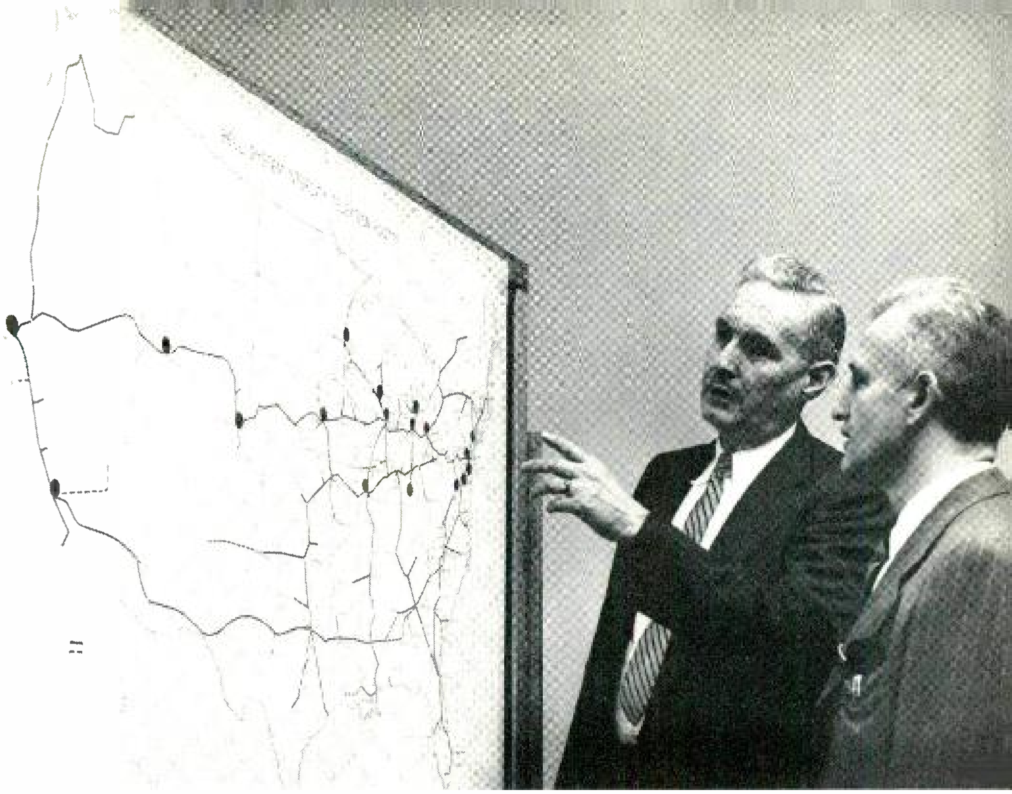


The author (left) and R. C. Edson discuss television transmission routes. Dots indicate cities that received first transcontinental color TV program.

Television and the Bell System

J. M. BARSTOW *Transmission Engineering*

With about 50,000 miles of Bell System television transmission channels interconnecting more than 278 stations in 174 cities, the communication needs of the rapidly growing television industry are playing an increasingly important part in Bell System planning. This extensive network and the forthcoming addition of color television with its more severe transmission requirements have presented many new and difficult problems. To acquaint its readers with the nature of these problems, the RECORD is publishing a brief description of the television process and its impact on the Bell System.

Most people in the United States are probably aware that telephone facilities, both local and long distance, provided for the nation by the Bell System, have grown tremendously in the fifteen years since 1939. It is doubtful, however, whether these people are aware of the rapid growth in television transmission facilities provided by the Bell System. Commercial transmission of television signals began in 1948 with two-way circuits, one between New York and Washington, D. C., and the other connecting New York and Boston. Three and one-half years later, at the end of 1952, there were about 33,000 one-way channel miles of intercity television circuits. By the end of 1953 about 50,000 one-way channel miles were available to the telecasters, an increase of about 50 per cent in one year.

The bandwidth employed in these circuits is rather astonishing in comparison with the three or four thousand cycles per second normally allotted to a telephone message channel. Fifteen years ago, providing and maintaining intercity circuits having an almost uniform amplitude and delay response from frequencies near zero to those over four megacycles would have been considered unlikely in the

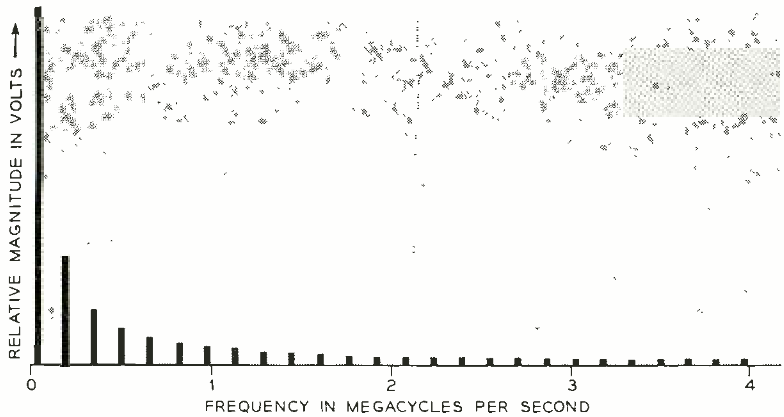


Fig. 1 — Frequency composition of typical monochrome television signal. Every tenth line harmonic is indicated.

near future. Today such circuits are commonplace, and the bandwidth frontier is now in the eight to fifteen megacycle range.

Local urban transmission is also important in these considerations. At first, through necessity, paper-insulated pairs were used for bandwidths from near zero to 4 megacycles in transmission circuits of this type. This introduced great equalization problems, and it was necessary to space amplifiers very closely. In a very short time, separately shielded pairs were provided in lead-covered cable, and a local transmission system involving standardized equalization sections and adjustable amplifiers was put into service. Almost simultaneously, a local microwave radio system was made available. These two systems are still standard today, although many modifications have been made in them.

These accomplishments mark the period from 1939 to 1954 as one of transition; perhaps the beginning of a new era in communications transmission. The development of wideband systems for long-haul facilities has a double purpose since they can be used economically for either telephone or television service. These changes and advances have been augmented by the needs of the television industry. The impact of television on the Bell System has therefore been to advance the development of wide band local facilities, and to encourage large-scale growth and development of special wide band circuits for long haul facilities, both cable and radio relay.

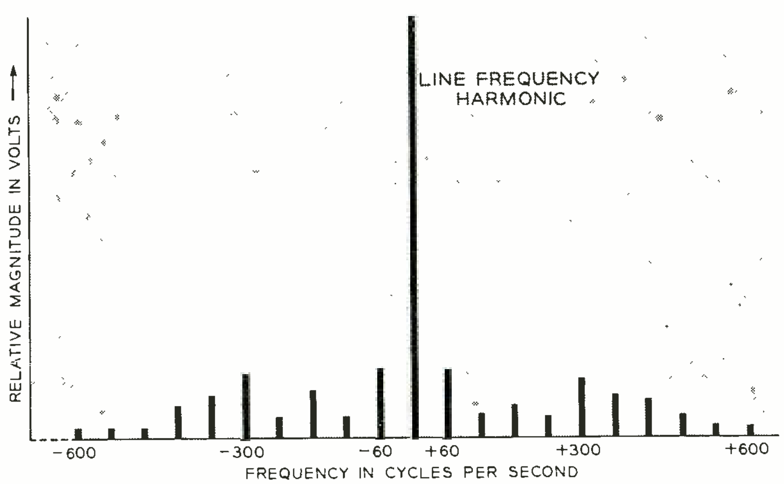


Fig. 2 — A line frequency harmonic and the surrounding 60-cycle sidebands.

During the past four years, a struggle has been going on within the television industry to decide what kind of a system would be used to transmit pictures in color. This struggle has now ended, at least for the time being, and a system has been adopted. With this system, all signals, including those for color, can be received in black-and-white on existing monochrome receivers. In addition, new color receivers will not only receive and present color signals in color, but will also be able to receive and present black-and-white signals in monochrome. These characteristics of the color system have caused it to be labeled "compatible;" that is, all television signals can be received by all receiving sets, but only the new color sets can present color pictures from color signals.

Although commercial transmission of television signals is relatively new, it is an important and well established business for the Bell System. In this regard, several fundamental questions occur including: Why is such a wide band (about four megacycles) required for a single one-way channel; what is the frequency composition of the transmitted signal, and what are the transmission objectives? The answers to these questions require a general description of the manner in which an image is traced on the face of a television tube, and the nature of the signal that makes this possible.

In addition to these questions and answers, many others arise concerning color television and the principles that are employed in obtaining a color signal and in producing a color picture. For the present, the composition of the color signal that the Bell System Operating Companies are asked to transmit will be described together with the characteristics which make it different from a monochrome signal.

A television picture is produced by a spot of light that travels rapidly back and forth across the face of a picture tube, gradually descending from top to bottom, then quickly going back to the top and traversing the tube again. This puts a succession of pictures on the tube that results in the illusion of continuous motion. In these pictures, when a light area is to be portrayed, the spot is intense or bright, and for a dark area it is less intense. This spot is produced by the fluorescence of phosphor material on the inside of the tube face under the influence of an electron beam. The illusion that the picture area of the tube is at least partially illuminated all over and all the time is obtained by the relatively slow decay time of the phosphor glow, and by the persistence of vision. Actually, the beam strikes an elemental area (smallest resolvable area of picture) 30 times a second and persists for only about one-eighth of a microsecond. As a result, a given elemental area is illuminated only 30/8,000,000 or about 1/270,000 of the total time.

TABLE 1

Pictures per second	30
Lines per second = pictures per second x 525	15,750
Picture elements per second = lines per second x (525 x 4/3) x 3/4	8.3×10^6
Cycles per second = $\frac{\text{picture elements per second}}{2}$	4.2×10^6

During the remaining time, the area seems to be illuminated because of the phosphor glow and the persistence of vision.

In 1941 the FCC accepted a set of standards, still in use today, that governs the bandwidth required to produce a good quality picture. These standards call for a repetition rate of thirty pictures per second, and an apparent sharpness that would be produced by 525 horizontal lines per frame, assuming that the bandwidth is extended until about equal horizontal and vertical resolution has been obtained. Also, a rectangular picture shape three units high and four units wide was adopted. These standards are sufficient to calculate the required bandwidth of 4.2 megacycles per second as shown in Table 1.

The factor 3/4 in the third line of this table is used to take into account the fact that, with 525 horizontal scanning lines, the vertical resolution is somewhat less than 525 picture lines. This results from the fact that the horizontal lines to be portrayed in a picture would have to coincide exactly with the scanning lines if they were to be accurately reproduced. If the number of horizontal lines to be portrayed approaches the number of scanning lines, some failure in portrayal occurs when the scanning spot happens to fall partly on a white line and partly on a black line. Hence, to produce a horizontal resolution about equal to the vertical resolution, the bandwidth should be extended only enough to enable about three-quarters of the (525 x 4/3) lines to be resolved. The factor 4/3 within the parentheses takes account of the aspect ratio of the picture, four units wide and three units high. The factor 1/2 used to obtain cycles per second from picture elements per second in

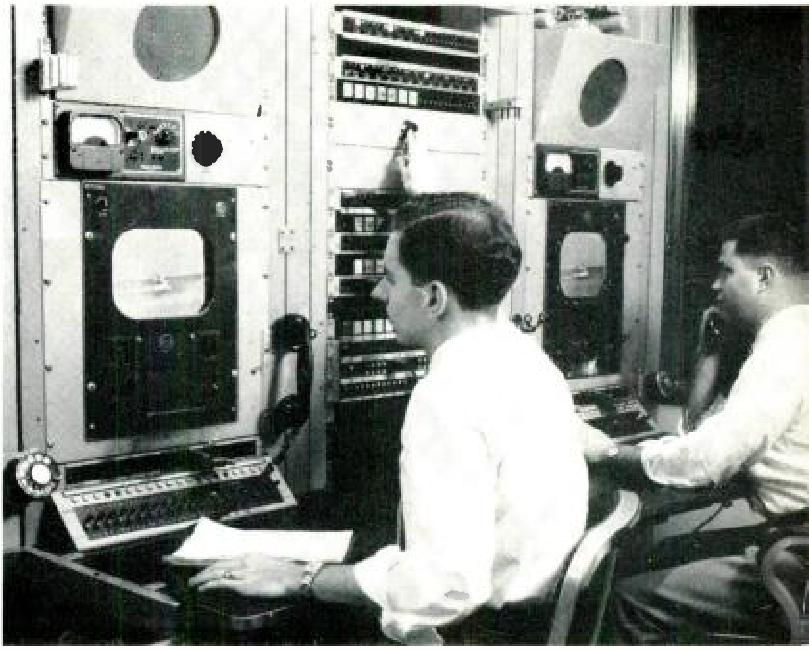
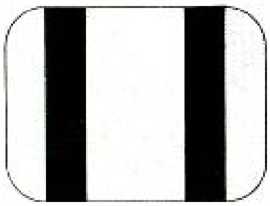


Fig. 3 — W. G. Goetz and R. L. Goes monitor television picture quality at the New York Long Lines building.

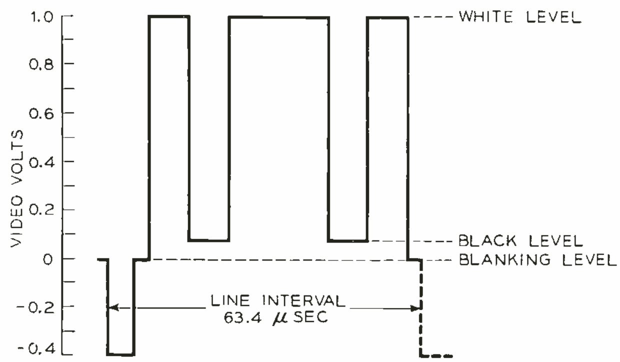
the last line in the table is derived from the fact that a single cycle has a positive and negative excursion so that each complete cycle can be said to produce two picture elements, one dark and the other one light.

In this derivation, no account is taken of blanking time that must be subtracted from picture time to allow the spot to return to the left side or to the top of the tube. Actually, only about 490 horizontal scanning lines are available for picture purposes since the remainder are blanked out while the spot moves from the bottom to the top of the picture. However, the bandwidth requirements are not altered by this blanking time.

In producing a picture, the spot begins at the top left of the raster (picture area), moves to the right tracing out the light and dark areas in the first line, quickly returns to the left side and traces out the third line, and so on to trace out the odd numbered lines to the bottom of the raster. The spot then moves back to the top left and proceeds to



(a) PATTERN ON PICTURE TUBE



(b) CORRESPONDING VIDEO VOLTAGE

Fig. 4 — A simple television picture and the corresponding video signal. (a) Two vertical black bars on a white field. (b) Video signal corresponding to two vertical black bars on a white field.

scan the even numbered lines to the bottom of the picture area. In this process, each line interval is 1/15,750 second in duration and scanning alternate lines from top to bottom requires 1/60 second. Thus one "frame" or full picture is produced in 2/60 or 1/30 second. This process is continuous as long as the set is turned on.

Some information regarding the frequency composition of a TV signal may be deduced at once from this description. First, the recurring movement of the scanning spot from the left to the right side of the raster in 1/15,750 second indicates that there must be a large 15,750-cycle component. In each movement of the scanning spot across the raster, different beam intensities occur according to picture content, and this means many integral harmonics of the 15,750-cycle fundamental line frequency are present. In addition, as the spot moves down the field traversing alternate lines, certain beam intensities occur repeatedly at intervals of 1/60 of a second. Thus, the line frequency harmonics are modulated at a 60-cycle rate, giving rise to 60-cycle sidebands on each line frequency harmonic. The net result is a signal frequency composition similar to that shown in Figures 1 and 2. Figure 1 illustrates the entire 4-mc bandwidth indicating the levels of line frequency harmonics for a typical signal. Nine-tenths of the harmonics have not been drawn in and 60-cycle components near zero frequency have been omitted for clarity. In this signal, the lower harmonics are fairly constant in magnitude while the upper harmonics are constantly varying depending on picture content. A small section of Figure 1 magnified to illustrate the presence of the 60-cycle sidebands that cluster about each line frequency harmonic is shown in Figure 2. These sidebands change in relative magnitude corresponding to changes in the picture content in the vertical direction.

The composition of a TV signal illustrated in Figures 1 and 2 in terms of amplitude versus frequency can also be described in terms of amplitude versus time. A particular picture, for example two black bars on a white field as shown in Figure 4(a), is produced by the signal represented as amplitude versus time in Figure 4(b). In this diagram the negative pulse at the left, below black level, is used by the receiving set to actuate a circuit that moves the beam back to the left of the raster. Since this beam strength is low, the return trace is not visible on the screen. As the beam starts to traverse the field, however, its level is high, corresponding to white. To portray the first bar, its strength decreases as shown. It then rises to portray the white between the bars, lowers for the second bar, and increases for the final white strip.

There are only a few similarities between the objectives set up for telephone and those for television transmission. In both systems, for example, it is desirable that the frequency components be transmitted with the lowest economically feasible amplitude distortion and interference. Almost all other objectives are so different that they form a new set of characteristics: the bandwidth is of the order of 1,000 times the bandwidth of a telephone channel; the amplitude distortion requirements are about ten times as severe as for a voice channel, in spite of the wider band, and interference requirements are about three times as severe in television transmission as in telephony.

In addition, delay distortion requirements are infinitely more severe since delay distortion has essentially no limits on message channels. In the transmission of sound programs for radio broadcasting, some delay distortion requirements are necessary, but those used in television transmission are of the order of 1,000 times more severe. These relations between requirements for telephone and television transmission make it apparent that a television system must be more precisely engineered and maintained than a telephone or sound program transmission system.

Since color television signals are more complex than monochrome signals, they are correspondingly more difficult to transmit. The frequency composition of a typical NTSC* color signal is shown in Figure 6. Comparing this with the signal shown in Figure 1, it may be seen that the luminance portion (solid line components) is identical with the monochrome signal, and that the chrominance portion (cross-hatched line components) is interleaved between the luminance signal components. The largest chrominance component shown is the color subcarrier at 3.579545 mc. The smaller chrominance components on either side of the subcarrier are the sidebands produced when the subcarrier is modulated in phase and amplitude to provide the receiving set with hue and color intensity information. Each chrominance component is separated from adjacent components by one line-frequency interval, and each component is an odd multiple of half-line frequency. The color subcarrier itself is equal to 455 times the half-line frequency. Half-line frequency is 7867 cycles per second for color (7875 for monochrome) to reduce interference from intermodulation between the color subcarrier and the sound carrier at 4.5 mc. As indicated in the figure, the chrominance sidebands extend upward to 4.2 mc and downward to about 2.0 mc.

* National Television System Committee.

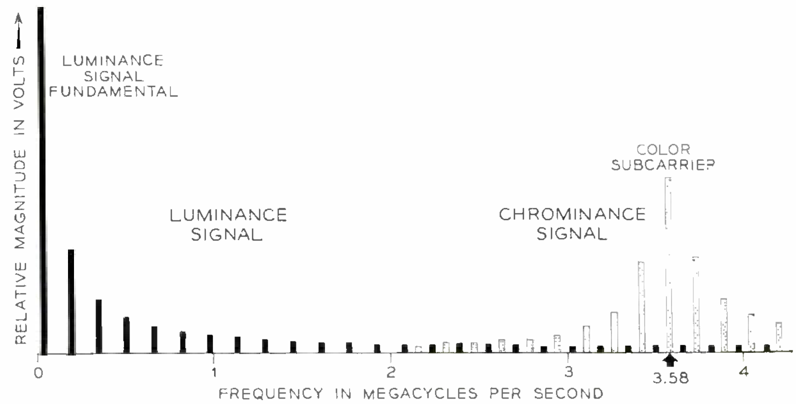


Fig. 6 — Frequency composition of a typical NTSC color television signal. One tenth of the components are shown.

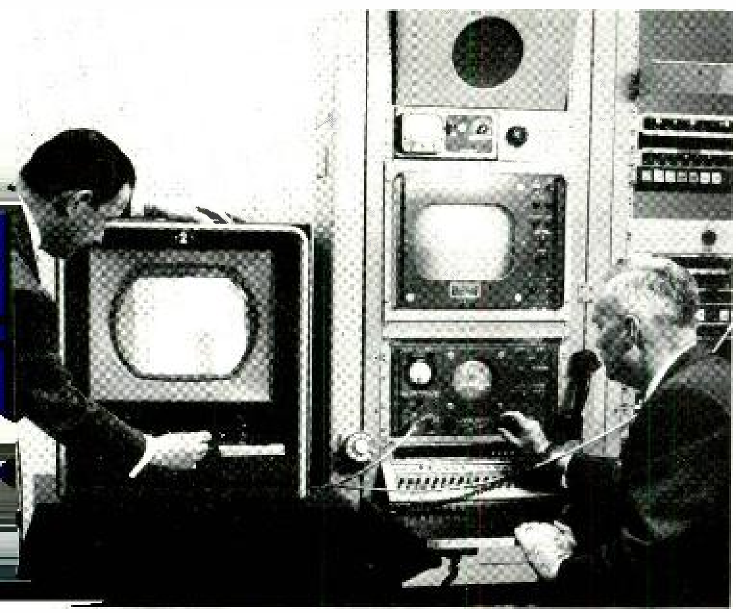


Fig. 5 — E. T. Fruhner, Long Lines engineer (left), and the author study a television color bar pattern.

In transmitting monochrome signals, it has been found that amplitude variations in the low frequency regions (60 cycles to 300 kc) produce more degradation than equal variations at high frequencies. Hence, specified transmission tolerances are larger in the 0.3 to 4 mc range than in the range below 0.3 mc. In a color signal, the amplitude of the color subcarrier performs approximately the same function that the amplitudes of the low frequency components perform for monochrome; that is, it carries information on the "saturation" of the color, while the low frequencies in monochrome carry most of the brightness information.

If large amplitude tolerances are permitted near the color subcarrier, intolerable variations in color saturations are observed in the color picture. Hence, amplitude variations at and near the color subcarrier must be restricted to approximately those that apply to the low frequency region, and the transmission problem involved is made correspondingly more difficult.

The second factor that makes color television transmission more difficult is the delay requirement. In this case, however, the differential delay characteristic — delay versus level — is of primary importance rather than the delay versus frequency characteristic most frequently referred to in wide band transmission. To understand this requirement, a further description of the nature of a color TV signal is necessary.

A color bar pattern as it would appear on the raster of a color television set is represented in Figures 7(a) and 7(b), the video signal corresponding to a time interval of one line. In Figure 7(a), various colors are indicated by their "brightnesses" as though the color bar pattern had been photographed in black-and-white. In 7(b) the first pulse is the line synchronizing pulse used to send the beam back to the left side of the raster. The next short burst of sine waves with an axis at the voltage corresponding to the monochrome blanking level is a synchronizing burst used by the receiver in decoding the signal. The next seven groups of sine waves with axes at different levels correspond to the seven color bars. Hue, saturation, and brightness information for each bar is carried in the phase, amplitude, and axis level, respectively, of these waves. The relationships are as follows:

(1) The phase of the group of waves representing a single color, measured with respect to the phase of the synchronizing burst, determines the hue of that color.

(2) The amplitude of the color carrier corresponds to the saturation of the color. The word "purity" has been applied to this characteristic and it indicates the extent to which the color approaches that of light of a single wavelength. Low purity (amplitude) would indicate dilution with other colors, tending to make the resultant move toward some shade between black-and-white.

(3) The level of the zero axis of a group of waves indicated by broken lines in Figure 7(b) representing a single color determines the brightness of the color. (Yellow and cyan have the highest zero axis levels and are the brightest colors in Figure 7. On the other hand, the waves representing blue, a dark color, have a low level axis.)

Signals corresponding to black-and-white are also shown in Figure 7. When the lower half of the color bar chart is scanned, the groups of sine waves disappear and the signal takes on monochrome characteristics. This is shown by the horizontal line at zero level corresponding to the black in Figure 7(a), and a similar line at the 100 level corresponding to the white area at the lower right of the raster in the same illustration.

Referring back to the groups of waves in Figure 7(b) representing the color bars, as indicated, these signals pass through a transmission system at different "dc" levels. Hence it is possible for them to be advanced or retarded slightly with reference to the waves of the synchronizing burst. When this occurs wrong hues are obtained in the resulting picture because, as stated, the phase of the group of waves determines the hue, and the phase is measured with respect to that of the synchronizing burst. Hence a new and severe requirement arises, namely that the phase relationship between the phase of the waves in the synchronizing burst and the phase of the color carrier waves must be preserved to within very close limits. These limits for over-all transmission from camera to receiving set have not been firmly established as yet but a change in hue due to a 5-degree phase shift can be detected visually. The term "differential phase" is applied to this phase shift versus level characteristic.

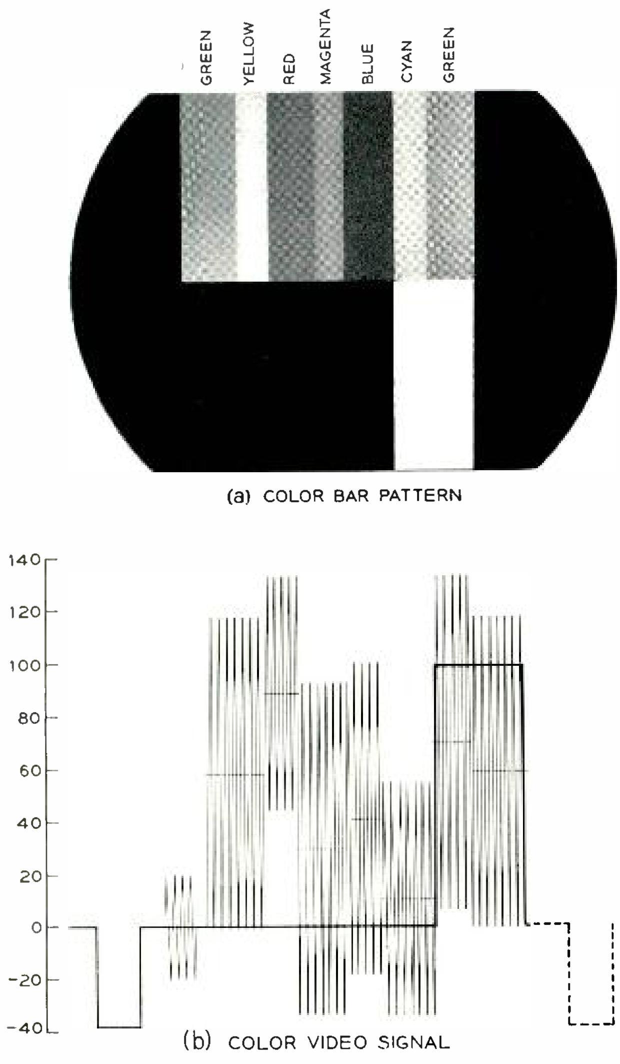


Fig. 7 — Representation of a color bar pattern (a) and the corresponding color video signal (b).

In brief, color television signals are more difficult to transmit because of the more severe amplitude requirements in the region of the color subcarrier, and because of the differential phase requirement. Other requirements are about the same as for monochrome although the importance of noise in the frequency region of the subcarrier is greater than that in the same frequency region for monochrome. In general the interference requirements are therefore somewhat more severe. The nominal over-all frequency bandwidth is the same.

The transmission systems provided by the Bell System for transmitting TV signals between studios, television operating centers in cities all over the United States, and telecasting stations are capable of giving satisfactory service for both monochrome and color signals, provided that the more severe requirements are applied for color transmissions. These more severe requirements mean, for the most part, better maintenance and, in the case of the differential phase requirement, a new type of maintenance requiring both new test equipment and transmission components. Since it appears that customer requirements will be for the transmission of monochrome and color signals in succession over the same circuits, it will probably not be feasible to have some circuits allocated solely to monochrome and some to color. Hence, the maintenance applied to all TV transmission systems must eventually be that which will be adequate for color. A program is now under way for making all television transmission circuits suitable for color signals.

THE AUTHOR

J. M. BARSTOW joined the Bell System via the Southwestern Bell Telephone Company during the summer of 1926 and became a member of A.T.&T.'s Development and Research Department in 1927. In his early work on noise evaluation and articulation tests, he was associated with the development of circuit noise and room noise meters and standards for noise measurement, at the same time working on coordination problems in joint studies with the Edison Electric Institute. During World War II he was engaged in several military projects both in this country and overseas. Since then he has been concerned with the development of the power line carrier telephone system and various problems associated with television and long distance telephone transmission. Mr. Barstow received the B.S. (1923) and M.S. (1924) degrees in physics from Washburn University and the University of Kansas, respectively. He is a member of the A.I.E.E., the I.R.E., the Acoustical Society of America, the Society of Motion Picture and Television Engineers, and Sigma Xi.

Dr. Kelly Named "Eminent Member" of Eta Kappa Nu

M. J. Kelly was one of three of the nation's leaders of industrial research to be initiated into Eminent Membership of the Eta Kappa Nu Association recently. The Association, an honor society for the electrical engineering profession, selected Dr. Kelly for his distinguished service in directing scientific research and for his many contributions to national scientific and military policy.

The two other engineers honored were Dr. W. R. G. Baker, vice president and general manager of the General Electric Company's Electronics Division, Syracuse, and Dr. Reinhold Rudenberg, professor of electrical engineering at Harvard University.

The induction ceremonies took place at a dinner meeting held January 18 in the Hotel Statler, New York.

Spectrophotometric Analysis

C. L. LUKE *Analytical Chemistry*

The Analytical Chemistry Group has developed highly accurate spectrophotometric methods, and these have proved valuable in providing analyses for both Bell Telephone Laboratories and the Western Electric Company. In transistor research, for example, these methods are used to measure minute quantities of contaminants in semiconducting materials. By passing light through a colored solution placed in a spectrophotometer, analytical chemists can determine the concentration of a dissolved substance, sometimes to an accuracy of one part in 100,000,000.

Because of the great variety of problems encountered by the Analytical Chemistry Group, many types of instruments are used, and new and more accurate techniques are constantly being evolved. Highly refined methods of analysis must be provided to serve the needs of other groups at the Laboratories and of the Western Electric Company. Many of these techniques have been described in two previous RECORD articles.*

With the development in the Laboratories of transistors and other devices employing semiconducting materials, methods had to be worked out for the determination of trace elements, or very small amounts of contaminants, in these materials. Since the chemical analysis of semiconducting materials presents many difficulties, special instruments and techniques must often be used.

One of the most successful of these techniques has been that of spectrophotometric analysis. In theory, this technique is simply a more precise form of the older classical visual colorimetry. By this older method, the concentration of a substance in solution is estimated from the intensity of the color of the substance itself, or of the color of a chemical compound of the substance. If, for instance, we want to find out how much iron is present in an acid solution of a zinc alloy, all we need do is to add sodium thiocyanate, whereupon the intense red color of the iron thiocyanate is formed. The concentration of the iron present in the original alloy can then be determined merely by comparing the intensity of this color with that of samples of known iron concentration.

Visual estimation of color, however, is very liable to errors, and in spectrophotometry, a photoelectric cell is substituted for the human eye. In addition to their accuracy, photoelectric cells have the ad-

* RECORD, *Nov.*, 1953, *page* 427; *Dec.*, 1953, *page* 470.

Above, as the first step in the analysis of germanium dioxide containing an unknown quantity of arsenic, the author is seen weighing out the sample of the compound.

vantage that they can detect light in the infra-red and ultra-violet regions, outside the range of human vision. They can also distinguish between colors when more than one is present in the same solution, a feat that is impossible to accomplish with visual colorimetry.

The arrangement of one type of spectrophotometer is shown diagramatically in Figure 1. A beam of light from a tungsten lamp is first directed by a series of mirrors to a quartz prism. Here the light is refracted and separated into light of the various wavelengths. By rotating this prism to the appropriate position, any wavelength of light can be selected. This monochromatic light is then reflected back and passed through an absorption cell containing a solution of the substance to be analyzed. The light is absorbed by the solution in proportion to the concentration of the unknown substance, and the intensity of the emergent light is measured by the photoelectric cell-potentiometer device. This intensity will thus be a measure of the unknown constituent. It can be used to determine concentration directly by means of the Beer Law calculation familiar to chemists, or more usually it is compared with a standard calibration graph, prepared beforehand by taking a series of samples of known concentration through the same procedure later used to analyze the unknown sample.

The measurement with the spectrophotometer, however, is only the final stage of the determination. To prepare for it, the chemist often must take his substances through a complex series of operations. A separation of the desired constituent from interfering metals may involve such familiar analytical processes as precipitation, distillation, solvent extraction, and electrolysis — each step performed under closely controlled conditions. In general, it is best to keep the number of separations at a minimum because of the ever-present problem of the purity of the reagents. This is especially true in the analysis of extremely small amounts of materials. Here, in fact, the purity of the reagent chemicals is usually the limiting factor in striving for great sensitivity. Ordinary distilled water, for instance, is not suitable for some of the operations preliminary to spectrophotometric analysis, and must often be purified further by special apparatus.

A few of the steps in an analysis, in this case for the determination of arsenic in germanium dioxide, are shown in the other photographs. It is now well known that the presence of a small amount of a contaminant like arsenic will greatly affect the electrical properties of transistors, and an accurate knowledge of the amount of arsenic present is of obvious importance. Spectrophotometric methods can detect arsenic in germanium dioxide with accu-

Fig. 1 — Diagram of spectrophotometer used for high accuracy analysis (right).

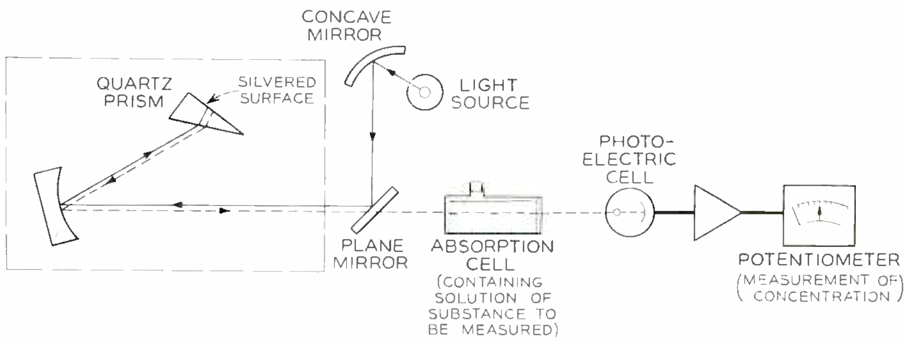


Fig. 2 — Preliminary to the actual analysis, a calibration curve of light intensity versus concentration is prepared. Miss Mary Campbell here transfers measured amounts of an arsenic solution to volumetric flasks.

racies approaching one part in 40,000,000, and phosphorus can be determined to even higher accuracies, up to one part in 100,000,000.

The determination of germanium contaminants is only one example of the wide variety of chemical analyses carried out by spectrophotometric methods. Two further illustrations will indicate the range of problems handled and will show in more detail the chemical processes involved.

A method was recently developed at the request of the Western Electric Company for the determination of traces of lead in copper metal. In this analysis a copper sample is first dissolved in dilute nitric acid. A large excess of a solution of ammonium hydroxide and potassium cyanide is then added to convert the copper and traces of zinc, nickel, and cobalt to colorless cyanides so they will not react with dithizone, a common organic color-forming compound used in the next step. Dithizone in a chloroform solution is then added, and the

Fig. 3 — At one point in the analysis, the arsenic must be separated from interfering ions by extraction into an organic solvent. The lower layer containing the arsenic is shown being removed.

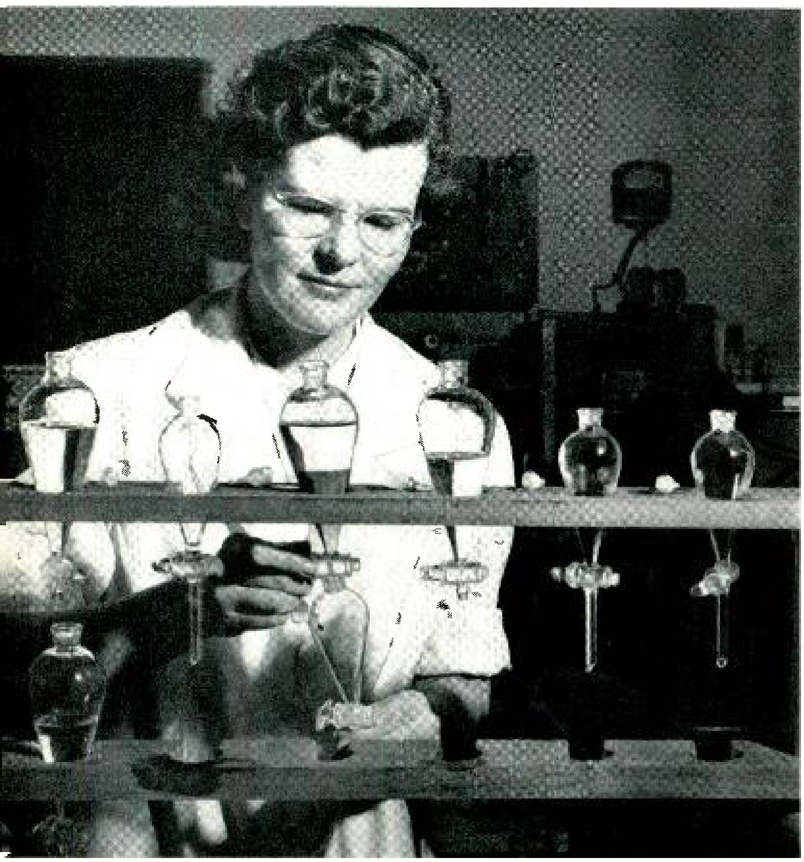


Fig. 4 — The test solution in an absorption cell is next placed in a spectrophotometer. The amount of light that can pass through this absorption cell is a measure of the concentration of arsenic in germanium dioxide.

solution is shaken until the lead is extracted as lead dithizonate. During the extraction, the color of the chloroform layer changes from the dark green of the dithizone to the cherry red of the lead dithizonate. This red layer is then drained into an absorption cell, and its color is measured with the spectrophotometer by using monochromatic light of 5150 Angstroms. The lead content of the unknown sample is then determined with the aid of a calibration graph that has been prepared in advance by analyzing, in the same manner, a series of copper samples of known composition.

Spectrophotometric methods have also been of use in the analysis of materials used in the construction of electron tubes. The composition of nickel cathodes must be closely controlled, and analyses have been developed for the determination of several metals that may be present in samples of nickel. The analysis for manganese is typical, and illustrates the ability of the spectrophotometer to distinguish between two colors when both are present in a solution. By this method, the manganese content can be determined without resorting to separations. The manganese is merely oxidized with periodate to produce the purple-colored permanganic acid, which is then measured spectrophotometrically with light of 5450 Angstroms. Such an analysis would be impossible by visual colorimetry because of the severe masking of the purple color by the green color of the nickel.

There is usually more than one spectrophotometric method available for a particular material. The choice of method to be used will usually depend on the amount of material to be determined and the amount and type of other materials present in the sample to be analyzed. In addition to its versatility, spectrophotometric analysis has many other advantages. Because of its high sensitivity, it is often possible to obtain an analysis on very small samples. In addition, it is often simpler, quicker, more accurate and more economical than many of the other methods.

THE AUTHOR

C. L. Luke became a member of the Laboratories staff on graduation from the University of Idaho in 1930 where he received his B.S. degree in Chemistry. Engaged in research and development of methods of chemical analysis, he is the author of several papers describing newly developed methods which have appeared in *Analytical Chemistry*. He is currently concerned with development of methods of analysis of trace impurities in semi-conductor materials. Mr. Luke is a member of the American Society of Testing Materials.

Frank B. Jewett Fellowship Awards

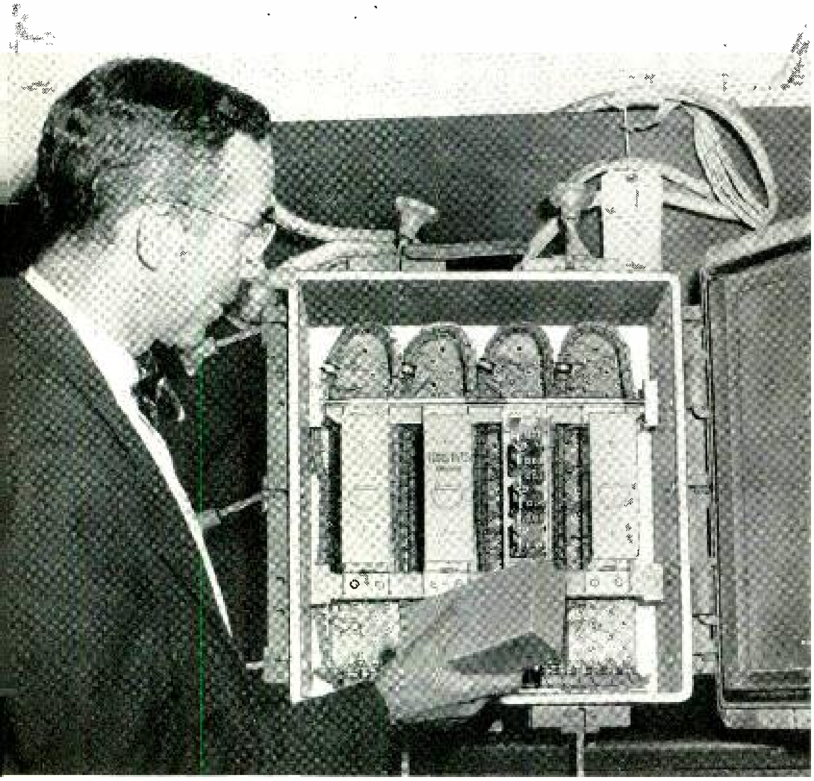
Five outstanding young scientists have been named by the Laboratories to receive the Frank B. Jewett post-doctoral fellowships for 1954-55. These awards are designed to stimulate and assist research in the fundamental physical sciences. The winners are: Dr. Stanley Deser of the Institute for Advanced Study and Brooklyn, N. Y.; Thomas Fulton of Harvard University and Cambridge, Mass.; Stanley L. Miller of the University of Chicago and Los Angeles, Calif.; Dr. Roger G. Newton of the Institute for Advanced Study and Buffalo, N. Y.; and Dr. Richard S. Pierce of Harvard and Mar Vista, Calif.

Three are physicists, one is a mathematician, and the fifth is a chemist. Dr. Newton and Dr. Pierce were among the award winners last year.

Grants for the fellowships were established in 1944 by the American Telephone and Telegraph Company, upon the retirement of the late Dr. Jewett as Vice President in charge of Development and Research. The awards this year grant $4,000 to each fellow and an additional $1,500 to the academic institution selected for his research.

Jewett fellows have conducted creative research at fourteen of the nation's leading centers of higher education, each recipient being free to select the institution he chooses for his research work.

The fellowships are awarded on recommendation of a committee of scientists from the technical staff of Bell Laboratories. Primary criteria are the research ability of the applicant, the importance of his proposed problem, and the likelihood of his growth as a scientist. The awards are post-doctoral, limited to those who have recently received doctors' degrees or who are about to receive them.



Emergency Transfer for Essential Services

J. H. CRAIG *Switching Engineering*

One of the major items in any national defense program is to assure continuation of essential communications during emergencies. Since the telephone is an important communication medium, provision should logically be made to maintain telephone service during such national emergencies. Bell Telephone Laboratories has provided such guaranteed telephone service through the development of emergency transfer facilities.

A bomb strikes! An entire section of a city is damaged and normal communications are likely to be disrupted. Confusion and disorder could easily prevail. At such a time, any interruption in communications could well mean disaster. The need is imperative and immediate for certain essential customers such as fire and police departments, hospitals, doctors, nurses, and all types of Civil Defense Personnel to maintain reliable communication. In such an attack, the telephone central office may have been damaged to the extent that only a trickle, or even no traffic at all, can be handled through it. How can these essential customers be provided with service under such conditions?

Several solutions come to mind immediately – radio, messengers, and special emergency telephone facilities. Speed is essential in organizing and conducting effective rescue work, and reliability of emergency communications is an important factor. Emergency telephone facilities, protected from damage and available immediately when a key is operated, provide an excellent solution.

How then can telephone service be maintained in the face of such an emergency? For one thing, it is expected that the principal need for this highly reliable telephone service will be in the heavily populated urban areas. These areas are generally characterized by a large number of scattered central offices, and wide use of underground cable. In these circumstances, complete destruction of all telephone service seems improbable, and it should be possible to transfer essential lines from a damaged central office to a preselected neighboring central office in an undamaged area. By providing equipment that normally connects essential customers to their "home" central office, yet during emergencies can transfer them to a neighboring office, the objective of uninterrupted service for essential customers will be reached. Figure 1 is a schematic diagram of such an arrangement.

Where there is no alternate central office, or in any case where it seems preferable, essential customers may be connected directly to other essential customers, or to a PBX (Private Branch Exchange). Figure 2 shows how this can be done. Magneto operation of ringing is provided where the customers are connected together directly. If a PBX is used, it supplies ringing current, and acts in a limited way as a substitute for the damaged central office.

To provide such transfer facilities as are shown in Figures 1 and 2, certain new circuits are required. The principal one is the switching relay circuit. This is arranged for remote control operation and, depending on the distance to the transfer key and the number of relays to be operated, can be used on 48-, 130-, or 260-volt sources. To provide reliable switching, the relays are U-type with twin contacts. There are protectors on the leads controlling the transfer relays, and a continuous test circuit automatically sounds an alarm for opens,

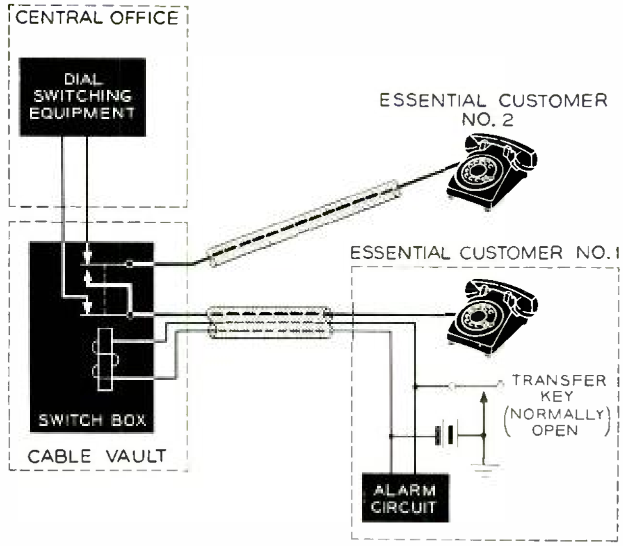


Fig. 2 — Emergency transfer facilities where one central office is replaced by a customer or PBX.

shorts, or grounds on those leads. In the event of a power failure, or the destruction of normal battery supply, standby dry battery power is available.

The switching relay circuit is arranged for use in either single-office or multi-office areas. For the

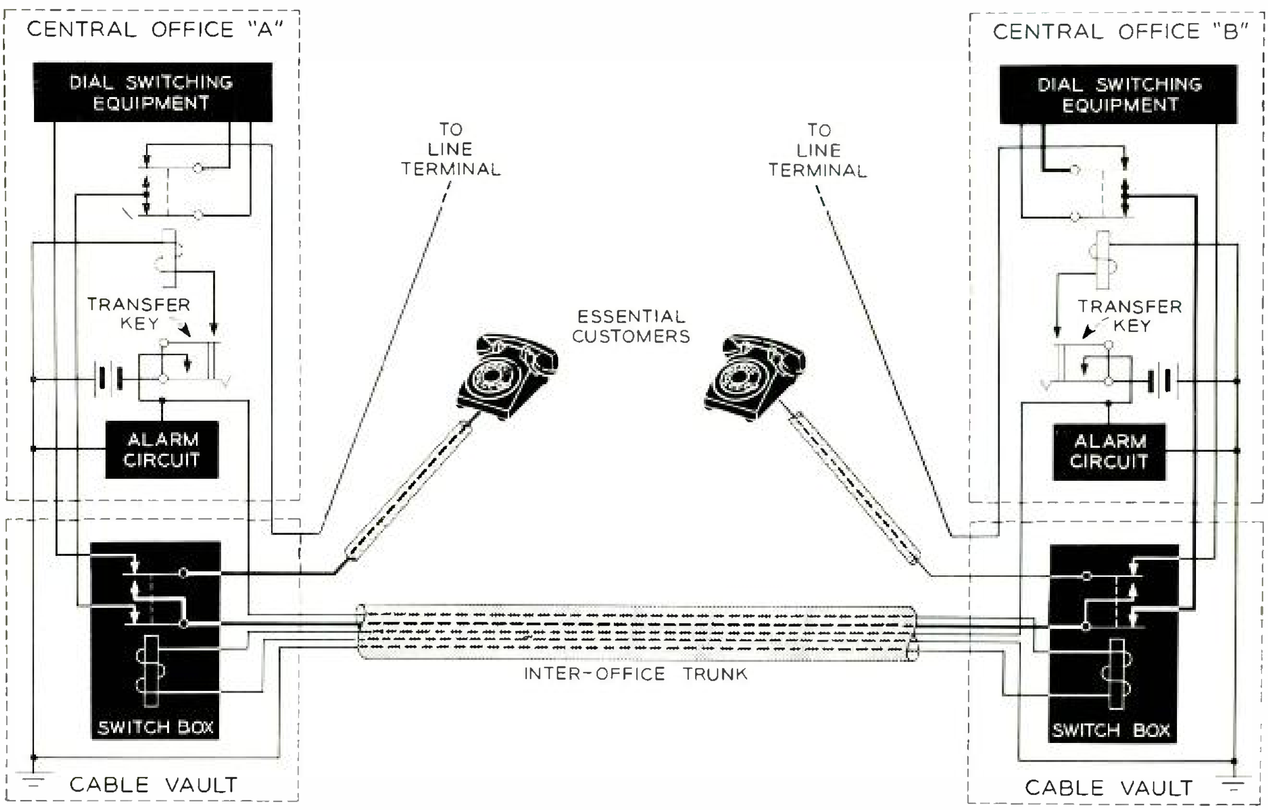


Fig. 1 — Block diagram of emergency transfer facilities between two central offices.

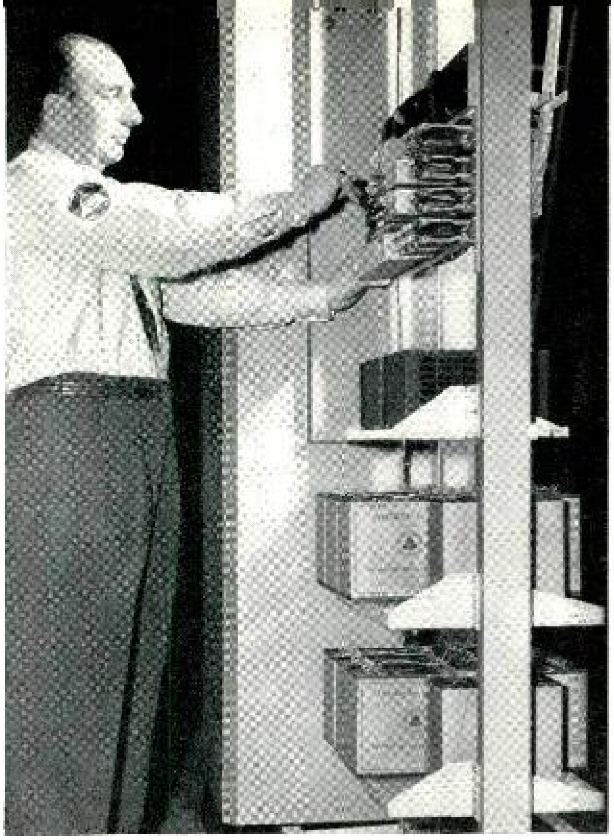


Fig. 3 — Edward Ammann of the New York Telephone Company shown with the central office switching equipment and power supplies for the emergency transfer facilities. The transfer key may be seen to the right of his hand.

latter, one switching relay circuit is required in the "home" office to transfer essential customers over to inter-office trunks to another office. Another switching relay circuit is then required in the far office to transfer essential customers over to the inter-office trunks from the damaged office.

In operation, assuming office A of Figure 1 is damaged, the transfer key at office B would be operated by personnel there. This operates switching relays in the manhole or cable vault at office A, cutting the essential customers over to the inter-office trunks. Switching relays at office B then connect these inter-office trunks to essential customers. The net result is to transfer essential customers at office A to the switching facilities of undamaged office B. The transfer key is located in the alternate central office B, outside the damaged area. A duplicate switching relay system and a control key in office A provide for the contingency of office B being destroyed.

For single office areas, only one switching relay circuit is required, as shown in Figure 2. In this case, the transfer key will be located on the premises of one of the essential customers. It is preferable for this to be a location using a dial PBX, since it can be used as a substitute switching center.

It would be quite futile to provide such elaborate precautions for emergency conditions, unless the switching relay circuits are adequately protected

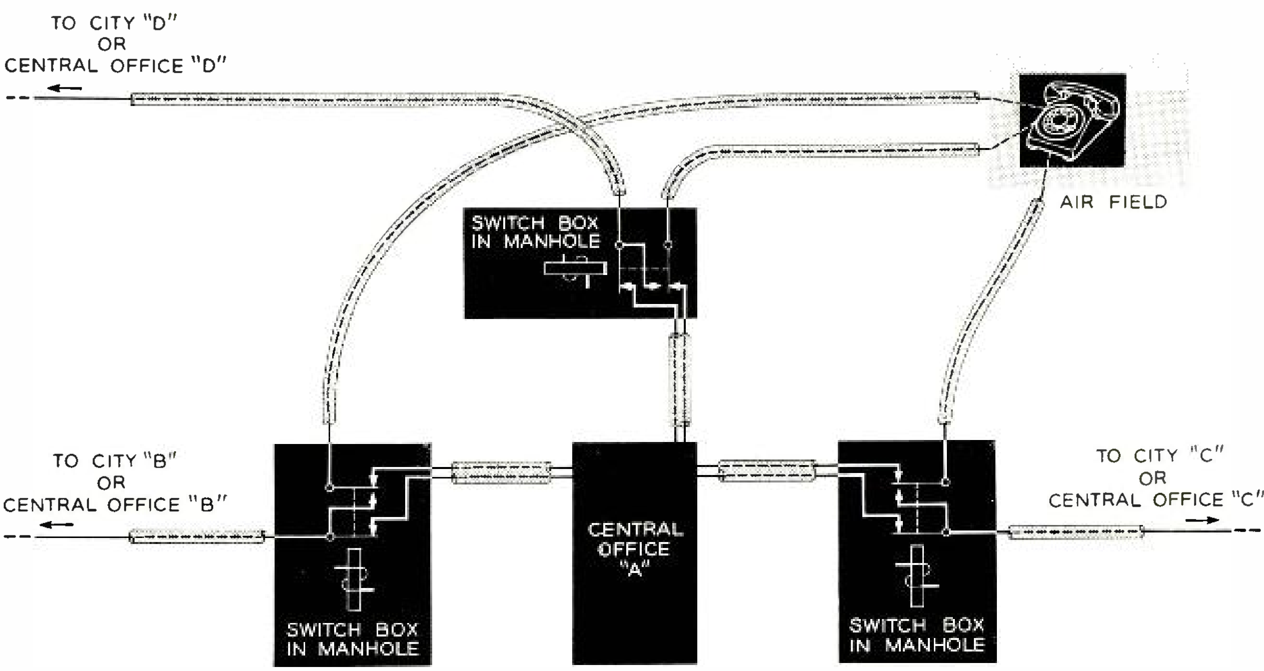


Fig. 4 — Diverse cable routes from an air field to a central office have separate transfer facilities, reducing the possibility of complete loss of communication.

from damage. For this reason, they are located in a manhole or cable vault associated with the "home" office. Being underground, there is little likelihood that bombs or falling buildings will damage the emergency circuits. Furthermore, apparatus required to transfer up to twenty-four circuits is mounted in a waterproof case, shown in Figure 3. The case is so wired that making appropriate connections inside it will include in the circuit the proper number of relays for the loop resistance and control voltage available. The protectors required for the control pairs are also located in this metal case. A larger number of circuits may, of course, be handled by using more than one case.

To insure a working path at all times, it is necessary to maintain a continuous test on the control pairs. This is done by a Wheatstone bridge and two polar relays, arranged to indicate opens, shorts, and grounds. Whenever one of these conditions occurs, an alarm bell sounds and an alarm lamp is lighted. An extension alarm circuit is available for use where the normal alarm location would be in an unattended station, and where it is desired to extend the alarm to a nearby central office. The transfer control keys are located on the alarm unit.

Many different applications will probably be made of this emergency service equipment, and many variations are anticipated. Figure 4 shows a possible military installation, with three different cable routes entering the "home" office A from different directions. Here the Army Air Field is located some distance away from the city. Damage to the "home" office would not disrupt essential military communication, but would provide a choice of three other cities to handle the necessary circuits. Sabotage of a cable could make such emergency service useless, but the provision of several alternate cable routes means that wide-spread cable-cutting would be necessary to cause serious trouble. While possible, this is not probable, and such an arrangement is an extra safety factor for emergency communication facilities

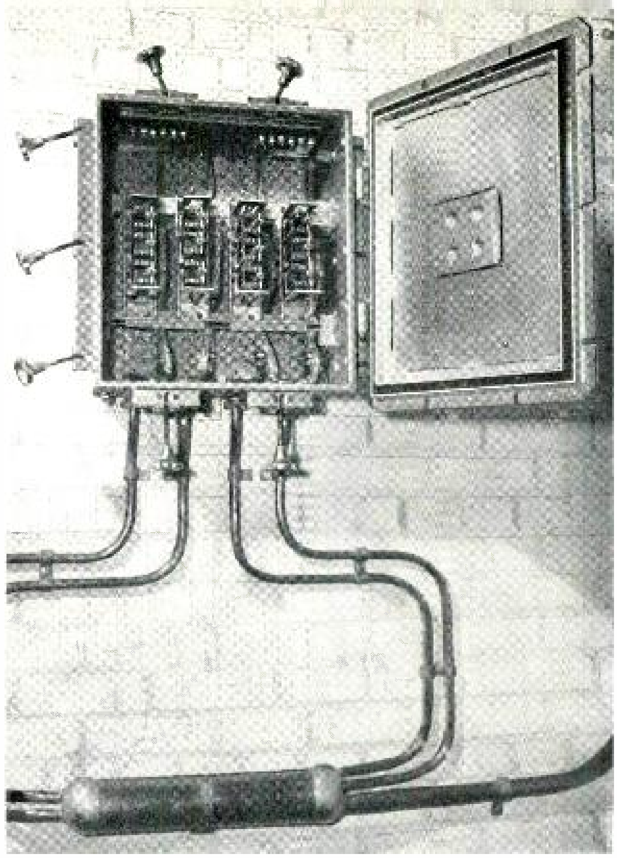


Fig. 5 — The transfer switching equipment in its protective case. This installation is on the wall of a cable vault in Hempstead, Long Island.

THE AUTHOR

John H. Craig was first associated with the Laboratories as a student in the M.I.T. cooperative course during 1937 and 1938 and the next year joined the systems department's trial installation group. He was a member of the technical employment and training group in 1940 and 1941. Following World War II work on airborne radar for the military, he turned his attention to the development of the control terminal and associated equipment for mobile telephone service. In 1949 he became interested in toll switchboard problems, and since July 1953 has been in charge of a group concerned with local dial systems including No. 1 crossbar, step-by-step, panel and community dial offices. Mr. Craig received the B.S. and M.S. degrees in Electrical Engineering from M.I.T. in 1939. While there he founded and was first president of the local chapter of Eta Kappa Nu, and for the past two years has been president of the New York alumni chapter.

Telephone Set for Hazardous Areas

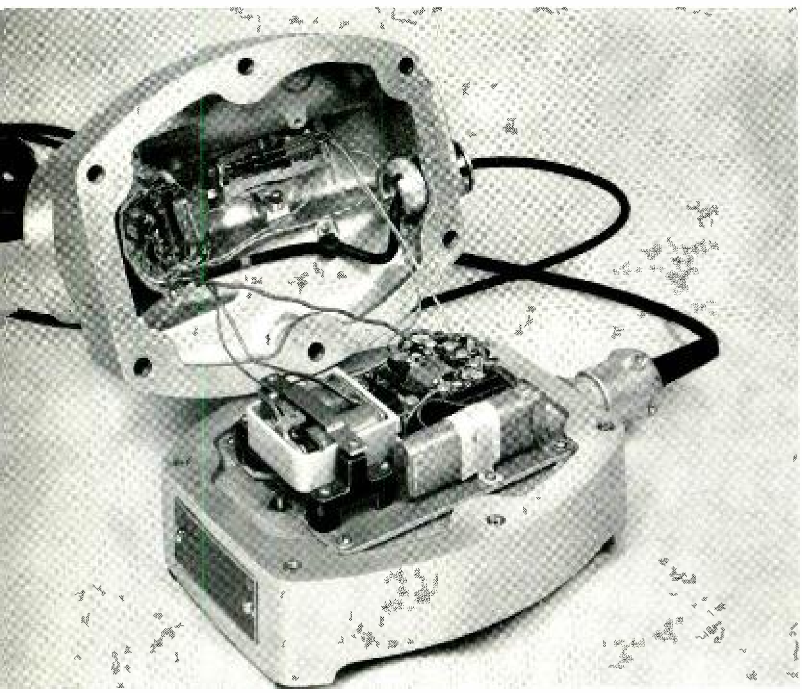


Fig. 1 — Induction coil, capacitors, and ringer are mounted in the base insert; switch and dial mechanisms in the cover. The screw-type shaft operating the clapper is on the left side of the base.

Although the standard telephone set is perfectly safe for all ordinary operations, a special set and special precautions are necessary when telephone service is required in areas where explosive gases may be present. In such areas, the small sparks that might occur inside a set could be dangerous. To meet such situations, the Bell System supplies the 320-type set*, suitable for either wall or pedestal mounting. The continued expansion of the chemical industries, however, and of such installations as the pumping stations located along pipe lines, has caused a demand for a desk-mounted set to supplement the previous model.

The KS-14476 telephone set, developed by the Station Apparatus Development Department, is desk-mounted and meets the requirements of the National Electric Code and Underwriters Laboratories for most hazardous areas. A Crouse-Hinds explosion-proof housing was already available, and

* Record, *October*, 1950, *page* 42.

into it Laboratories engineers have incorporated the Western Electric apparatus. The completely assembled set is shown in Figure 1.

Fundamentally, this set is designed not to prevent the ignition of explosive gases, but to prevent the escape of flame from inside the housing should any internal explosion occur. Even though the internal components might be damaged, the set itself will not constitute a hazard to the area in which it is mounted.

A critical factor involved in the design is the close tolerance maintained at the points where shafts enter the housing – for example, the shaft that operates the externally mounted clapper and gongs shown in Figure 2. A close-fitting bushing and a sufficient length of shaft ensure that any internal flame will be cooled to extinction along the side of the shaft before it reaches the outside of the set. To avoid excessive shaft lengths, however, the KS-14476 uses threaded shafts for the ringer and dial mechanisms, the effect of which is to provide a flame path around the threads of the screw equivalent to a much longer smooth shaft. When securely bolted together, the base and top cover of the set thus protect the outside atmosphere from any flame that might be caused by internal sparks.

Several other precautionary measures are taken. Two high resistances are bridged across the capacitor units mounted in the base, shown in the lower part of Figure 1, to remove any charges that might be stored in the capacitor before the set is opened. The transmitter and receiver units are so designed that removing the outside caps will not interrupt the circuit and create a hazardous condition. To prevent malfunctioning of the set's external elements, rigid metal conduit brings the line into the hazardous area, and fittings are filled with sealing compound. The rigid conduit runs to a Condulet fitting and the flexible line cord and hand-set cord enter the metal housing by means of special explosion-proof glands. Protectors with fuses in the line circuit are installed outside the hazardous area, additional protectors being required when the line circuit is near high voltages.

The installation and maintenance of this set are rigidly controlled. It is installed only upon proper authorization, and care is taken that the installation procedure does not create hazardous situations. Line connections are always disconnected before the set is opened, and to obtain full protection, periodic inspections are required so that broken or

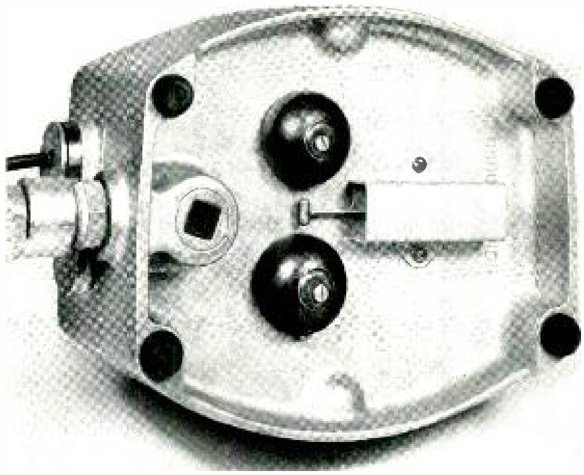


Fig. 2 — The clapper and gongs mounted on the underside of the base. Also shown are the sealing glands through which the line cord and the hand-set cord enter the set.

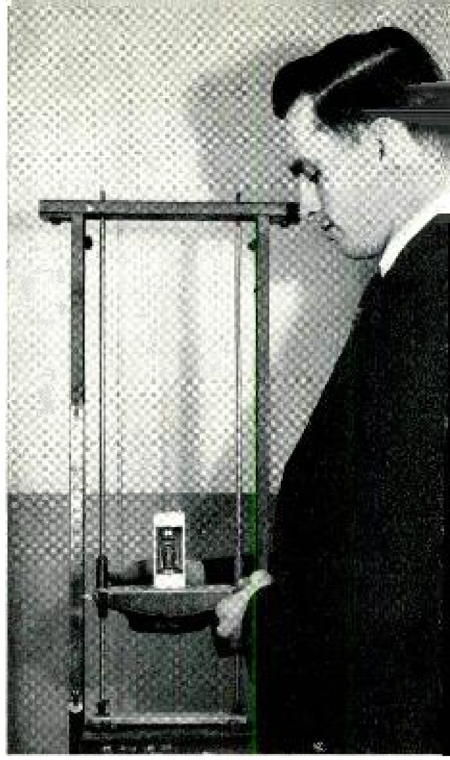
worn parts may be replaced, and other abnormal conditions, however slight, may be corrected without delay. Sets that require major repairs are taken outside the hazardous area.

C. A. Johnson
Station Apparatus Development

A Shock Tester for Small Apparatus

F. W. STUBNER *Electronic Apparatus Development*

Mechanical shock damage to electrical apparatus may occur in handling during manufacture, shipping, or during its service life. To determine the ability of electron tubes or other light equipment components to withstand the rigors of the anticipated conditions, a shock tester is used which is capable of providing information for a wide range of shock magnitudes and durations.



H. M. Langan operating the shoc testing apparatus.

A small shock testing machine producing well defined shocks of the desired magnitude and duration is extremely useful for investigating the shock resistance of equipment components. Even though not all components are subjected to shocks during their service life, they still must be designed strong enough to withstand shocks due to normal handling in manufacture and shipping.

Shock, as defined by Webster, is a blow or impact. It implies the transfer of mechanical energy from one body to another in a relatively short but finite time. In one of its simplest forms, one may visualize a single shock pulse to be of semi-sinusoidal shape having a certain magnitude and duration as indicated in Figure 1. This idealized shock pattern is the one most generally used to analyze and study the strength of structures. As will be seen later in this discussion, the magnitude, duration, and acceleration-time wave form of a shock may have significant effects on the structure that is being evaluated.

Mechanical shocks can be produced in a large number of ways and many machines have been devised to test resistance to shock. Unfortunately most of these machines produce shocks with a very complicated acceleration-time wave form, so that the test results obtained with them do not lend themselves to simple analysis. A mechanical structure tested on different machines may respond differently to shocks of the same nominal acceleration and shock duration. Due to the varying amount and character of high-frequency acceleration components produced by these machines, it is not possible to assign definite severity factors to the various machines to indicate the relative effects of shocks produced by them. A necessary condition for two test machines of different designs to give comparable results for any of a variety of mechanical structures being tested is that they both produce "hash-free" acceleration, i.e., a simple definable shock pulse without pronounced higher frequency components superimposed on this pulse.

A vertical shock tester, shown in this headpiece, has been used by the Electronic Apparatus Development Department for a number of years for checking the mechanical shock resistance of electron tubes. This tester has been patterned after the American Standards Association Shock Testing Mechanism for Electrical Indicating Instruments, but has been considerably modified to secure a larger range of shock acceleration and shock duration, and a shock pulse that is relatively free from higher frequency components. In its present form it consists of a cast aluminum table that is free to slide on two vertical rods as indicated in Figure 2. A steel anvil is attached to the underside of the

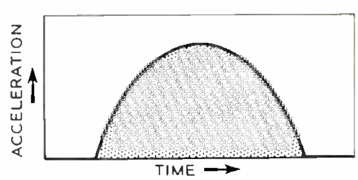


Fig. 1 — A shock is considered to be a simple shock pulse of sinusoidal acceleration-time relation.

table, and a flat strip of spring steel shown as the "leaf spring" in Figure 2, rests on the two steel supports so that it acts like a simply supported beam.

Drop tests are performed by rigidly clamping the test specimen on the table and letting the table fall freely upon the spring from a predetermined height. At the first rebound the table is caught by hand to prevent further shock of the specimen at reduced values. Since the mass and the frequency of the fundamental mode of vibration of the table are large in comparison with the corresponding parameters of the specimen and the spring, the acceleration of the table during the interval of its contact with the spring approximates a half-sine-wave pulse.

The peak table acceleration produced by the impact is equal to

$$G = \sqrt{\frac{2\,h\,K}{W}}$$

where G is measured in gravitational units (32 feet per sec per sec), h is the height in inches through which the table falls, W is the weight of the table and specimen, and K is the spring constant of the particular spring used. Four springs are available with different values of K to provide a wide range of acceleration. A closeup view of the tester is given in Figure 3.

Figure 4 illustrates the shape of a typical acceleration pulse produced by a drop on one of the springs, and also the strain induced in the spring by this drop. The center trace is a 1,000-cycle timing wave. The acceleration-time trace was recorded with a Westinghouse Quartz Crystal Accelerometer in conjunction with a 5,000-cycle low pass filter. The filter was used to suppress signals due to the 20,000-cycle fundamental resonant frequency of the accelerometer, which is excited by the initial impact of table against spring. The strain-time trace was obtained with strain gages fastened to the center of the underside of the spring.

The accelerogram shows a predominant frequency of approximately 5,000 cycles superimposed on the shock pulse. This high frequency is that of the fundamental mode of the table, excited by the metal to metal impact of table and spring. It is sufficiently high to have no influence on most tube structures tested on this apparatus. The strain curve illustrates the stress produced in the leaf spring by the table impact and the higher frequency post shock vibrations of the spring after the table has left contact with the spring.

The relation of height of fall of the table versus the maximum acceleration obtained for a given spring is usually presented in graph form for ease of use. Figure 5 shows this relation for a typical spring and several values of specimen weights. These curves are merely plots of the equation for the same value of K but different values of W. They represent the maximum value of G to which the test table itself is subjected by a drop, and thus for any object rigidly fastened to it such as a tube envelope. The effect of this acceleration on various elements within the tube may be greater or less than these values by an amount indicated in Figure 6*. This curve shows the relation between amplification factor Δ and the ratio of the duration of impact of a half-sine-wave pulse to the natural half-period of a specimen, (T_2/T_1). The amplification factor is a measure of the ratio of dynamic stress to static stress on a specimen; that is, the static stress calculated from maximum acceleration alone, when multiplied by the severity factor gives us the maxi-

* Bell System Technical Journal, *July*, 1945, *page* 353.

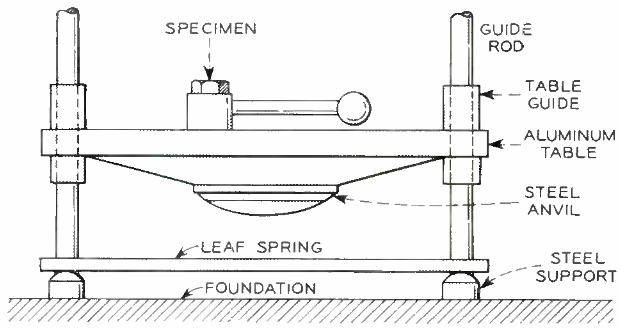


Fig. 2 — Schematic of the test mechanism.

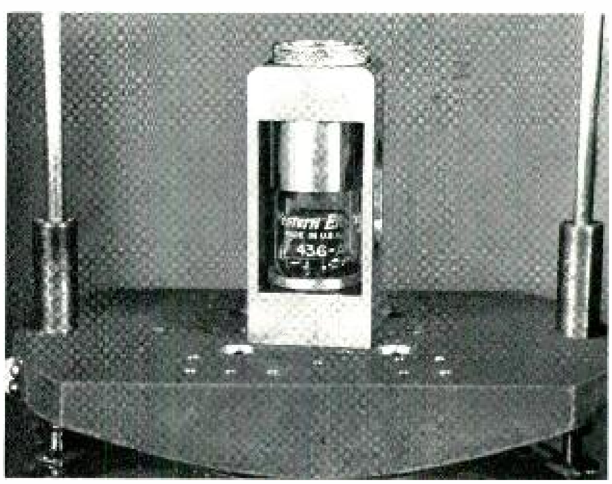


Fig. 3 — A closeup view of the shock test table with a 436A electron tube in place.

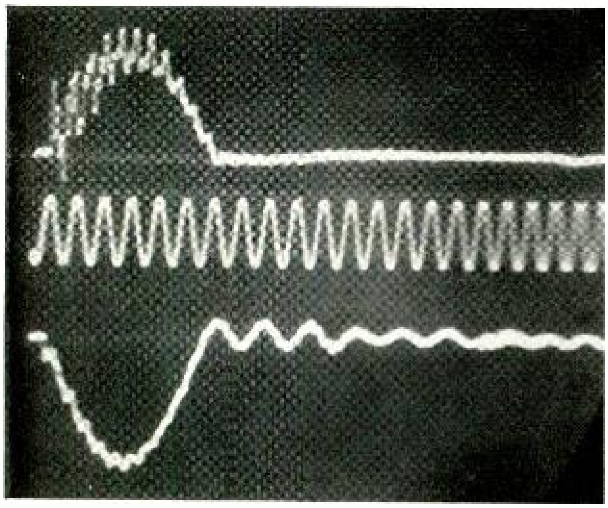


Fig. 4 — An accelerogram of the acceleration of the table during a test and the corresponding strain in the leaf spring. The center wave is a 1,000-cycle timing wave.

mum dynamic or transient stress for values of T_2/T_1. The curve shows the relations for a system with one degree of freedom and no damping. Internal damping, inherent in any mechanical system, will reduce the severity factor depending on the amount of damping. It should also be borne in mind that the amplication factors for shock pulses other than the semi-sinusoidal case considered here differ from that shown in Figure 6.

The relatively simple structure of the Western Electric 249B electron tube may be used to illustrate the above relations and the purpose of employing the various stopping springs in investigating the responses of structures to shocks of given durations. Figure 7 shows the outline of this tube and the mechanical equivalent of its anode and heater structures. The lowest resonant frequencies of these components are 200 cps and 120 cps, respectively. If the tube is to be subjected to a shock of a certain magnitude and 7 ms duration, in a direction perpendicular to the tube axis, then the severity or amplication factor for the anode is 1½, while the factor for the heater structure amounts to 1¾. That is, the maximum dynamic stresses produced in these components by the shock acceleration will be 1½ and 1¾ times (respectively) higher than would be attained by a static (e.g., centrifuge) test carried to the same nominal acceleration as the peak shock magnitude.

When the shock duration is shorter than the half-period of vibration of a specimen, the maximum strain occurs after the peak of the impact. To demonstrate this, a small cantilever beam was constructed having a fundamental frequency of 90 cps (half period of vibration = 5.5 ms). A strain gage was fastened near the clamped end of this beam. The strains recorded by this gage as a result of a 4 ms shock, imparted to the clamped end of the beam, are illustrated in Figure 8 together with the acceleration pulse. A double beam oscilloscope was used to illustrate the phase relations between the shock and the resulting stresses in the beam. The small decay of the post shock vibration is due

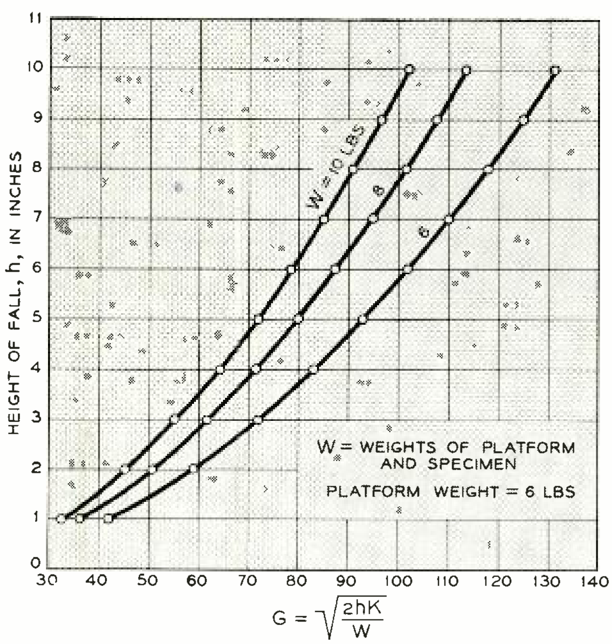


Fig. 5 — Plot of maximum acceleration against fall in inches for three values of weight.

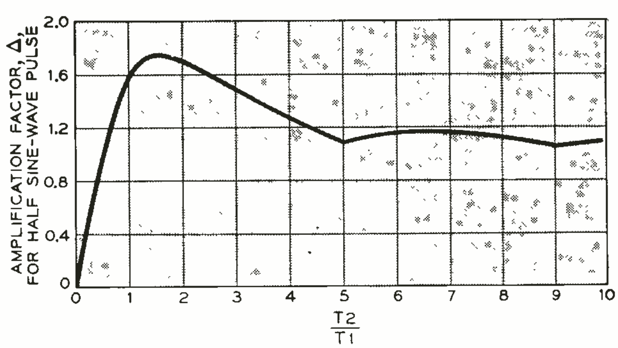
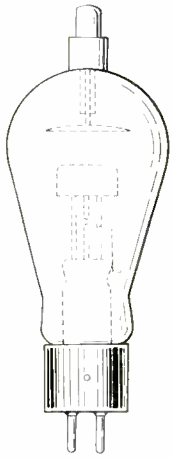


Fig. 6 — Plot of amplification factor against the ratio of the duration of the shock pulse to the natural half period of the specimen.



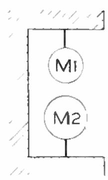


Fig. 7 — Outline of the 249B tube and the mechanical equivalent of the anode and heater structures.

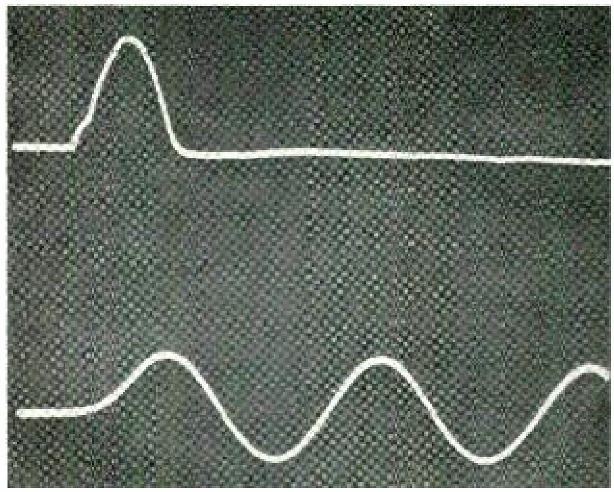


Fig. 8 — Phase relation of shock pulse and cantilever response.

to the small damping inherent in the steel beam.

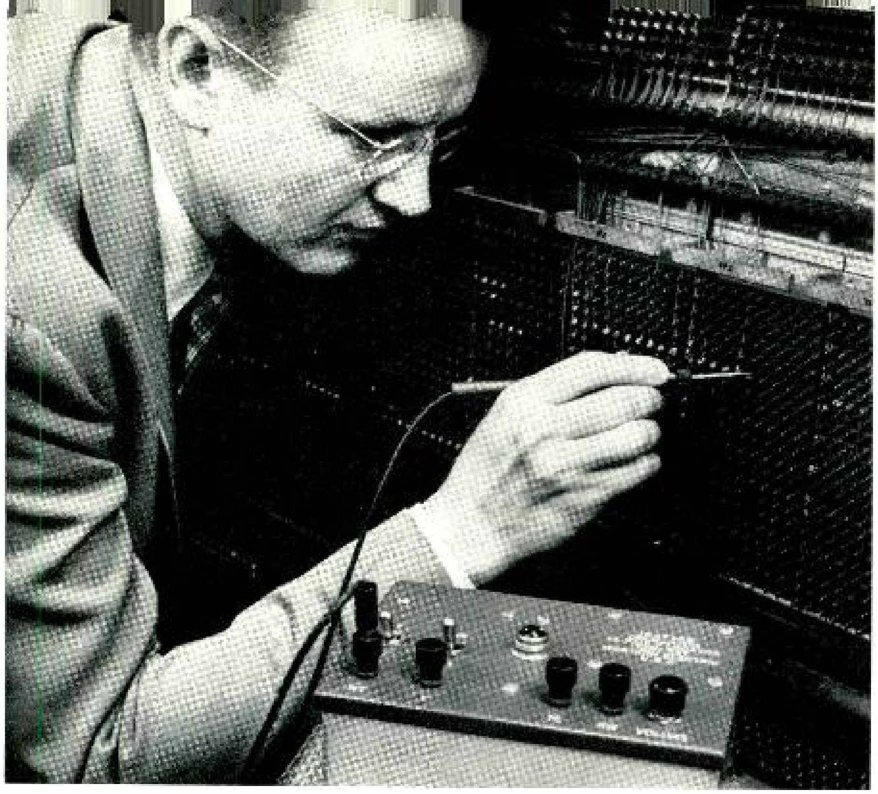
The vertical drop tester is used by the Electronic Apparatus Development Department primarily for shock testing light electron tubes, but it is equally practicable for shocking other light equipment components. The maximum specimen size and shock capacity of the tester is largely limited by its physical size and the maximum permissible stresses produced in the leaf springs by the table impacts. The maximum load rating is nominally given as four pounds.

Although the shock characteristics of the tester can be predicted closely, certain conditions must be met. For practical purposes these conditions are met for the thinner springs if the tester is mounted on a solid foundation, but the losses become progressively higher for heavier springs and loads. In addition, the relative magnitude of the high-frequency components superimposed on the shock pulse increase with the stiffer springs. In many applications these very high frequency vibrations are sufficiently attenuated before they reach the specimen under test. In testing electron tubes, the response of most tube elements to these frequencies is negligible. There are, however, structures, such as brittle carbonized filaments, which are highly sensitive to sharp impact and high frequency vibrations. Results obtained in testing such structures, therefore, may lead to erroneous deductions, unless properly interpreted.

In spite of the above limitations, the tester is a very useful instrument since its shock output, which can be varied over relatively wide limits, is reproducible and of simple wave form. If necessary, acceleration checks may readily be made for given conditions before proceeding with the tests.

THE AUTHOR

F. W. Stubner received his B.S. degree from Cooper Union in 1930. The preceding year he had become a member of the Laboratories' research drafting department. In the capacity of design engineer he was concerned with the design and building of apparatus and testing equipment for telephone instruments and submarine cable. Transferring to the Electronics Apparatus Development Department in 1940, he worked on the design of vacuum tubes, magnetic switches, and glasswork for the carbon deposited resistor. Since 1944 he has been associated with the applied mechanics laboratory, responsible for strength tests on vacuum tubes, shock and vibration studies, and associated design assignments. In 1948 he transferred to Allentown, Pa. Mr. Stubner is an associate of the I.R.E., a member of the Engineers' Club of the Lehigh Valley, and a member of the Society for Experimental Stress Analysis.



Locating Conductor Faults with Sound "Whistler"

A. MAJLINGER *Switching Systems Development*

The "whistler" principle, which has been used by Western Electric and Operating Companies to locate conductor faults, is the basis for a new test set designed at the Laboratories. This test set provides a standard instrument that incorporates improvements gained from the experience of earlier designs. In the operation of the whistler, the distributed capacitance of a conductor under test is used in a "tank" circuit that will oscillate over the audible range of frequencies. The pitch (whistle) of the tone, or its absence, determines the type of trouble. A second process of placing a steady 500-cycle tone on the faulty conductor, and of tracing this tone with a probe, locates the specific physical position of the fault.

Inside a modern telephone office there are many miles of conductors used for completing talking or signaling circuits, and these must be kept free of troubles. Maintenance of such conductors becomes especially important when they serve as connecting paths between common control equipment – circuits that participate only briefly in a telephone call and are used very many times over during a busy-hour. A conductor that is open, crossed, or grounded in a common control switching path could seriously affect a large volume of telephone traffic. Detecting such troubles in connecting paths and in multiple wiring has always been a problem to the maintenance forces. Automatic maintenance test equipment built into crossbar switching systems tells that a trouble exists, but it does not ordinarily indicate its specific location.

To locate these kinds of trouble, a new and efficient method ("whistler") was devised by the Western Electric Company. This set has been used to make integrity checks of newly installed conductors in crossbar office units or additions in existing offices, and assures the installer that his work is free of trouble crosses and opens. Other whistlers employed by Operating Companies have been useful for locating circuit troubles quickly in permanent installations. To provide a standard instrument for Western Electric and all Operating Companies, and to effect improvements that their experience has indicated, a new fault locator test has been designed at Bell Laboratories. In addition to detecting conductors having faults, this set also aids in locating the actual point of the fault along the connecting path.

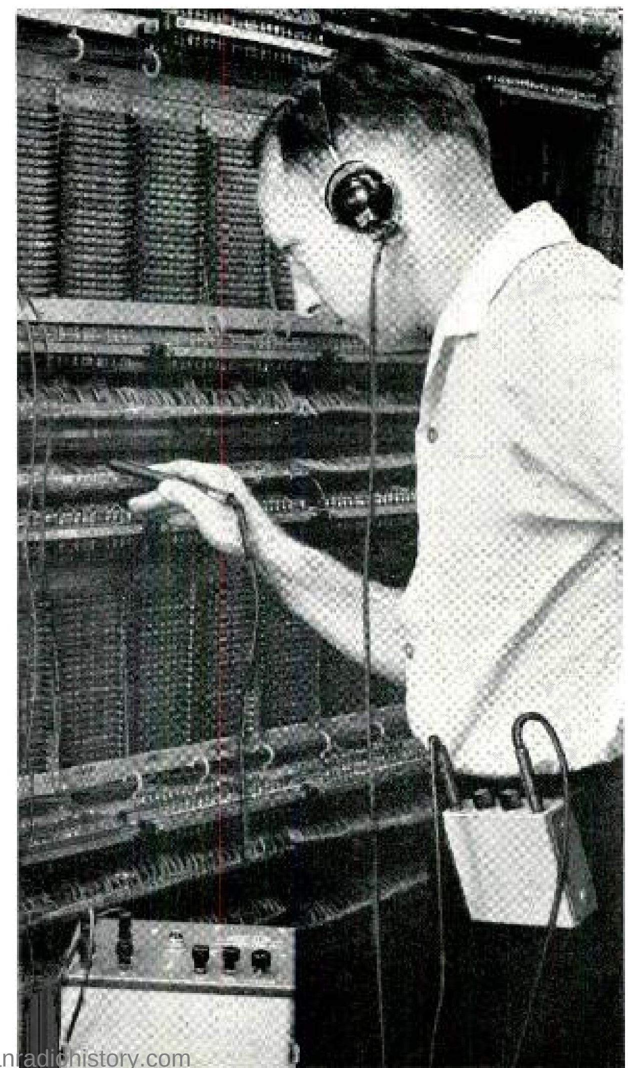
Unlike more familiar test sets that ordinarily depend upon visual readings, the new set determines the trouble condition on the faulty conductor by a "whistle," or audible tone whose frequency changes in response to trouble conditions. The pitch of this whistle tells whether a conductor has a fault, and it also tells what fault of the three – open, cross, or ground – it is. The model developed at the Laboratories is called the 1A fault locator test set, and has become a valuable maintenance tool, particularly for finding and clearing troubles in complex switching systems of the crossbar type.

There are a great many groups of paths in a crossbar office. In any particular one of these groups the conductors are uniform in length and are arranged in bundles called cables. The conductors in a particular cable normally have similar capacitances to ground, and it is this characteristic of the conductor that is necessary and sufficient to operate the test set. From this capacitance, the set determines whether any of these conductors has a capacitance different from all the rest in the cable. At the same time it tells whether the capacitance is too much (cross) or too little (open). After it accomplishes the task of finding the faulty conductor or conductors, it is able, if the fault is a cross, to locate the fault precisely.

Since trouble-free conductors with the same length have similar distributed capacitances to ground, this capacitance can be used in an oscillator circuit to produce sounds of about the same pitch. However, a conductor that has become crossed with another in the group produces a lower pitched whistle; a conductor that has become crossed to ground or to a conductor carrying battery produces no whistle at all; and open conductors produce a higher-pitched whistle. On crosses to battery or ground, moreover, the oscillator will indicate the fault even if it is through a contact resistance that is several times that of the conductor under test.

The oscillator is designed for speed and ease of application on a test. The headpiece and Figure 4 show the layout of its top panel. To the left is a toggle switch with the two positions W (whistle) and T (tone). The W position prepares the oscillator for whistling to find the faulty conductor and to identify the type of trouble. The T position arranges the oscillator circuit for supplying the 500-cycle tone, used in the second operation of finding the actual location of the trouble. Another switch next to it selects either the high or low range for whistling; this switch remains in the low range position for the 500-cycle tone. Four connecting terminals are located in a row at the bottom, and the volume control is at the extreme right. The ground-indicating pilot light is in the center of the panel. A three-conductor power cord provides ac and ground connections into the oscillator. An adapter and its associated grounding clip provides for power outlet operation.

Fig. 1 — Here the probe is being used by W. W. Connick to determine the actual location of two crossed conductors in a cable.



The basic circuit and its fundamental components in a typical application are shown in Figure 2. The tank circuit consists of capacitor C1 in the oscillator, the distributed capacitance C2 of the cable, and inductor L in the oscillator. A part of this tank circuit is selected by switches; for whistle testing, capacitance C2 is used, whereas for generating the 500-cycle tone, C2 is replaced by capacitor C3, and in this case the circuit is completely in the oscillator. In either case the switched element is capacitance, which combines with the inductive element to produce a characteristic frequency of oscillation.

For the whistler operation the tone is amplified so that it can be heard from a loudspeaker associated with the oscillator in another part of its circuit. The loudspeaker, located in the oscillator case, has a wide frequency range but is most effective from 300 to 3,000 cycles per second. When the oscillator is used for the tone source, however, its output is connected to a faulty circuit in which a cross exists. Two terminals on the top panel of the oscillator provide a connection to a telephone circuit for listening at a remote point. When making continuity tests of conductors extending over several floors, this remote listening connection speeds the work because both men hear the tone through the common talking circuit. Finally, the ranges of the oscillator permit testing conductors varying in length from a few inches of wire to ten thousand feet in two steps. Two switch positions are sufficient to take care of testing the ten thousand feet of wire. An intermediate point is chosen at approximately one thousand feet, since wire lengths beyond this are only occasionally encountered. Hence, the high range is mainly for testing on multiples where the equivalent build-up of wire approaches ten thousand feet.

The complete 1A fault locator test set is shown in Figure 3. In the upper right of the figure is the oscillator (the featured item in the set) and below it are its associated cords, including a pick used for whistle testing. The amplifier is at the left and the probe and special telephone receiver, which are associated with it, are at its right. The belt clip and shoulder strap used for carrying the amplifier, and the strap used for fastening down the oscillator, are in the center. The carrying case that houses all of these items is at the top left. The weight of the amplifier is 2 lb and the oscillator 4 lb; the complete set in its carrying case weighs 12 lb.

The procedure for using the oscillator on a test is as follows: The oscillator is placed near the test position, and the power plug is connected to a 115 volts, 60-cycle source. The ground clip associated with this plug is then connected to a convenient central office ground. The pilot light, when lighted,

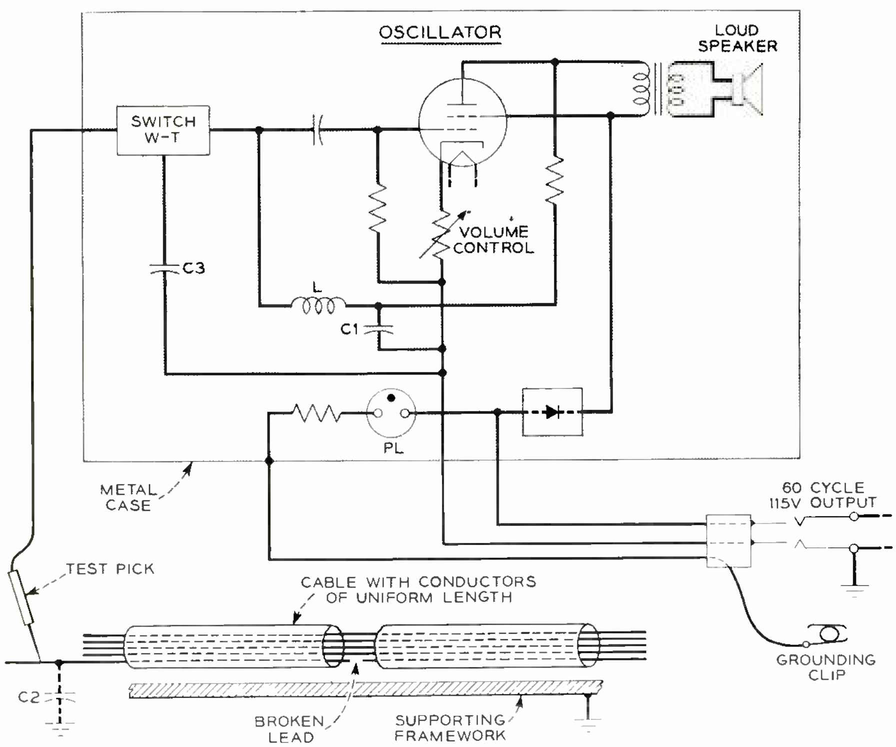


Fig. 2 — Schematic of test oscillator showing connections for determining a faulty conductor. The test pick is applied successively to each of the conductor terminations.

Fig. 3 — The 14 fault locator test set showing the component parts. The carrying case holds all of the elements for easy transportation.

shows that a proper ac ground connection has been made into the oscillator; in offices that do not have polarized power outlets, the power plug may have to be reversed for the lamp to light. This ground is important since it provides the return path for the ground side of the conductor circuit under test.

After a slight warm-up time the test man sets switches to the low range whistle testing positions and adjusts the volume to a convenient level, or better still to no sound at all, for locating faults on open-circuited conductors uniform in length. Under this adjustment the oscillator cuts in only after application of the pick to a conductor under test; otherwise it remains off. This method is preferred because others who are working in the vicinity could be distracted by a continuous sound. To establish a reference pitch, the test man touches the pick to several terminations of the conductors in a group chosen to be tested for faults. He now is ready to methodically test all of the conductors in the group. This type of test is illustrated in the photograph shown on page 102.

One of the desirable properties of the oscillator arranged as a whistler is its ability to detect troubles in working circuits without interfering with service. For example, in No. 5 crossbar number group circuits,* a single cross could cause serious interference to the flow of terminating traffic for as many as 1,000 customers, if one of these circuits had to be removed from service even temporarily to clear the trouble. A typical trouble may be a cross in the multiple wiring in a multicontact relay or the locking or shorting of one contact on the relay. The cross on the multiple may be handled like a cross between two conductors, but the locked or shorted contact requires special treatment. Since one side of the circuit involving the locked or shorted contact is determined by analysis of information on trouble record cards, the other side of the circuit involving the lock must be located. It is necessary to know any two points in the circuit involving the trouble lock or short, for only then can the oscillator 500-cycle tone be applied with the current flowing through the lock or short. A simple way of finding the unknown side is to attach the oscillator to the known terminal and allow it to whistle. Then terminals in the number group fields are contacted with a high resistance to ground: first, any terminal in the vertical or horizontal group field; second, any terminal in the ring-

* Record, *July*, 1950, *page* 298.

ing combination and vertical file field; and third, any terminal in the line-link field. One of the three points contacted will cause the whistle to stop. It is only necessary to contact any terminal out of all of the terminals in a particular field since they are all electrically tied to each other. This identifies the other point in the circuit, and now a complete circuit path is known with the trouble at some unknown point in it. Now the point of lock or short in this circuit can be located by applying the 500-cycle tone between the point analyzed from the trouble record cards and the one found by applying the whistler; the probe leads the way to the wiring at the locked contact.

To locate a cross between two conductors, the oscillator is connected to both conductors, as in Figure 4, and the selection switch T (tone) is operated. This applies a 500-cycle tone to these conductors through the trouble cross. This tone is traced to the trouble cross by using a probe, amplifier and receiver as shown in the same figure. The amplifier (powered with hearing-aid batteries) may be conveniently carried with the shoulder strap or belt clip. The probe, which is about as long as a pencil and about double its diameter, is held (at 90 degrees) adjacent to one or both of the conductors involved in the cross that is carrying the 500-cycle current. The probe is moved along the conductor until the tone disappears in the telephone receiver, and this locates the cross. A small inductor in the probe picks up the 500-cycle tone in the faulty conductor and delivers it to the amplifier; the output from the amplifier is heard in the telephone receiver. The amplifier can be turned off by merely disengaging the plug associated with the cord to the special telephone receiver.

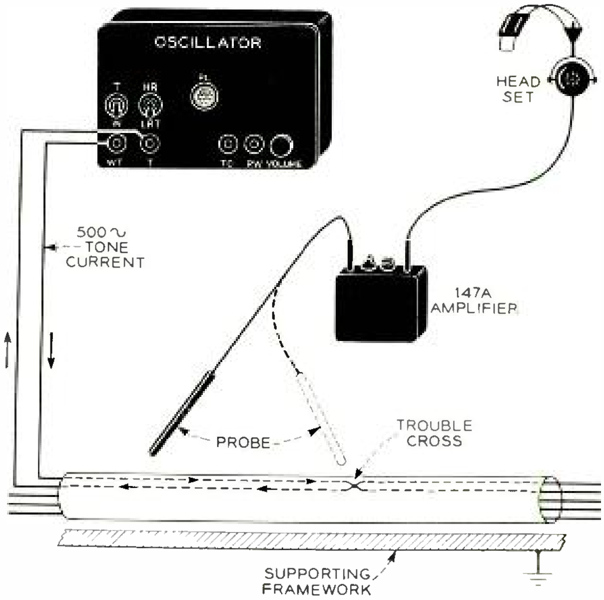


Fig. 4 — Test arrangement of 1A fault locator test set for locating a cross on two conductors. When the probe passes the cross, the 500-cycle tone is no longer transmitted to the headset.

Trouble crosses to battery or ground are treated like crossed conductors except for a gain adjustment in the amplifier. These trouble crosses produce a more extensive field, hence the sensitivity

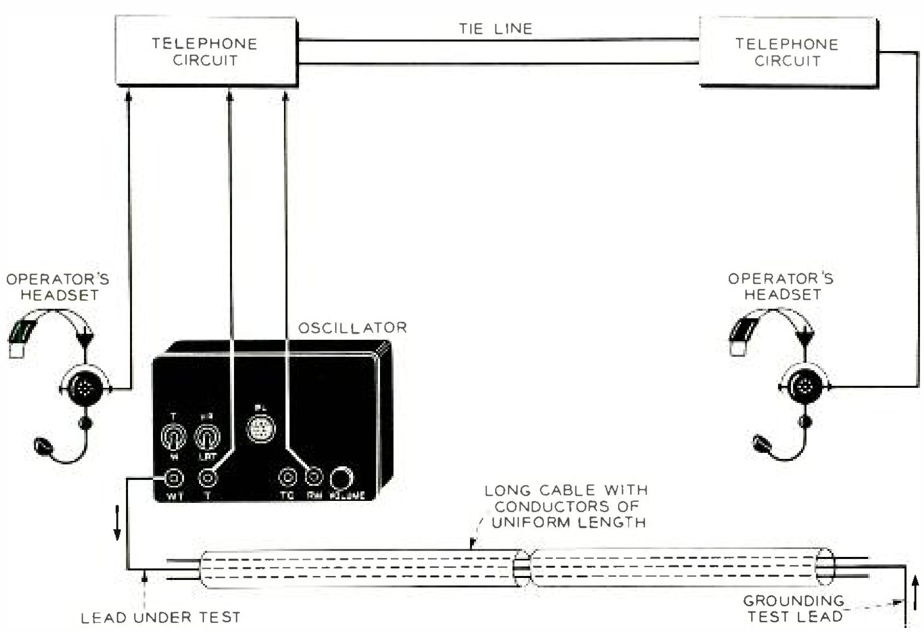


Fig. 5 — Circuit scheme used for determining the continuity of conductors in a long cable. When the cable terminations are in positions remote from each other, a telephone circuit is used for the transmission of the whistler tone.

of the probe must be reduced. Now it is necessary to hold the probe close to the trouble conductor, thereby reducing the influence of stray fields in adjacent battery or ground leads. This is required since the battery or ground lead involved in the cross may be connected to other conductors near the conductor under test.

Figure 5 shows how the test set can also be used by two men to make continuity and cross checks (integrity) on conductors between terminations. This test may be done in one of two ways depending upon distances involved: (1) when both men are within audible range of the loudspeaker associated with the oscillator, or (2) when they are stationed remotely for tests on long conductors, in which case, they must be in telephone communication with each other. On tests of long conductors, some of the output signal from the oscillator circuit is superimposed on the telephone circuit, and thus the test man at the far end also hears the characteristic whistle. When the test man at the far end hears the correct whistle he applies ground to the conductor. If the whistle stops, it indicates that the conductor is continuous.

By means of the procedure described, a group of conductors uniform in length may be quickly checked for integrity.

THE AUTHOR

ANTHONY MAJLINGER joined the Laboratories in 1934 as a messenger while still in his 'teens. From 1938 he did switching laboratory work, entering the Apparatus Department in 1940. While designing communications power equipment for the Bell System and the armed forces, he completed much of his undergraduate work at Cooper Union, leaving there in 1943 to receive his B.E.E. at Brooklyn Polytechnic Institute in 1946. He is presently doing graduate work in physics at Brooklyn Polytechnic. He was engaged from 1947 to 1949 in relay contact studies for the Systems Department. For the past four years, Mr. Majlinger has been concerned with automatic message accounting circuits for No. 1 crossbar and No. 5 crossbar, circuit design on automatic telephone switching circuits and design of a portable fault finding test circuit. He is a member of the Institute of Radio Engineers.

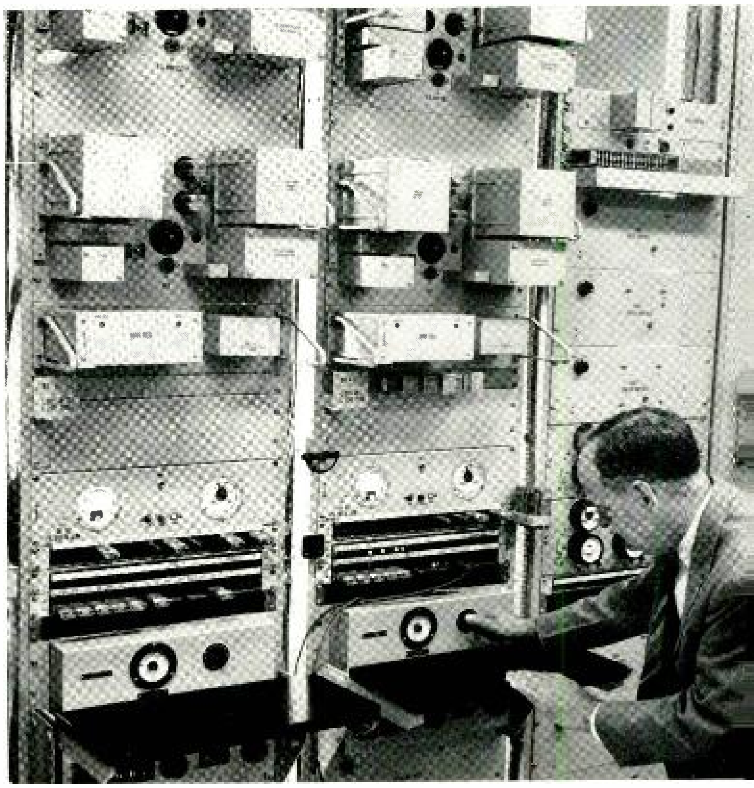
Closed Loop TV for New York Police

The New York Telephone Company recently furnished the New York City Police Department closed-loop microwave facilities to permit the prisoner line-up at the New York City headquarters to be viewed at the Police Department's Brooklyn headquarters. In this trial of the system, detectives took the part of prisoners in the line-up. A microwave transmitter was used to direct the video material to the Empire State Building where it was relayed to a receiver at the Brooklyn headquarters. At this location, arrangements were made for connection of the Telephone Company's circuit to a 27-inch viewer. The camera work was performed at the New York headquarters by RCA. If the Police Department decides that viewing of this kind is essential to their work, the plans are to extend the loop to a number of police locations, for viewing by their detectives who would otherwise have to make trips to the New York headquarters.

It is expected that any permanent installation of this television system would be made over wire circuits rather than radio.

Wire Line Entrance Links for TD-2

J. W. BEYER
Transmission Systems Development



A fundamental requirement in the design of telephone transmission systems is that any new development must be capable of operating with previously installed systems. This means that provision must be made to connect new systems into the pattern of the existing plan. When a TD-2 radio relay system is established, the interconnections that are needed are provided by wire line entrance links.

Fig. 1 — Checking an equalizer associated with the 64-kc pilot at a wire line entrance link.

In the TD-2 radio relay system, each of as many as twelve broadband channels, six in each direction of transmission, may be used to transmit either a television signal or a signal consisting of hundreds of telephone messages. When they are used for telephone service, these TD-2 channels are connected by circuits, called "wire line entrance links," to telephone terminal equipment of the type used for the L1 coaxial carrier system. The link consists of a panel of equipment at the carrier terminal, another panel at the radio terminal, and an interconnecting cable between the two.

Where the radio equipment is located in the toll office building containing the carrier terminal equipment the entrance link cable may be short – perhaps only a few hundred feet in length. It is not always practical, however, to locate a radio relay station at a toll office because of unfavorable terrain or intervening buildings which interfere with radio transmission. In such cases the TD-2 radio station may be several miles from the toll office building in which the carrier telephone terminal equipment is located, and hence a longer entrance link cable is required.

The wire line entrance link circuits perform a number of tasks. In a transmitting link as it is presently used, for example, several hundred carrier telephone signals are transmitted to each of two TD-2 channels, a working channel and a protection channel which is used if signal quality in the former falls below established standards. Conversely, in the receiving link, the signal on either the working or the protection channel must be selected and transmitted to the telephone terminal equipment. Amplification must be provided in the links since signals must be transmitted between the carrier telephone and the radio terminals at the proper level.

Since the connecting cable of the entrance links vary from several hundred feet to several miles in length, the circuit details differ somewhat, but fundamentally they consist of the components shown in Figure 1. This block diagram represents a link where the trunk between the radio equipment and the terminal is not more than 2,400 feet long.

In the transmitting link as shown in Figure 2, a hybrid coil is used to apply the signals from the carrier telephone terminal to parallel links connected to the working and protection TD-2 channels. A 64-kc pilot signal is also introduced in the links through the network arm of the hybrid coil. In the receiving link, this pilot is used to help determine whether the output of the working or the protection TD-2 channel should be transmitted to the terminal equipment.

After the telephone signals have been divided by the hybrid coil and the pilot has been added, a fixed gain amplifier raises the level of the signals to the value required by the longest circuit expected to be encountered. An adjustable pad is then used to establish the over-all gain required by the trunk length of the particular link in which it is used. An equalizer compensates for the frequency versus attenuation characteristic of the entrance link cable.

The elements in the receiving link are similar to those in the transmitting link except that a line switch, operated either manually or automatically, is provided to connect the carrier telephone terminal equipment to either the working or protection channel.

Automatic switching in the receiving link is under the control of a pilot and noise indicator. Switching takes place when the 64 kilocycle pilot varies beyond predetermined limits or when noise in the working channel becomes excessive even though the working line pilot remains within limits. A narrow band of noise at 2064 kc is selected by a filter and when a fade occurs in the radio channel, the noise level increases rapidly. When it reaches a predetermined level in the working channel, the line switch selects the output of the protection channel, provided the noise level for that channel is sufficiently low.

A new automatic switching arrangement for TD-2 systems in which one protection channel will serve as many as five working channels, is in the final stages of development. This arrangement will make

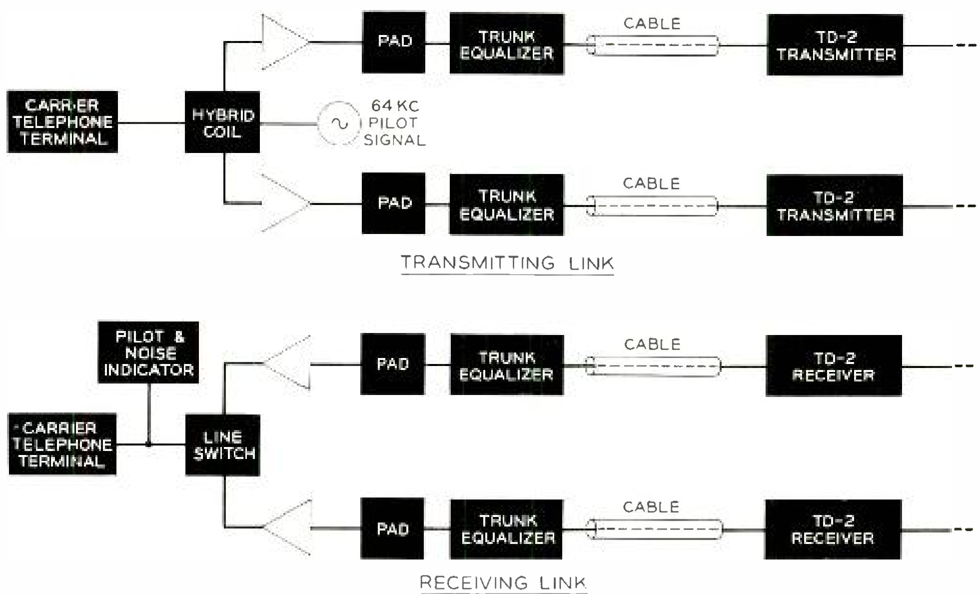


Fig. 2 — Block diagram of a typical wire line entrance link for TD-2.

more efficient use of the radio relay system and will replace the present switching system when it becomes available.

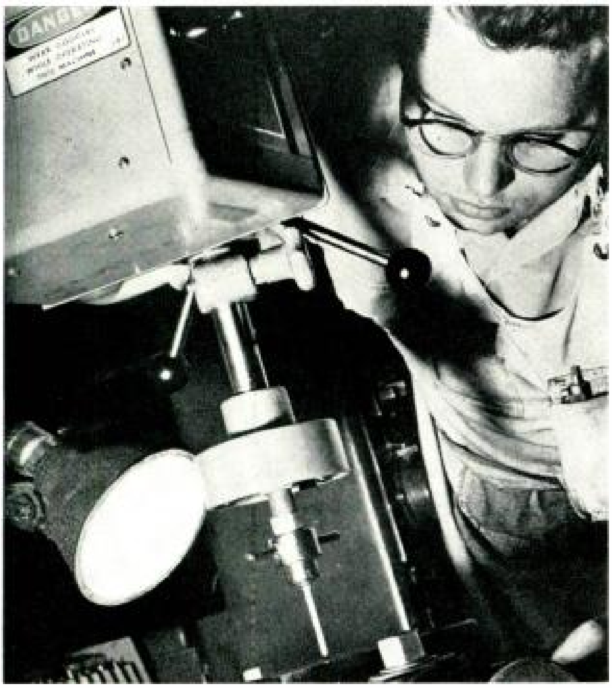
The wire line entrance links described have been for applications where the radio equipment is located no more than 2,400 feet from a toll office. When the intervening distance is greater than 2,400 feet but less than the normal L1 repeater spacing, 7.9 miles, the same basic arrangement is used but a second amplifier is included to overcome the loss in the additional cable. When the cable length exceeds 7.9 miles a standard L1 coaxial system auxiliary repeater is inserted in the link at an intermediate point, and additional cable equalization is provided.

The preceding description has referred only to the provisions for telephone service in the TD-2 system. When television service is required, a different type of entrance link is used, usually the A2-video transmission system.*

* Record, *December*, 1951, *page* 556.

THE AUTHOR

Jesse W. Beyer's work has been concentrated in the field of carrier telephone systems and microwave radio relay. His first assignment at the Western Electric Company in 1919 was in the development of telephone transmission measuring equipment. He transferred to the Laboratories in 1925, and four years later joined a group concerned with the development of carrier telephone systems. He was associated with the development of the eight-channel microwave radio relay system for the Signal Corps during World War II and subsequently has continued his work in carrier systems. At present he is particularly concerned with coaxial cable systems. Mr. Beyer received his B.S. degree in E.E. in 1915 from the State College of Washington. He is a member of the A.I.E.E. and the I.R.E.



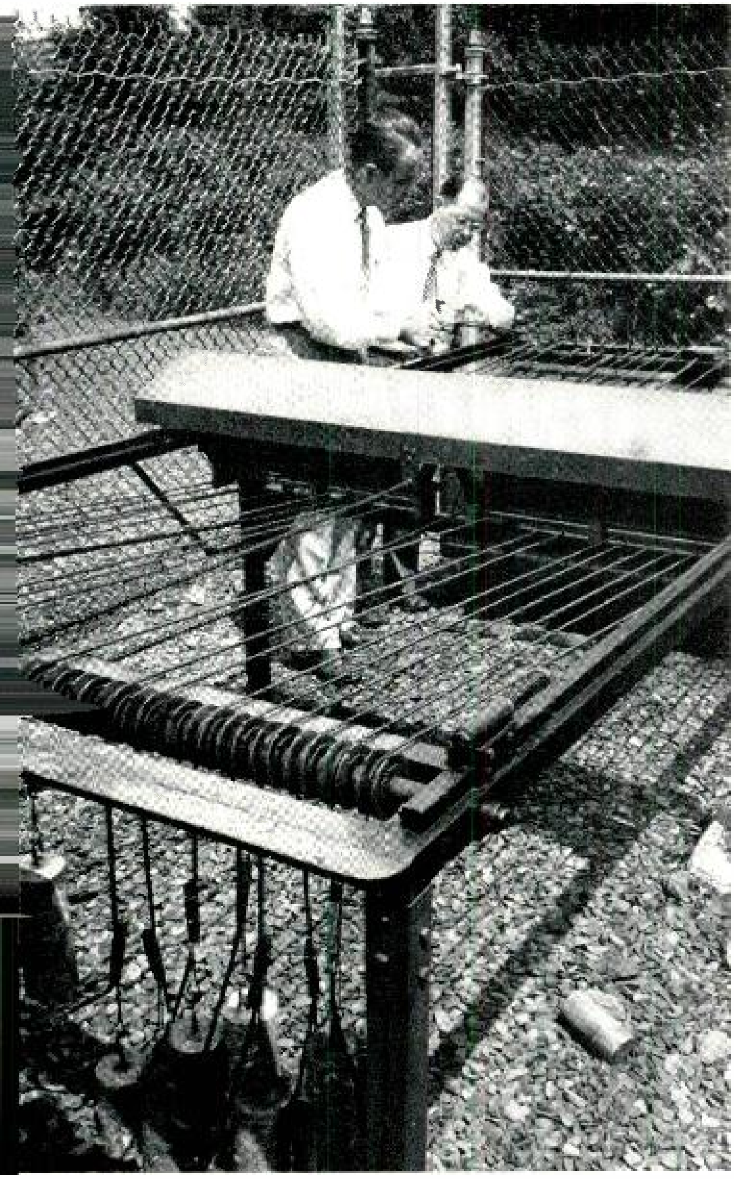
Drilling With Electricity

Although it looks pretty much the same as an ordinary drill-press, this machine uses electricity to disintegrate hard metal like magic. A blue electric arc flickering at the drilling of the device is the only evidence that it is in operation, but holes appear in the metal being worked just as if it were being drilled. Used for the rough shaping of extremely hard metals, the machine eliminates much of the lengthy and costly grinding usually necessary. The electron drill is in use at Western Electric's Allentown Plant.

Wire Abrasion Tester

Drop wire, the insulated and jacketed wire that spans the distance from the telephone pole to the customer's premises, is subject to many types of abrasion; the most familiar is from rubbing against tree branches. The evaluation of jacketing compounds for abrasion resistance is a continuing study at the Laboratories; many types of tests have been made, and others are in progress. In the past, two principal types of tests have been used. Those at the Chester Field Laboratory are of long duration and include the effects of weathering on wires strung through thick tree growth. In the other type, accelerated indoor tests have been made on a small scale, but in general have proved unsuccessful because of the lack of frictional heat dissipation in the samples and the lack of weather effects.

H. A. Wells (left) and C. C. Kingsley inspect wear produced by the wire abrasion tester at the Murray Hill Laboratories. The abrader bar of the machine can be seen pressing against the tensioned wires.



The wire abrasion testing machine shown in the illustration was designed to combine the better features of the accelerated indoor tests and the long duration outdoor tests, including the effect of variable weather conditions. The machine will produce in one week the abrading effect which takes approximately one year to produce in the trees at the Chester Field Laboratory. The wire samples are attached to the machine at the right in the photograph, and pass over pulleys at the other end where they may be dead-loaded with weights to any desired tension. The rails on the sides of the machine support the carriage. Mounted on the underside of this carriage, the vertically adjustable abrader bar of stainless steel can be seen pressing against the drop wires, thus producing the desired pressure on the wire under test. This carriage runs along the lengths of the wires and makes a complete cycle back and forth over the wires in about 40 seconds. The relatively slow traverse of the carriage reduces the effects of heat of friction and more nearly simulates abrasion under natural plant exposure conditions. A fluid coupling and time-delay mechanism alleviate the stress on the motor, which must start approximately every 20 seconds. The machine is equipped with a counter to record completed cycles, and with limit switches to shut the apparatus off in the event of a failure in the reversing mechanism.

This machine has been useful in evaluating experimental designs of wire and wire guards while the longer-term corroborative tests in trees at Chester are in progress. One such wire design, with more than ten times the resistance to abrasion exhibited by present neoprene jacketed drop wire, has been produced for limited field trials by several Companies.

H. A. Wells
Outside Plant Development

J. B. Fisk Elected Vice President

James B. Fisk

Ralph Bown

William O. Baker

James B. Fisk, Director of Research in Physical Sciences at the Laboratories, has been elected Vice President in charge of Research, effective March 1. He succeeds Ralph Bown, who continues as a Vice President with a new assignment in charge of the long-range planning of Laboratories programs. Dr. Bown will continue his present responsibilities in connection with the Patent Department. Dr. Fisk will be succeeded as Director of Research in Physical Sciences by William O. Baker, who has heretofore been Assistant Director of Chemical and Metallurgical Research.

James B. Fisk

Dr. Fisk, who joined the Laboratories in 1939, has had a distinguished scientific career, including two years as Director of Research of the Atomic Energy Commission and simultaneously Gordon McKay Professor of Applied Physics at Harvard University. He is currently a member of the General Advisory Committee of the Atomic Energy Commission as well as the Science Advisory Committee of the Office of Defense Mobilization.

During World War II, when the potentialities of the microwave magnetron for high-frequency radar were discovered, Dr. Fisk was selected to head the development group at the Laboratories. After the war, he was placed in charge of electronics and solid state research. It was work in this area that resulted in the invention at the Laboratories of the transistor, the revolutionary electronic device which has attracted such widespread attention. In 1949 when he returned to the Laboratories from the Atomic Energy Commission and Harvard, Dr. Fisk was placed in charge of research in the physical sciences.

Dr. Fisk received his bachelor's and doctor's degrees from M.I.T. From 1932 to 1934 he was a Proctor Travelling Fellow at Cambridge University, and from 1935 to 1939 a Junior Fellow in the Society of Fellows at Harvard. He also served as Associate Professor of Physics at the University of North Carolina.

Dr. Fisk has served on several government committees and advisory boards, both during and since the war. He is a Fellow of the American Physical Society and the American Academy of Arts and Sciences and was formerly a Senior Fellow of the Society of Fellows at Harvard, as well as a member of a number of scientific and professional societies.

Ralph Bown

Dr. Bown has had a distinguished career in the administration of industrial research that includes nearly thirty-five years with the Bell System. Before his appointment as Vice President in charge of Research in 1952, he had served as Director of Research since 1946, in which post he succeeded Dr. M. J. Kelly, now President of the Laboratories.

Much of Dr. Bown's work has been concerned with various aspects of radio broadcasting and ship-to-shore and overseas telephony. He was a division member and consultant of the National Defense Research Committee, specializing in radar, and in 1941, he visited England to study radar operations under combat conditions. He also served as expert consultant to the Secretary of War.

Dr. Bown, who has been widely recognized for his pioneering work in the broad field of communications engineering, was awarded the Morris Liebmann Memorial Prize by the Institute of Radio Engineers for 1926, and in 1949 he received the Institute's Annual Medal of Honor. In 1927 he served as President of the I.R.E. He served as a captain in the Signal Corps in World War I, prior to joining the Research and Development Department of the A.T.&T. Co.

He was named Assistant Director of Radio Research of the Laboratories in 1934, Director of Radio and Television Research in 1936, and in 1944 was appointed Assistant Director of Research.

Dr. Bown is a Fellow of the I.R.E., the American Association for the Advancement of Science, the Acoustical Society of America, the American Physical Society and the American Institute of Electrical Engineers. He received the degrees of M.E., M.M.E. and Ph.D. from Cornell University.

William O. Baker

Dr. Baker joined the Laboratories as a research chemist in 1939 after receiving his doctoral degree from Princeton University and his bachelor's degree from Washington College, Md. During his graduate years at Princeton, he held a Harvard Fellowship and a Proctor Fellowship.

His research work has been primarily concerned with investigations of the molecular structure and physical properties of polymers, particularly the fundamental constitution of synthetic rubbers and plastics. His ideas concerning microgel as a highly cross-linked giant molecule of distinctive properties, a concept new to science. having led to a better fundamental understanding of the behavior of man-made polymers, particularly synthetic rubbers. This concept has also suggested the process that may be employed by nature in the synthesis of proteins. There have been many practical by-products and related aspects of this work and Dr. Baker's investigations have had considerable impact, both on chemical theory and the chemical industry as a whole.

Dr. Baker has collaborated in significantly fruitful studies of the effects of such processes as molding and annealing of polystyrene. polyamides, cellulose esters. and other plastics, facilitating their wide use in communications equipment; molecular size and shape controls in polyethylene, qualifying it for cable sheath and insulation, and reactivity of saturated polyesters in casting and encapsulating resins.

Because of his outstanding contributions, Dr. Baker was asked during World War II to serve with the Office of Scientific Research and Development and the Office of Rubber Reserve for the government, and since the war he has served in several governmental consultant posts.

Before becoming Assistant Director of Chemical and Metallurgical Research in 1952, Dr. Baker was in charge of the Laboratories' work in synthetic rubbers and plastics. He is a member of a number of professional societies, including the American Chemical Society, the American Physical Society and the American Society for Testing Materials.

Symposium on Light Microscopy

A new *Symposium on Light Microscopy* recently published by the American Society for Testing Materials is the result of work done by top men in the field of light microscopy. F. G. Foster of the Laboratories and R. P. Loveland of Eastman Kodak Company were co-chairmen of the symposium.

Presented as the fiftieth anniversary publication of the society, the book presents the wide scope of light microscopy in industry. To many, the term microscope means bacteriology, medicine, and clinical chemistry. New developments have broadened the use of the instrument to include studies of metals, concrete, plastics, and textiles. Many examples of these uses are presented, amply illustrated by photomicrographs and diagrams.

Committee E-I of the Society sponsored the symposium, and has recently created a new subcommittee on microscopy with Mr. Foster as chairman.

New Microwave Route

Plans for a supercommunications highway stretching more than 1,000 miles across the Southwest, from northern Texas to California, were made known in a recent application filed with the FCC. The proposed route eventually would extend from Amarillo to Los Angeles, and passing through Albuquerque.

The contemplated system would greatly augment facilities now providing telephone communications in the Southwest and would make it possible for Albuquerque and other cities in this area to be interconnected for network television service. Plans call for construction of the system to be undertaken in three steps. Initially, two westbound video channels would be provided between Amarillo and Albuquerque, planned for service by late this summer. The next section of the proposed project would be an eastbound channel from Los Angeles to a point near Baker, California, to provide network television service to Las Vegas. The final section between Baker and Albuquerque would be built at some future date.

Highlights from the A T & T Annual Report

"Bell System progress took many forms in 1953," Cleo F. Craig, President of the American Telephone and Telegraph Company, told the share owners in the 1953 Annual Report.

"Outstanding was the steady improvement in service quality. Operators handled calls on the average with greater speed. Maintenance men kept the service even more dependable, more free from mechanical failure. Installers and construction crews put in more and more telephones and lines and switching equipment of new design and greater capabilities."

In eight years since the war, the Bell System has added more than 19 million telephones. The gain in 1953 was 1,900,000. In November, the 50-millionth telephone was presented to President Eisenhower as a symbol of the telephone's achievement and responsibility. In this country, 160 million people use more telephone service than all of the two billion people elsewhere in the world.

The Bell System spent more than $25 million a week, or about $1.4 billion in 1953, to enlarge and improve telephone facilities. Earnings on total capital in 1953 were at the rate of 6.1 per cent, compared with 5.9 per cent in 1952, while net income of the System equalled $11.71 per share of A T & T stock, compared with $11.45 in 1952.

Operating taxes paid by the System were $799 million, an increase of $93 million over 1952. Excise taxes paid by customers and collected by the System for the Government were $670 million last year. Direct taxes on Bell System service were thus $1,469 million – an average of more than $3 per telephone per month. Mr. Craig pointed out that "This heavy burden discriminates against telephone users. They are paying higher than 'luxury' excise taxes on a service that is not at all a luxury. Representatives of the System have therefore made several appearances before government bodies in the past year to urge that these excise taxes be reduced."

Continuing heavy construction is essential to a first-rate job of meeting telephone customers' wants. Mr. Craig expects 1954 to be another year of heavy construction, which should go far toward meeting all the needs of telephone users. To finance new construction, the System has obtained large amounts of additional capital. The net increase in share owners in 1953 was 45,000 and the total number at the end of the year was 1,265,000.

Bell Telephone Laboratories and Western Electric continue to make contributions of fundamental importance to telephone progress. New equipment developed by the Laboratories and made by Western Electric plays an essential part in the long-distance dialing program. One example is the apparatus that automatically records information for billing customer-dialed calls. Another is the new 4A switching system that went into service last year in four cities. This uses transistors, the new electronic device invented at the Laboratories, in equipment that routes long-distance calls automatically.

Plans for the first telephone cable system across the Atlantic were announced in December. It will be owned jointly by the A T & T Company, the British Post Office, which provides telephone service in Great Britain, and the Canadian Overseas Telecommunication Corporation. Electron-tube amplifiers developed by the Laboratories, designed to work unfailingly for years at the bottom of the sea, make the cable system possible. The cable will be more than 2,000 nautical miles long and will be able to carry 36 simultaneous conversations. Construction will take three years and will cost about $35 million.

Electronics research has resulted in a new device called the "backward wave" oscillator. This new tool is expected to have important uses in the development of future microwave radio relay systems with increased capacity for carrying long-distance telephone calls and television programs.

Rural service was extended by the addition of about 275,000 telephones, and to help in further extending service to farmers, the Laboratories has developed a new wire facility – "B" rural distribution wire. Six pairs of copper wires insulated with polyethylene are stranded around a steel core, providing an economical transmission means. In addition, a new system using transistors to increase the message-carrying capacity of rural telephone wires is now undergoing field trials.

As in the past, the Laboratories and Western Electric are major contributors toward national defense. Among these is Nike – named after the Goddess of Victory – the nation's first combat-ready anti-aircraft guided missile system. This remarkable weapon is designed to search out and destroy hostile aircraft which by height, speed, and evasive tactics might escape conventional weapons.

Another noteworthy defense project was the construction for the Air Force of the first experimental units of a "Distant Early Warning Line" of radar stations on the northern shores of Alaska and Canada, only 1,200 miles from the North Pole. This line would give prompt and positive warning of hostile aircraft. Specially qualified personnel from all parts of the System – the Laboratories, Western Electric, and the Operating Telephone Companies – worked together on the task, performing it successfully and with great speed.

At the end of 1953, more than 81 per cent of all Bell System telephones were dial, and customers as well as operators are dialing an increasing number of long-distance calls. Customers in Englewood, N. J., Birmingham, Mich., and East Pittsburgh can now dial their own long-distance calls direct to about 13 million telephones in 14 metropolitan areas from coast to coast. Washington, D. C., and Detroit have a new type of system that extends the dialing range in those cities.

The increase in long-distance facilities last year was 20 per cent, the largest since the war, and 40 million miles of voice-ways now criss-cross the nation. Many of the new long-distance channels were obtained by adding "carrier" equipment to increase the capacity of existing lines. However, there were also important extensions, notably 3,300 route-miles of radio relay systems. These now extend for more than 10,000 miles and provide nearly five million miles of telephone circuits – 13 per cent of all long-distance voiceways.

As 1954 began, the Bell System television network reached 260 stations in 161 cities. Nearly 50,000 miles of long-distance TV highways bring network programs within range of 100 million or more people. Eighteen cities received color television pictures of the Tournament of Roses parade held in Pasadena on New Year's Day, 1954, and additional facilities for transmitting color television will be arranged for as the needs of the broadcasting companies indicate. Theater television used Bell System facilities seven times last year, with the largest network of this kind serving 45 theaters in 33 cities from coast to coast.

Bell System overseas telephone service last year handled about a million calls over 147 direct radio-telephone circuits between the United States and foreign countries.

More than 12,000 telephones in automobiles and other vehicles can now be connected with the nationwide system. Automatic telephone answering service, by means of equipment that the customer can switch on when he leaves home or office, is steadily expanding. A variety of modern facilities were made available to industrial customers.

In cooperation with the Air Navigation Development Board and the Civil Aeronautics Administration, the Bell System has undertaken to develop communication facilities and services for an improved system of air traffic control. By applying in this field the new knowledge and techniques that telephone research is making available, the Bell System expects to make a further important contribution to the progress of aviation.

"Telephone people did a fine job in 1953," Mr. Craig pointed out, "and that means among other things that in a safe industry they worked even more safely. They have done so for nine years in a row. And for the second consecutive year, they won for their companies the National Safety Council's highest Award of Honor for significant improvement in safety performance.

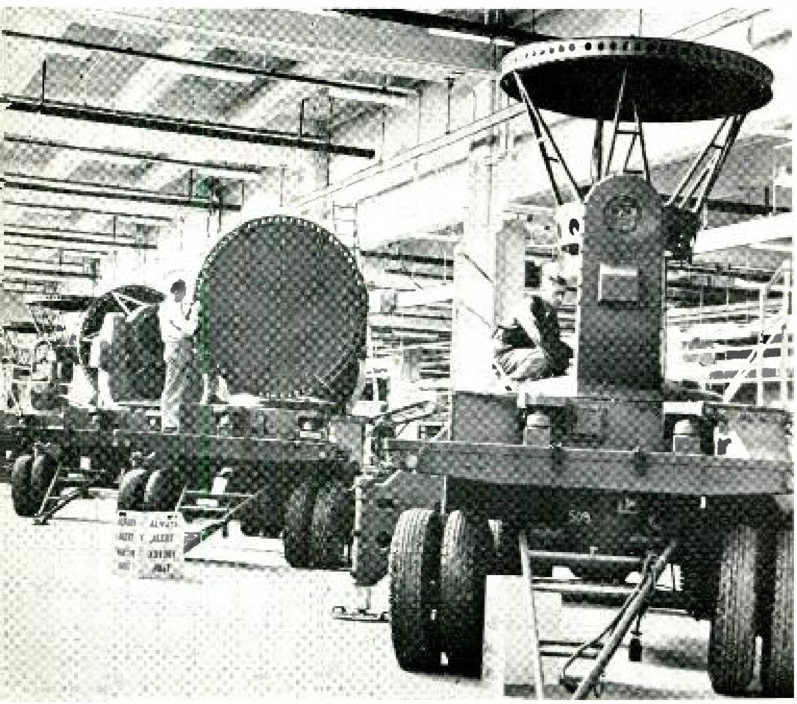
"The people of the Bell System are devoted to their calling and to the needs of the people they serve," Mr. Craig continued, "Theirs is a service of neighbor to neighbor – human, personal, friendly and courteous. To say that 1953 was a constructive and successful year is also to say, 'They made it so.' "

Western Electric Has Record Year

Looking like roller-coasters at an amusement park, conveyors at Western Electric's Indianapolis Works move housings for 500-type telephone sets from one operation to the next. Such streamlined manufacturing methods helped make possible Western's 1953 production record.

The year 1953 was another record breaker for Western Electric. Stepped-up activities in manufacturing, distributing, installing and purchasing equipment and materials to meet Bell System needs, and attainment of high production on military orders, sent sales figures soaring to $1½ billion at year's end – the highest mark in the Company's 84-year history. Of this record amount, more than $1 billion represented sales to the Bell operating companies and $440 million was sales of military equipment to the U. S. Government.

Western Electric factories producing telephone equipment set several new records. Shipments of carrier terminals, microwave amplifier bays and telephone and telegraph repeaters were the largest in the Company's history. Production of exchange cable was higher than in any previous year. Over 3,200,000 telephones were shipped. Manufacture was started on a number of new products including centralized automatic message accounting equipment as well as equipment necessary for modification of circuits to transmit color television.



A major production achievement was NIKE, America's first combat-ready, surface-to-air guided missile air defense system. Here final checking proceeds on mobile antenna units used in the system.

As production steadily grew, manufacturing facilities kept pace to reach a total of nearly $402 million invested in buildings, machinery, and equipment. Ground was broken for a new plant in North Andover, Mass., construction continued on the new plant at Winston-Salem, N. C., and space for manufacturing was leased in two other cities.

In addition to the large volume of orders the Distributing Houses processed for direct shipment from Western's factories and suppliers, the houses delivered to the Bell companies $290 million worth of new material from their own stocks, and their repair shops reconditioned $135 million worth of used telephone equipment. The repair shop volume in 1953 was up 25 per cent over the previous year.

To complete the tremendous $290 million in stock sales, Western's distributing people had to select, ship and bill a total of 19 million items. Pile all this material together in one city block and the stack would tower ten times higher than the world's tallest structure, the Empire State building.

Distribution's physical growth also kept pace with its performance. The 29th distributing house was placed in operation at Syracuse, N. Y. last year and work was started on three more new houses to replace leased quarters — all in the interests of providing faster, lower-cost service to Bell companies. Moreover, sites were purchased during the year in four cities for more new buildings to replace inadequate quarters.

Western's Installation organization, too, had a record-shattering year. Turned over to the operating companies in 1953 were 1,782,000 dial lines — enough to provide telephone service for a city bigger than Chicago — and over 5,300 switchboard positions, an increase of 11 per cent over the previous year. Equipment to service some 7,400 long-haul inter-state circuits was added to existing facilities.

Many Western installers worked on the 4A toll crossbar offices through which the Bell companies can eventually provide nationwide customer toll dialing; four are already operating in large cities, work is proceeding on another seven, and 1954 will see seven more offices started. Another headline project was the first installation of CAMA (centralized automatic message accounting). Other installers put in repeater and terminal facilities that enabled the Bell System to add a number of cities to the nation's TV network.

Despite higher wages and the increased cost of certain raw materials, continuing production economies and a large volume of business enabled Western to maintain the reduced price levels established in 1952.

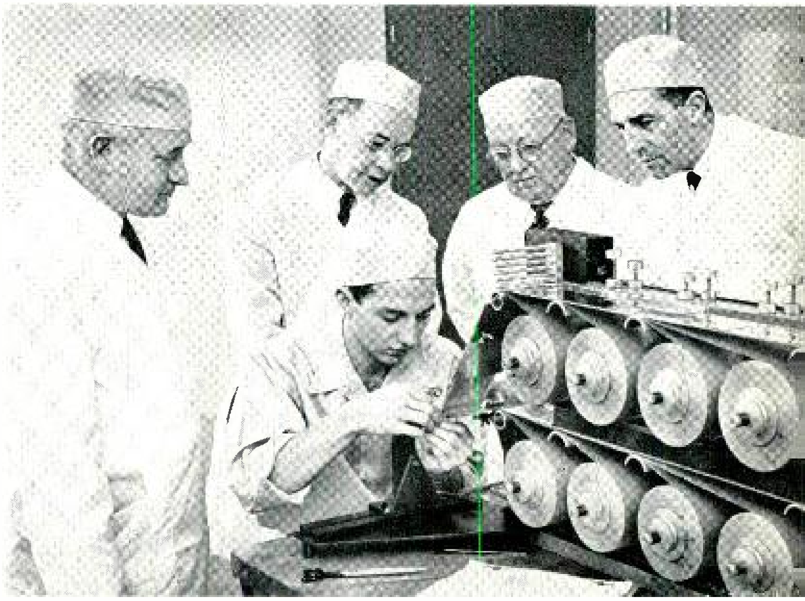
Contributing to these manufacturing, distribution, and installation records was a fourth segment of the Bell System supply organization — Purchasing — whose members combed the markets in the United States and foreign countries to procure the needed supplies and materials. Total purchases for the year had a value in excess of $680 million. This sum was paid to approximately 27,000 large and small suppliers located in 2,700 towns and cities.

Transporting raw materials and finished products where they were needed cost Western Electric approximately $40 million in 1953. This was an increase of nearly 10 per cent over 1952 and reflected the greater volume of operations. Yet, more than $2½ million was saved in the process as a result of the Traffic Organization's emphasis on cost reduction — by consolidating shipments wherever possible, arranging full car shipments with stops for partial unloading, recovery of overcharges, and collection of loss and damage claims.

One of the most important of Western Electric's efforts was in the field of national defense, which accounted for about 28 per cent of total sales. The most spectacular job was attainment of full scale production of Nike, America's first combat-ready, ground-to-air guided missile system.

Historic Operation

Under the glare of powerful overhead lights, men robed and capped in white watch a technician perform an operation—on a capacitor winding machine. This machine is part of the facilities set up to produce repeaters for the transatlantic cable, and the spotless environment is a precaution against foreign particles getting into repeater components. Watching the operation are C. D. Duncan, Long Lines, M. B. McDavitt, Director of Transmission



Development at the Laboratories, H. V. Schmidt of Western Electric, and P. J. Halsey of the British Post Office.

More Network TV

Stations WRDW-TV, Augusta, Ga., and WTOC-TV, Savannah, Ga. were recently added to the Bell System's nationwide network of TV facilities. WRDW-TV became Augusta's second station to be connected for network service and WTOC-TV, Savannah's first.

Network programs for both stations are fed from intercity facilities extending between Columbia, S. C. and Jacksonville, Fla., to a telephone building in Augusta. Local facilities carry the programs from there to WRDW-TV's studio location, while a newly constructed 129-mile radio-relay route provides service for WTOC-TV. With the addition of the two stations, network television service is now available to 278 stations in 174 cities in the United States.

Talks by Members of the Laboratories

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

A.I.E.E. Winter Meeting — New York City

Bennett, W. R., The Source and Properties of Electrical Noise.

Bozorth, R. M., Magnetic Research in Japan in 1953.

Cory, S. I., A New Portable Telegraph Transmission Measuring Set.

Getz, E. L., Experience with Nationwide Dialing at Englewood, N. J.

Hamilton, B. H., A Transistor Error Detector and Silicon Diode Voltage Standard Circuit for Regulating Low-voltage Rectifiers.

Hochgraf, L. and Watling, R. G., Telephone Lines for Rural Subscriber Service.

Kelly, H. P., Differential Gain and Phase Measurements in Color Television.

Lee, C. Y., Switching Functions on an N-dimensional Cube.

Legg, V. E. and Owens, C. D., Magnetic Ferrites — New Materials for Modern Applications.

Morin, F. J., Transistor Materials.

Owens, C. D., see Legg, V. E.

Tukey, J. W., The Measurement of Noise Spectra.

Watling, R. G., see Hochgraf, L.

Windeler, A. S., Polyethylene Insulated Telephone Cable.

American Physical Society — New York City

Brattain, W. H. and Garrett, C. G. B., Electrical Properties of the Interface Between a Germanium Single Crystal and Electrolyte.

Darrow, K. K., "The American Physical Society at Columbia University."

Fuller, C. S. and Severiens, J. C., Mobility of Impurity Ions in Germanium and Silicon.

Garrett, C. G. B., see Brattain, W. H.

Hagstrum, H. D., Theory Concerning Auger Electrons Ejected from Metals by Ions.

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

Read, W. T., Jr., Electrical Properties of Dislocations in Plastically Deformed Germanium.

Rorden, H. C. and Wegel, R. L. (Retired), Structure of the Vibration Pattern of Transverse Waves in Slow Circular Jets.

Vogt, E. and Wannier, G. H., Quantum Mechanics of the Scattering by a r^{-4} Attractive Potential.

Wannier, G. H., see Vogt, E.

Wolff, P. A., Theory of the Energy Distribution of Secondary Electrons.

Other Talks

Becker, J. A., The Absorption Properties of Oxygen on Tungsten as Seen in the Field Emission Microscope, N. Y. Professional Chapter, Alpha Chi Sigma, Newark.

Campbell, W. E., Solid Lubricants, American Society of Lubrication Engineers, Cincinnati; and Microchemical Methods in the Solution of Wear and Lubrication Problems, American Society of Lubrication Engineers, New York City (Presented by H. V. Wadlow.)

Chapanis, A., Human Factors in Engineering Design, Sixth Annual Industrial Engineering Institute, Berkeley, Calif., University of California, Berkeley, and University of California at Los Angeles; and Designing Machines for Human Use, University of California at Los Angeles.

David, E. E., Ears for Electronic Brains, I.R.E. Montreal Section, Montreal, Canada.

DeCoste, J. B. and Wallder, V. T., Weathering of Polyvinyl Chloride — Wire and Cable Applications, American Chemical Society, Northern N. J. Section, Newark.

Evans, H. W., TD-2 Microwave Radio Relay System, Radio Club of America, New York City.

Felker, J. H., Electronic Digital Computers, Morris County Engineering Meeting, Dover, N. J.

Finch, T. R., Circuit Application of Transistors, I.R.E., Louisville, Ky. and Indianapolis, and A.I.E.E.-I.R.E. Joint Meeting, New Haven, Conn. (Presented by F. H. Blecher).

Greenidge, R. M. C., Some Modern Techniques in Packaging of Electronic Apparatus, I.R.E. Symposium on Electronic Equipment Design, Garden City, N. Y.

Haines, A. B., Magnetic Amplifier Applications in Communications, A.I.E.E. Study Series on Magnetic Amplifiers, New York City.

Hagstrum, H. D., Auger Electrons Emitted from Metals by Ions, Physics Colloquiums, Cornell University, Ithaca, N. Y., and Columbia University, New York City.

Hamming, R. W., The Organization of a Computation Laboratory for Research Services, James Forrestal Research Center, Princeton University, Princeton, N. J.

Harvey, F. K., Focusing Sound with Microwave Lenses, I.R.E. Northern N. J. Section, Montclair, N. J.

Heidenreich, R. D., Electron Metallography of Precipitation and Phase Transformation, American Institute of Mining and Metallurgical Engineers, New York City.

Herring, C., Thermoelectric Power of Semiconductors, Physics Colloquium, University of Wisconsin, Madison, Wis.

Jensen, A. G., The Present Status of Color Television, Engineer's Club, Kiwanis Club, Electrical Board of Trade, and Personnel of Southwestern Bell Telephone Company, St. Louis.

Kock, W. E., Ears for Electronic Brains — A Discussion of Automatic Speech Recognition, A.I.E.E., Philadelphia; and Speech, Music, and Hearing, A.I.E.E. Communications Section, New York City.

Mallina, R. F., Solderless Wrapped Connections, I.R.E. Symposium, New York City.

McKay, K. G., Avalanche Breakdown in Silicon, McGill University, Montreal, Canada.

Merz, W. J., Some Physical Properties of Ferroelectric Barium Titanate Single Crystals and Their Uses as Memory Devices, R.C.A. Laboratories, Princeton, N. J.

Munson, W. A., Psycho-physical Measurements, Columbia University Lecture, New York City.

Perry, Miss J. E., Increase in the Penetration and Retention of a Wood Preservative Due to the Action of Mold Growth, Beta Beta Beta Biological Honorary Society, Rutgers University, New Brunswick, N. J.

Quate, C. F., Recent Progress in Microwave Tubes, Applied Science Colloquium, Harvard University, Cambridge, Mass.

Rea, W. T., Military and Communication Applications of Transistors, Armed Forces Communication Association, Chicago Chapter, Chicago.

Reiss, H. The Sorption of Nitrogen Dioxide by Cellulose Acetate, American Chemical Society, Northern N. J. Section, Newark.

Ross, I. M., The Transistor, Middletown Scientific Association, Middletown, Conn.

Sawyer, B., Transistors, Seminar of Solid State Physicists, Carnegie Institute of Technology, Pittsburgh.

Seckler, H. N., Automatic Control Circuits, A.I.E.E., Chicago.

Wallder, V. T., see DeCoste, J. B.

Washburn, S. H., Digital Control Circuits and Systems, A.I.E.E. Subsections, Lexington, Ky. and Louisville, Ky.; and Design of Digital Control Circuits, Students at University of Kentucky, Lexington.

Wintringham, W. T., Color Television Signal, Radio, Electronic, and Television Manufacturers Association Symposium, Chicago.

Aluminum Outdoor Telephone Booth

Glistening with aluminum, glass, and colorful enamel, a new outdoor telephone booth will soon appear along the nation's highways and elsewhere to help supply the increasing demand for outdoor telephone service. Field tests have indicated that the new metal-glass booth will require less maintenance than the standard wood-constructed outdoor booth now in general use.

Designed by Bell Telephone Laboratories and purchased for the telephone companies by Western Electric, the new-type booth embodies a number of up-to-date design features. These include the use of extruded aluminum sub-assemblies somewhat similar to those employed in the sash frames of modern railroad car and bus windows.

All structural parts are of metal. The interchangeable panels are either colored porcelainized metal or clear shatterproof glass set in grooved rubber strips. The flat, slightly overhanging aluminum roof has raised strips set back at the front and sides to direct rainfall to the rear of the booth. Ventilation is obtained by louvered panels and air exit openings behind the roof overhang.

Two fluorescent lamps in a ceiling fixture supply light at night and illuminate "Telephone" signs near the top of the booth. The telephone directory is in a rack that forms part of the shelf inside this slightly larger booth.

Although a metal floor will be an optional feature, the booth is designed for use without one since in most cases it will be anchored to a floor or concrete slab.

Patents Issued to Members of Bell Telephone Laboratories During December

Anderson, J. R. – *Magnetic Head* – 2,662,120.

Becker, E. J. and Biondi, F. J. – *Method of Desulphurizing Carbon-Coated Metals* – 2,662,839.

Bennett, W. R. – *Cathode-Ray Decoder for Pulse Code Modulation* – 2,664,504.

Berger, U. S. – *Frequency Modulation Detector* – 2,664,505.

Biondi, F. J., see Becker, E. J.

Brattain, W. H. – *Semi-conductor Translators* – 2,663,829.

Carr, J. A., Haskell, F. V., Sutton, S. M., and Walter, O. L. – *Swivel Connector* – 2,663,748.

Christensen, H. – *Mountings for Semiconductors* – 2,662,997.

Darlington, S. – *Semiconductor Signal Translating Devices* – 2,663,806.

Dorff, L. A. – *Arrangement for Single-Channel Time Sharing* – 2,662,974.

Goddard, C. T. – *Electrode Support and Spacing Structure for Electron Discharge Device* – 2,663,819.

Harley, J. J. – *Cable Lashing Machine* – 2,663,544.

Haskell, F. V., see Carr, J. A.

Hilsinger, H. A., Jr. – *Friction Device for Operating Knobs in Adjustable Apparatus* – 2,660,904.

Ilgenfritz, L. M. – *Humidity Indicator* – 2,663,190.

Insley, N. and Tanner, T. L. – *Circuit Regulating Device* – 2,663,782.

Kock, W. E., – *Directive Antennas* – 2,663,797.

Koenig, W., Jr., – *Electrical Transmission System Including Bilateral Transistor Amplifier* – 2,662,123.

Lewis, W. D. – *Electromagnetic Wave Microwave Frequency filters* – 2,663,848.

McMillan, B. – *Electrical Amplifier Circuit* – 2,662,124.

Meacham, L. A. – *Transistor Amplifier with Conjugate Input and Output Circuits* – 2,663,766.

Mohr, M. E. – *Electrical Wave Transforming System* – 2,663,795.

Mougey, W. E. – *Spirally Applied Conductively-Contacting Cable Armor* – 2,662,931.

Mueller, G. E. – *High Frequency Amplifier* – 2,661,441.

Oliver, B. M. – *Semiconductor Signal Translating Devices* – 2,663,830.

Raisbeck, G. and Wallace, R. L., Jr. – *Low-Input Impedance Transistor Circuits* – 2,663,796.

Ryder, R. M. – *Two-Way Transistor Electrical Transmission System* – 2,662,122.

Singer, F. J. – *Multiplex Carrier Telegraph System* – 2,662,933.

Spencer, H. H. – *Current Supply Apparatus* – 2,664,538.

Sutton, S. M., see Carr, J. A.

Tanner, T. L., see Insley, N.

Teal, G. K. – *Preparation of Apertured Metal Screen* – 2,662,274.

Teal, G. K. – *Preparation of Two-sided Mosaic Screen* – 2,662,852.

Wallace, R. L., Jr., see Raisbeck, G.

Walter, O. L., see Carr, J. A.

Walsh, E. J. – *Method of Making a Fine Wire Mesh* – 2,661,029.

Walsh, E. J. – *Electron Discharge Device* – 2,663,818.

Wier, A. J. – *Shielded Electrical Conductor with Grounding Strand* – 2,663,752.

Out-of-Hour Lecture

J. Reid Anderson gave the latest in the out-of-hour lecture series last month, speaking on *Ferroelectric Storage Devices*. These informal lectures, presented during the fall and spring, are designed to acquaint members of the Laboratories with certain areas of the technical program. Equipment and systems incorporating a sense of "memory," or information storage, have been used for many years in the Bell System, and are also finding considerable use in digital computers. Examples of these applications are the storage of dialed digits until a connection is made to a called telephone, and the recording of billing information in automatic message accounting systems. A continuing search is under way for new devices and circuits that might be used for storage or memory purposes in various switching systems.

A new device, employing the physical properties of ferroelectric materials such as barium titanate, shows considerable promise as a means for storing information. Mr. Anderson's lecture covered a brief explanation of the materials, their physical structure and electrical properties, and their use in experimental storage circuits.