for the L3 coaxial carrier system to triple the message carrying capacity of coaxial cable. The resulting electrical requirements, however, presented a variety of new problems that had to be solved. In these tubes, for example, the control grid wires, one-tenth the size of a human hair, are placed two-thirds the thickness of a hair away from the cathode. These spacings are so small that precise optical measuring techniques had to be devised before the tubes could be mass-produced by the Western Electric Company.

Continuing pressure for more and more broadband facilities brought about by increased numbers of long distance telephone calls and the growing television industry has resulted in a rapid development of all sorts of electron tubes as well as other system components. Early electron tubes, such as the historically famous 101F repeater tubes, cannot be used in new systems because they are not capable of the broadband low-distortion performance that is necessary for successful operation of these systems. Design considerations of the L3 system, for example, were such that no existing electron tubes could meet all the specific requirements. For this reason three new electron tubes* were developed: the 435A, the 436A, and the 437A.

In a general sense there is no "best" electron tube, and the development of one new tube does not make all others obsolete. For a particular application, however, abilities of different tubes to provide the desired performance may be compared on a relative basis. In new multi-channel carrier systems these performance requirements may be expressed in terms of the ability of a tube to provide useful amplification over broad frequency bands. In this regard, the voltage gain of any one tetrode or pentode electron tube can be doubled if the user is willing to accept a useful bandwidth reduced to one-half the initial value. Thus, for any one tube design, the product of voltage gain and bandwidth is found to be constant within certain limitations. This product, generally called the "gain-band figure of merit,"

*The Development of Electron Tubes for a New Coaxial System, B.S.T.J., 30, No. 4, Part 2, *October,* 1951 by G. T. Ford and E. J. Walsh.

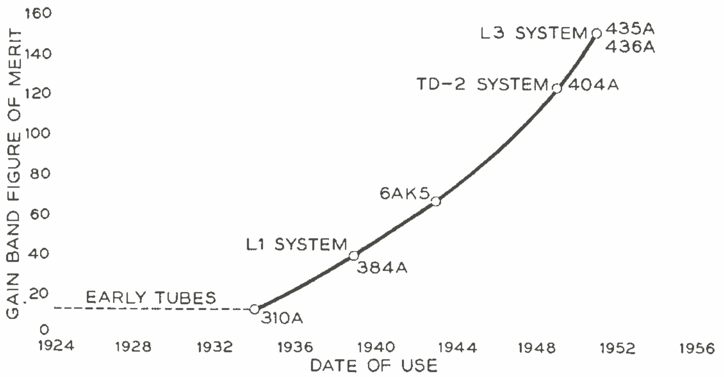


Fig. 1 — Electron tube "gain-band figure of merit" versus date in which various tubes were used.

provides a simple descriptive means of comparing broadband electron tubes of different design. A history of progress in this respect is shown in Figure 1. As shown, the gain-band figure of merit has nearly doubled every five years in the past twenty years.

Higher gain-band figures of merit have been achieved in the new tubes by using the finest practicable control grid wires, and by placing these wires close to and parallel with the cathode plane. The control grid wires used are one-tenth the size of a human hair, and are placed two-thirds the thickness of a hair away from the cathode. Since the cathode is visibly red, operating at a temperature of approximately 700 C, these rather severe conditions have presented some difficult mechanical problems.

In the three new tubes, the grid to cathode space has been made 2¼ mils (one mil is equal to one one-thousandth of an inch), the wire diameter less than 1/3 of a mil, and there are approximately 400 wires to the inch. These dimensions might be more readily visualized if a tenfold enlargement is considered. If all dimensions were enlarged ten times, the grid wires would be the size of a human hair 2½ inches long, and the cathode would be 1¾ inches wide by 4 inches long. The separation between each of the wires would be only the thickness of a very fine sewing needle, and each wire would be stretched tighter than a violin string. This arrangement is illustrated on the first page of this article which shows a cut-away view of the 436A tube. The construction of the 435A and 437A is similar to this and all statements apply equally well to any of these tubes.

There are two major differences between the more familiar 6AK5 and new tubes of this type. First, the grid is the newly developed fine-wire frame type* that was first used in the 404A tube. Second, the limits on critical dimensions have been successfully reduced below those previously considered to be the practical minimum. These two items constituted the major mechanical problems that are involved in the L3 electron tubes.

Grids used in the 436A and 437A tubes are larger than those used in the 404A and are positioned about 10 per cent closer to the cathode. The significance

*Record, *April,* 1950, *page* 165.

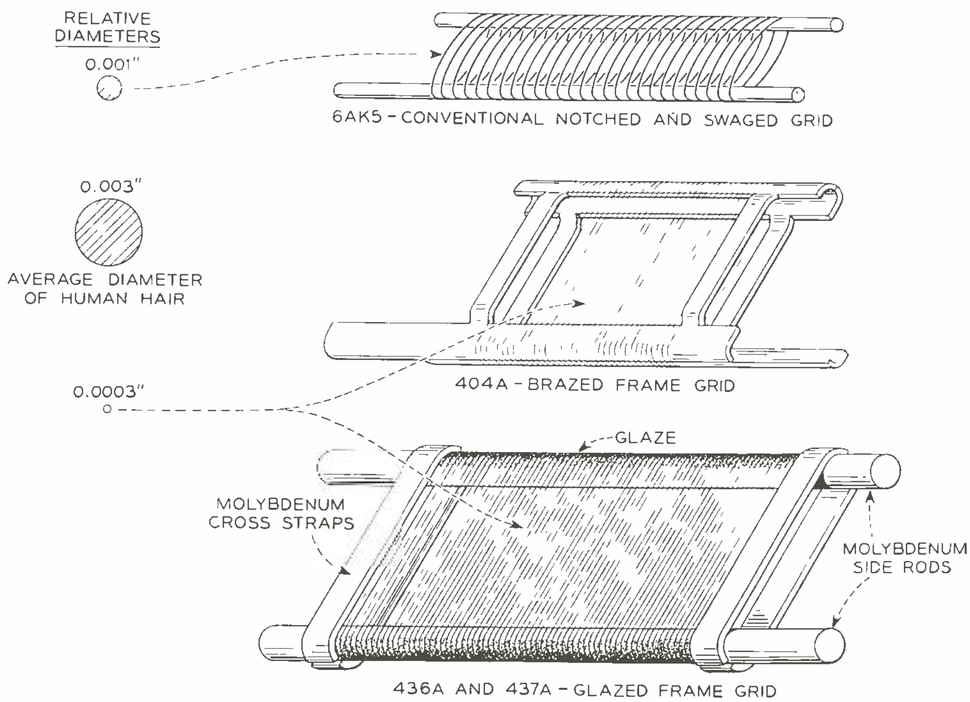


Fig. 2 — Control grids and relative wire sizes for 6AK5, 404A, and L3 Carrier (436A and 437A) electron tubes.

of this is that with the grid wires longer than before and closer to the cathode, greater precautions must be taken to prevent their sagging and shorting against the hot cathode.

Some typical vacuum tube control grids and comparative wire diameters are illustrated in Figure 2. The 6AK5 grid is known as a notched and swaged type; so called because in its manufacture large side rods are notched to receive the small lateral wire which is wound into the notch, after which the metal at the top of the notch is swaged over to lock the smaller wire in place. The 404A grid is made by blanking and forming two pieces of sheet molybdenum, placing them together, wrapping them with 0.0003 inch diameter tungsten wire, and finally gold brazing the entire unit. This type of frame grid construction was not suitable for use in the larger 436A and 437A grids, however, because of the increased difficulty of maintaining critical dimensional tolerances. A type of grid construction that had first been used in the 418A tube was hence refined and adapted for use in the new tubes. The 436A grid consists of two large molybdenum side rods (0.038 inch in diameter) that are joined at each end by two molybdenum cross straps. A small diameter lateral wire is wrapped around the large side rods at 400 turns per inch in the region between the cross straps. The lateral wire is later bonded to the side rods by means of a glass glaze as shown in Figure 2.

This new frame type control grid is the largest single factor in obtaining the high figure of merit attained in these new tubes. It makes use of the finest practicable wire that will withstand the stresses incurred in the fabrication and use of the grids. This wire is 0.0003 inch diameter tungsten, and has a breaking strength of the order of 500,000 pounds per square inch. When it is being wound around the grid frame, the wire tension is automatically monitored, and is held to about 9 grams. This is equivalent to a load of 300,000 pounds per square inch which is of the order of fifteen times the allowable working stress for steel building girders. The molybdenum sheet and rod used in the grid frame, like tungsten, is a refractory (i.e., high melting point) metal. It is the only metal presently available that could be economically used, and that would stand the fabrication stresses as well as the stresses due to high temperature operating cycles. Molybdenum and tungsten have temperature coefficients of expansion that are in the approximate ratio of 5:4 with molybdenum having the higher value. This makes it necessary to use the lowest possible temperature cycling in fabrication to minimize distortion due to differential thermal expansion. For this reason, the relatively low temperature glass-glaze bonding is used.

The combination of long grid length, long lateral wire span, and the necessity of having each of the two faces of the grid plane and parallel, dictated the

Fig. 3 — Mrs. Claire Briede at Bell Telephone Laboratories using a machine developed by the Western Electric Company to wind a 436A grid.

use of a grid frame that was inherently easier to fabricate in the larger sizes than the blanked and formed sheet metal frame used in the 404A tubes. The side rod type frame grid supplied the desired properties in that it provided two really parallel and true grid planes since each plane is determined simply by the side rod diameter. This diameter is readily controlled to ± 0.0001 inch by commercial centerless grinding and polishing procedures. The grid planes also remain fixed relative to each other because the welded grid frame is very rigid.

Welding the molybdenum grid straps to the molybdenum side rods presented a problem. If not properly made, the weld regions are quite brittle and have little mechanical strength. This weld problem was overcome in three ways: first, by using reproducible welding pressures obtained by eliminating bearings in the welding head, and by the use of pneumatic controls; second, by using welding fixtures that control the depth of weld, and third, by the use of accurate controls for the welding currents.

Glass bonding of the lateral wires to the side rods is used to increase the residual lateral wire tension in the finished grid. This, in turn, reduces the possibility of grid to cathode shorts. In addition, it contributes to the stability of tube operation by increasing the natural frequency of vibration of the lateral wires to a level high enough to avoid any degradation in tube characteristics.

The problem of vibration in these fine wire grids is an interesting one. Loose grid laterals are undesirable because the electrostatic forces that exist when the tube is in operation will, under proper conditions, make these wires vibrate, and thus cause unstable performance. This same condition could also occur if the vibrations were induced by an external stimulus of some sort. To overcome this difficulty, the lateral wire is wound around the grid frame under the maximum possible tension; the grid is then given the lowest possible heat treatment to bond the laterals to the side rod. It is in this latter respect that glass glazing is useful since it can be carried out at about 715°C, whereas gold brazing requires a temperature about 350° higher. This reduction in temperature increases the final mechanical resonant frequency of the lateral wire by about 25 per cent.

Typical curves showing the relation between the winding tension and the observed mechanical resonant frequency of the lateral wires after bonding are shown in Figure 4. These curves were obtained by winding a number of grids, each at a particular wire tension, and then measuring the mechanical resonant frequency of the lateral wires. The method of observing these resonant frequencies is shown schematically in Figure 5. Basically, one side of the grid is placed parallel to and only a few mils away from a metal plate. This plate and the parallel grid wires simulate the two plates of a "capacitor." When an alternating voltage of the proper frequency is applied, the grid wires vibrate at their natural mechanical resonant frequency. Thus, by moving across the desired frequency band, a rapid and non-destructive test of the entire grid can be made.

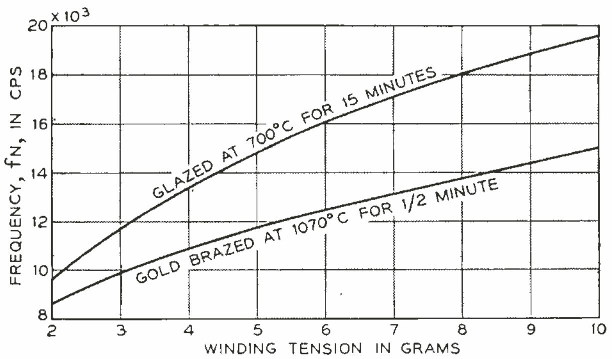


Fig. 4 — Natural frequency of vibration versus winding tension for gold brazed and glass glazed grids.

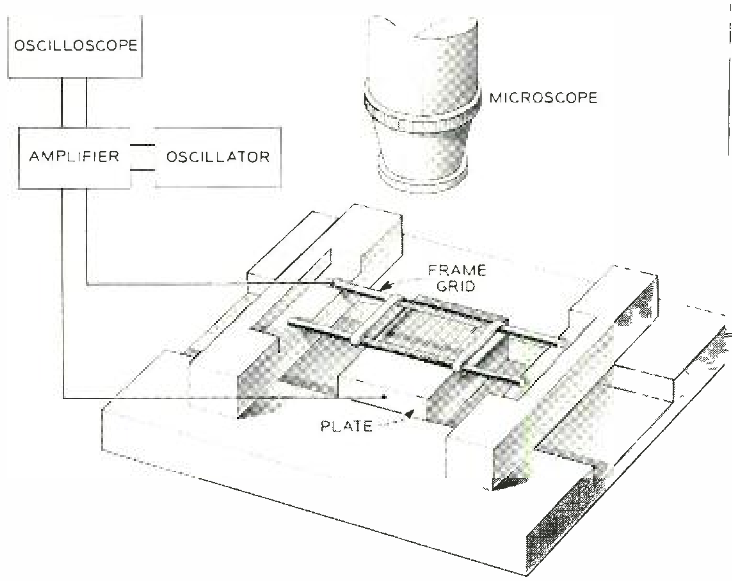


Fig. 5 — Schematic diagram of apparatus used to measure grid wire vibration frequencies.

A difference between the 404A grid and the newer grids that is not apparent from the illustration is the method used to coat the grid wires with gold. Using gold-coated grid wires is not a new idea; in fact, practically all of the Bell System high gain tubes have had gold-coated grids. The purpose of the gold layer is to prevent electron emission from the grid wires and thereby improve tube stability. In the 404A tubes the gold flows into the lateral wires during the gold brazing operation. Since glass glazing is used in the new tubes, however, the gold must be plated onto the lateral wires in a separate operation. Controlling the thickness of this gold layer so that the increase in wire diameter is limited to the order of 0.00002 inch presented a number of difficulties. Proof that the methods used for control are adequate, however, is available in the tube characteristics, and their associated limits. These measured characteristics of a completed electron tube provide a better check of mechanical differences in the structure than can be obtained with the finest micrometer.

Uniformity of tube characteristics is in part controlled by uniformity of the control grid pitch. The grids for these tubes are wound on a machine that was developed by the design group of the Western Electric Company at Allentown, Pennsylvania. The machine, illustrated in Figure 3, was designed specifically for production line use on fine-wire frame type grids that have a large number of turns per inch, and where accuracy of pitch is essential.

Obtaining mica insulators with correctly positioned holes of the proper size also presented a problem. The basic difficulty is that the mica sheet from which such insulators are obtained is a laminated material composed of many layers that will separate fairly readily into laminations of the order of 0.0001 inch thick. When a hole is punched through this mica, as it must be for this application, jagged points always remain around its edge, making it difficult to locate and measure the holes. Limits on the critical hole sizes and locations have been set at ± 0.0003 inch, and these limits have been met on a production basis by using an optical projection method of checking the micas. The method is illustrated in Figure 6 showing a glass plate on which broken lines are ruled that completely encompass all the tolerances in question. A satisfactory mica is one with holes that fall entirely within the ruled lines. The factor that makes this projection device so attractive is its simplicity. Instrument and operator errors are also eliminated.

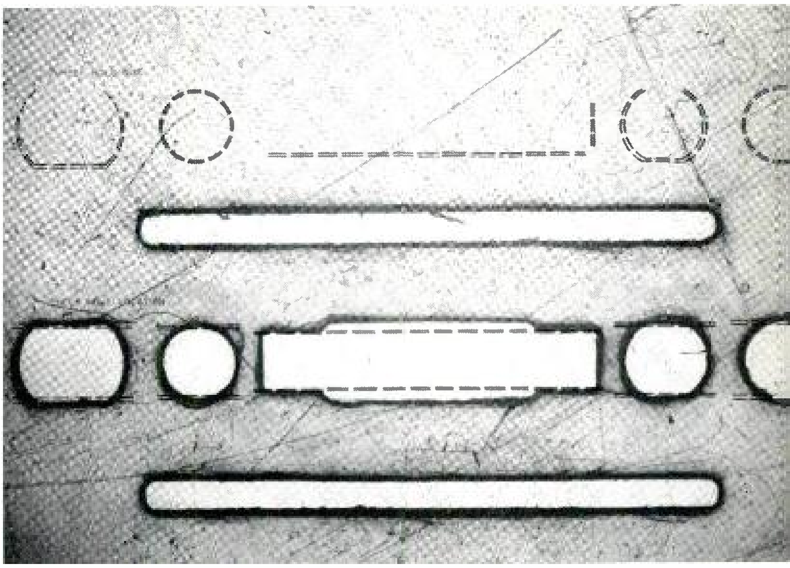


Fig. 6 — Screen of optical projection apparatus showing a mica insulating disk in position.

Control of dimensions in the construction of these tubes has been a basic problem. Certain of these dimensions are so critical that existing measurement methods leave a great deal to be desired. All the newest and best methods of measurement have been applied to this project but the spread in the final product has made the use of quality control methods necessary in many phases of production. By using quality control charts, groups of parts that deviate from the desired range can be observed and replaced before they are mounted in tubes. This results in a reduction of direct production expense, and at the same time, insures a finished product with well controlled parameters.

THE AUTHOR

Edward J. Walsh joined the Laboratories as a technical assistant in 1928 and became a Member of the Technical Staff in 1939, studying mechanical engineering at Cooper Union night school during the intervening years. His early work on the construction of glass enclosures for vacuum tubes was followed by design work on the enclosures and on small vacuum tubes. During World War II, he was engaged in the structural design of magnetrons, proximity fuse tubes and reflex oscillators. More recently he has been associated with the design of small, close-spaced electron tubes for radio relay and L3 carrier systems.

Ladders and Fungi

In the Bell System, where workmen must splice and repair aerial cable and attach wires to the sides of buildings, about fifteen thousand extension ladders are bought yearly at a cost of more than a third of a million dollars. For electrical safety reasons, all of these ladders are made of wood.

Wood, however, has a disadvantage that has been the subject of continuous research for many years – susceptibility to decay. In ladders, this decay generally manifests itself in the ends of the hardwood rungs where they are tenoned in softwood side rails. In this instance the hardwood – hickory, for example – is attacked by a virulent fungus which ordinarily does not attack softwoods. It is in this tenon joint of rung and side rail that are found the conditions of temperature and mois-

Installer using ladder while attaching drop wire to farm house, Maryville, Tennessee.

W. C. Sturzenegger inspecting ladders undergoing weathering tests at Chester, New Jersey, Laboratories.

Murray Hill bio-assay laboratory where fungi attacking ladder rungs were studied. Miss P. M. Hazard preparing to sterilize wood blocks for tests.

ture on which the decay-producing fungi thrive.

Two plans of attack on this decay problem have been followed by the Outside Plant Development Department. The first of these is the reduction of decay in ladder rungs by dipping them in a pentachlorophenol-mineral spirits solution for a period of ten minutes prior to ladder assembly. A five percent concentration of pentachlorophenol in a petroleum base is used. The solution also contains a water-repellent material that further minimizes the risk of infection by fungi. This procedure, although adding slightly to the annual bill for new ladders, is expected to reduce the likelihood of rung failure and to reflect over-all savings through longer ladder life and lower maintenance costs. The second plan of attack, detection of decay in ladders returned from the field for repairs, consists of sounding the rungs by means of a wood mallet. This method has undergone trial and has been adopted as a standard repair-shop procedure. Although this testing does nothing to eliminate decay, it does reveal decayed tenons and cracked rungs, thus reducing the possibility of accidents stemming from these sources.

G. E. Hadley,
Outside Plant Development

New York—Chicago L3 System

Another communications milestone was reached when the Bell System recently opened for service the major section of a new-type coaxial cable system. The new L3 system was placed in service on a 916-mile New York-Chicago route that passes through Newark, Philadelphia, and Cleveland. This route bears the heaviest public and commercial communications traffic in the United States.

A coaxial cable, such as the one being used on this route, is about as thick as a man's wrist. It contains eight copper tubes, no bigger in diameter than a fountain pen. Electronic apparatus called "carrier" makes it possible for the cable to "carry" many conversations over a single pair of tubes at the same time. It can also "carry" television, teletypewriter and telephoto messages. The carrier system presently used on most coaxial routes, known as the L3, enables a pair of tubes to carry 600 telephone conversations simultaneously, or a single tube to carry one TV program.

The L3 system has triple the telephone capacity of any cable transmission system now in use and a bandwidth double that of conventional video channels. Its components had been under development since near the end of World War II. This system makes it possible to transmit 1,800 conversations at the same time over the same pair of tubes without interference. It is also possible for two tubes – one in each direction – to carry two TV programs and 600 telephone conversations simultaneously.

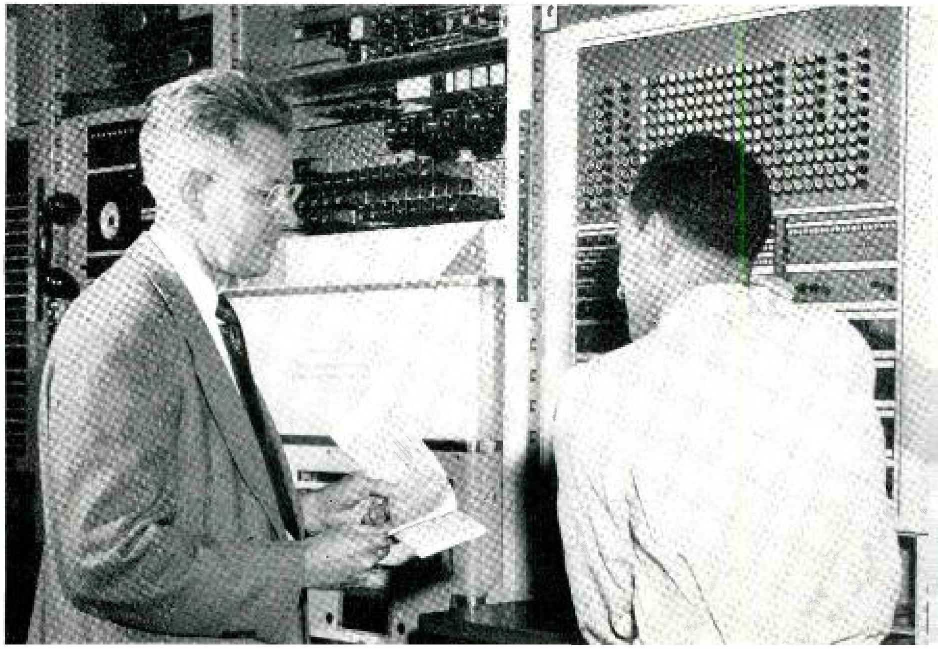
The L3 carrier, which has been under development at Bell Laboratories for several years, is a most important contribution to communications. It is the first carrier system on which both television programs and telephone conversations can be sent together over a pair of coaxial pipes. It will also serve as an important adjunct to the automatic long-distance switching systems that are gradually being added to key cities in the Bell System network. The net effect will be to provide faster and more dependable service – always the Bell System goal.

Conversion of the route to L3 took more than a year and cost $10,000,000. About 120 amplifying stations already in existence along the route at about eight mile intervals had to be re-equipped. Another 120 stations were added, each one halfway between the old stations. Thus, the route now has an amplifying station every four miles. Newly-developed wide-band amplifiers at each station are really the "heart" of the system and are as important a development as the equipment at each terminal point.

Four tubes in the New York-Chicago cable have now been converted to L3 between Chicago and Newark. Extensions to New York City and White Plains, N. Y. are due soon, in addition to the conversion of two more tubes along the entire route. The cable is to be used for telephone service initially. A second L3 project, now under construction between West Palm Beach and Miami, would be the first such system used for TV.

No. 5 Crossbar — Marker and Transverter Testing

C. W. HAAS
Switching Systems Development



The author analyzing a trouble recorder card while M. Mazzella sets up a test call on the master test frame keyboard.

When something goes wrong in your television receiver, considerable time may be spent in locating the trouble. If it were possible to have the set diagnose its own trouble and leave a message telling what is wrong, the process of eliminating the difficulty would be far more efficient. Something like this does actually happen in a No. 5 crossbar office. When trouble develops, a trouble recorder makes a record of the condition of the circuits involved. A master test control circuit is used in conjunction with the trouble recorder to further localize the fault and aid in clearing it. One of its several functions is that of testing markers and transverters, described in this article.

In the No. 5 crossbar system, a master test control circuit is used for controlling tests of most of the service circuits. This control circuit was developed primarily for testing markers and transverters. Most of its other features — line verification and setting up of connections for register, sender, trunk, and line tests — take advantage of its fundamental ability to control the marker and transverter.

In testing any circuit, there are three fundamental requirements. First, the test condition or input to the circuit must be applied. Second, the reaction of the circuit or its output must be made available. Third, the results of the test must be determined by analysis of the output in relation to the input.

This master test control circuit provides the input and test conditions for testing markers and transverters, but uses only a limited number of lamps for displaying a few of the major and special test results. For complete test results, use is made of the same trouble recorder* that records service trouble conditions. The maintenance attendant performing the test determines from his analysis of the trouble recorder card whether the marker or transverter has functioned properly.

* Record, *May*, 1950, *page* 214.

Under control of keys on the master test control panel, markers and transverters being tested can be directed to associate themselves with any possible combination of circuits and channels which might be encountered in service. Thus, if a trouble recorder card indicates that a certain combination of circuit elements is involved in a trouble condition, the call can be reproduced by the master test control circuit using the same circuits and channels. Because of the integration of the marker and the transverter with the circuits to which they connect, a test of either a marker or a transverter also tests many of the functions of the circuits that are associated with them.

In the case of the marker, there are three general classes of tests provided for the three general types of marker operations. First, the dial-tone class tests the ability of the marker to establish a connection between a calling customer and an originating register. Second, the originating class tests the ability of the marker to receive information from an originating register, and to establish the required connection to a trunk. Third, the incoming class tests the ability of the marker to receive information from an incoming register and to establish the required connection from an incoming trunk to a called customer or to a tandem or toll outgoing trunk. Transverters are tested by the master test control circuit for their ability to receive information from senders and to function with AMA translators and recorders.

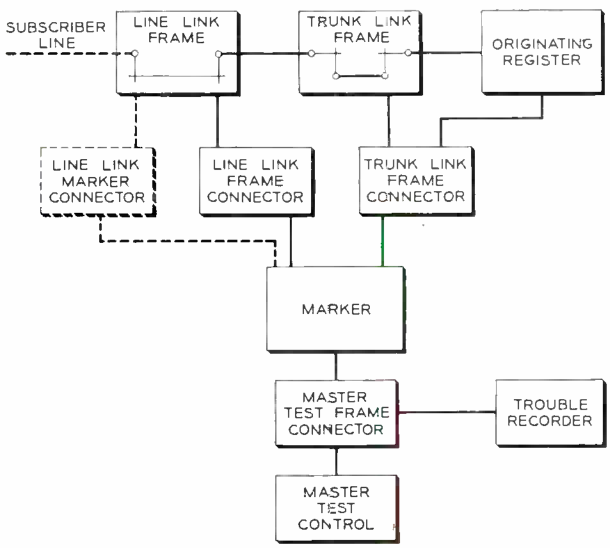


Fig. 1 — Block diagram illustrating the connections used on dial-tone marker tests. The broken lines represent circuits that are simulated by the master test control circuit.

The master test control circuit obtains test access to both markers and transverters by means of the master test frame connector which also provides means for connecting to the trouble recorder. By operating the "record" key on the master test control panel, the trouble recorder can be made to furnish a card on any call.

Before describing the dial-tone class test of the marker, it is desirable to review the actual performance of the marker from the time a customer picks up his receiver until dial-tone is returned to him. When the customer lifts his receiver, the line link frame on which his line hold magnet appears, connects to a marker. The line link frame indicates to the marker its number, the location of the customer's line hold magnet, and his class of service. The marker uses this information to establish a connection between the customer's line and an originating register in which it stores, for future use, the record of the customer's line location and class of service.

To test these functions of the marker, the master test control circuit simulates part of a line link frame and line link marker connector. Any line link frame number and any line link location may be set up on the key panel as illustrated in Figure 2. The master test control circuit connects to the marker to be tested through the master test frame connector to gain access to the leads over which the marker would normally receive information from the line link frame. The marker then proceeds to select an originating register and to establish a connection between it and the location of the line indicated by keys on the test frame. The marker receives the actual class of service assigned to the line by the cross-connections in the line link frame. Both class of service and line location are stored in the register by the marker in the normal manner. Figure 1 illustrates the connection established. A trouble recorder card taken on a dial-tone class of test shows the information received by the marker from the test circuit and the information transmitted from the marker to the originating register. The card also shows which originating register in the system was used and the path that was used to set up the connection.

To insure that service is not interrupted on a customer's line corresponding to the designations used to establish conditions of the test, and conversely to see that the use of the line by the customer cannot affect test results, the marker is prevented from actually operating the line hold magnet during the course of a marker test. When a line

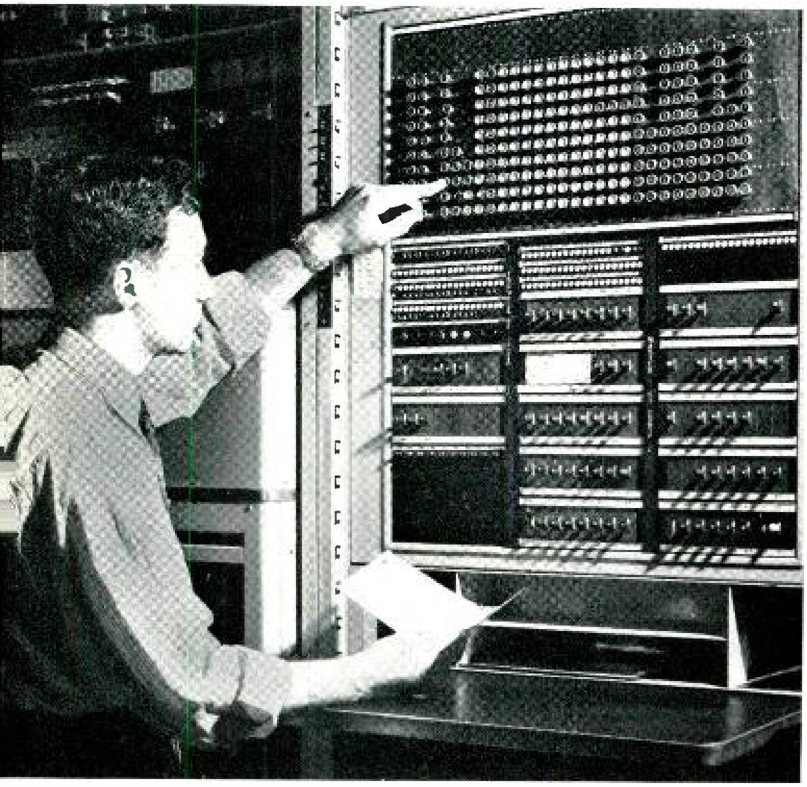


Fig. 2 — M. Mazzella using the master test frame keyboard at the No. 5 crossbar office in Englewood, New Jersey.

hold magnet would normally be operated by the marker, as in establishing a connection between an originating register and a customer's line, the line hold magnet operating circuit is directed instead to a relay in the master test control circuit which simulates the line hold magnet. As far as marker operation is concerned, the process is the same as though the connection had been established to the customer's line. Any line location can thus be used for marker tests even though the line itself is in use on a service call.

As mentioned previously, the second general class of marker test, the originating class, tests the ability of the marker to receive information from an originating register, and to establish the required connection to a trunk. This test simulates the action that takes place after the customer has completed dialing into the originating register when the register connects to a marker so that the talking connection may be completed. In actual service, the originating line location and class of service initially stored in the register is transmitted to the marker along with the number that had been dialed by the customer. The marker determines from the office code and class of service the required route, which may include intra-office, outgoing, inter-marker group, or vacant code routes. The marker also selects a trunk in the route, attaches a sender if it is required, and then completes the talking connection.

In testing these features of the marker, the master test control circuit simulates the originating register. Keys on the test circuit panel may be operated to simulate any calling line location, class of service, and called number. The test circuit puts information into the marker through the master test frame connector, which obtains access to leads over which the marker normally receives information from the originating register. The marker sets up a connection according to its translation of the office code portion of the called number and class of service, and the trouble recorder produces a record of the marker operation. If an intra-office route is used, two cards are produced, one showing the connection between the trunk and the called line, and a second showing the connection between the trunk and the calling line.

The third class of marker test, which is the incoming class test, concerns the ability of the marker to establish incoming call connections. In normal operation, incoming calls from other offices are pulsed into incoming registers. After pulsing has been completed, the incoming register connects to a marker which sets up a connection to the called number or to a tandem or toll outgoing trunk as required. The incoming register tells the marker the number of the trunk line frame on which the incoming trunk is located and, if it is a tandem or toll incoming trunk, the register gives the trunk number. The register also transmits to the marker the called number, which it has registered, along

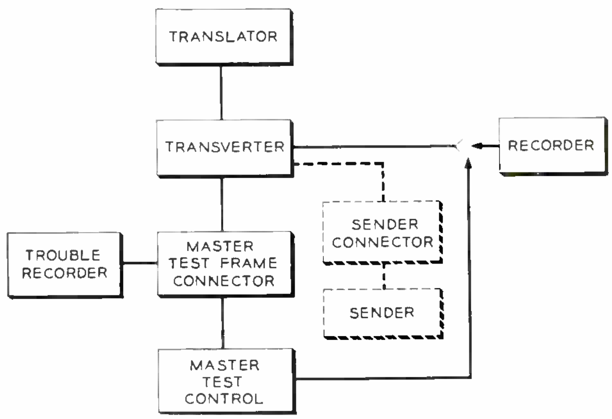


Fig. 3 — Block diagram illustrating the connections used on a transverter test. Broken lines represent circuits simulated by master test control circuit.

with information that is required by the marker to direct it to connect to office A or B or to translate code digits.

To test the ability of the marker to establish these incoming call connections, the test circuit simulates an incoming register connected to an incoming trunk. Keys are provided for simulating any kind of incoming trunk, regular, special, tandem, toll, pulse conversion or inter-marker group. Any called number may be set up on keys. Test results, as for other tests, are obtained from trouble recorder cards.

Testing the transverter using the master test control circuit involves checking the transverter for its ability to receive information from senders, and to function with AMA translators and recorders. During the normal process of establishing outgoing or intra-office calls requiring automatic message accounting, the sender connects to a transverter and transmits to it the location of the calling line, the called number, the number of the AMA recorder associated with the trunk involved, and other information required for proper billing. The transverter connects to a translator which converts the calling line location to the directory number. The transverter then connects to the proper AMA recorder where the calling directory number, trunk number, and, for detailed billing, the called number are perforated in the AMA tape.

To test a transverter, the test circuit simulates a sender and may either simulate the AMA recorder or may permit a service recorder to be used. This is illustrated by Figure 3. Any calling line location, called number, recorder number, and other billing information may be set up on keys. For most tests, the AMA recorder is simulated to avoid unnecessary tape entries.

Transverter output is transmitted to the AMA recorder in two, four, or five steps to be perforated in the tape in two, four, or five lines, depending on whether the entry is for bulk, detailed or foreign area billing. Keys are provided on the master test control panel which permit the transverter to be blocked at any line while a trouble recorder card is being perforated.

To illustrate a typical test call, the shaded buttons in Figure 4 show the setting of keys for testing the ability of a marker to establish a dial-tone con-

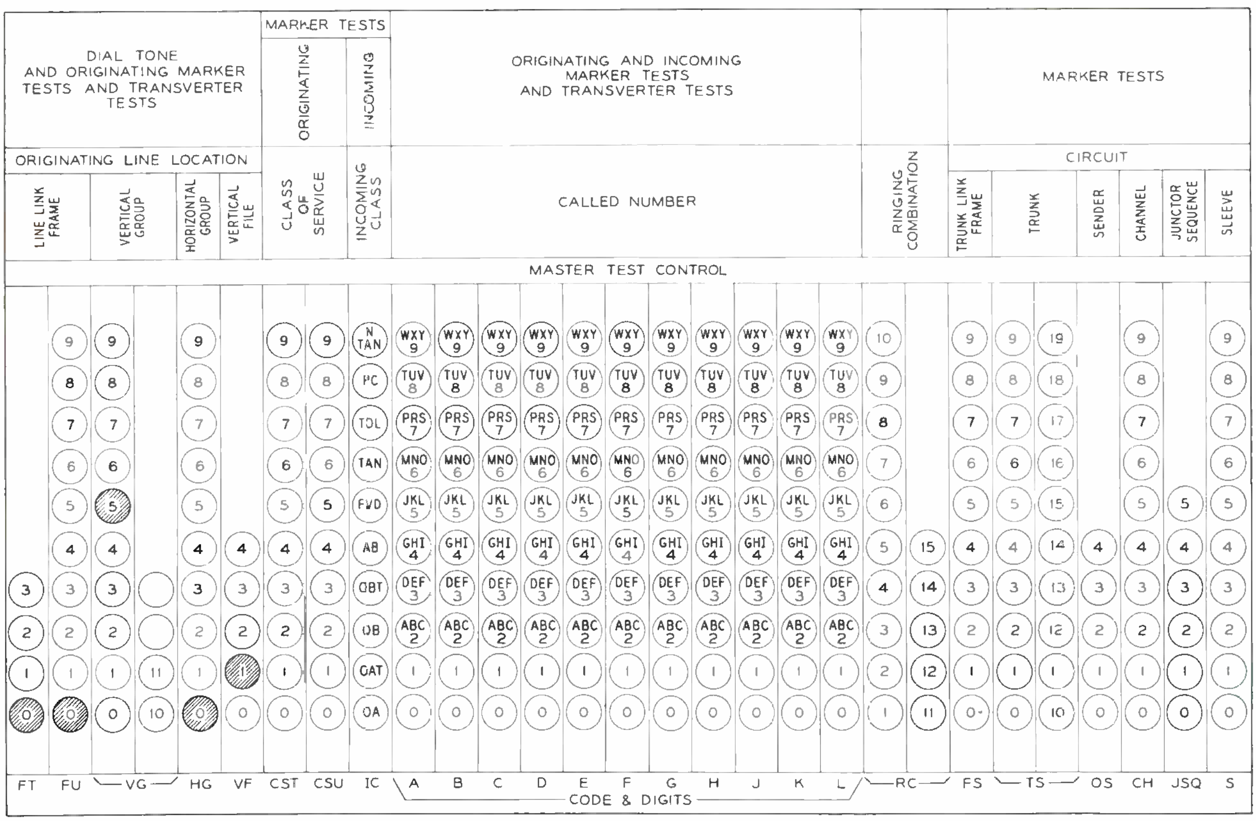
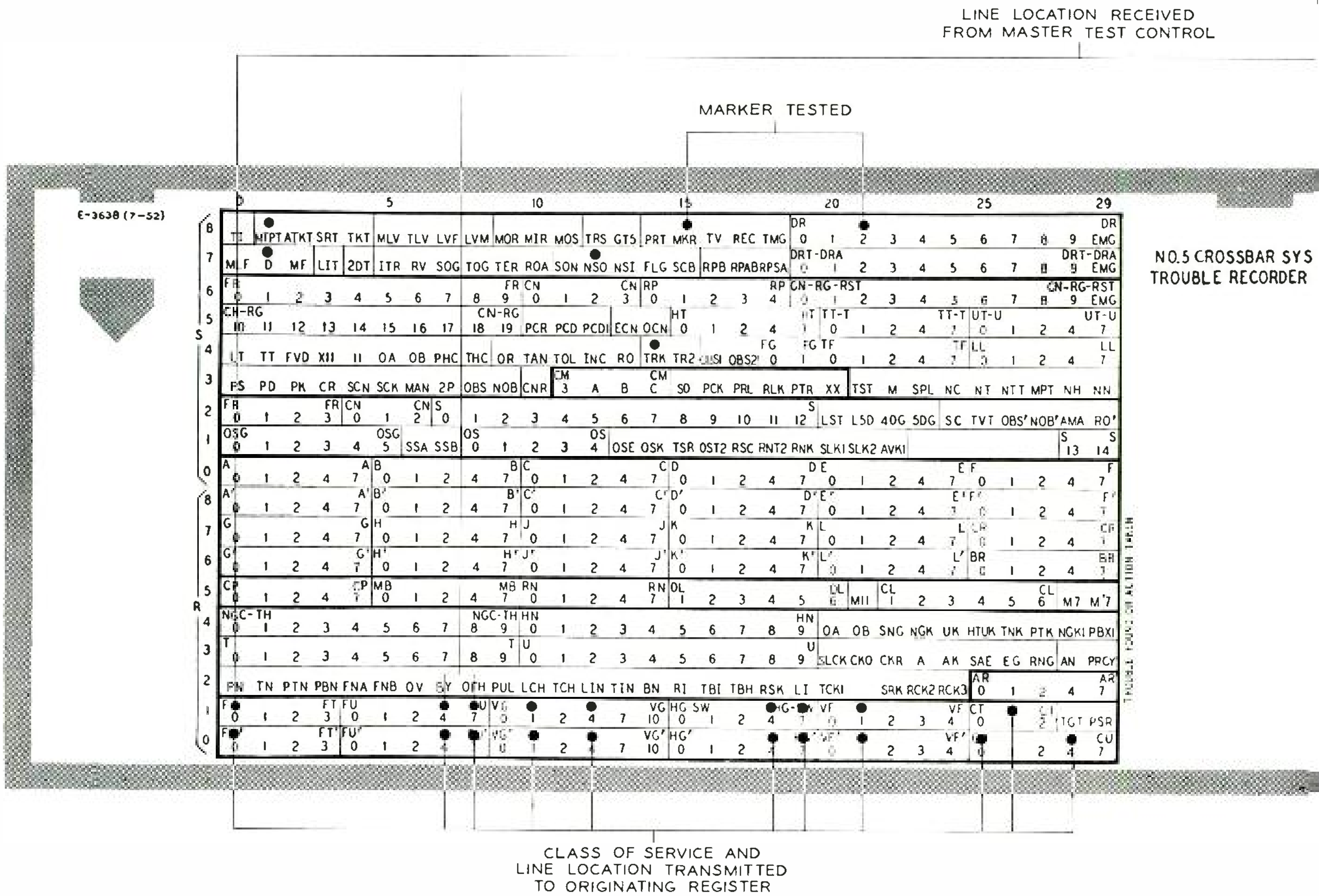


Fig. 4 — Diagram of the master test frame keyboard. Shaded keys would be depressed if customer line appeared on line link frame 0, vertical group 5, horizontal group 0, and vertical file 1.



nection from a customer's line located on line link frame zero, vertical group 5, horizontal group zero, and vertical file 1.

The master test control circuit connects to the marker through the master test frame connector shown in Figure 1. The line link marker connector through which markers are seized in service (shown in the illustration by broken lines), plays no part in the test call but is simulated by the master test control circuit.

When the marker has selected an originating register it establishes a connection between the register and the line location set up on the keys. The test circuit prevents the marker from operating the line hold magnet so as to prevent interference to either the customer or the test call. When the marker has

THE AUTHOR

Charles W. Haas, Jr., started his Bell System career in 1935 as a station installer with the Chesapeake and Potomac Telephone Company and after related experience as a switchman for panel office and No. 1 crossbar systems, was associated with the design of an automatic line test circuit for No. 1 crossbar. Transferring to the Laboratories in 1944 he was first assigned to the development of radar test sets at Point Breeze, Md., and since 1945 has been engaged in the design of test circuits and the dial-tone marker circuit for No. 5 crossbar. Mr. Haas received the B.S. degree in Electrical Engineering from the University of Maryland in 1934.

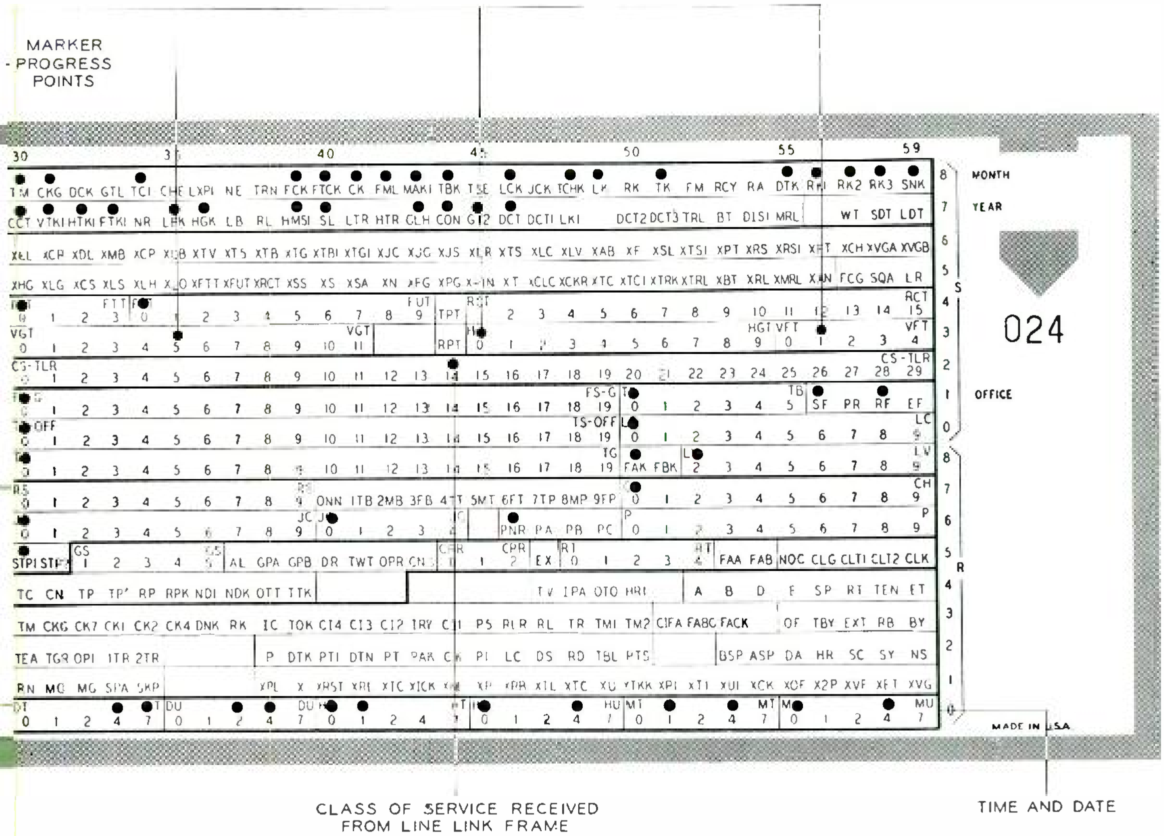


Fig. 5—Trouble recorder card produced as a result of a dial-tone marker test.

completed its task, the test circuit directs the trouble recorder to produce a recorder card of the marker action before releasing the marker.

The trouble recorder card (Figure 5) produced by this test shows that the line location received from the test circuit in one form was correctly converted in the marker to a different form and transmitted to the register. Vertical group VGT5, for instance, was received from the test circuit on one out of twelve leads, and was transmitted to the register on two out of six leads as VG'1 and VG'4. Likewise class of service was received from the line link frame as CS14 on one out of thirty leads and was transmitted to the register on one out of three leads as class tens (CT1) and two out of five leads as class units (CU0 and CU4).

New Sandia Contract Signed

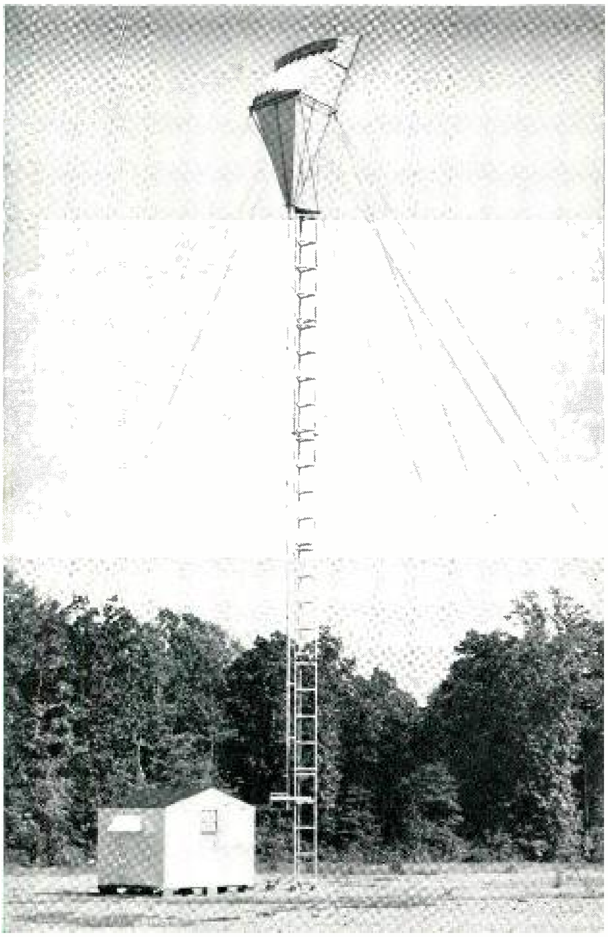
Western Electric, at the request of the Atomic Energy Commission, recently signed a new contract for the continued operation of the Commission's Sandia Laboratory at Albuquerque, N. M., until the end of 1958. The work is performed for Western Electric by its subsidiary, the Sandia Corporation.

The Atomic Energy Commission turned to the Bell System in 1949 to speed up the engineering and production of atomic weapons through the integrated research, development, and manufacturing skills of Bell Telephone Laboratories and Western Electric. Scientific services and technical and managerial assistance will continue to be provided by both organizations. Sandia Laboratory has an important function in bridging the gap between research and manufacturing operations on atomic weapons. Work includes design, development, engineering, and prototype production.

Terms of the new contract are substantially the same as the agreement under which the past work has been done and are still on a non-profit basis for both organizations.

Improved Radio Relay for Southern States

A new radio relay route, for both telephone and television service, has been planned for construction across three Southern states. The projected route would be equipped with newly developed receiving and transmitting antennas having a far greater circuit capacity than any now in use. The route, from Jackson, Miss., through Shreveport, La.,



A developmental model of the new radio relay antenna at the Holmdel Laboratories.

to Dallas, Tex., would augment coaxial cable and open-wire lines now providing communications to the deep South.

The proposed route is needed for telephone and network television since, in the past five years, the requirement for telephone circuits in the Dallas-Jackson section has increased more than 70 per cent and further increases are anticipated.

Fourteen stations would be built along the projected route, equipped with tapered-steel antenna towers ranging in height from 75 to 300 feet. Each tower would support new-type horn-reflector antennas. Another achievement of Bell Telephone Laboratories, the antennas feature a number of improvements over the standard type used on microwave routes since 1947. They are designed for simultaneous use in the 4,000, 6,000 and 11,000 megacycle bands, while the antennas used on most Bell System routes operate in the 4,000-megacycle band. The improvement will make it possible, ultimately, for the new antenna to carry several times as many channels as its forerunner.

The new antenna would have a new-type "wave guide," the device used to carry microwave signals between repeaters on the ground and antennas at the top of the tower.

Five channels on the proposed 430-mile system would be developed initially. They would include one westbound video channel, one channel in each direction for telephone service, and one in each direction for protection and maintenance.

Network TV

Two television stations, WTRI, Schenectady, N. Y., and WSLI-TV, Jackson, Miss., were recently connected to the Bell Telephone System's nationwide network of television facilities. Network programs for WTRI are fed over the New York-Albany radio relay route. In Albany, the signals are received at the telephone building; from there, a seven-mile loop flashes them to WTRI's studio-transmitter on Bald Mountain in Troy, N. Y.

Intercity facilities from Atlanta, Dallas, and Memphis provide network programs for WSLI-TV. In Jackson, the video signals are also received in a telephone company building, and are then carried to the station's studio over a local channel. These two stations bring the network service total to 287 stations in 182 cities in the United States.

Teletypesetter Circuit for Sports Coverage

A teletypesetter circuit, which enables the setting of type by remote control, was established last month for the Associated Press. Set up to carry sports news, the circuit links over twenty cities, extending from the A.P. headquarters in New York City north and west to Duluth, Minn., north and east to New Haven, Conn., and south to Miami, Fla. This is the first teletypesetter circuit of this customer to be used exclusively for sports coverage.

New Type Telephone Booth

A radically new type of telephone booth was recently tested for customer reaction in Boston's South Station. Unlike the usual booth, it contains no telephone instrument. A small white-handled key and a volume control are the only controls, and the customer can telephone without holding an instrument.

An instruction card tells the story: to initiate a call, raise the white key and release; to end the call, depress the white key and release. The volume may be adjusted to the desired level at any time. The customer may rest bundles or a purse on the usual convenient shelf, but does not have to hold an instrument; a speaker and microphone, recessed into the wall of the booth, may be seen just behind the young lady's head.

Developed by the Laboratories, the booth was previously tested for performance at Walter Reed Hospital in Washington, D.C. At present, such trial installations can only be made where an attendant is on duty, since there is no coin box or dial in the booth.

Field Engineering Changes

J. H. Miller, who has been Laboratories Field Engineer in Denver since the establishment of the office there in August, 1948, has transferred to the Mountain States Telephone and Telegraph Company to accept the position of Equipment Maintenance Engineer. J. H. Corp, recently transferred to the Laboratories from the Michigan Bell Telephone Company, has replaced Mr. Miller as Field Engineer in Denver.

Papers Published by Members of the Laboratories

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

Barstow, J. M., and H. N. Christopher, The Measurement of Random Monochrome Video Interference, A.I.E.E., Commun. and Electronics, pp. 735-741, Jan., 1954.

Bashkow, T. R., Stability Analysis of a Basic Transistor Switching Circuit, Proc. National Electronics Conference, 9, p. 748, Feb. 15, 1954.

Blecher, F. H., Automatic Gain Control of Junction Transistor Amplifiers, Proc. National Electronics Conference, 9, p. 731, Feb. 15, 1954.

Coy, J. A., Heat Dissipation from Toll Transmission Equipment, A.I.E.E., Commun. and Electronics, pp. 762-768, Jan., 1954.

Case, R. L., and Iden Kerney, Program Transmission Over Type N Carrier Telephone, A.I.E.E., Commun. and Electronics, pp. 791-795, Jan., 1954.

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

Fracassi, R. D., and H. Kahl, Type ON Carrier Telephone, A.I.E.E., Commun. and Electronics, pp. 713-721, Jan., 1954.

Hanson, A. N., Automatic Testing of Wired Relay Circuits, A.I.E.E., Commun. and Electronics, pp. 805-857, Jan. 1954.

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

Kerney, Iden, see R. L. Case.

Kretzmer, E. R., An Amplitude-Stabilized Transistor Oscillator, Proc. National Electronics Conference, p. 756, Feb. 15, 1954.

Linville, J. G., A New RC Filter Employing Active Elements, Proc. National Electronics Conference, **9**, p. 342, Feb. 15, 1954.

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

Morin, F. J., Lattice Scattering Mobility in Germanium, Phys. Rev., **93**, pp. 62-63, Jan. 1, 1954.

Pennell, E. S., A Temperature Controlled Ultrasonic Solid Delay Line, Proc. National Electronics Conference, **9**, p. 255, Feb. 15, 1954.

Perkins, E. H., and J. J. Mahoney, Type-N Carrier Telephone Deviation Regulator, A.I.E.E., Commun. and Electronics, pp. 757-762, Jan., 1954.

Remeika, J. P., Method for Growing Barium Titanate Single Crystals, Am. Chem. Soc., J., **76**, pp. 940-941, Feb. 5, 1954.

Shockley, W., Some Predicted Effects of Temperature Gradient on Diffusion in Crystals, Letter to the Editor Phys. Rev., **93**, pp. 345-346, Jan. 15, 1954.

Walker, L. R., Dispersion Formula for Plasma Waves, Letter to the Editor, J. Applied Phys., **25**, pp. 131-132, Jan., 1954.

Talks by Members of the Laboratories

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

I.R.E. National Convention — New York City

Aamodt, T., and Harvey, F. K., Large Area Microphones for Distant Pickup Use.

Felch, E. P., Israel, J. O. and Kummer, O., Frequency-Standard Controlled Wide Range Oscillator.

Follingstad, H. G., An Analytical Study of *z*, *y*, and *h* Parameter Accuracies in Transistor Sweep Measurement.

Hanson, R. L., High Fidelity in Audio Engineering.

Israel, J. O., see Felch, E. P.

Kock, W. E., High Fidelity and the Hearing Process.

Kummer, O., Transistor Frequency Scanner; see also Felch, E. P.

Landry, W. R., Application of a Minimum Phase Matrix to Adjustable Equalizer Design.

Moore, E. F., Electronic Computers.

Packard, G. N., Performance of the Bell System Primary Standard of Frequency.

Rounds, P. W., Equalization of Video Cables.

Shannon, C. E., Electronic Computers.

Talpey, E. T. and MacNee, A. B. (University of Michigan), The Nature of the Uncorrelated Component of Induced Grid Noise.

American Physical Society — Detroit and Ann Arbor

Bozorth, R. M. and Sherwood, R. C., Magnetostriction of Cobalt; see also Nesbitt, E. A.

Haynes, J. R. and Hornbeck, J. A., Decay in Photoconductivity Associated with Hole Traps in *n*-Type Silicon; see also Hornbeck, J. A.

Hornbeck, J. A. and Haynes, J. R., Decay in Photoconductivity Associated with Deep Electron Traps in *p*-Type Silicon; see also Haynes, J. R.

Kohn, W., Bombardment Damage of Germanium Crystals by Fast Electrons.

Lewis, J. A., see Mason, W. P.

Mason, W. P. and Lewis, J. A., Magnetostriction and Magnetic Anisotropy of a Hexagonal Crystal.

McKay, K. G., Avalanche Breakdown in Silicon.

Nesbitt, E. A., Williams, H. J. and Bozorth, R. M., Factors Determining the Permanent Magnet Properties of Single Crystals of Fe_2NiAl.

Sherwood, R. C., see Bozorth, R. M.

Stern, F., Spin Waves in Antiferromagnetic Face-Centered Cubic Lattices.

Williams, H. J., see Nesbitt, E. A.

Conference on Analytical Chemistry and Applied Spectroscopy — Pittsburgh

Albano, V. J., see Campbell, W. E.

Campbell, Miss M. E., see Luke, C. L.

Campbell, W. E. and Albano, V. J., Coulometric Analysis of Surface Films on Metals.

Campbell, W. E. and Vincent, Miss S. M., Determination of Water in Some Organic Materials.

Campbell, W. E., see Garn, P. D.

Garn, P. D. and Campbell, W. E., A Ball-and-Cup Absolute Microviscometer.

Jaycox, E. K., A Spectrochemical Procedure of General Applicability.

Luke, C. L. and Campbell, Miss M. E., Determination of Magnesium in Nickel.

Vincent, Miss S. M., see Campbell, W. E.

Other Talks

Beck, A. C., Waveguides, A.I.E.E. Student Branch, City College of New York, New York City.

Biddulph, R., Auditory Perspective, I.R.E. Meeting, Cleveland.

Bovet, H., Gyromagnetic Resonance in Ferrites at Microwave Frequencies, Physics Colloquium, New York University, New York City.

Bozorth, R. M., Two Problems in Ferromagnetism, Metal Science Club, New York City.

Campbell, W. E., Microchemical Techniques in the Solution of Lubrication and Wear Problems, American Society of Lubrication Engineers, Pittsburgh.

Campbell, W. E., Solid Lubricants, American Society of Lubrication Engineers, Sectional Meetings, Milwaukee, Wis. and Dayton, Ohio.

Chapin, D. M., Conversion of Solar Energy to Electrical Energy by Silicon *p-n* Junction Cells, Semiconductor Session, American Institute of Mining and Metallurgical Engineers, New York City.

Cioffi, P. P., The Nature of Ferromagnetic Materials, Summit Association of Scientists, Summit, N. J.

Clark, A. B., New Technologies and Trends in Telephone Development, Western Society of Engineers General Meeting, Chicago.

Egerton, L., Some Factors Affecting the Dielectric and Piezoelectric Properties of Barium Titanate Ceramics, Ceramic Dielectrics Symposium, Rutgers University, New Brunswick, N. J.

Getz, E. L., Customer Dialing of Long Distance Telephone Calls, I.R.E. Meeting, Toledo.

Gilbert, J. J., Key West-Havana Cable, Reserve Officers Association, Governors Island, N. Y

Groth, W. B., Automatic Message Accounting, I.R.E. Meeting, Brooklyn.

Groth, W. B., Principles of Tape-to-Card Conversion and Fundamentals of the A.M.A. System, National Machine Accountants Association, Bridgeport, Conn.

Hanson, R. L., The Physics of Music and Hearing, I.R.E. Symposium, Cleveland.

Heidenreich, R. D., Electron Microscopy, Yale University Colloquium, New Haven Conn.

Herring, C., Surface Energy of Solids and its Role in Sintering, International Business Machines Corporation, Poughkeepsie, N. Y.

Higgins, W. H. C., Project NIKE, Capital Cities Post, American Ordnance Association, Schenectady, N. Y., and A.I.E.E.-I.R.E. Student Chapter, University of Illinois, Urbana, Ill.

Honaman, R. K., Frontiers of Communication, Mountain States Telephone and Telegraph Company, 75th Anniversary in Denver and other points in Arizona, Utah and Texas.

Hornbeck, J. A., Transistor Physics – A Demonstration Lecture, Evening of Physics, Kalamazoo College, Kalamazoo, Mich.

Ingram, S. B., The Development of Technical Ability in the Engineer, A.I.E.E. New York Section, New York City.

Kelley, R. A., Equalization Aspects of the L3 Coaxial Carrier System, Seminar, University of Illinois, Urbana, Ill.

Keister, W., Mechanized Intelligence, A.I.E.E.-I.R.E. Student Chapter, Oklahoma Agricultural and Mechanical College, Stillwater, Okla., A.I.E.E.-I.R.E. Joint Chapter and Oklahoma Society of Professional Engineers, Oklahoma City, A.I.E.E. Meeting, St. Louis, and A.I.E.E. Meeting, Kansas City, Kans.

Lewis, H. A., The Transatlantic Telephone Cable, Kiwanis Club, Summit, N. J.

Loomis, T. C., Metal Chelates Cyclohexenediaminetetra-acetic Acid, and Complexometric Titration Procedure for Brass Analysis, American Chemical Society, Kansas City, Mo.

Lundberg, J. L. and Thurmond, C. D., Transistor Chemistry, Radio Interview, Station WMTR, Morristown, N. J.

Masek, F. E., Component Developments and Their Application in the Bell System, A.I.E.E.-I.R.E. Student Branch, Kansas State College of Agriculture and Applied Science, Manhattan, Kans.

Mason, W. P., Magnetostriction and Magnetic Anisotropy of a Hexagonal Crystal, Bell Telephone Laboratories, Murray Hill, N. J.

McMillan, B., Mathematics in Communication, Mathematics Club, Rutgers University, New Brunswick, N. J., and Mathematical Association of America, New York City.

Meszar, J., A Highly Complex Digital Control System, A.I.E.E.-I.R.E. Sponsored Meeting, Cincinnati.

Morton, J. A., The Transistor – A New Way of Life, Engineers' Club, Philadelphia.

Quate, C. F., Recent Progress in Microwave Tubes, A.I.E.E.-I.R.E. Student Branch, University of Michigan, Ann Arbor, Mich., and A.I.E.E.-I.R.E Student Branch, Ohio State University, Columbus, Ohio.

Rea, W. T., Military and Communication Applications of Transistors, Armed Forces Communication Association, New Haven, Conn.

Rowen, J. H., Ferrites and Non-Reciprocal Microwave Circuit Elements, A.I.E.E.-I.R.E. Joint Meeting, Columbus, Ohio.

Shackleton, S. P., Opportunities in Electrical Engineering, Senior High School, Mamaroneck, N. Y.

Schimpf, L. G., Transistor Circuit Applications, I.R.E. Meeting, Lancaster, Pa.

Schumacher, E. E., Communications Metallurgy, Pennsylvania State College, State College, Penn.

Terry, M. E., Design of Experiments to Detect Assignable Causes, American Society for Quality Control, Newark.

Thurmond, C. D., see Lundberg, J. L.

Wilkinson, R. I., Uses of Probability in Telephone Engineering, Rotary Club, Larchmont, N. Y.

Bell System Waives Royalties For Hearing Aids

American manufacturers of hearing aids will henceforth be able to use Bell System inventions without payment of patent royalties. Bell System research in the field of telephony is focused on the fidelity of sound transmission in all its applications. The telephone itself is a by-product of the early experiments of Alexander Graham Bell, who had a life-long interest in helping the deaf. Making patents available without royalty to hearing aid manufacturers is a further contribution to the work to which Mr. Bell was dedicated.

The offer includes the royalty-free use in hearing aids of the transistor – the tiny, rugged electronic device, invented at Bell Telephone Laboratories, that can do most of the things an electron tube can do and requires only minute amounts of power. The transistor is particularly well suited for use in modern-day hearing aids. Its minute size, low power requirements, and almost unlimited life enable lightweight instruments to be made more compactly than is possible with electron tubes, and with reduced cost of battery replacement.

The offer was made in letters to hearing aid companies by the Western Electric Company, manufacturing and supply branch of the Bell System, which handles patent licensing for the System. If they so desire, hearing aid manufacturers will be licensed to use the applicable Bell System patented inventions without any royalty obligation. Any firm that is licensed under this arrangement can also make transistors for inclusion in hearing aids that they make or can have the transistors made by another manufacturer.

This is not the first time the company has offered royalty-free licenses on by-products of telephone research that benefit the physically handicapped. Other instances are the artificial larynx, which frequently enables an individual who has lost his larynx to speak again, and the recording of talking books for the blind.

Patents Issued to Members of Bell Telephone Laboratories During February

Augustadt, H. W. and Kannenberg, W. F. – *Automatic Volume Control* – 2,668,874.

Blair, R. R. – *Varistor Curve Tracer* – 2,669,004.

Boghosian, W. H., Och, H. G., and Weber, B. T. – *Gun Data Computer Having Spot Correction Means* – 2,669,386.

Brewer, S. T. – *Marking and Switching System* – 2,668,195.

Carpenter, W. W. – *Record Controlled Reproducing System* – 2,669,304.

Cory, S. I. – *Telegraph Signal Distortion Indicating and Measuring Device* – 2,668,192.

Cutler, C. C. – *Electromagnetic Lens* – 2,669,657.

Edmonds, R. W. – *Broad Band Testing* – 2,669,691.

Felker, J. H. – *Regenerative Transistor Amplifiers* – 2,670,445.

Gent, E. W. and Myers O. – *Electromechanical Translator* – 2,668,877.

Goodall, W. M. – *Noise Reduction in Quantized Pulse Transmission Systems with Large Quanta* – 2,669,608.

Graham, R. E. – *Vertical Synchronizing System* – 2,668,873.

Gray, F. – *Code Selector* – 2,669,706.

Hall, N. I., Hecht, G. and Koechling, C. D. – *Electronic Register for Telephone Switching Systems* – 2,668,931.

Hecht, G., see Hall, N. I.

Harrison, C. W. – *Vertical Synchronizing System* – 2,668,927.

Jonas, H. C. and Sears, R. W. – *Electron Discharge Device* – 2,668,927.

Kannenberg, W. F., see Augustadt, H. W.

Koechling, C. D., see Hall, N. I.

Lakatos, E. – *Computer for Multiple Ballistics* – 2,670,134.

McKay, K. G. – *Alpha Particle Counter* – 2,670,441.

Maggio, J. B. – *Limiter Amplifier Circuit* – 2,669,654.

Mason, W. P. and Matthias, B. T. – *Piezoelectric Transducer* – 2,669,666.

Matthias, B. T., see Mason, W. P.

Meacham, L. A. – *Triangular Wave Generator* – 2,669,656.

Mitchell, D. – *Radiotelephone Communication System* – 2,670,435.

Mohr, M. E. – *Signaling System Employing Electron Beams* – 2,670,405.

Myers, O., see Gent, E. W.

Och, H. G., see Boghosian, W. H. and Parkinson, D. B.

Parkinson, D. B. and Och, H. G. – *Plotting Board* – 2,669,500.

Pearson, G. L. – *Methods for Determining Electrical Characteristics of Semiconductive Bodies* – 2,669,692.

Pfann, W. G. – *Semiconductive Photoelectric Transducer* – 2,669,635.

Sears, R. W., see Jonas, H. C.

Stibitz, G. R. – *Complex Computer* – 2,668,661.

Weber, B. T., see Boghosian, W. H.