BELL LABORATORIES RECORD

VOL. XXVI • NO. 2 • FEBRUARY 1948

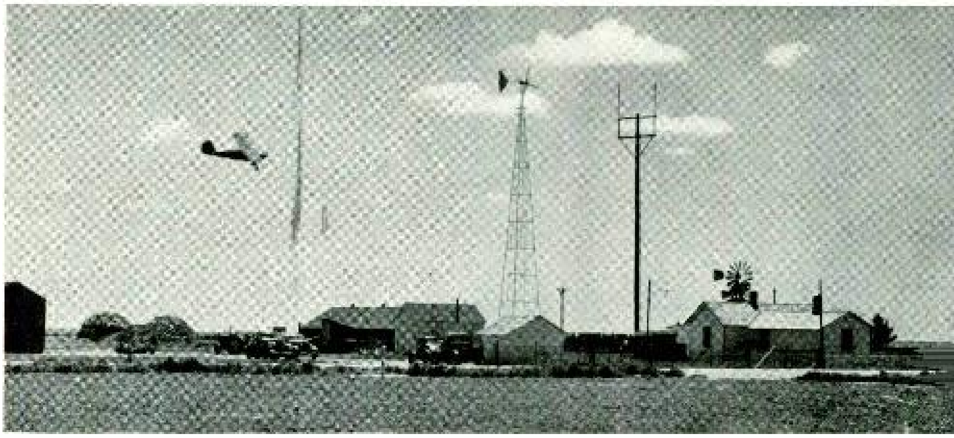
H. W. NYLUND
Radio
Transmission
Development

RURAL PARTY-LINE SERVICE BY RADIO

Since August, 1946, a radio party line serving eight ranchers in the vicinity of Cheyenne Wells, Colorado, has been operating on a trial basis. With a population of only 695 persons, Cheyenne Wells is the county seat of Cheyenne County, in the pasture lands of the eastern part of the state. Its inhabitants and those of its satellite town of Kit Carson, twenty-five miles to the west, are engaged primarily in supplying the ranchers and their families with services and manufactured commodities. The one-room telephone office at Cheyenne Wells, shown in Figure 1, has a single-position No. 12 switchboard* and a counter over which cash transactions are made between the operators and the ranchers when they use the telephone on their visits to town. There are also several public telephones in the hotels, garages, drug stores, and restaurants. Telephones in Kit Carson are served from an unattended community dial installation with a trunk to the switchboard at Cheyenne Wells.

Rural telephone lines are scarce in areas such as this because of the distances involved and the difficulty of maintaining individual pole lines fanning out on roads and trails that are sometimes impassable. Radio, however, offers communication by lightweight terminal equipment that is rel-

*RECORD, *December*, 1932, *page* 94.



C. F. Blackwelder's ranch receives radio telephone service through the two antennas on the pole to the right of the windmill, which is used for power generation. Mr. Blackwelder is shown approaching in his private plane

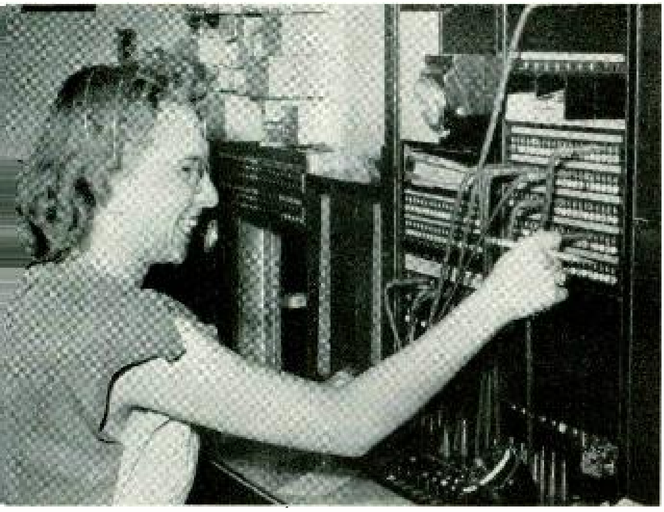


Fig. 1—Switchboard at Cheyenne Wells. Radio cabinet against the wall just visible beyond the operator

atively easy to install or to remove to another location. Since there was no radio equipment suitable for trying out rural service, the Laboratories was asked to plan and provide a system using emergency mobile equipment already available. This was done, and we are now coöperating with the Mountain States Company in studying the results of their operation of the system.

The type of system decided on for this trial is similar in principle to the rural power-line carrier system,* but instead of superimposing the carrier on the power lines, it is radiated to the subscribers' antennas. Figure 2 shows the system as applied to two typical subscribers whom we will call Brown and Jones.

*Record, *October*, 1947, *page* 363.

At the Cheyenne Wells central office, shown at the left of the illustration, a radio transmitter is arranged to transmit on frequency f_1. The vacuum tube heaters of this transmitter are continuously energized, but plate power is disconnected when the line is idle. Also at the central office are two radio receivers, one for each of two frequencies, f_2 and f_3, assigned to all the subscriber transmitters. The central office receivers are energized continuously, and ready to receive a call. A central office control terminal is also provided to interconnect the audio circuits to the transmitters and receivers, and to convert signaling pulses to the proper form for use in different parts of the circuit, since the radio sets do not directly transmit 20-cycle ringing current or supervisory signals.

At each radio subscriber station there is a telephone set, a radio transmitter and receiver, and a control terminal to connect the telephone set with the receiver and transmitter, and to perform the signaling and switching functions. The subscribers' receivers are energized continuously to receive calls, but the transmitters are normally turned off to save power. The telephone set is the widely used combined

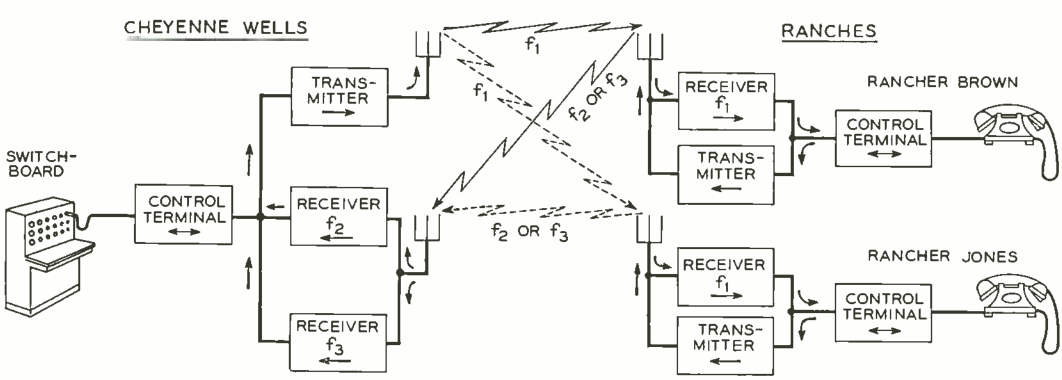


Fig. 2—The radio system as applied to two ranchers. Frequency f_1 is used for transmission from Cheyenne Wells to the subscriber and f_2 is the normal frequency for transmission in the other direction

set—the 302-C—modified so that one of the buttons on which the handset rests may be pulled up—like the exclusion key in the 1-A key telephone system*—to turn the transmitter on.

On a call from town to rancher Brown, for example, the operator connects a cord to a jack in the switchboard and then rings rancher Brown's code. The 20-cycle ringing current causes the transmitter to send out pulses of carrier interrupted at a 20-cycle rate on frequency f_1, and these pulses ring the telephone bells of all the radio subscribers. Recognizing his code, rancher Brown picks up his telephone after the ringing ceases, and pulls up the "transmitter-on" button in the handset cradle to start his radio transmitter. It then emits carrier at frequency f_2, which differs from f_1 so as not to operate the local receiver. This carrier reaches the central office receiver tuned to f_2, and, through suitable relay operations, turns on the central office transmitter, thus completing the radio route from the switchboard to the Brown ranch. Conversation may then take place. When rancher Brown replaces his telephone set on the cradle, his transmitter is automatically turned off, which restores the system to normal so it will be available for use by other subscribers.

When rancher Brown calls someone in town, he picks up his telephone and listens to the handset receiver. If the circuit sounds clear, he knows that the line is not being used, and he then pulls up his transmitter-on button to start his transmitter and thus signal the operator. If the call is for someone not on the radio circuit, the operator in Cheyenne Wells completes it as she would any other call. If it is to another station on the radio system, which on party lines is called a "reverting" call, the procedure is a little different, and the third radio frequency f_3 is employed.

Circuits in the subscribers' radio transmitters are arranged so that when the transmitter is started while there is no radiation of frequency f_1 from Cheyenne Wells, the subscriber's transmitter operates on the f_2 frequency. If there is radiation present at frequency f_1, however, the transmitter will operate on the f_3 frequency. On

*Record, *June*, 1940, *page* 315.

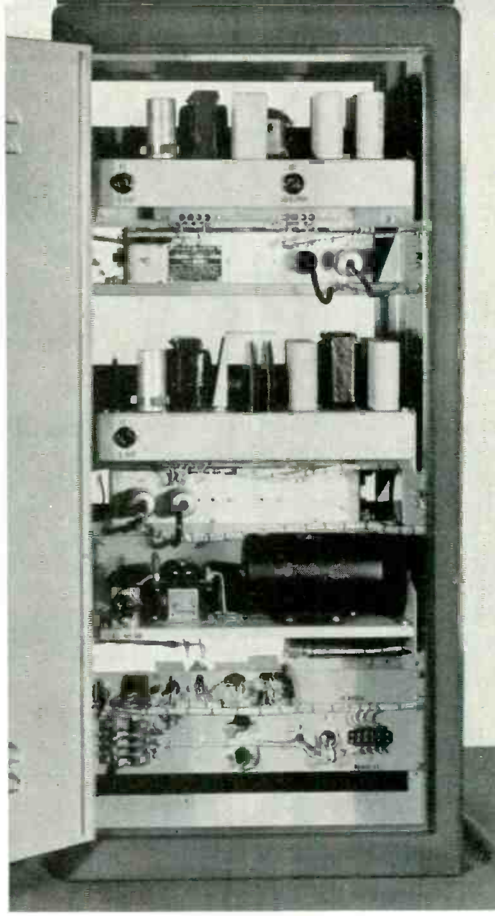
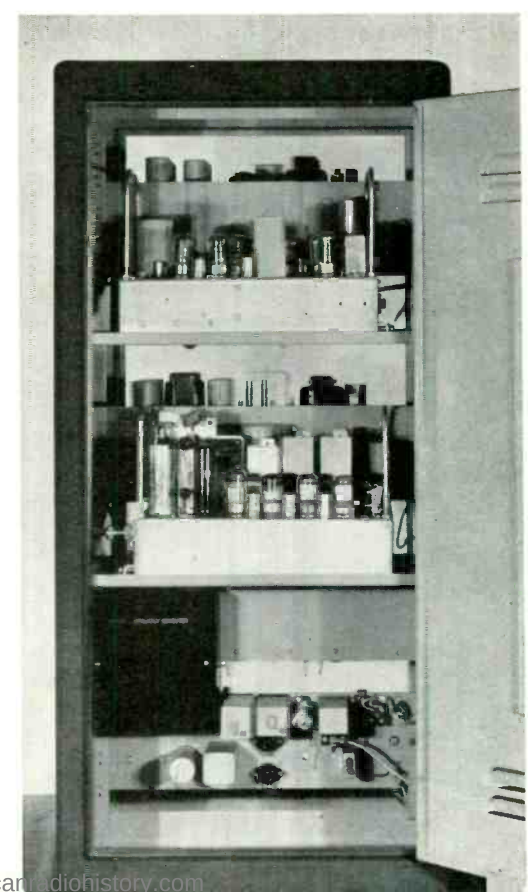


Fig. 3—Radio cabinet on subscriber's premises —power side above, radio below



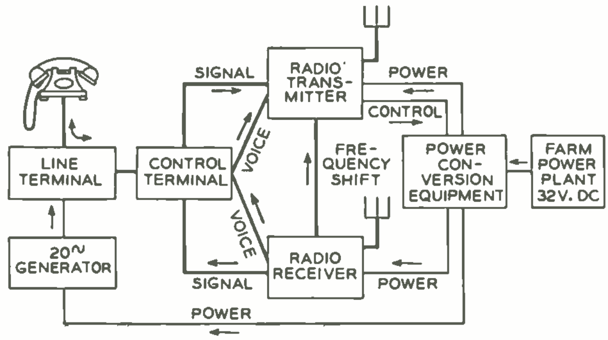


Fig. 4—Block schematic of the electrical arrangement of the units in a subscriber's terminal

television broadcasting. The central office transmitter is assigned 44.2 mc, and its maximum rated power output is 60 watts. This power is amplitude-modulated at a 20-cycle rate while ringing the subscribers' bells. During speech, it is frequency-modulated with a maximum deviation of ±15 kc. The transmitter and both receivers are crystal controlled, and are powered from the 60-cycle, 110-volt town mains.

The crystal-controlled subscribers' transmitters are assigned 49.0 mc for f_2 and 49.2 mc for f_3. Each has maximum rated output power of 10 watts. This power is amplitude-modulated when the subscriber

a call from rancher Brown to rancher Jones, Brown gets the operator on his f_2 frequency as already described, gives her the number he wants, and then hangs up momentarily to disconnect his transmitter. He then picks up his handset but does not pull up the transmitter-on button and thus his transmitter is not put in operation. As the operator rings the code for rancher Jones, Brown listens on the line. When Jones answers, the f_1 frequency from Cheyenne Wells goes on in the usual manner, and then Brown pulls up his transmitter-on button. Since f_1 frequency is on the air at this time, Brown's transmitter operates on the f_3 frequency. Jones and Brown then talk, Jones' transmitter operating at f_2 frequency to the f_2 receiver at Cheyenne Wells and Brown's transmitter operating at f_3 frequency to the f_3 receiver.

This use of two subscriber-transmitting frequencies, f_2 and f_3, also prevents a call in progress from being interfered with by some other station on the radio circuit trying to place a call. If Brown is talking, for example, using frequencies f_1 and f_2, and Jones starts to place a call, then Jones' transmitter will go on at f_3 frequency because of the radiation of f_1 frequency. It therefore will not interfere with the Brown call, which is using the f_2 frequency.

In the Cheyenne Wells trial, the three frequencies f_1, f_2, and f_3 are temporary assignments in the 44-50 mc band, which is in process of being evacuated by FM broadcasting but is later to be shared with

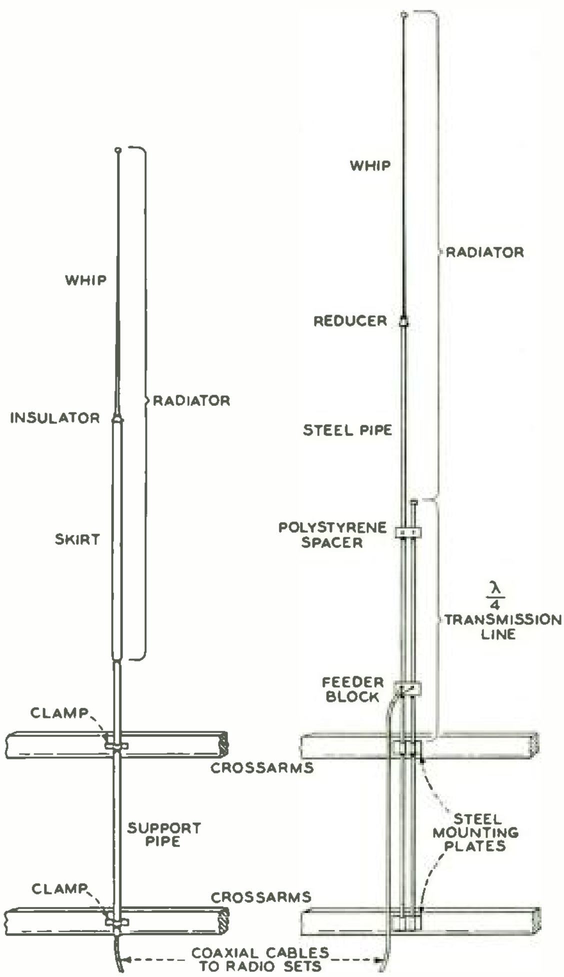


Fig. 5—Coaxial antenna at left, J type at right

signals the operator by operating his switchhook and transmitter-on button, and is frequency-modulated up to ±15 kc by speech. Filamentary type tubes are used to insure quick starting and to save power. The receivers are crystal controlled.

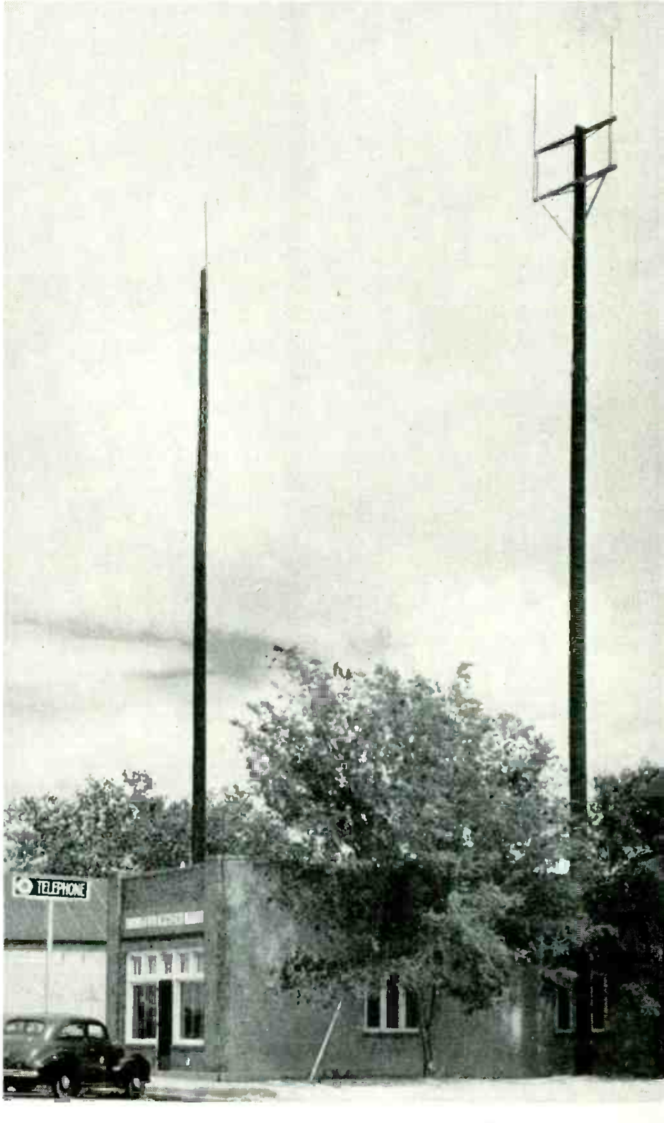
The subscriber's radio, signaling, and power conversion equipment is located in a gray steel cabinet, shown with the doors open in Figure 3. This cabinet is normally kept locked for the protection of the subscribers and their families. A similar cabinet is used to contain the central office equipment in Cheyenne Wells. For operating lights, washing machines, radios, and other electrical equipment, the ranches have power plants with 32-volt batteries which are for the most part charged by wind-operated generators. Supplementary gasoline-driven generators are sometimes used during periods of heavy loads or light winds. Since the radio sets were designed for intermittent operation on 6-volt automobile batteries, it was necessary to remove the original power supply equipment, and provide new circuits and equipment to convert the 32-volt supply to proper form. The development of this power conversion equipment required new transformers, synchronous vibrators, and filters, and considerable experimental work to avoid interference.

A diagram of the electrical arrangement of the units in the subscriber's terminal is shown in Figure 4. Besides providing separate voltages for the transmitter and the continuously energized receiver, the power plant operates a 20-cycle vibrator for generating the ringing current to operate the bells. The relays for controlling signaling and for shifting from f_2 to f_3 are also designed to operate from a 32-volt source.

Two different types of antenna structures are on trial at the ranches, as shown in Figure 5. Both are vertically polarized, non-directional, half-wave, which for this frequency range results in radiators ten to eleven feet high. One of them, of the coaxial type, consists of a steel whip which is a vertical extension of the inner conductor of a coaxial cable leading to the radio set. The outer conductor terminates in a bronze skirt which extends below the whip and is insulated from it. A coaxial steel support pipe is joined to the skirt at the insulator. A star-shaped lightning arrestor is arranged in the coaxial space below the insulator.

The other type of antenna, known as the J type, was assembled at Cheyenne Wells, using galvanized steel pipe and vanadium steel whips. The half-wave radiator is fed by a quarter-wave transmission line made of similar pipe so that the support, one side of the line, and the radiator are all one piece of pipe. The coaxial cable is connected to the two pipes forming the transmission line about a foot above the bottom

Fig. 6–Receiving and transmitting antennas



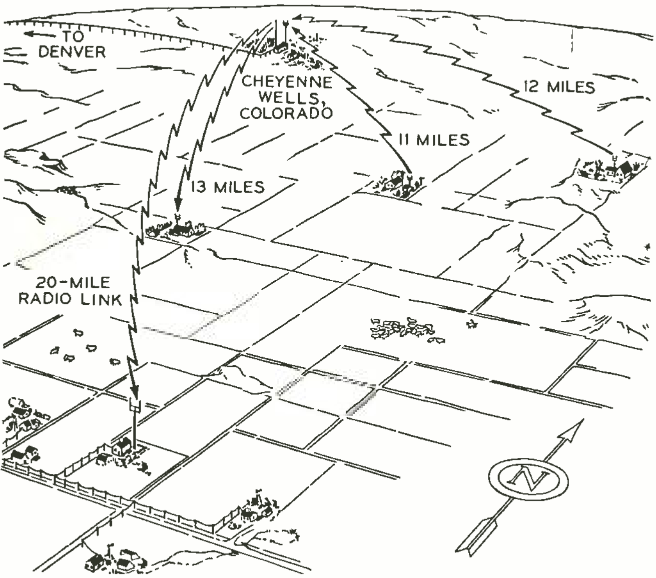


Fig. 7—Bird's-eye view of the trial radio system

of the line. The entire structure is at d-c ground potential, and no lightning arrestor is provided. Connection from the antennas to the radio sets is by insulated, flexible coaxial cables 0.4 inch in diameter, having a characteristic impedance of 72 ohms.

Two antennas, one for transmitting and the other for receiving, are clamped to the ends of standard wooden cross-arms mounted on a telephone pole for each ranch. The poles range in height from 25 to 50 feet above the ground. The antennas at the central office, shown in Figure 6, are mounted on two poles 80 feet above the ground. One pole supports the single transmitting antenna and the other, almost 50 feet away, supports two receiving antennas—one for f_2 and one for f_3.

As shown in Figure 7, a wire line extends from the radio installation farthest from Cheyenne Wells to four nearby ranches, each of which is provided only with a telephone set and standard protection equipment. Each of these telephones actuates and is actuated by the common radio installation in the same manner as a telephone installed at a ranch having a radio installation of its own. This wire line is an important part of the experiment, since it must be maintained by traveling sixty miles over difficult roads and trails. It is constructed of poles twenty feet long and four feet in the ground, with spans of 450 feet in the north-south direction and 350 feet in the east-west direction, which is broadside to the north winds. The wires are high strength solid steel, 0.109 inch in diameter. A ground wire is installed on each pole to reduce the chance of lightning damage.

The area selected for this experiment provides all the varieties of weather encountered in the United States. It thus offers an opportunity to observe the effects of sunlight, wind, dust, rain, hail, sleet, and lightning on the equipment as it is installed. The continuing interest and cooperation of the participating subscribers have contributed greatly to the promise of success of this new experiment in communication. For the first time in history, ranchers can talk by radio telephone with each other, or with any telephone reached by the Bell System.

THE AUTHOR: H. W. NYLUND received the B.S. degree from Iowa State College in 1925 and immediately joined the Laboratories. After some years with the step-by-step circuit-testing group, he transferred to Inspection Engineering—now Quality Assurance. He served as field engineer in St. Louis, in San Francisco, and then, from 1932 to 1938, as a field group supervisor. Since then, except for three years following 1940 with Transmission Development working on echo suppressors and underwater sound projects, he has been with Transmission Engineering, occupied with various radio projects and antenna investigations.

W. S. BISHOP
Chemical
Laboratories

SYNTHETIC HARD RUBBER

Temporary loss of natural rubber due to Japanese encroachment in 1941 necessitated rapid conversion to synthetics by the Bell System and other producers of rubber goods, not only for the bulk of the soft types but also for major proportions of the hard varieties. All synthetics in use during the war period differ markedly in chemical and physical properties from the natural grade. The replacement of natural rubber by the synthetic variety necessitated a change in processing the raw stock and the acceptance of certain different physical characteristics of the finished product.

Natural rubber is essentially a long chain polymer whose symmetry imparts very definite characteristics not completely duplicated by the synthetics. Short period cold-milling—shearing between differential speed open rolls—of a natural smoked sheet or pale crêpe rubber reduces the molecular weight. Such "broken down" or "dead" natural rubber is a soft plastic mass with slight recovery powers when stretched and a ready dispersion in ordinary rubber solvents. When the requisite amount of sulfur has been incorporated and the compound calendered (passed between equal speed open rolls), the result is a very smooth non-shrinking sheet that is a prerequisite in hard rubber processing.

GR-S, the synthetic which was used during the emergency for Bell System hard rubber is, on the other hand, a molecular system of 76.5 parts butadiene and 23.5 styrene combined in a most irregular manner. Since this heterogeneous feature and the molecular weight averages may vary with the manufacturing source, the chemical and physical properties are not always constant. This is evidenced by variation of solubility and viscosity of that portion of the hydrocarbon which is soluble in benzene, called the sol portion; also by differing amounts of cross linking of particle structure in the benzene insoluble portion, called the gel portion. Variations of these factors in each of these portions are reflected in GR-S processibility; and are intimately associated with specific manufacturing details such as type of emulsification, coagulation and constancy of control. However, it must be recognized that the material produced in a given plant is now much more uniform than that of earlier years.

The four operations normally involved in both natural and synthetic hard rubber production are: the "breakdown" previously

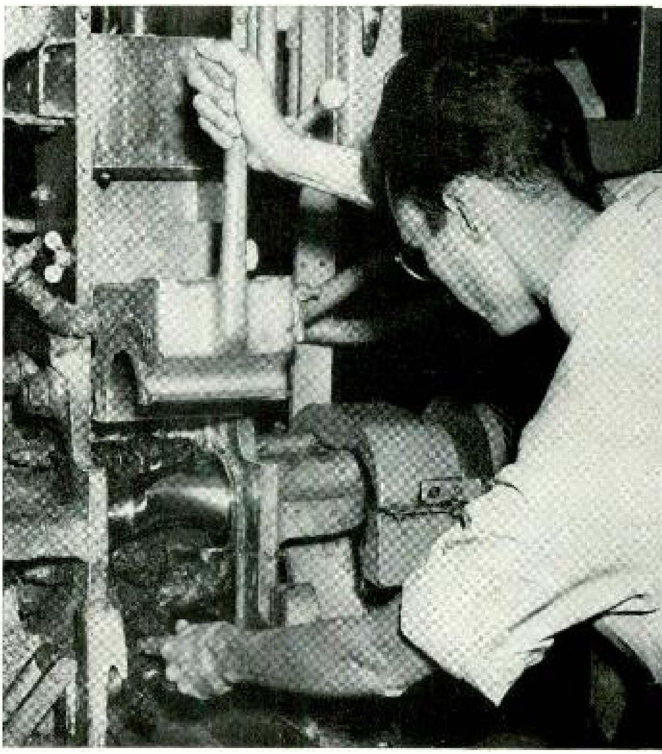


Fig. 1—W. H. Lockwood at Murray Hill observes the result after a batch destined for synthetic hard rubber has been masticated in the heated closed-type mixer

mentioned; compounding by the addition of vulcanizing ingredients; either calendering or extruding to the final form, and curing. Since "breakdown" actually converts the rubber into a plastic mass, the subsequent processing behavior is such that the compound may be made into sheets, rods and tubes having wrinkle-free surfaces.

Unlike natural rubber in the first processing sequence, cold-milling of GR-S does not result in molecular disintegration into a completely plastic mass. Although part of the gel portion is broken into a dispersible mass in this process, the viscosity, which is a measure of molecular weight, remains high. As long as a synthetic rubber maintains its high molecular weight, or contains gel in a fairly high viscosity, sol processing is a problem.

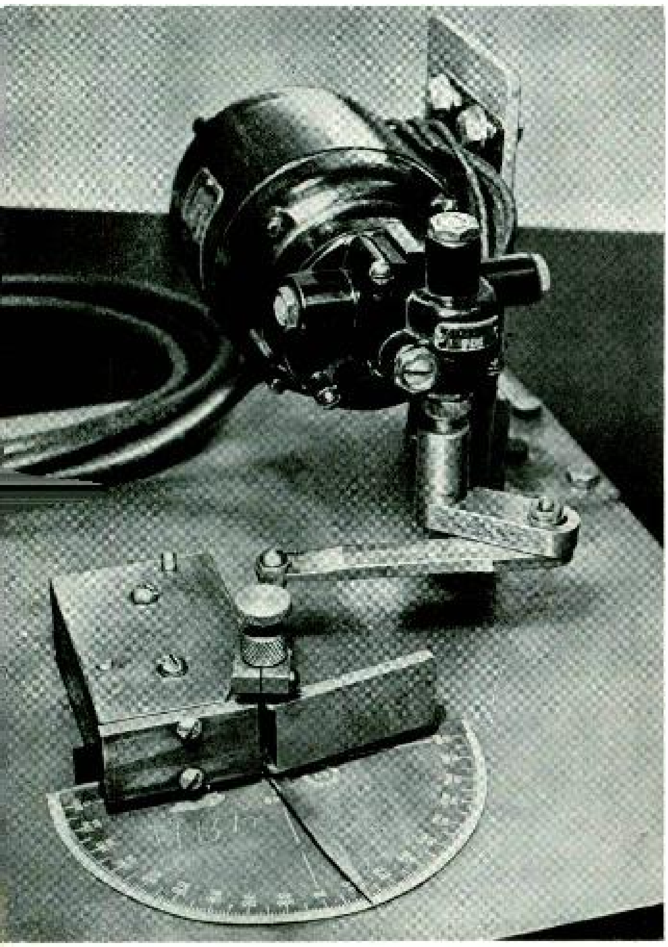


Fig. 2—Simple tool developed for comparative tests of hard rubber brittleness. The sample is gripped in the jig's left front section and the sample is bent at a constant rate. A pointer directly indicates the breaking point

To obtain a "dead" synthetic which has satisfactory behavior in production, it is necessary, therefore, to add pigments or hard rubber dust as fillers or to resort to a hot (325 degrees F.) breakdown in a mixer with shaped enclosed rolls, as shown in Figure 1; this latter action is in effect a kneading operation with close clearance between shearing blades. During this type of breakdown, two changes take place: while the gel content is increasing, the viscosity of the sol is decreasing sharply and the resulting product is then a dispersion of gel particles in a soft and tacky mass. Since plasticity depends in a large measure on fluidity of the sol, a satisfactory processing is thereby achieved. In general, and in spite of large differences in their original sol and gel contents and in molecular weights, all presently available GR-S stocks may be brought to the same degree of processibility with this hot breakdown method by using longer time, higher temperatures or a combination of both.

Compounding, the incorporation of the vulcanizing ingredients—sulfur, accelerator, hard rubber dust and inorganic fillers—is next performed on an open mill or in a cold enclosed mixer. For example, natural rubber requires 47 parts of sulfur per hundred of whole polymer for hard rubber with most desirable properties, whereas GR-S requires about 45.4 parts.

The calendering operation produces smooth sheets 32 to 62 mils thick. After being cut to size, a number of these sheets are layered between tin plates to any desired thickness. Tanks are loaded with these layers and then filled with water, the whole being subjected to steam in an autoclave for a length of time that depends on the compound and the end properties sought. Rods and tubes are produced by extrusion, then coated with talc, sandstone or hard rubber dust and vulcanized in steam in the dry state.

Since hard rubber vulcanization is a heat-producing reaction, a slow rise, at times over a period of hours, to the final vulcanization temperature (from 298 to 307 degrees F.) is essential for heat dissipation.

Curing time normally varies between four and ten hours. Following this cure, the tin is stripped from the sheets, which are then sheared, drilled, punched or broached to those sizes and shapes required for telephone apparatus. Tubes and rods are ground to proper diameters.

Physical properties of cured GR-S stock are not greatly inferior to the natural rubber, with the exception of the very important one, machinability. Natural hard rubber is tough and it will withstand punching, drilling and broaching without chipping or breaking, but many of these same operations cannot be performed readily on the synthetic grade. Several compromises are acceptable, however. In instances where it is necessary to utilize certain other advantageous inherent properties, poor machinability may be overcome by using greater care or harder tools. In other cases, the basic formula may be revised to a lower sulfur content which increases the product's cold flow and thereby yields a softer product; this same result also may be attained by applying less curing time.

The ordinary tests for cold flow, tensile strength, elongation, impact and transverse strength are not indicative of machining behavior in the synthetic rubbers. Approximation of tool wear may be obtained by drilling a large number of holes in a half-inch thick sample block. From a plot of increasing time required for penetration to equal depths, estimation of tool wear may be made. A brittleness test, however, is most nearly related to chipping and cracking under actual machining conditions. A tool, shown in Figure 2, has been developed by the Laboratories for this latter test in which a half-inch strip of the hard rubber sample, $\frac{1}{32}$ to $\frac{1}{16}$-inch thick, is clamped in the left vise section as shown, the other half being bent through an angle at a constant rate by a motor-driven lever arm attached to a pointer moving through 90 degrees. Thus the bend at break is measured directly. Natural ebonite will withstand a full 90-degree bend, whereas synthetic hard rubber may break with as low a bend as 20 degrees.

The Bell System generally uses high grade ebonite because of its unique combination of electrical and mechanical properties. Tensile strength and elongation are the two properties to which least attention is paid, due to the fact that requirements of low cold flow, high flexual and high impact values automatically include the first two properties. At times, though, compromises must be accepted. For instance, in certain apparatus where low cold flow is desired for sake of stability in service, severe machining operations on the telephone piece parts demand the use of a higher cold flow material. That is to say, the material usually chosen is such as to give the fabricator no more than tolerable difficulty while maintaining the cold flow value within a range suitable for service.

While GR-S had been far more successful than a mere stop-gap material during the war and early post-war periods, the Bell System has again concentrated on the natural variety, now that this is available, maintaining an interest in the synthetics only where special requirements would dictate its use.

THE AUTHOR: W. S. Bishop received a B.S. from the Massachusetts Institute of Technology in 1925 and shortly thereafter joined the Chemical Department of the Laboratories. During the twenty years following he was engaged in research and development in the fields of rubber, synthetic resins and organic syntheses. In August, 1946, he joined the Outside Plant Development Department to work with the wire development group.

CARRIER TELEGRAPHY IN THE BELL SYSTEM

B. P. HAMILTON
Telegraph Development

Experimental work on carrier methods of transmission starting about 1914 led to the development of a carrier*-telegraph system, which was first put in service between Pittsburgh and Harrisburg late in 1919. Previous to this development, the two wires of an open-wire line would normally provide one telephone channel and two d-c composited telegraph channels. This new carrier-telegraph system used frequencies between 3,000 and 10,000 cycles, entirely above the transmitted voice range at that time, and made it possible to add ten more telegraph channels without interfering with the ordinary telephone or the d-c grounded telegraph channels. Besides having the advantage of giving many more telegraph channels on each pair of wires than had been possible with any of the earlier telegraph circuits, the carrier system also provided channels of considerably better grade of transmission, particularly for long distances, one of the reasons being the use of electronic rather than mechanical repeaters at many of the intermediate points. Also, no duplex balancing circuit was required to separate the two directions of transmission, since different carrier frequencies were used for the two directions, and these frequencies were kept from interfering with each other by tuned circuits.

The circuit arrangement of one of the early carrier-telegraph systems was essentially as shown in Figure 1. Twenty carriers are employed for the complete ten-channel system, ten for each direction, and each frequency is provided by a separate oscillator. The frequencies which were later adopted are given in Table I on page 61. The carrier circuit is connected to the line through a high-pass filter that blocks the voice and d-c telegraph frequencies (below about 3,000 cycles), and readily passes all higher frequencies. A low-pass filter in the telephone branch of the circuit blocks the high frequencies and readily passes all the voice frequencies and the d-c telegraph currents. To the telegraph side of the high-pass filter are connected 20 tuned circuits; each of these selects one of the carrier frequencies and blocks the others. The ten sending tuned circuits are connected to ten vacuum-tube oscillators, and the ten receiving tuned circuits are connected to the input of ten receiving amplifier-detectors.

The loop circuit is of the balanced type similar to that used with the "metallic" system already described.* Signals coming in over the loop operate the sending relay. With the armature of the relay on the marking contact, current from the oscillator is allowed to flow to the line, but with the armature on the spacing contact, ground is connected to the oscillator circuit to short-circuit the carrier. Carrier signals coming in over the line are selected by their tuned circuits, amplified, rectified, and then passed to their associated receiving relays, which operate to send signals over the loop.

For long circuits, vacuum-tube repeaters were used at 250 or 300-mile intervals, where repeater stations were already in use to house repeaters for the voice circuits. The telegraph repeaters consisted of two amplifiers, one for each direction, with filters for separating the two directions of transmission.

Early in 1920, this system was extended from Pittsburgh to Chicago, and in 1921 was continued to Oakland, Calif. In con-

*RECORD, *December*, 1925, *page* 147.

*RECORD *Story* 2748.

nection with tests made on the Chicago-Oakland sections, carrier-telegraph channels were connected in tandem by looping back and forth between Chicago and Oakland to form a telegraph circuit approximately 30,000 miles long. This is thought to be by far the longest telegraph circuit ever to have been operated at that time, even for experimental purposes. The d-c telegraph circuits in use during this period had been extended from coast to coast in this country, and the longest circuit in regular service in the world seems to have been across Siberia, a distance in the neighborhood of 4,000 miles. The length of a carrier-telegraph circuit operated as a test was increased to 108,000 miles in 1932.

This high-frequency carrier telegraph was successful in providing high-grade telegraph circuits without interfering with the use of the lines for voice-frequency telephone or d-c telegraph. About 1,800 high-frequency telegraph channel terminals were installed in the Bell System, making available about 900 telegraph circuits averaging between 500 or 600 miles in length. About 1930, the high-frequency carrier telegraph was superseded as far as manufacture of new equipment was concerned by a system using voice frequencies, which had originally been developed for cable circuits.

Development of this voice-frequency carrier-telegraph system for cables was started about the time the open-wire carrier-telegraph system was being extended from Pittsburgh to Chicago. The high frequencies of this latter system could not be economically applied to the cable circuits in use at that time, while a voice-frequency system would not only have the advantages of the former system, but in addition could be applied directly to any four-wire voice channel on either open wire or cable. Also, another advantage that voice-frequency carrier telegraph has over d-c telegraph in cable is that it provides a much faster "break";* that is, the receiving operator can interrupt the sending operator and obtain control of the circuit quickly because of the greater speed of transmission. The de-

*RECORD, *June*, 1946, *page* 224.

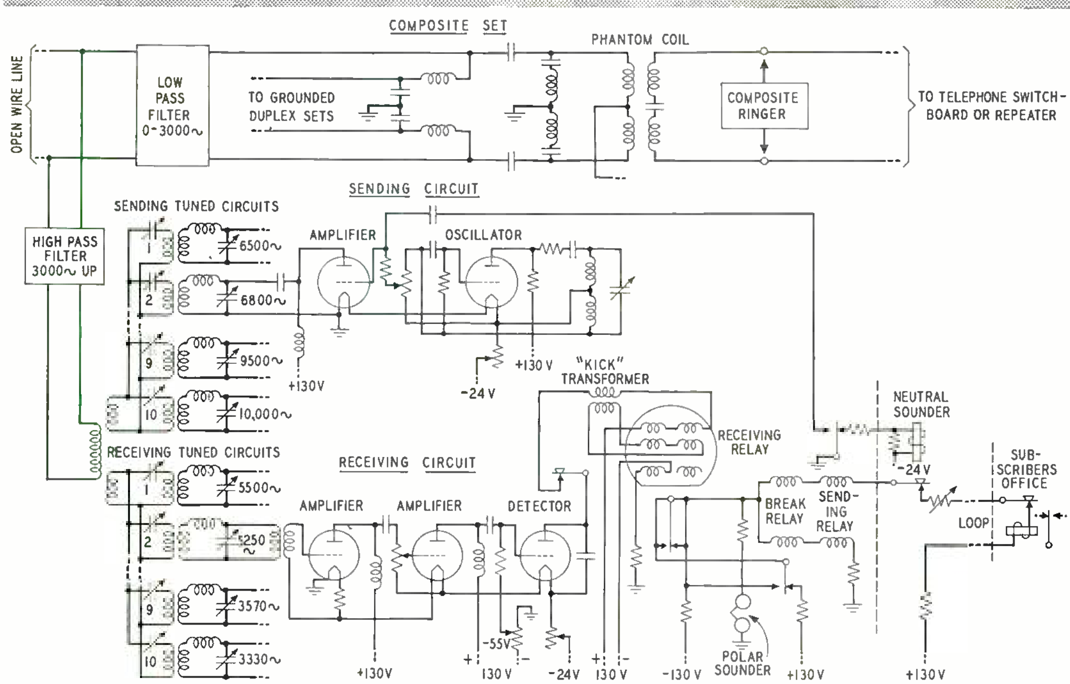


Fig. 1—Simplified schematic of the first carrier-telegraph system

lay or time required for a signal to traverse the line and repeaters is greater, in general, with d-c telegraph than with carrier telegraph. For transmission over cable conductors, i.e., with the metallic telegraph system, this delay for long circuits is so great as to prevent a fast break. Carrier telegraph, on the other hand, gives a satisfactory break even over long cable circuits. Since breaking was involved in most of the telegraph service of the Bell System, this higher speed of break transmission was very desirable.

As originally developed, the system employed first ten, then twelve, carrier frequencies, placed 170 cycles apart from 425 to 2,295 cycles, inclusive. It was applied initially to four-wire voice-frequency telephone circuits in cable. One pair carried the signals in one direction and another pair carried the signals in the other direction, and the same frequencies were employed for both directions of transmission.

The circuit arrangement was as shown in Figure 2. It was designed for the same loop circuit used by the high-frequency system, and the general arrangement of the circuit was similar. Instead of using oscillators to supply the carrier, however, a machine generator was employed. This consisted of a small motor and on the same shaft an inductor alternator with twelve rotors. This method avoided the relative drift between the various carrier frequencies, which was difficult to avoid with the oscillators then in use. Instead of using simple tuned circuits to separate the various channels, as the high-frequency system did, the voice-frequency system used band-pass filters. The lower channel frequencies used, as well as the sharper cut-off obtained with these filters, made it possible to reduce the channel frequency spacing, which varied from 250 to 500 cycles with the earlier system, to 170 cycles.

Voice-frequency carrier telegraph has proved very satisfactory, and about two-thirds of the Bell System telegraph mileage is now handled by this system. Since its development, a number of improvements have

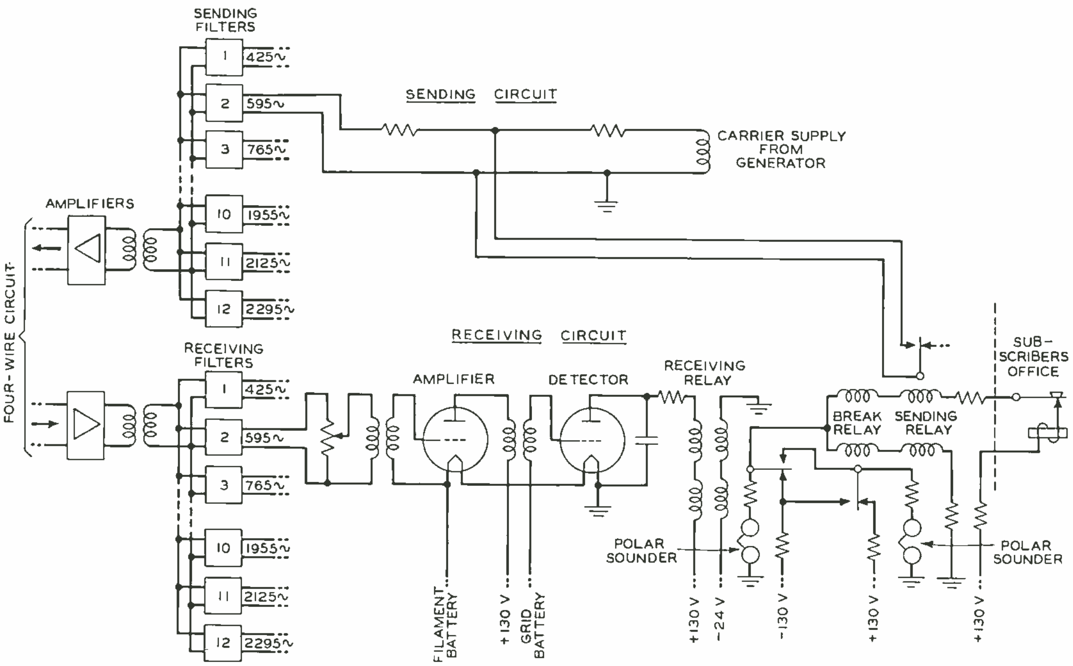


Fig. 2—The 12-channel voice-frequency system that replaced the high-frequency system

been made in the telegraph system and associated circuits to widen its scope and to improve its operation.

One of the first of these modifications was undertaken to permit a voice-frequency carrier-telegraph system to be used on any carrier-telephone channel as well as on a voice channel. The difficulty in applying it to carrier-telephone channels arose from the wide variation in talking volume on other channels of the same carrier-telephone system. Unusually loud volumes would tend to overload the repeaters and thus affect the current in the carrier-telegraph system and cause distorted signals. This was avoided by placing volume limiters of the vacuum-tube type at the sending end of each carrier channel used for speech. With this addition, and a few minor modifications of the telegraph circuit, the voice-frequency carrier-telegraph system could be applied to any type-C carrier-telephone channel. At the present time it can be applied to any carrier-telephone system: such as the K system for cables, the D, H, and J systems for open-wire lines, or the L system for coaxial.

Another improvement was the level compensator, which has already been described in the RECORD.* As described in a previous article,† the polar telegraph systems, to a large extent, give immunity from changes in line characteristics either by applying equal values of voltage for marking and spacing pulses or by making the voltage at the center of the line approximately the same for both. This advantage is lost, however, when carrier is transmitted for the mark, and no carrier for the space. As a result, a varying distortion of the signals will occur as the attenuation characteristics of the line change: strong pulses will cause longer signals and weak pulses, shorter. The level compensator avoids this by automatically regulating the sensitivity of the detector to compensate for changes in level at the receiving end of the line.

Another important change was in the carrier supply. As already pointed out, the individual oscillators of the high-frequency system had been replaced by a machine generator in the first voice-frequency carrier system. This system had the disadvantage, however, that trouble in the motor generator usually put all the carrier channels in a given office out of service until a spare generator could be cut in. Also, there was some difficulty in maintaining sufficiently constant speed of the motor, and thus the carriers would tend to drift away from their assigned positions. Since the high-frequency carrier system was developed, oscillator design had been so improved that a high degree of stability could be obtained, and it was decided to again use individual oscillators to secure the carrier frequencies. To hold all the carriers to their proper relative positions, the oscillators were all locked in step with harmonic frequencies obtained from a control oscillator.

TABLE I—FREQUENCIES FOR THE FIRST CARRIER-TELEGRAPH SYSTEM

Channel Number	Frequency in Cycles Per Second West to East	East to West
1	5,500	6,500
2	5,250	6,800
3	5,010	7,110
4	4,770	7,440
5	4,530	7,800
6	4,290	8,180
7	4,050	8,590
8	3,810	9,030
9	3,570	9,500
10	3,330	10,000

One of the difficulties that must be faced with any carrier system is the occurrence of high peaks when the various carriers all reach their maximum values at the same time. An extensive study was made of this subject, and has already been published.* As a result of the findings of this study, about half of the carrier oscillators have their leads reversed to shift their phase 180 degrees. This results in a large reduction in the size of the possible peaks, and has proved to be of considerable advantage.

A recent change in the voice-frequency telegraph system, made about 1940, was to increase the number of channels from twelve to eighteen, to make use of the wider band voice channels made available

*RECORD, *October*, 1939, *page* 46.

†RECORD, *October*, 1947, *page* 370.

*RECORD, *August*, 1941, *page* 367.

about this time. It was accomplished by adding one lower carrier frequency at 255 cycles and five higher ones extending from 2,465 to 3,145 cycles, inclusive. The original twelve frequencies were not changed, and the new ones, like the old, were separated by 170 cycles. This change gives a 50 per cent increase in the number of telegraph channels of each system. With this new system, eighteen telegraph channels may be substituted for one telephone channel on any of the types of inter-city cable and open-wire carrier-telephone systems in the country, excepting type-C carrier telephone from which fourteen channels are obtainable.

THE AUTHOR: B. P. HAMILTON was graduated by Columbia University in 1913 with the E.E. degree. He taught there for two years and then joined the Engineering Department of the American Telephone and Telegraph Company in 1915 to work on equipment design and later on field tests of high-frequency and voice-frequency carrier-telegraph systems. Mr. Hamilton's work has also involved development problems in connection with the Key West-Havana submarine cable and transcontinental carrier-telegraph systems. Since 1930 he has been engaged in developing voice-frequency carrier-telegraph systems and applications to carrier-telephone channels.

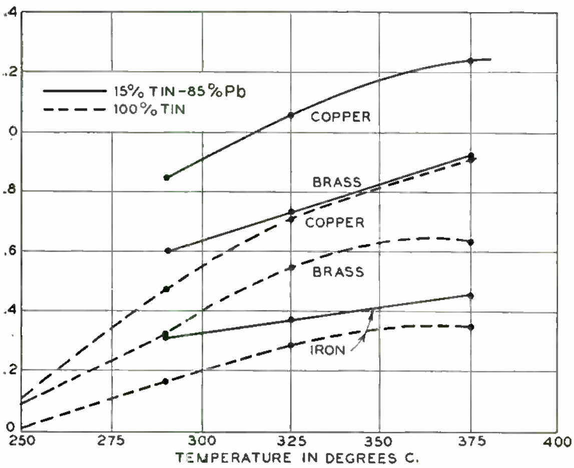
J. R. PIERCE AND R. R. HOUGH HONORED BY ETA KAPPA NU

Two members of the Laboratories are among six recognized by Eta Kappa Nu as outstanding young electrical engineers. The awards were presented on January 26 at a dinner in Pittsburgh. Recipients were J. R. Pierce of Electron Dynamics Research and R. R. Hough of Radio Development, N. I. Hall, a member of the Laboratories from 1940 to 1947 and now of Hughes Aircraft, and three other engineers affiliated respectively with Westinghouse, General Electric and Carnegie Tech. Laboratories men to receive honorable mention were J. W. McRae, W. E. Ingerson, W. A. Depp, and J. A. Morton. Past winners were W. E. Kock and L. A. Meacham.

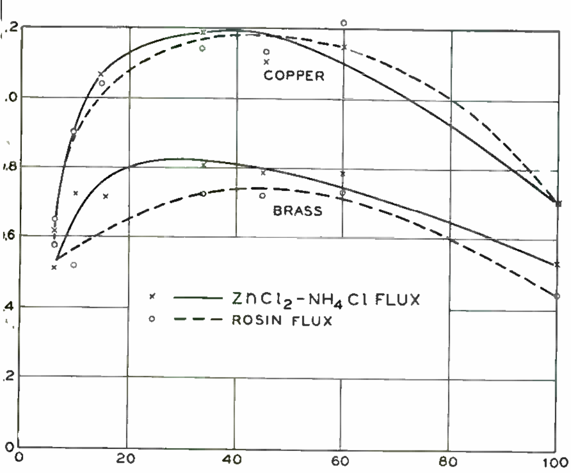
The awards were established in 1936 by Eta Kappa Nu, national honorary electrical engineering fraternity, to recognize young electrical engineers for "meritorious service in the interest of their fellow men." The achievements considered in making selections are very broad, and include professional achievement, what the young engineer has done for his community, state, or nation, and how he has demonstrated his cultural development. Candidates are nominated by sections of the American Institute of Electrical Engineers, by faculty members of engineering colleges, and by key men in the electrical industry.

To qualify for the award, the candidate must be not older than 35 years nor be out of college for more than 10 years by May 1 of the year for which he is cited. After qualifying on these two counts, the candidate is judged on the basis of accomplishment in technical, professional, and social fields. Final selection of candidates is made by a Jury of Awards composed of well-known engineers from industry and educational institutions.

RAPID WETTING TEST FOR SOLDERS



Extent of rise of lead solder and of tin versus temperature using cleaned wires, zinc chloride-ammonium chloride flux, and 15-second immersion time



Extent of rise versus tin content in lead-tin solders using cleaned wires, 325 degrees C. solder bath temperature, and 15-second immersion time

Tin conservation, necessitated by the war, required the use of solders either tin-free or of low-tin content. To determine how well these new alloys wet the surfaces of the metals on which they are applied, the Laboratories devised a simple test. Twisted pairs of wires are immersed vertically in a bath of molten solder, which is held at a predetermined temperature, and the height to which the liquid rises between the wires from the surface of the solder by capillary action in fifteen seconds is observed. This height depends on the temperature and composition of the alloy, the diameter and thermal conductivity of the wires, their twist and cleanliness, the nature of the flux, and the time of immersion. By maintaining other factors constant, the variation in wetting ability as a function of any one factor can be readily determined.

The height to which molten solder rises in a given time between wires of a twisted pair is used as a rapid test of the wetting properties of solders. G. S. Phipps is shown below. Conditions under which tests are conducted tend to approximate those encountered industrially

POLYRODS

G. E. MUELLER
Formerly of
Radio Research

One of the very effective war-time radar antennas was the polyrod array used for fire control on some of the larger warships. Conceived by C. B. H. Feldman and developed under his direction, it consisted of a three-row array of forty-two tapered dielectric rods, visible in Figures 1 and 2. In early studies of this type of radiator, polystyrene was found to be a very satisfactory material for the rods, and thus the name polyrod came to be applied to the individual radiating element.

Waveguides in the form used extensively during the war consist of hollow metal tubes with the waves confined to the space inside them. It is not necessary, however, that the tube be empty; it could be filled with dielectric, and even a uniform rod of dielectric material alone would serve, as has already been described.* With a rod of dielectric material used as a waveguide, part of the energy travels inside the rod, and part in the space around it. The larger the diameter of the rod and the higher the dielectric constant, the greater the proportion of power retained within the rod. Transmission through such rods is stable as long as no irregularities are encountered. When a discontinuity is met, however, radiation will take place from the rod; energy traveling along the outside will radiate outwards, and energy from the inside will move outside to take its place. This action continues for a considerable distance beyond the discontinuity.

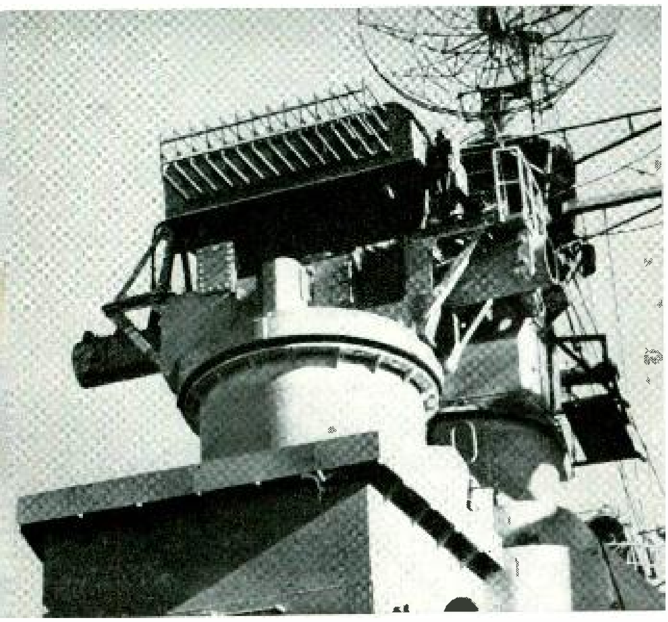


Fig. 1—The polyrod antenna on a United States warship

Because of the radiation induced by discontinuities, dielectric rods have not proven satisfactory as waveguides for general use. When radiation is desired, however, as in antennas, the dielectric rod becomes very useful. By proper design a rod can be made an "end-fire" radiator; that is, the greater part of the radiation will be straight ahead along the axis of the rod.

For use as a radiator, the rod is usually sheathed in metal at its base end, and then the metal is abruptly terminated, leaving the dielectric rod to project from it. This constitutes a severe discontinuity, and from this point on, the rod radiates. The first rod experimented with was of uniform rectangular cross-section, one-half λ by one-third λ, throughout its length, where λ is the free-space wavelength for the frequency used. Radiation patterns for three lengths of rods are shown in Figure 3. Here, as in all subsequent cases, the patterns are essentially symmetrical about the rod axis. The gain—the ratio of the power radiated along the axis to that which would

*Record, *May*, 1936, page 283.

have been radiated along the axis had the radiation been the same in all directions —increases with the length of the rod, being 12½ db for the 3λ rod and 17 db for the 9λ rod.

The radiation pattern obtained from a polyrod depends on the amount of energy radiated from point to point along the rod and on the phasing of the radiation at each point. The energy radiated per unit length is controlled by varying the diameter or the dielectric constant of the rod. Phasing, which is determined by phase velocity along the dielectric line, is controlled in the same manner. In practice, it is much easier to vary the diameter, keeping the dielectric constant fixed. It turns out possible to proportion a polyrod so that both the energy radiated and the phasing are simultaneously given favorable values for efficient end-fire radiation.

The principal defect of the pattern for the uniform polyrod shown in Figure 3 is the relatively large amplitude of the minor lobes. This is materially improved by tapering the cross-section for the first half of the rod. A rectangular rod one-half λ square at the base and tapering to one-quarter λ by one-half λ at the mid-point was tried, with the result shown in Figure 4. The tapering was confined to the magnetic plane. Comparing this with the solid curve of Figure 3 will show that the gain is increased and that the amplitudes of the minor lobes are decreased. A cylindrical rod of the same length and tapered from 0.5 λ to 0.3 λ at the mid-point gave very similar results.

A complete solution of the behavior of the rods from Maxwell's equations, giving the local fields in the vicinity of the dielectric and explaining the effect of discontinuities, is exceedingly complex. It has been found, however, that the behavior of the rod can be very satisfactorily predicted by assuming the rod to consist of a row of radiators, infinitely small and infinitely close together, and then adding their individual effects over the length of the rod for the conditions assumed. From this is readily derived the radiation pattern as a function of rod length and of phasing along the rod. The analysis can be modified to include the effects of tapering and of losses. Experimental results check this type of theoretical calculation so satisfactorily that exact analysis has not been felt necessary.

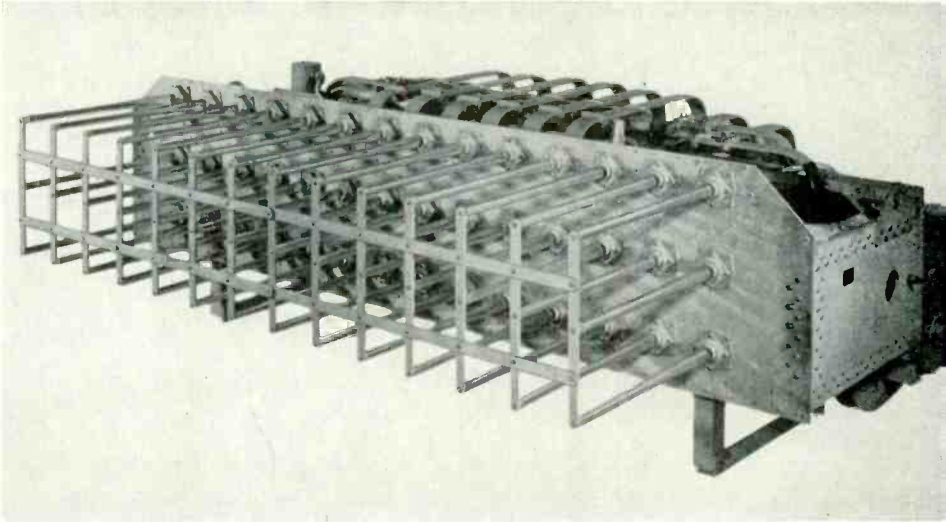


Fig. 2—A three-row, forty-two rod antenna array developed for the U. S. Navy

A clamping socket holds the polyrod firmly in place, and a two-iris transformer electrically couples the guide to the rod. Methods have also been developed for coupling from a coaxial conductor to a polyrod. Here also the polyrod is fed directly by a waveguide, but this, in turn, is coupled to a coaxial conductor.

The frequency response of a polyrod is inherently broad. At present, the usable band width is limited primarily by the frequency response of the coupling arrangement from polyrod to waveguide or coaxial line. Without adjustments for tuning the coupling devices, band widths from one to four per cent have been realized.

In general, the performance of a polyrod is affected by proximity to any metallic or dielectric objects, and the gain and pattern must be determined empirically for each new configuration. In most circumstances, however, the behavior of a polyrod is little affected by nearby objects. A metal rod may be placed parallel

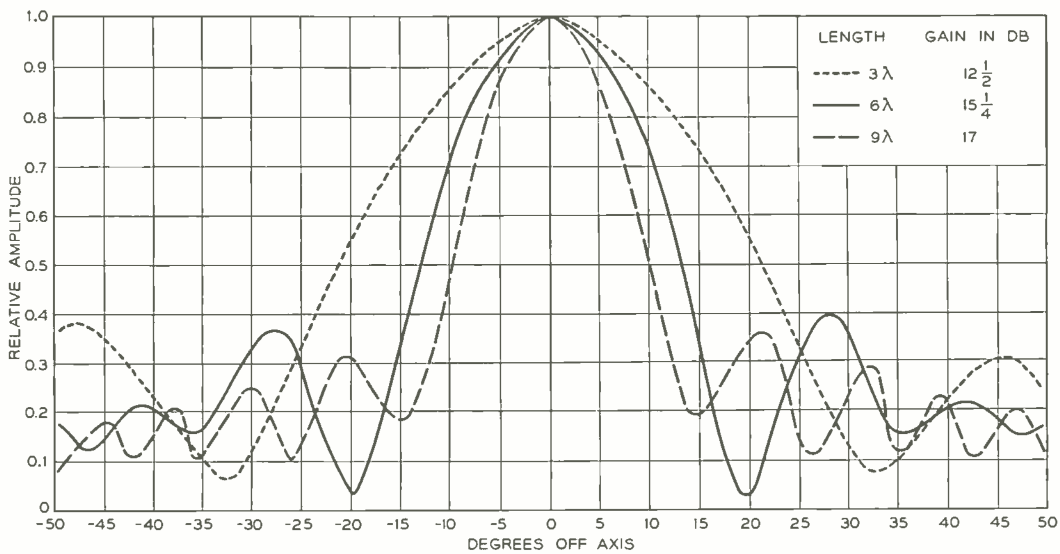


Fig. 3 (above)—Radiation from uniform rods

Fig. 4 (below)—Radiation pattern for a tapered rectangular rod

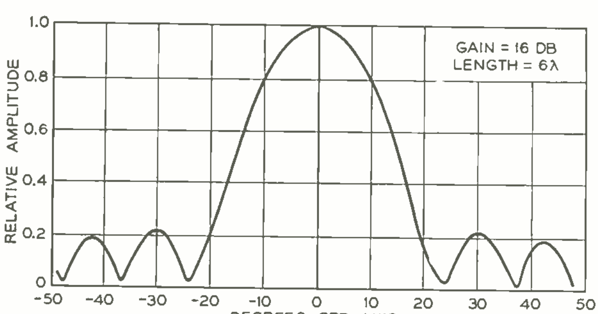
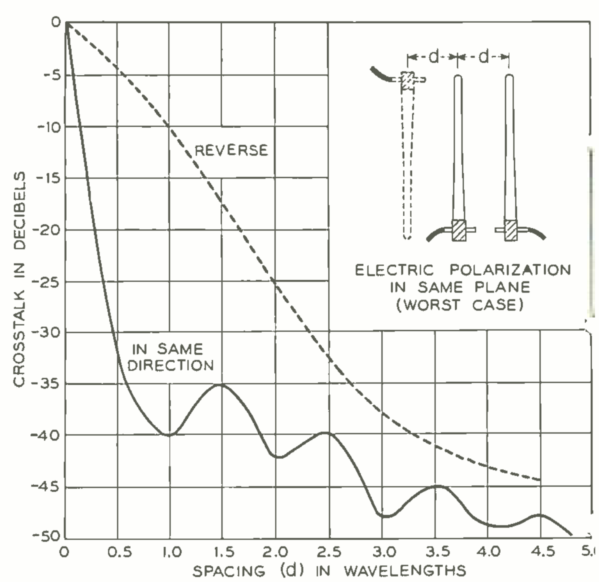


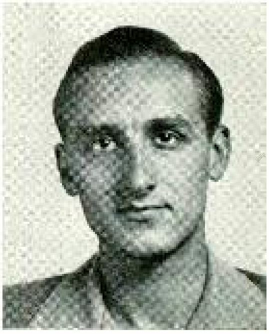
Fig. 5 (right)—Crosstalk between adjacent polyrods is negligible for spacings greater than a wavelength



to it without seriously affecting its behavior as long as a separation of a wavelength or more is maintained. Sheets of dielectric material may be brought even closer without adverse effect. The crosstalk between adjacent polyrods, that is, the power received in one radiator when the other is energized, is shown in Figure 5. For polyrods pointing in the same direction, separations greater than a wavelength insure low mutual coupling.

This freedom from crosstalk when the rods are more than a wavelength apart, and the mechanical simplicity of the rod suggested its use in scanning arrays for radar. In this application it proved very effective during the war with a fire-control radar system for cruisers and battleships. Its convenient physical form, high electric efficiency, and relative freedom from external disturbances, make it attractive for applications requiring gains of from 15 to 20 db.

THE AUTHOR: G. E. Mueller received a B.S. degree from the Missouri School of Mines and Metallurgy in 1939 and an M.S. degree from Purdue in 1940. He then joined the Technical Staff of Bell Telephone Laboratories and engaged in television and radio research. During the war he worked largely on radar developments, including the polyrod antenna described in this issue. Mr. Mueller left the Laboratories last fall to become Assistant Professor of Electrical Engineering at Ohio State University.



VOLUME 25—BOUND COPIES AND INDEX

Bound copies of Volume 25 (January, 1947 to December, 1947) are now available at $2.75, foreign postage 25 cents additional. Remittances should be addressed to Bell Laboratories Record, 463 West St., New York 14, N. Y. A separate index to Volume 25 of Bell Laboratories Record *is also available upon request*

HIGH-FREQUENCY OSCILLOSCOPES FOR PULSES AND OTHER TRANSIENTS

W. L. GAINES
Transmission
Engineering

Cathode-ray oscilloscopes had been in use by the Laboratories for nearly a quarter of a century, but when the Pearl Harbor attack plunged us into a nearly one hundred per cent war-development program, no oscilloscopes available were adequate for studies of the radar apparatus that soon became one of our major interests. Radar pulses are of the order of a microsecond in duration, and may be sent out at rates of several thousand per second. To spread out the images of these pulses on an oscilloscope so that their form may be studied, sweep speeds far higher than any used before were needed. Moreover, the pulses may be sent out at irregular intervals, and thus the usual oscillating type of sweep circuit would not properly superimpose successive pulses, and faint or even unusable images would result. In addition, the amplifiers, even when giving a uniform amplitude response with frequency, did not have the proper phase characteristics. Different frequency components, because of varying delays through the amplifier, would not arrive at its output in the proper time relations, and a distorted* or unrecognizable image would be produced. Radically improved oscilloscopes were thus needed at once. During the course of the war, a number of oscilloscopes were developed by the Laboratories for testing work, and some 15,000 were manufactured for the armed services. Some of these are shown in Figure 1. Although designed primarily for radar studies, some of these oscilloscopes have been finding a steadily widening field of use, and oscilloscopes of still higher capabilities will play an important part in communication research of the future.

The limitations of the more usual oscilloscope with a relaxation type of sweep circuit* may be illustrated by assuming that a one-microsecond pulse recurring one thousand times a second is to be viewed. With a four-inch sweep repeating one thousand times a second, the one-microsecond pulse would appear as a faint spike only four-thousandths of an inch wide. If, in addition, the pulses were not separated by exactly equal intervals, successive pulse images would not superimpose, and the resulting image would be faint and fuzzy in outline. To make it possible to clearly display these very short pulses recurring at perhaps irregular intervals, a radically dif-

*Record, *January*, 1932, *page* 138.

*Record, *August*, 1931, *page* 571.

A D-151326 oscilloscope in a Systems Department laboratory is being used by Ruth Aitken

ferent control of the sweep circuit was necessary. To spread the pulses out on the oscilloscope, the entire sweep should occupy a time more nearly comparable to the length of the pulse than to the period of repetition. This would require an ability to start the sweep at any desired point of the repeating cycle, and also to control its speed so that the full sweep could be made to occupy as short a time as needed to spread out the pulse satisfactorily.

Since the early radars were synchronized by sine waves, similar control was adequate for the first oscilloscopes developed, but to meet the requirements noted above, new dar work and variously referred to as an enabling pulse generator, a start-stop oscillator, a single-shot multivibrator, and a trigger circuit, was employed. On receiving a pulse, such a circuit goes through one cycle of operation, restores to its static condition, and remains at rest until the next pulse arrives.

A short delay was inserted in the signal channel to give the sweep circuit time to get under way. With such an arrangement, the pulsing rate, within the limits of the design, is of no concern, since each pulse starts the sweep circuit anew, and the pulse will appear an interval after the sweep be-

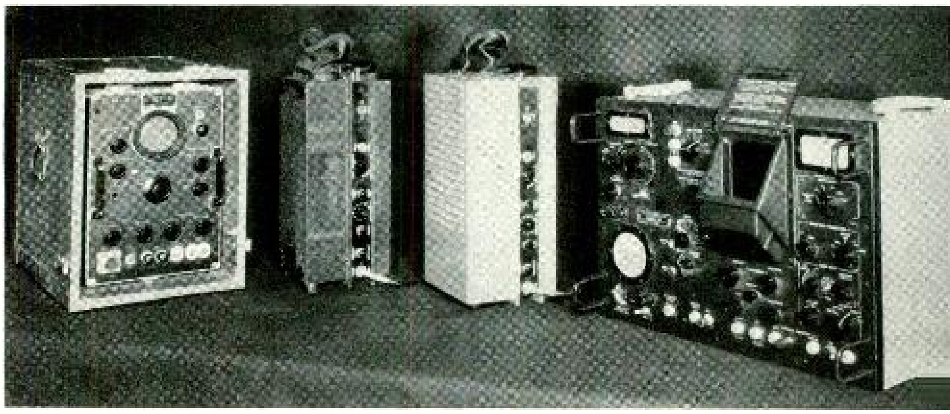


Fig. 1—Some of the radar oscilloscopes developed during the war. From left to right, these are: the BC-910-A, the TS-34/AP, the TS-34A/AP, and the TS-239/UP

sweep circuits were devised which would permit fast sweeps to be started at any time during the sine wave cycle. Thus the image of a pulse occupying only a small portion of the timing cycle would be spread out to cover a relatively large distance along the sweep axis. Some eighty oscilloscopes incorporating these features were built, and they were known as the BC-910-A. One is shown at the left of Figure 1. As many as three connecting cords in addition to the power cable were required. These oscilloscopes did good work in helping to maintain some of the early radars used primarily for submarine search.

Sine-wave synchronization became awkward, however, because of the widening range of radar pulse rates and the introduction of irregular rates. It was therefore decided to design an oscilloscope in which each sweep would be triggered independently by the pulse to be viewed. To accomplish this, a circuit used extensively in ra-

gins equal to the delay interval. Because of their wide application to radar systems, these were known as "universal" oscilloscopes, and nearly 1,600 were built. They were supplied to both Army and Navy under the code numbers BC-1087-A and CW-60AAY, respectively. The BC-1087-A is shown in Figure 2.

Although this oscilloscope was widely used, and was very satisfactory in its operation, its weight of over sixty pounds was a handicap. As a result, ways were studied for producing a lighter instrument. These studies resulted in the TS-34/AP and its splashproof brother, the TS-34A/AP, both shown in Figure 1. A two-inch cathode-ray tube was used with a lens for magnifying the image, and the entire oscilloscope was only seven inches square by fifteen inches long. It withstood rigid shock and vibration tests and proved an extremely useful instrument. Some 14,000 were ordered.

After the "universal" oscilloscope design was well under way, development was started on an oscilloscope embodying the same general principles but with a wider range of control and other features that would make it suitable as a general laboratory test instrument. For such use, size and weight are not controlling factors, and thus features that could not be justified in a more portable set could properly be included. This instrument was known as the D-151326 laboratory oscilloscope, and forty-four units were produced, of which three were delivered to the armed services. Many of the others are now in the Laboratories and performing useful work in many fields. This oscilloscope is shown in use in illustration on page 68.

A block diagram for this oscilloscope is shown in Figure 3. For studying radar pulses or any disturbances occurring at irregular intervals, only a single connection is made to the oscilloscope for the signal—to the lead at the lower left. For radar work, this signal could be supplied from a small dipole mounted where it would pick up the pulses. Leaving the vertical signal attenuator, the signal divides: part going to the synchronizing attenuator and thence to the start-stop sweep circuit, and the remaining part to the vertical signal amplifier by way of the delay circuit. This latter circuit delays the signal one-half microsecond to permit the sweep circuit to get under way before the signal reaches the vertical deflector plates.

On receipt of the signal, the sweep circuit applies a voltage to the grid of the cathode-ray tube so as to permit the electron beam to pass, and applies the sweep voltage to the horizontal deflector plates. One-half microsecond after this, the signal voltage, amplified without appreciable phase distortion, is applied to the vertical deflector plates so that the signal will be displayed. At the conclusion of the single sweep, the entire circuit restores to normal. On receipt of the next pulse, the same process is repeated, and the second trace will be exactly superimposed on the first, since its timing on the oscilloscope is controlled by the arrival of the pulse and not by the time between pulses.

The duration of the sweep is controllable and may be adjusted to display the pulse to the best advantage. A delay control is also included in the sweep circuit to permit the beginning of the sweep to be delayed until some given time after the arrival of the triggering pulse. It might, for example, be desired to view a short pulse following the trigger pulse by an interval of 300 microseconds. If the sweep were made long enough to include this entire period, the image of the pulse it was desired to study would be very short. By delaying the sweep until just before the desired pulse arrives, however, the pulse may be spread out to give an easily studied image.

The other circuit components shown in Figure 3 are provided to extend the usefulness of the oscilloscope. Measurement of time is accomplished, for example, by timing markers which are of known uniform spacing and are synchronized with the start-stop sweep. Provision is made for applying a voltage to the horizontal deflector plates, as well as to the vertical deflectors so that the relationship of two signals may be studied directly. A relaxation sweep circuit is also provided, which permits the oscilloscope to operate in the more usual continuous fashion, and provision is also

Fig. 2—The BC-1087-A oscilloscope was supplied to both the Army and Navy

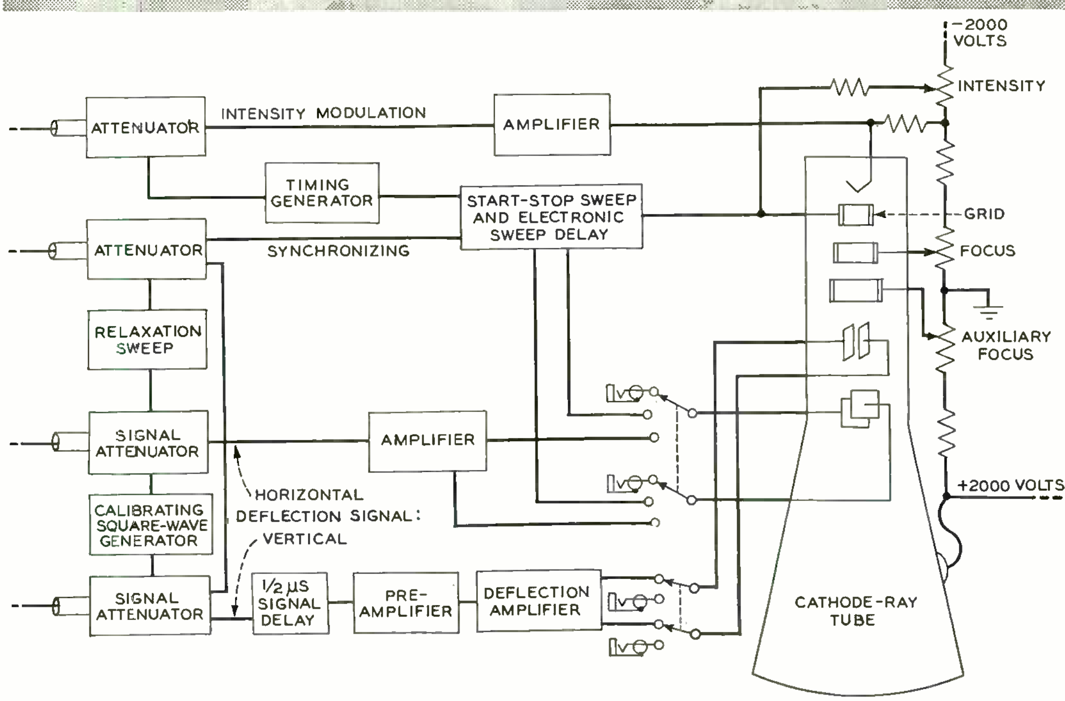


Fig. 3—Block diagram for the D-151326 oscilloscope

made for an external synchronizing connection. A square wave generator is included to provide a square calibrating wave.

A number of unusual features are included in the set to simplify and improve its operation. The arrangement (devised outside of these Laboratories) provided to improve the visibility of the image and to simplify the measurement of voltage and time is shown in Figure 4. A piece of green plexiglas, making an angle of forty-five degrees with the face of the oscilloscope, is placed between the operator and the front of the tube, and is enclosed on all four sides so that light can reach the plexiglas only from the tube or from the front. Only green light can pass through the plexiglas, and the oscilloscope image, which is green, readily passes while other color components or lights are reflected away from the operator because of the angle at which he looks at the plexiglas. Reflections from the face of the tube, ordinarily annoying, are almost entirely absent.

At an angle of forty-five degrees below the plexiglas, and thus at right angles to the face of the tube, is an orange-colored scale which is reflected in the plexiglas as though it were directly marked on the face of the oscilloscope, thus avoiding parallax between the scale and images traced on the oscilloscope screen. Because this scale is orange, its image is very plainly distin-

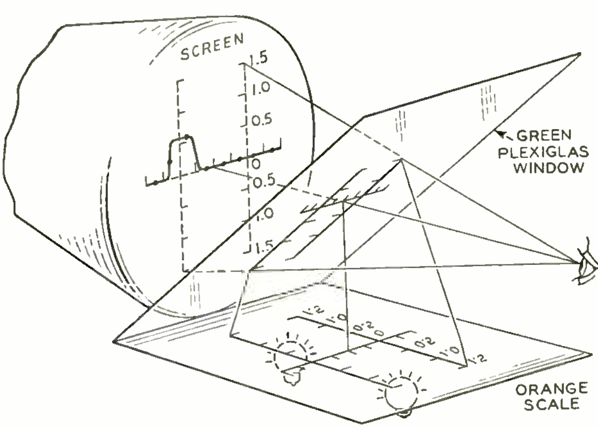


Fig. 4—Method used to obtain scales on the face of the cathode-ray tube and to reduce reflections

Principal Characteristics of High-Frequency Oscilloscopes

	BC-910-A	BC-1087-A CW-60AAY	D-151326 OSCILLOSCOPE	TS-34/AP	TS-34A/AP	TS-239/UP
Frequency Band Signal Channel Cycles/Sec.	1,000–2,000,000	1,000–2,000,000	1–8,000,000	20–3,000,000		2–5,000,000
Sweep Time μSec.	10 and 120	3 to 18 50 to 250	3 to 5,000 (1 to 100,000)	5, 50 and 250	5 to 8 20 to 50 120 to 280	1 to 100,000
Sweep Delay	No	No	Yes	No		Yes
Time Scale Intervals—μSec.	None	1.0	.1, 1, 10, 100	1.0		.2, 1, 10, 100, 500
Self-Contained Voltage Meas.	No	No	Yes	No		Yes
Weight—Pounds	114	62	420	26	29	60

guishable from the oscilloscope trace and does not interfere with it.

Experience gained in building this laboratory oscilloscope and the early test oscilloscopes made it possible to design an improved oscilloscope for radar testing. Coded the TS-239/UP, and shown at the right in Figure 1, it is, so far as known, the most nearly "universal" oscilloscope that has yet been produced.

Some of the important differences between the four maintenance oscilloscopes and the laboratory D-151326 oscilloscope are given in the accompanying table. It will be noticed that the weights of all the maintenance oscilloscopes up to the TS-239 decrease successively. All but the TS-239 had been designed for use in airplanes, while the latter was designed for use at bases, so that weight was not so important a consideration.

With communication constantly tending toward the use of higher and higher frequencies, including pulse techniques in the microwave region, the need for oscilloscopes of this type will increase. The wide experience already gained supplies a good foundation for continued developments, and work is now in progress on an oscilloscope using the same general operating principles as those described herein, but possessing superior operating capabilities.

THE AUTHOR: W. L. Gaines joined the Department of Development and Research of the American Telephone and Telegraph Company in 1926, coming from the Massachusetts Institute of Technology, where he studied electrical engineering. For the first three and one-half years he was with a test group in West Virginia, working on induction problems connected with a railroad electrification. In 1934 he came to the Protection Development Department of Bell Telephone Laboratories, where he has continued work on low-frequency induction problems and the design and construction of special apparatus for protection development studies.

L. E. HERBORN
Electrical
Measuring
Apparatus

A CONDUCTANCE UNBALANCE BRIDGE

New crystal channel filters* have recently been developed for the J, K, and L broad-band carrier systems to secure a smaller filter while still providing the high degree of separation required. These filters are lattice type structures, in which the crystal units provide the main body of the lattice. For proper operation, it is essential that the capacitances and conductances the crystal units interpose in the series branches be very nearly identical with those interposed in the diagonal branches. Inequalities of the capacitance components of the units may be compensated by adjustable capacitances in the filter circuit, but there are no means provided for adjusting for differences in the conductance components. In manufacturing the crystal units, therefore, it is necessary to control the conductance unbalances. The actual amount of conductance is of secondary importance, but the conductance in the series branches must equal that in the diagonal branches to very high precision. To make this possible, a conductance unbalance bridge was developed that would compare conductance contributions of a crystal plate to these branches. This bridge will also compare conductances of the various branches in a combination of four crystal plates forming a complete crystal unit, so that only those meeting the requirements would be used.

The crystal plates are wire supported† in sealed glass containers, and are of the divided plating type: the plating on each face of the crystal plate is divided longitudinally along the center line to give effectively two crystal elements. A lattice type filter section is used, with two crystal elements—each of different resonance frequency—in parallel in each branch. Since the two elements in each branch are of different resonance frequencies, they cannot be provided by one crystal plate. Hence, the two elements provided by one crystal plate are connected in opposite series or opposite diagonal branches. The connections for the plates connected in the two series branches are as shown in Figure 1.

Associated with each plate, there are four conductances: from 1 to 2 and from 3 to 4 through the plate, and from 1 to 3 and from 2 to 4 along the plate. The two

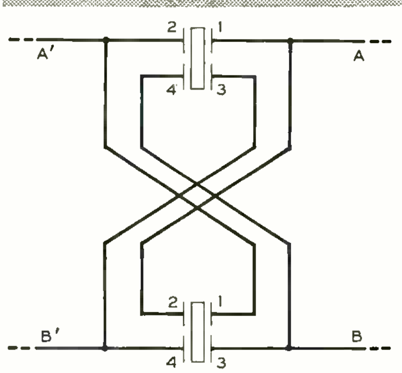


Fig. 1—Connections for the crystal plates for the two series arms. Two other plates, not shown above but connected in a somewhat similar manner, comprise the diagonal arm

former are in the series connection, while the latter two fall across the circuit diagonally, as evident from the diagram. It is the difference between the sum of the first two and the last two that must be kept very small. The bridge required for measuring this difference had to be able to detect differences as small as 0.001 μmho—the equivalent of an insulation resistance of 1,000 megohms—measured at frequencies slightly above the operating frequency of the crystal unit.

Since there is capacitance as well as conductance between the four terminals of a

*Record, *January*, 1948, *page* 13.
†Record, *April*, 1945, *page* 140.

crystal unit, the bridge for measuring differences in conductances must be capable of independent balance for both the capacitance and conductance components of the admittance. To secure this independence of balance to the accuracy required, it is necessary to design the bridge to have a low Q; in other words, the ratio of susceptance to conductance must be made considerably less than one for each arm. Another major requirement was to secure a high conductance stability with change in temperature: better than 0.0005 μmho.

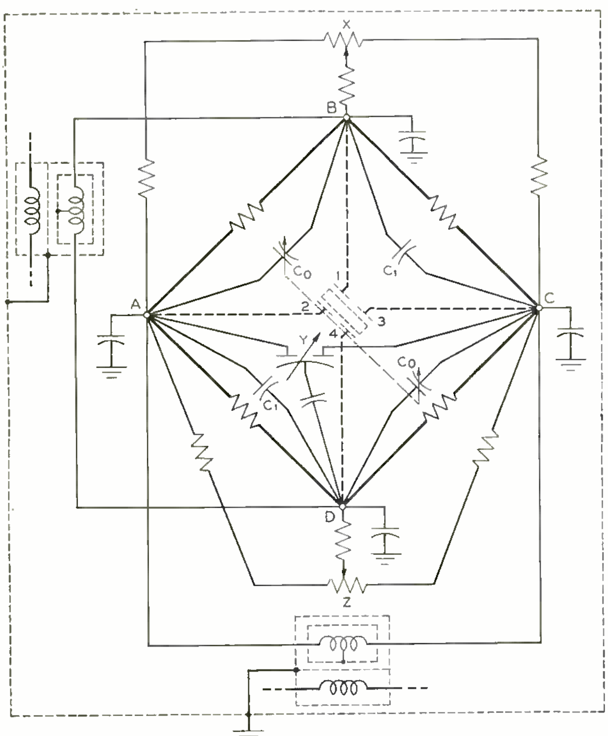


Fig. 2—Schematic of the conductance unbalance bridge showing a single crystal plate connected

The predominant elements of the bridge are the four equal-resistance ratio arms shown in heavy lines in Figure 2. These are of relatively large wattage and are also wound from the same spool of wire and thoroughly annealed, so that they will be identically affected by changes in temperature. Two adjustable resistance networks, drawn outside the ratio arms in Figure 2, provide the adjustment for conductance balance. The greater part of the resistance of these latter networks is in the two fixed resistances between points B and D of the bridge and the adjustable elements of the networks. Since this fixed section is in effect in both of the associated arms of the bridge, any slight change in resistance due to temperature will have the same effect on both arms, and thus will not affect the balance. The adjustable resistor connected to the D point of the bridge is controlled by a dial calibrated to read conductance unbalance up to 0.06 μmho. The companion network connected to point B is controlled by an uncalibrated dial, and is used for obtaining balance before the crystal is connected to the bridge.

Crystal plates are connected to the bridge, as shown by the dashed lines in the center of Figure 2. The capacitances from 1 to 2 and from 3 to 4 fall across the AB and CD arms, respectively, while the very much smaller and essentially negligible capacitances from 1 to 3 and from 2 to 4 fall across the arms BC and AD. Since the objective of the test is to determine conductance unbalance for the crystal from its effect on the bridge balance, it is necessary to include in the bridge circuit itself balanced capacitances corresponding to the crystal capacitances, so that the bridge may be properly balanced before the crystal is connected. The adjustable capacitances marked C_0 in Figure 2 serve this purpose. To balance the capacitances C_0, the fixed capacitors C_1 are connected in the BC and AD arms. The crystal units used in the 219-type channel filters introduce capacitances in the circuit ranging from 1 $\mu\mu$f to as much as 25 $\mu\mu$f. Since greater accuracy is obtained in the bridge measurement when the capacitances in the bridge arms are maintained small, the capacitances marked C_1 in Figure 2 each consist physically of three capacitors, so that the one with the capacitance value nearest but above that of the crystal unit under test is selected by a dial on the bridge panel. After the proper value for C_1 is selected, and before the crystal unit is connected to the bridge, a zero balance for the bridge is obtained by adjusting C_0 and the fine adjustment marked Y in

Figure 2 for capacitance balance, and by adjusting x for conductance balance with the dial controlling adjustment z in the zero position. In making the unbalance test on crystal unit assemblies, the procedure is similar to that for the individual crystal plates, except that C_1 is set to the lowest capacitance value, since approximately equal capacitances are added by the unit to each bridge arm.

After this zero balance has been obtained, the crystal is connected as shown, and C_0 is adjusted downward to remove from the bridge circuit just the amount of capacitance added by the crystal. This again brings the bridge into balance with the same capacitances in the circuit as at zero balance. The capacitances from 1 to 3 and from 2 to 4 of the crystal are so small

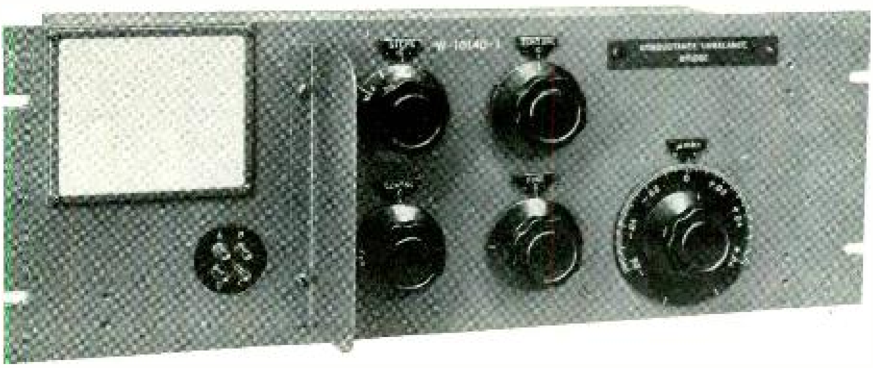


Fig. 3—Front view of the conductance unbalance bridge showing controls

as to have almost negligible effect and they do not influence the balance because the very small addition they do make falls across arms BC and AD and is compensated by the adjustment of C_0.

After this capacitance balance is obtained, the dial controlling z is moved to secure a conductance balance. The conductances from 1 to 3 and from 2 to 4 are, of course, not negligible, and the bridge will be out of conductance balance because of the difference between these conductances placed across the bridge arms. After conductance balance has been obtained by manipulating z, the equation for the bridge is $AC = BD$ where A represents the conductance in the arm AB, B that in the arm BC, C that in CD, and D that in AD. Each of these four conductances consists of a large and a small component; the large component is the conductance of that arm before the crystal was connected, and the small component, that added by the crystal. If the conductances in the bridge arms at zero balance are represented by capital letters and the much smaller conductances added by the crystal by small letters, the balance equation may be written:

$$(A+a)\ (C+c) = (B+b)\ (D+d)$$

which when multiplied out gives

$$AC + Ac + Ca + ac = BD + Bd + Db + bd$$

A, B, C, and D are all equal, and thus the AC and BD terms may be removed. The two terms ac and bd, since they are the product of two very small quantities, are of a lower order of magnitude than such terms as Ac or Bd, and thus the terms ac and bd may be neglected. With these changes, the equation becomes: $Ac + Ca = Bd + Db$. Since A, B, C, and D are all equal, they may be divided out, thus leaving: $c + a = b + d$ for balance with the crystal connected. This balance was obtained by adjusting z, however, and thus $(c+a) - (b+d) = \Delta z$. The reading of the dial controlling z thus gives a conductance unbalance directly.

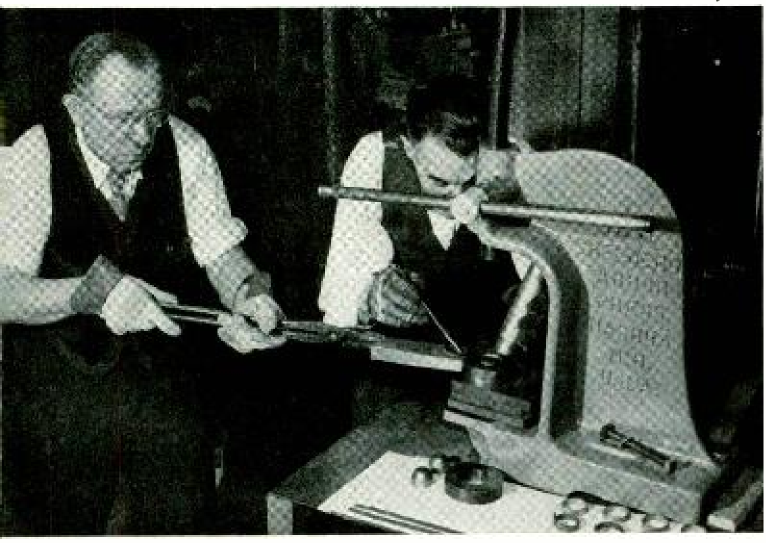
To secure the accuracy and stability required, a number of precautions were necessary besides those already mentioned. Electrical symmetry is required with respect to the diagonally opposite corners of the bridge. This has been accomplished by assembling the parts around the four fixed resistors, and by wiring with twisted

THE AUTHOR: L. E. HERBORN joined the Technical Staff of the Laboratories in 1923, and until 1928 was associated with the Research Department on the development of terminal equipment for high-speed submarine cables. At the completion of this work he transferred to the Apparatus Development Department, where he engaged in the development of precision impedance measuring equipment. During the war he collaborated in the circuit development of the submarine total field depth charge. Mr. Herborn has the degree of B.S. in E.E. from Cooper Union and is an Associate of the American Institute of Electrical Engineers.

pair the parts connecting to the diagonally opposite corners of the bridge. In addition, any capacitance unbalances found in building the bridge are padded out with small capacitors. These expedients result in a bridge having a large degree of stability and equal Q's in the arms.

The appearance of the bridge panel is shown in Figure 3. The dial at the upper left selects the particular value required for c_1, while the dial at the upper right controls the x, or zero conductance, balance. The dial at the lower left controls the c_0 capacitances together, while that immediately to the right of it controls the adjustment of Y. The large dial at the lower right gives the conductance unbalance—or Δz of the above equation.

Since this bridge is inexpensive to build, and measures the conductance unbalance quickly by one measurement, it offers a rapid method of controlling the quality of crystal units. It is now being used by the Western Electric Company for production work to sort out any crystals that do not meet conductance requirements. The labor required for making this test is a minimum, but results in considerable saving of time and expense by avoiding the assembling of faulty crystals in filters, which otherwise upon completion would be rejected for not meeting the over-all tests.



Hot Remalloy spiral segments are pressed into rings for experimental magnet production. M. Tompa holds the hot segment which D. Wallace guides to the die. In the foreground are samples illustrating the stages of processing from strip to ring

R. C. EDSON
Transmission
Engineering

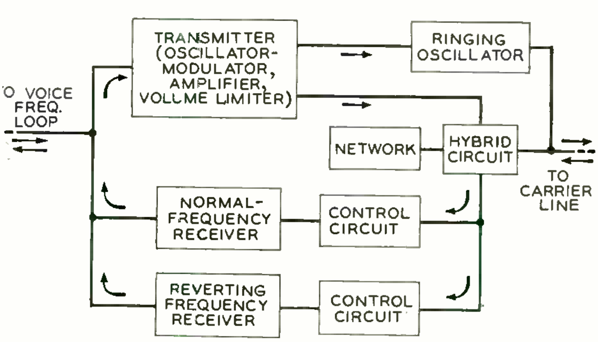
M1 CARRIER: THE COMMON TERMINAL

When M1 carrier* channels are used on power lines, a "common" terminal for each of the six possible channels is mounted on, or adjacent to, one of the power line poles nearest the telephone central office. It consists of a carrier transmitter, two carrier receivers—one for each of the two frequencies provided by the subscriber's transmitter—and a basic unit used for converting the two-path carrier links to the single-path connection to the central office, for applying ringing, and for performing other control functions. The major elements provided for a single carrier channel are shown in block form in Figure 1. Each of these terminals may serve a number of subscribers—the number of "parties on the line," in ordinary party line terms—and for each common terminal there will be a wire line to the central office.

The carrier receivers employed at the common terminal are very similar to those used at the subscribers' stations—differing primarily in the arrangements of the output circuits. The carrier transmitters also are similar to the subscribers' transmitters, but they have only one crystal instead of two, since the subscribers of one channel always receive on the same frequency. The main difference, however, is the addition of a volume limiter to offset the wide variation in the volume of the incoming speech. Connections to the M1 system may be made either from lines of the local central office or from toll lines, and the variation in volume may exceed 35 db. Without some form of volume control, it would not be possible to provide an adequate signal-to-noise ratio for the subscribers.

A somewhat unusual feature of this limiter, shown in Figure 2, is that its only active element is the vacuum tube used as the oscillator-modulator of the transmitter. The modulator grid of this tube is supplied from a winding of the transformer shown at the left, which forms part of the hybrid

*RECORD, *October*, 1947, *page* 363, and *November*, 1947, *page* 413.



ig. 1—Block schematic for the major elements in a ommon terminal

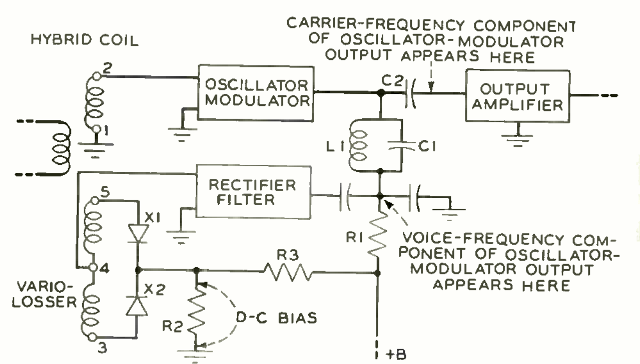


Fig. 2—Simplified schematic of the volume limiter at the common terminal

circuit, and the output circuit of the tube includes both voice-frequency and carrier-frequency components. These are separated by the filter formed by C1, L1, and C2. The carrier frequencies are passed to the output amplifier for transmission over the carrier circuit, while the voice frequencies, appearing across resistor R1, are rectified and filtered. The output of the filter connects to the vario-losser, which consists of two copper-oxide varistors and a pair of windings on the transformer that supplies the grid input to the oscillator-modulator. A bias voltage obtained from the B supply is also connected across the vario-losser, verses, and their resistance rapidly decreases. Under these conditions, the varistors form a low-resistance shunt across the vario-losser winding, and reduce the signal applied to the oscillator-modulator.

The limiter circuit is so designed that the signal modulation for low input levels is increased, while the high input volumes are limited. Without limiting, the increase in signal modulation for low input volumes could not be obtained without causing serious overmodulation when the signal input is high. Since the limiter changes the linear relationship between the low volumes and the high, the volume of speech heard at a

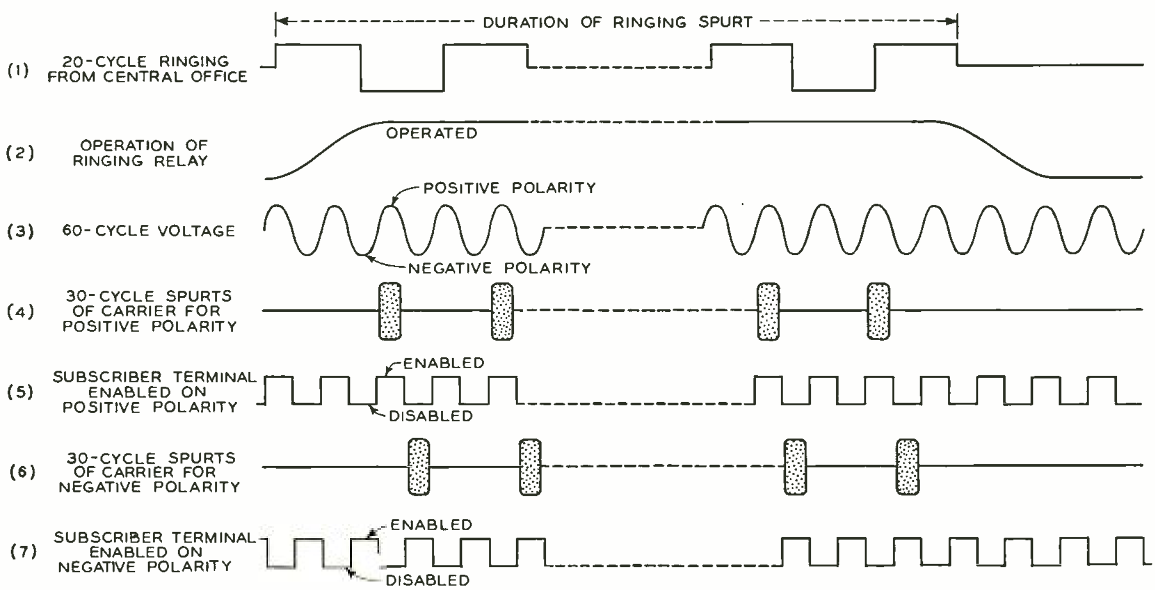


Fig. 3—Timing diagram for the ringing signals

but the poling is such that the voltage appearing across X1 and X2, because of the bias voltage, is opposite in sign to that due to the rectified voice currents. With little or no speech input, the bias voltage predominates, and its polarity is such that the varistors are in their non-conducting or high-resistance state. As a result, the vario-losser winding is essentially open-circuited, and the input to the oscillator-modulator is the same as it would be without a volume control. As the voice input increases, however, the voltage across the varistors re- subscriber terminal is adjusted so that the low speech volumes are about 8 db greater than without a limiter and the highest-speech volume is about 7 db weaker. Any background noise entering the carrier channel from the voice-frequency loop, or through the hybrid loss from the common terminal receiver during silent intervals, will consequently be heard in the subscriber's receiver at a level only 8 db higher instead of the 15 db increase in signal modulation provided by the limiter circuit.

The function of the hybrid circuit is to

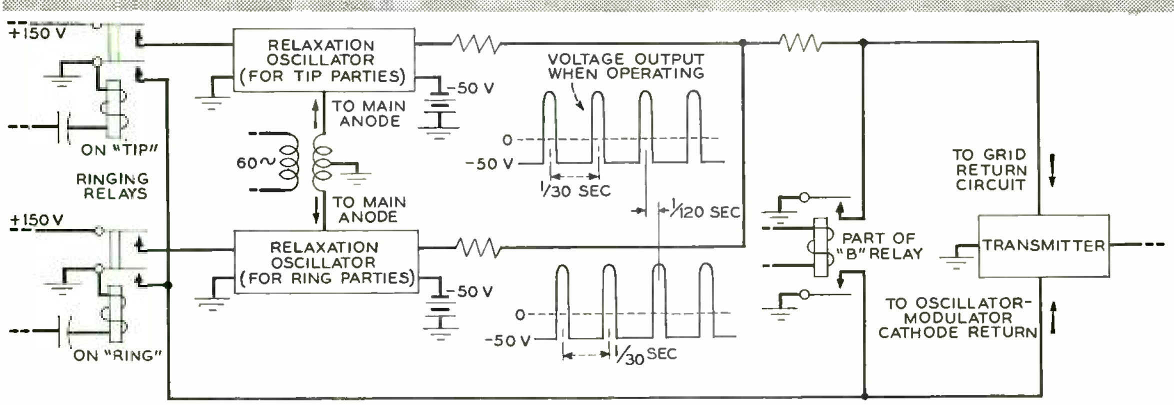


Fig. 4—Simplified block schematic of the ringing circuit at the common terminal

permit speech on the central office trunk to pass to the transmitter, and speech from the carrier receiver to pass to the central office trunk and not across the hybrid to the carrier transmitter. How effective the hybrid is in preventing transmission of speech and noise from the receiver to the transmitter depends on the balancing network employed. Since the lowest signals are usually those from toll lines, the network is designed to balance the normal toll condition. For a reverting call, that is, one from one subscriber to another on the same carrier channel, it is necessary for the speech from the carrier receiver to pass across the hybrid to the carrier transmitter. This is made possible by arranging the reverting-frequency receiver, whenever it is receiving a signal, to operate a relay that changes the balancing network of the hybrid so that the loss across the hybrid becomes low.

The common terminal also includes provisions for ringing the subscribers. To conform with the usual party line practice, this ringing may be either full code or divided code, that is, each subscriber may hear all the rings or only half the rings. With wire-line circuits, this difference is brought about by applying ringing across the two wires of the circuit to give full code ringing, and by applying it from one or the other wire to ground to give divided code ringing. Since, with a power line carrier system, ringing from one wire to ground is not feasible, an entirely different method of obtaining divided ringing has been developed. A sequence of short pulses of carrier is derived by allowing the 20-cycle ringing current from the central office to operate a relay that applies d-c voltage to a relaxation oscillator, and each pulse from this oscillator is applied to the grid of a carrier transmitter to produce a corresponding pulse of carrier. Timing of these pulses is controlled by the 60-cycle supply voltage, which is connected to the oscillator circuit. The rate of rise of the voltage across a capacitor in the oscillator circuit is adjusted so that the gas tube will discharge at a fixed point of every second cycle of the 60-cycle voltage. As a result, a pulse is formed every thirtieth of a second, and thus the carrier ringing pulses are at a 30-cycle rate.

To be able to provide divided ringing, two relaxation oscillators are supplied. Each of them is started by a separate relay: one is operated when the ringing is from one side of the central office line to ground, and the other when the ringing is from the other side of the line to ground. The a-c control voltages applied to the two oscillators are reversed with respect to each other, and thus one operates at a point on each second positive half cycle of the 60-cycle supply, and the other on the equivalent point of each second negative half cycle. As a result, the pulses from one oscillator start 1/120th of a second (or 8⅓ milliseconds) before or after the pulse of the other oscillator, but both recur at a 30-cycle rate.

The pulses themselves are about 6 milliseconds in duration, and thus there is an interval of 2 or 3 milliseconds between the end of a pulse of one series and the beginning of a pulse of the next. How these pulses cause ringing at the subscriber's station has already been described.*

Time relationships for the entire ringing sequence are indicated in Figure 3. Each spurt of 20-cycle ringing current from the central office, shown on line 1, operates a ringing relay which remains operated for the duration of the spurt, as shown in line 2. During its operated period, a positive voltage is applied to the relaxation oscillator, and a 60-cycle voltage is also applied, as indicated on line 3. Every other positive half cycle will result in a pulse from the oscillator, as shown in line 4. Had the other ringing relay and oscillator been operated, the pulses would be caused by the negative half cycles, as shown on line 6. The subscribers' receivers are made operative during positive or negative half cycles of the 60-cycle current, as indicated on lines 5 and 7, and thus receive only pulses caused by the corresponding half cycle at the common terminal. Dashed lines in the middle section of Figure 3 indicate that there is a train of pulses lasting as long as the original spurt of ringing current.

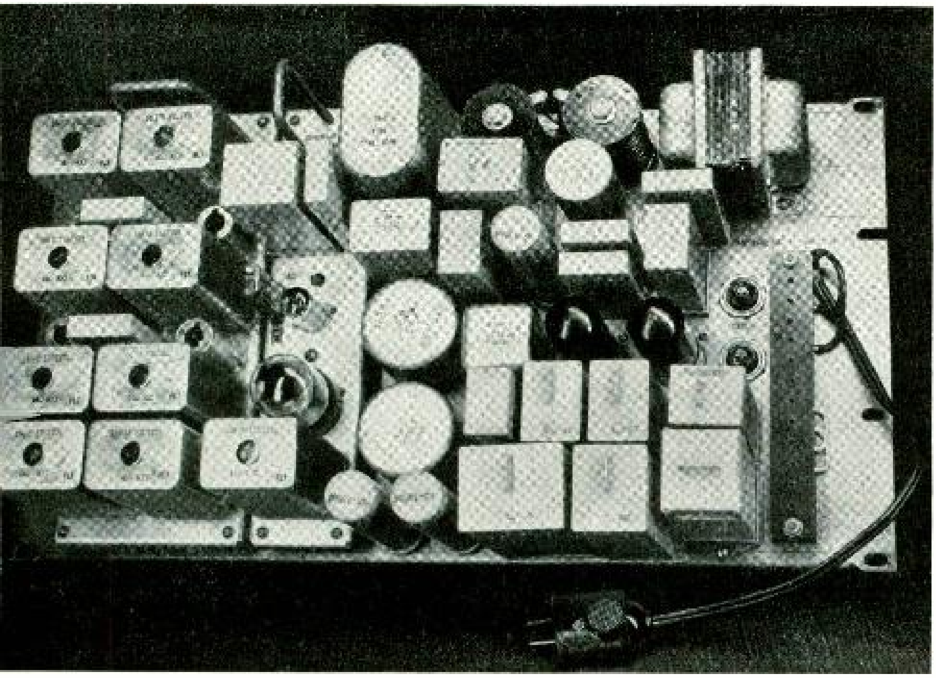


Fig. 5—The common terminal consists physically of: a basic unit, at the right; a narrow transmitter unit; and a receiver unit, at the left

A semi-block schematic of the ringing circuit at the common terminal is shown in Figure 4. On operating, each ringing relay applies +150 volts to the oscillator and ground to the cathode return circuit of the oscillator-modulator tube of the transmitter. During the intervals while the gas tubes of the relaxation oscillators are not discharging, a −50-volt bias is applied to the grids of both the transmitting tubes. The ground on the cathode return of the oscillator establishes the condition for oscillation, but the −50-volt bias on the grids of both tubes prevents the oscillations from being amplified and appearing at the transmitter output. When the gas tube of the relaxation oscillator discharges, however, the −50-volt bias is removed and a positive pulse instead is applied to the grids of the transmitter so that a carrier pulse will be transmitted.

When neither ringing relay is operated and when no carrier is being received, the ground connection to the cathode return of the oscillator is not made, and thus no carrier is generated. When carrier is received

*Record, *November,* 1947, *page* 413.

THE AUTHOR: R. C. Edson received a B.S. degree from the Pennsylvania State College in 1930. In July of the same year he joined the Department of Development and Research of the American Telephone and Telegraph Company and was transferred to the Laboratories in 1934. His work until the time of World War II was chiefly in connection with the determination of suitable crosstalk and noise standards for telephone systems. During the war he was concerned with communication systems for the Armed Forces. When work was again started on power line carrier telephone, he became a member of the group developing the M1 system.

from a subscriber station, however, B of Figure 4 operates and grounds both cathode and grid return circuits to put the transmitter in a condition to accept speech modulation.

Physically, the common terminal comprises three units attached to a 19-inch mounting plate 10½ inches wide, as shown in Figure 5. The largest of the three units—that at the right—is the basic unit, and is the same for all terminals. To the left of the basic unit is a narrow transmitter unit and a somewhat wider receiver unit. Both of these are plug-connected to the basic unit and are readily replaceable. Since as many as six M1 channels may be provided over a single transmitting circuit, considered from the common terminal end, six transmitting frequencies and six pairs of receiving frequencies may be required. To provide them, six transmitters and six double receivers are made available. The proper ones are plugged into the control terminal to suit the particular channel desired. This unit arrangement simplifies the manufacture and also the assembly and maintenance of the common terminals.

British Horological Institute's Gold Medal for 1947 presented to W. A. Marrison in recognition of his pioneer researches in the development of the quartz crystal clock

NEWS AND PICTURES OF THE MONTH

RESEARCH AIDS IN CAUSE OF PEACE

The same intimate and fruitful coöperation among the Armed Services, the universities and the industrial laboratories which forged the weapons of victory in World War II constitutes a powerful force for peace.

This was the message brought to the recent research conference of the Navy Industrial Association in Washington by Dr. M. J. Kelly, Executive Vice-President of the Laboratories and one of the country's leading authorities on the technology of modern warfare.

Discussing the rôle of scientists and technologists in the Nation's preparedness program, Dr. Kelly said their special responsibility was "the up-to-the-minute extraction from the ever-increasing reservoir of basic knowledge about our material world, the special 'know-how' for the creation of the most effective instruments for defense and attack warfare, followed closely by their development and perfection, so that they can be produced in the tremendous quantities our industry is uniquely capable of."

"If we accomplish this," he said, "and do it with sufficient speed—always crowding the forefront of newly acquired fundamental knowledge in its application to new military science, technology, and instrumentalities, I am confident that, in the foreseeable future, no nation can acquire a technological warfare potential sufficiently near in its power to our own that it will dare to initiate war.

"If we, the scientists and technologists of our country, accept this challenge and measure up to the potentialities of the situation, we will provide our Nation's best insurance for peace. What an opportunity for service for each of us!"

Dr. Kelly preceded an analysis of the national research program with statistics illustrating its broad scope and vast size. The Nation's entire national research and development budget, exclusive of atomic energy, for 1947 was $1,160,000,000. Of this, $500,000,000, or approximately 43 per cent, was earmarked for military preparedness. One-fifth of this amount, or $100,000,000, was spent in Army and Navy laboratories, while the other $400,000,000 was expended under contract in university and industrial laboratories.

As a yardstick, Dr. Kelly pointed out that as recently as 1940 the country's total research and development effort was only $345,000,000 and only $185,000,000 in 1930.

"Making a most generous allowance for the effect of post-war inflation on costs," he said, "the military or preparedness research and development effort of 1947 is greater than that of our Nation in 1930 in all its areas of research and development. It involved roughly the equivalent full time of some 35,000 scientists and engineers, with double their number of technical aides, some 100,000 in all. Never in all peacetime history, I am sure, was there such a huge technological effort."

Dr. Kelly said he found it helpful in many respects to compare the national research program with that undertaken by Bell Laboratories. This latter effort, in dollar volume and number of scientists and engineers, is roughly one-fifteenth that of our national military research and development program and thus is an excellent small-scale model.

Within the limited confines of an address, Dr. Kelly was able to consider briefly only a few of the many problems involved, but he selected three of paramount importance: first, the content of the program; second, the problem of selecting a professional staff and, finally, the organization of the effort.

In discussing the first of these, Dr. Kelly emphasized the potentially great value of the Joint Research and Development Board, of which Dr. Vannevar Bush is chairman, for the effective coördination of research and development for preparedness.

"The problem of selecting superior men to carry out the program also presents a number of complexities," he said, "particularly the danger of diluting the competence of the staff under the pressure of expansion." In this respect, he urged limited expansion of the professional staff through addition of only highly competent men, but an increase in the ratio of technical aides to the professional staff. "Expedients such as this," he said, "must be used to spread the Nation's available supply of high-quality scientists and engineers, so that neither the military preparedness program, the industrial laboratories, nor the universities suffer from a lack of good men."

Concerning the organization of the effort, Dr. Kelly advocated the application of principles and techniques that industrial laboratories have found to be most effective after years of experiment and observation.

He cited as examples the maintenance of fluidity of objectives, constant coördination of results, the blending in proper proportions of various skills and the maintenance of a high level of group enthusiasm and coöperation.

"A uniform application of these management principles and techniques for research and development operations to the entire preparedness program will have a profoundly beneficial effect, and can be a major factor in insuring its fully meeting the objective.

"There are many other areas where opportunities almost as large exist," he concluded. "Time has permitted no more than this small sample. Those of us in responsible charge of any sectors of this vast program must canvass and recanvass our situation to make sure that we are taking advantage of every opportunity to make for a more imaginative, creative, and productive effort. The summation of these efforts of each of us is bound to make for a nation so well and continuously prepared that it can be truly said that the three groups represented here tonight have provided our Nation with its best insurance for peace."

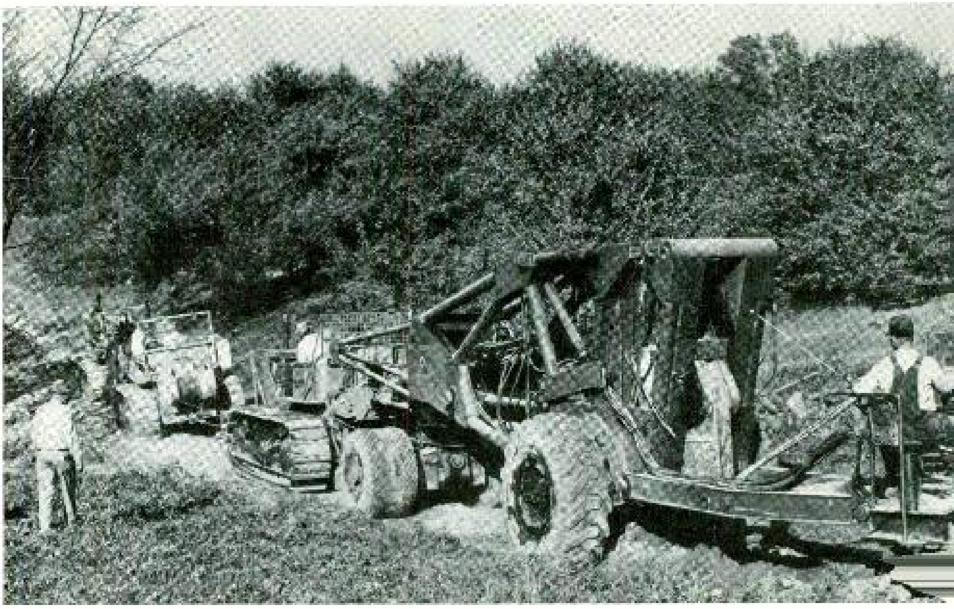
Coaxial Cable and Radio Relay Routes Move Southward and Westward

Bell System coaxial cable and radio relay facilities already installed or under construction at the end of 1947 totaled some 7,000 route miles, and construction planned for the next few years will about double the present mileage. In 1948, the Bell System expects to complete the laying of coaxial cable over the main route from the East Coast westward to Chicago, begin construction on the New York-Chicago radio relay system and go ahead with the necessary installations to provide two-way television channels on certain important routes.

Shortly after the coaxial is in to Chicago, two-way television service will be available over this route, including connections at Pittsburgh, Cleveland and St. Louis.

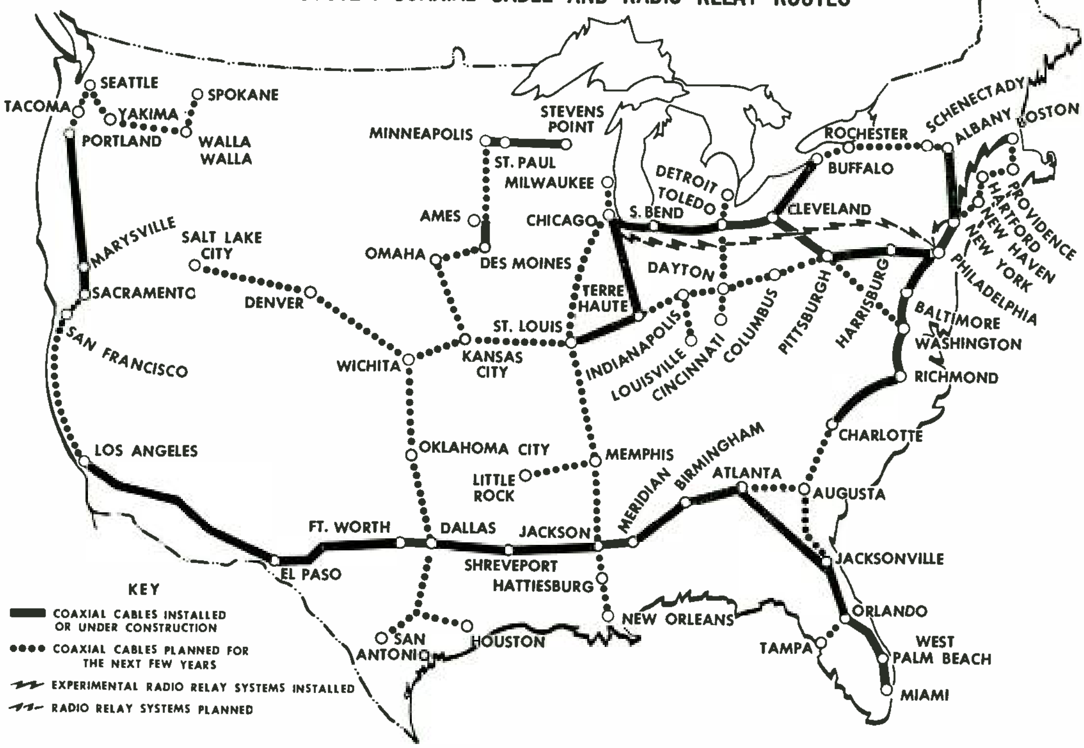
The New York-Chicago radio relay system, planned for completion in 1949, also will provide for branching facilities to such major cities as Pittsburgh and Cleveland.

On the East Coast, the year 1948 will witness the extension of television channels from Washington south to Charlotte, N. C., over the coaxial cable, with connecting equipment at Richmond, and the addition of more facilities between New York and Washington.



Like a huge, latter-day prairie schooner, the newest and biggest Long Lines cable plow—the C-60—rolls up the Hudson Valley behind three powerful tractors laying coaxial cable on the route between New York and Albany

BELL SYSTEM COAXIAL CABLE AND RADIO RELAY ROUTES



The first coast-to-coast coaxial cable, joining Florida and California, has gone into service over a 2,600-mile southern route that leads from Jacksonville to Atlanta to Dallas to Los Angeles. With the completion of the Phoenix-Los Angeles section on November 15, the last gap was closed. Early in 1948, this new transcontinental coaxial link will be extended through to Miami, making a 3,000-mile Los Angeles-Miami span.

Constructed jointly by the Long Lines Department and the Associated Companies through whose territory it passes, the new cable will provide needed long distance facilities along its route as well as channels for program transmission and other services.

There has been notable progress by Associated Companies in furnishing local television facilities, such as studio-transmitter links and local pick-up links. More than 50 such facilities have been furnished during the last year at such cities as New York, Philadelphia, Baltimore, Washington, St. Louis, Detroit, Boston, Pittsburgh, Chicago and Los Angeles. For pick-up facilities, wire has been used in some cases and radio in others.

Training Program in Human Relations Given by the A T & T

G. W. Lees, Jr., and Morton Sultzer participated in a series of training discussions on Human Relations in Management given at 195 Broadway during January by the A T & T Personnel Relations Department. For many years it has been a primary objective of the Bell System to develop teamwork among its people. Purpose of the conference was to review fundamental principles in this field and to consider their practical application.

A. L. Johnsrud Wins Central Park Night Photography Contest

A. L. Johnsrud was awarded first prize at the regular monthly meeting on December 17 of the Photographic Club for his photograph of Central Park taken at night during a field trip following the November meeting. Second prize went to H. Eckardt and third to C. A. Fischer. W. F. Sefcik received Honorable Mention. The sole judge of the contest was E. K. Alenius, who also conducted a print clinic during the meeting.

A WINTER'S TALE

Snowbound Bell Laboratories plowed their way from under the record snowfall of December 26 with almost no physical damage to the buildings at the various locations. The heaviest snow, thirty inches, occurred at Deal and Holmdel; everywhere the banks were shoulder high after plowing. Within the week the snow was followed by an ice storm which left the trees at northern locations in jeweled encasements of ice.

Early on the day of the snowfall, the Murray Hill Plant Department realized the need of removing cars from the parking lots before they became snowed in. Of the 296 cars then at the Laboratories, all but twelve were driven off.

Once people were on their way home, the Plant Department resumed the mammoth task of clearing the grounds, by then a fairyland of snow. R. C. Keyser, foreman of the grounds, and his crew of seven men, had arrived to clear the snow at 5:30 a.m. Friday. Using plows on two trucks plus a plow on a farm tractor, they worked on through the night and into the following day until 4:30 p.m. By Sunday, arrangements were made for a contractor to send a caterpillar bulldozer to Murray Hill to open areas on the roads and lots where the drifts were unusually high. Some crews at that location worked double shifts and remained on the premises for more than 24 hours.

On Friday, January 2, those who reached Murray Hill found it a wonderland of ice-encased trees. As elsewhere in the area, damage to trees and shrubs was heavy. During the ice storm and after it, Mr. Keyser and George Gordon patroled on snowshoes a two-mile track area through the woods beneath the overhead power line to see if any trees were in danger of falling on the cables and cutting off the supply. In spite of the severity of the storm, and despite the fact that the local area suffered widespread interruption of electricity, there was no interruption of the power at the Laboratories. Likewise there was no fuel problem for lack of oil deliveries because a sufficient supply to carry through an emergency has always been maintained.

Whippany prides itself on the way it weathered both storms. The plant was open and ready for all who could make their way there. Changes in the Plant shifts were made during the storms, though not at all on schedule.

West Street also weathered the snowstorm well. Two hand plows plus a tractor plow kept the sidewalks well plowed. Car service between West Street, Graybar and Fourteenth Street was interrupted from December 26 at 1:20 p.m. until January 5 because of the snow and later the ice on city streets. During the

storms, reliefs for all shifts were made with some minor delays. In the H section of West Street, snow sliding off the roof took away a section of the gutter above one setback.

With the roads around the Deal Laboratory blocked, the maintenance group managed to get in and out on foot, and to bring food to three men who elected to remain in the buildings rather than brave the storm. The plow-equipped truck was at work all of Friday, Saturday and Sunday keeping the internal roadways clear.

The Holmes Guards who protect Holmdel remained on the property for 48 hours during the snowstorm before other guards were able to get through to relieve them. Meanwhile the caretaker plowed night and day trying to keep the grounds open. His equipment was a V-shaped plow on a truck and a caterpillar bulldozer. However, despite all his work, the snow on the roadways had drifted so badly by Monday, December 29, that it was necessary to cut through the fields to make a single lane to the main road in order to get cars off the grounds. By Tuesday, the grounds were open.

All along the storm's path, which began in Texas, damage was reported to telephone plant, but nowhere so heavy as in New Jersey, where 35,000 telephones were out of service, principally due to drop wire breaks.

Thanks to adequate stocks of repair materials and the moving in of repair gangs from outside the area, service was promptly restored. Western Electric made emergency shipments of 36 million conductor feet of rubber-covered wire and 32 million conductor feet of lead-covered cable, with poles, hardware, strand and supplies in proportion.

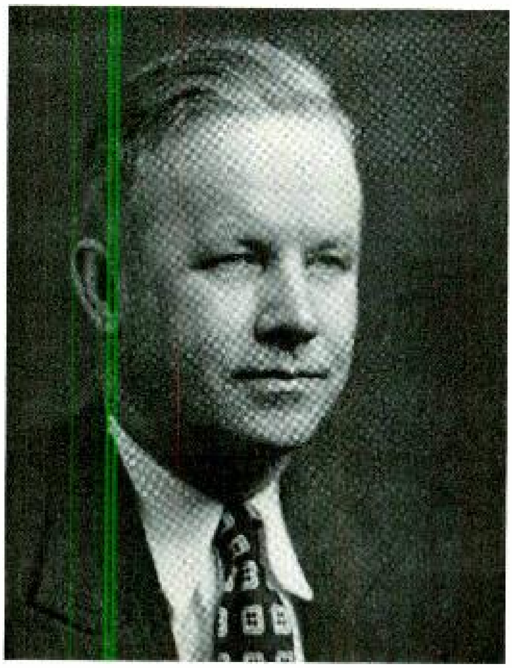
R. G. McCurdy Dies Suddenly

Ralph G. McCurdy, Director of Transmission Apparatus Development, died suddenly on January 10. He began his career in telephone work soon after his graduation from the University of California in 1913 as an Engineering Assistant to the California Joint Committee on Inductive Interference, sponsored by power and railroad interests of the state and the Bell System. Three years later he joined the A T & T, but for another year was assigned to the California investigation. He then entered the Engineering Department in New York and continued in a broader field his work on noise induction from power and railway systems. Under his direction, rapid advances were made in the design of basic measuring instruments and techniques as well as in the development of measures for mitigating noise interference. In 1924, Mr. McCurdy became identified with the work of the Joint Subcommittee of the National Electric Light Association, now the Edison Electric Institute, and the Bell System. In this work, he served as Chairman of several Technical Committees. The coöperative work which his organization carried on with engineers of the power and electrical manufacturing companies furnished the basic technical data needed for the development of construction and operating practices now employed by the power and telephone companies to prevent interference.

Incident to the D & R consolidation, in 1934 he transferred with his department to the Laboratories as Noise Prevention Engineer. Three years later he assumed broader responsibilities as Assistant Director of Trans-

G. R. Frost demonstrating a crossbar switch during a lecture to the third class of the Telephone Switching Design School at Fourteenth Street. Of the men taking the course, two are from the Northern Electric Company and the rest are members of the Laboratories. Their course is full time for five and a half months mission Development and in 1940 he became Director of Transmission Engineering. During that period his efforts resulted in marked progress in alleviating noise interference and in the design and construction of basic measuring instruments and techniques for noise curtailment in telephone circuits.

In 1943, Mr. McCurdy became head of Transmission Apparatus Development, with responsibility for the engineering of transformers, capacitors, networks, crystal units, and electrical measuring apparatus. During the war this department participated in scores of Laboratories projects, and in particular was



RALPH G. McCURDY, 1891-1948

responsible for the magnetic airborne detector, the magnetic gradiometer for locating spent torpedoes, and measuring apparatus for degaussing and for sonar.

Mr. McCurdy married Leila M. Ruffner, June 10, 1914. He is survived by his wife, four sons, two daughters and five grandchildren. For many years he was a member of the governing board of the First Presbyterian Church of Englewood, where he formerly lived. More recently he was a member of the Ridgeview Presbyterian Church of West Orange.

Because he liked people, Ralph McCurdy was himself universally liked; and because of his technical competence and straight thinking he was respected by all who knew him.

Changes in Organization

Effective January 1, the following changes in organization of the Laboratories were made:

Systems Development Department

H. H. Lowry, Assistant Director of Systems Development reporting to Vice-President A. B. Clark, was placed in charge of the activities directed by the following department heads: F. J. Scudder, Director of Switching Development; H. A. Affel, Director of Transmission Development; M. H. Cook, Director of Systems Engineering, formerly known as Equipment Development.

M. B. McDavitt was transferred from Transmission Engineering and became Assistant Director of Switching Engineering, reporting to T. C. Fry.

R. L. Lunsford, Switching Equipment Engineer, with his group was transferred from Equipment Development to Switching Development, reporting to Mr. Scudder.

A. C. Dickieson was transferred from Transmission Development to Transmission Engineering to replace Mr. McDavitt and became Radio Transmission Engineer, reporting to G. W. Gilman.

E. I. Green, Assistant Director of Transmission Development, became responsible for short-haul carrier, general carrier and broadband carrier terminals, voice-frequency systems, and transmission testing systems.

G. N. Thayer was transferred from Electronic and Television Research to Transmission Development and became Transmission Development Engineer, reporting to H. A. Affel. Mr. Thayer is responsible for submarine cable, New York-Boston microwave, overseas radio, and other radio.

L. G. Abraham, Transmission Development Engineer, assumed responsibility for video wire systems in addition to his other duties.

A. D. Knowlton, Transmission Equipment Engineer, and A. A. Oswald, Radio Equipment Engineer, together with their group engaged in these activities, were transferred from Equipment Development to Transmission Development and report to Mr. Affel.

Apparatus Development Department—I

In addition to his other duties, Vice-President D. A. Quarles assumed general Laboratories' responsibility for the military and specialty products development programs. R. E. Poole succeeded M. H. Cook as Director of Specialty Products.

The following changes were made in the organization formerly reporting to Mr. Poole: W. H. Doherty, Radio Development Engineer, reports to Mr. Poole in charge of naval radar

Sixty-seven carollers of The Systems Christmas Chorus sang in the 9th floor drafting room on Christmas Eve. Their voices were picked up by a microphone, amplified and transmitted into the courtyard, so that people whose rooms faced the courtyard could hear the carolling

and broadcast transmitter development. J. F. Wentz was transferred from Transmission Development and reports to Mr. Poole as Radio Development Engineer in charge of airborne radar development.

Research Department

H. S. Black was transferred from Transmission Development to Electronic and Television Research and reports to J. W. McRae. In his new capacity, Mr. Black assumes responsibility for research in new methods of communication.

Income and Expense Records

Income and Expense Records have been distributed by Personnel to members of the Laboratories requesting them. The booklet is made up of a number of work sheets to aid in preparing a budget and in classifying expenses to help one to account for receipts, balances, disbursements, savings and insurance. Copies are still available on Extension 435 at West St.

News Notes

M. J. KELLY visited the Michigan Bell Telephone Company at Detroit on December 19 and addressed the supervisory force on some development programs now in progress at the Laboratories.

DR. KELLY, on December 30, talked to all members of staff of the Research Department about the policies and work program of the Laboratories, giving special attention to the program of the Research Department.

R. BOWN, H. FLETCHER, R. M. BURNS, L. A. WOOTEN, W. SHOCKLEY and A. H. WHITE visited Dr. P. M. Morse, Director of the Brookhaven Laboratories, at Patchogue, Long Island. They also made a tour of inspection of the Laboratories.

C. E. SHANNON, at the Deal-Holmdel Colloquium on January 9, discussed the general relationship between signal-to-noise ratio and band-width requirements for the efficient transmission of intelligence. The material was similar to that presented at the November meeting of the New York Section of the Institute of Radio Engineers.

C. M. HARRIS spoke on *Acoustic Impedance Measurement of Very Porous Screens* before a meeting of the Acoustical Society of America on December 12 at Los Angeles. He also attended a meeting of the Ad Hoc Committee of the Acoustical Society of America which is concerned with Standards. They meeting was held on December 11 in Los Angeles.

W. SHOCKLEY and H. D. HAGSTRUM attended American Physical Society meetings in Chicago at one of which Dr. Shockley presented a paper on *Half-Dislocations.* He also spoke on *Ferromagnetic Domains* at the Columbia University Physics Colloquium.

R. D. HEIDENREICH and DR. SHOCKLEY have written on *Electron Microscope and Electron-Diffraction Study of Slip in Metal Crystals* in the Letters to the Editor column of the *Journal of Applied Physics,* November, 1947.

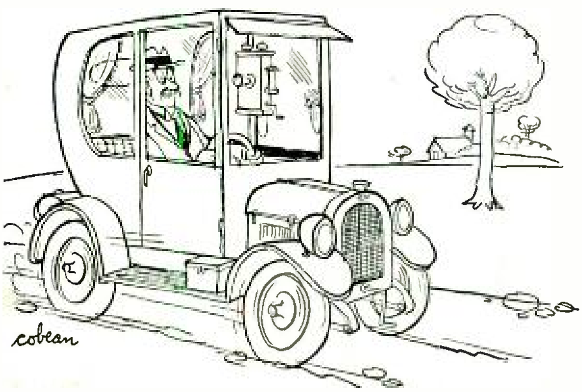
R. M. Bozorth talked on the general subject of *Magnetism* before the Washington Section of the American Institute of Electrical Engineers, the Office of Naval Research in Washington, a Massachusetts Institute of Technology Colloquium and the Princeton section of the Institute of Radio Engineers. He has been appointed a member of the Subcommittee on Atomic Constants of the National Research Council.

J. R. Haynes spoke on *The Print Out Effect and Its Use in the Study of Motions of Electrons in Silver Halide Crystals* at the University of Chicago; at the Carnegie Institute of Technology; and at a meeting of the American Physical Society in Houston.

C. Kittel addressed the Yale Theoretical Colloquium in the Sloane Physical Laboratory on *Theory of Ferromagnetism Domains.* He also addressed the Yale Physics Club Colloquium on *Microwave Resonance Absorption in Paramagnetic and Ferromagnetic Materials.*

F. M. Wiener, with G. A. Miller and S. S. Stevens of the Harvard Psycho-Acoustic Laboratory, is joint author of Volume 17.3 of the Summary Technical Report Series of the N.D.R.C. Entitled *Transmission and Reception of Sounds Under Combat Conditions,* the volume deals in detail with the work in physical and psychological acoustics carried out during the war at Harvard University under the N.D.R.C., Section 17.3.

C. H. Townes has joined the staff of the Columbia University Physics Department as Associate Professor. Dr. Townes will teach atomic and molecular physics in both the graduate and undergraduate schools and will also continue his research in the field of microwave spectroscopy.



By Permission. Copyright The New Yorker Magazine, Inc.

T. H. Neely Heads Reserve Electronic Warfare Battalion

T. H. Neely, of Toll Systems Development, is also a Commander in the Naval Reserve and in his spare time is directing the activities of a reserve electronic warfare battalion at the New York Naval Shipyard. This is the first such battalion to be activated in this district. Its purpose is the training of qualified personnel in all phases of electronics. This is to be accomplished by conducting graded courses in electronics theory and practice and the men will work with the latest types of radar, sonar, loran and communication equipment.

The battalion operates the master control radio station for the Naval Reserve in the Third Naval District. The station also transmits on the amateur radio bands with the call sign K2NR and has made contact with amateur stations all over the world.


U. S. Navy Photo

In this simulated Combat Information Center, Commander Neely (left) directs the training of a group

Members of the battalion meet on any one of four week-day evenings and receive a day's pay for each two-hour drill attended. Active duty for two weeks each year is authorized and consists of a short cruise or a brief tour at the shipyard. Young men with a high school or college background in electronics are eligible if they are between the ages of 17 and 40 or veterans of any branch of the Armed Forces.

←*For its initial appearance in* The New Yorker, *a caption for this cartoon was superfluous. Factually minded readers of the* Record *will wonder if there ever was such a telephone. J. T. Lowe, Curator of our Historical Museum, says "No," and adds that from the earliest days the receiver was hung on the left side of the box*

News Notes

G. F. SCHMIDT attended conferences at Archer Avenue on problems of the new operator transmitter unit.

W. J. BRACKMAN, A. C. DICKIESON and G. RODWIN visited Burlington in regard to the production of radio transmitters and receivers.

K. E. GOULD and L. G. ABRAHAM visited The Pacific Telephone and Telegraph Company during December in connection with the completion of the first transcontinental coaxial cable system and with plans for extending the system to Seattle in September.

H. T. BUDENBOM participated in a conference at the Naval Research Laboratory at Anacostia.

A. A. CURRIE spent four weeks at Fort Baker, California, assisting in service tests of military equipment for the Coast Artillery Corps.

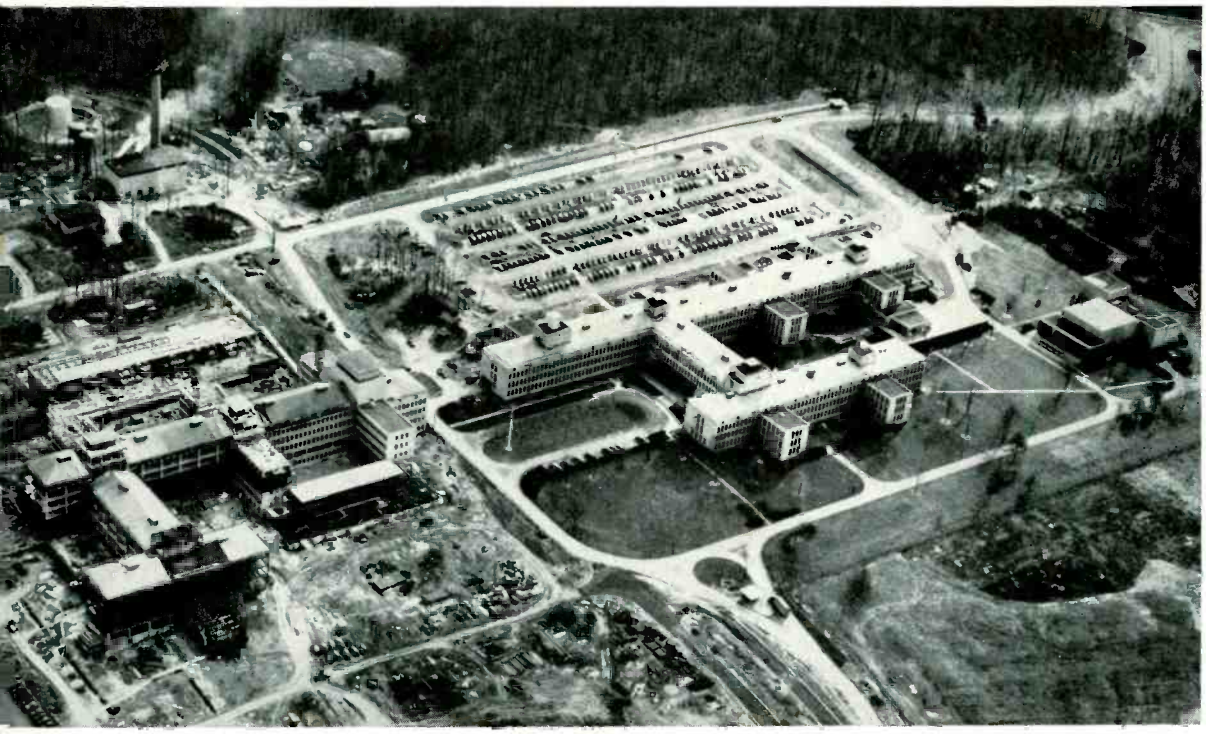
H. J. WILLIAMS attended the Midwest meeting of the A.I.E.E. at Chicago on November 5 and spoke on *Recent Development in Magnetic Powder Patterns.*

K. K. DARROW attended the meeting of the American Physical Society that was held on November 28 and 29 at Houston, Texas. Dr. Darrow gave a talk at New Orleans on *The Physicist Looks at Metals* before the New Orleans Academy of Sciences and Tulane University Chapter of Sigma Xi, in a joint meeting on December 2. This same talk had been previously given before the Washington, D. C., Section of the A.I.E.E. He also lectured on *Cosmic Rays* before the Nassau Club at Princeton. He was appointed to the committee of the American Physical Society for selection of nominees to honorary membership. Dr. Darrow also attended meetings of the New York State Section of the American Physical Society at Schenectady, the American Philosophical Society at Philadelphia, and the American Physical Society and the American Association for the Advancement of Science at Chicago.

WHILE C. H. AMADON, who is regularly stationed in Denver, was on a Pacific Coast inspection trip with F. F. FARNSWORTH, his thirtieth service anniversary occurred. So the occasion was celebrated at Santa Cruz by a luncheon in his honor, attended by a number of Pacific Telephone and Western Electric people with a total of 277 years of service to their credit. Mr. Farnsworth presented a six-star pin to Mr. Amadon during the luncheon.

E. B. CAVE represented the Laboratories in interference proceedings before the Primary Examiner at the Patent Office in Washington.

Murray Hill as it appeared on December 10, 1947. Photo by Fairchild Aerial Surveys, Inc.



February Service Anniversaries of Members of the Laboratories

35 *years*

Mary Colleran
R. C. Davis
Martin Johnson
B. W. Kendall

30 *years*

Stanley Bernard
I. S. Betzner
Mary Donnelly
P. A. Doscher
Lillian Hoffman
Marguerite Johnston
F. C. Kuch
E. E. Schumacher
W. A. Shewhart
Victor Subrizi
W. F. Vieth

25 *years*

P. E. Buch
V. I. Cruser
W. W. Fritschi
F. J. Hallenbeck
L. E. Herborn
Frank Holi
W. H. Lichtenberger
Arthur Meyer
R. R. Riesz

20 *years*

W. E. Cobb
R. H. Colley
J. B. De Coste
H. V. Farnham
H. C. Geissler
D. W. Grant
F. C. Hellwinkel
A. A. Hoch
Albert Holler
E. F. Krommer
James Maguire
Mildred Maher
F. E. Masek
L. H. Morris
Burrell Stallard
S. C. Tallman
W. H. Tappen
H. C. Theuerer
J. A. Twomey
L. A. Wooten

15 *years*

Emma Kennedy
Kathleen Ward
R. F. Woods

10 *years*

M. E. Mohr
Eleanor Orio
E. H. Sharkey

W. P. Mason's article on *Theory of the Ferroelectric Effect and Clamped Dielectric Constant of Rochelle Salt* was published in *The Physical Review*, November 1, 1947. In the same issue, Mr. Mason wrote on *Electrostrictive Effect in Barium Titanate* in the Letters to the Editor column.

R. M. Burns and V. J. Albano participated in a symposium at Pittsburgh on *Cathodic Protection*, sponsored by the Electrochemical Society and the National Association of Corrosion Engineers.

W. G. Guldner attended a round table discussion at the General Electric Company, Pittsfield, of methods used for the determination of small amounts of carbon in steel. He also attended, with F. J. Biondi, the *High Vacuum Symposium* at Cambridge, which was sponsored by the National Research Corporation and the American Chemical Society.

J. R. Townsend has been appointed a member of the Survey Committee of the American Standards Association.

G. T. Kohman, H. W. Hermance and T. F. Egan conferred with telephone company engineers in Philadelphia and Chicago on dust and central office ventilation.

J. H. Schaff has been elected for a three-year term to the Executive Committee, Institute of Metals Division, American Institute of Mining and Metallurgical Engineers.

J. T. Mulller conferred at Fort Monmouth on problems encountered in equipment mounted on trucks and trailers.

V. H. Baillard, S. M. Sutton, J. M. Hardesty and C. R. Brearty considered clay conduit manufacturing problems and specification requirements with suppliers at Brazil, Indiana and at Pittsburgh.

H. E. Kern attended a meeting of the Diode Committee of the American Society for Testing Materials in Philadelphia to discuss the standardization of materials and tests used with thermionic oxide cathodes.

John W. Deist, toll transmission engineer with the Wisconsin Telephone Company at Milwaukee, is now at the Laboratories assisting in the development of a new carrier telephone system. A trial of this system is planned between Milwaukee and Madison next summer.

R. O. Wise observed the type testing of radar equipment at Wright Field.

A. H. Hearn inspected poles in line in the vicinity of Hagerstown and Frederick, Md., with engineers of the Chesapeake and Potomac, and with representatives of the Southern Bell in the vicinity of Atlanta and of Gastonia, North Carolina.

D. C. Smith, A. Burkett, J. T. Dixon and M. B. McDavitt went to Atlanta and locations in South Carolina to discuss small exchange and rural line problems with engineers of the Southern Bell.

Dr. Eduardo Amaldi, Professor of Physics at the University of Rome, spoke in the Murray Hill Auditorium on December 12 on *Scattering of Fast Neutrons by Medium and Heavy Elements*. A delegate to UNESCO, he is noted for his studies on neutrons.

The following members of the Laboratories are organizers of the technical sessions of the national convention of Radio Engineers to be held in March, 1948, in New York City: J. C. Schelleng, *Propagation;* A. G. Jensen, *Television;* and Pierre Mertz, *Active Circuits*. L. E. Hunt is the New York representative of the Technical Committee.

Joan Rubin, a member of the Switching Development Department, was honored on December 16 by Drexel Institute of Technology when she received the first B.S. degree in Electrical Engineering ever conferred on a woman by that Institute. Mrs. Rubin completed her course in September and joined the Laboratories on October 6. A resident of Elizabeth, she finds her careers in engineering and homemaking compatible. She began managing the two at seventeen when she married as a student at Drexel

F. J. Biondi attended the sessions of the Chemical and Metallurgical Committees of Section A Sub-Committee VIII of Committee B4 of the American Society for Testing Materials meeting in Philadelphia. H. M. Cleveland and Mr. Biondi spent several days at Allentown conferring on electron tube problems. They also visited the J. T. Baker Company in Phillipsburg, N. J., to discuss new material problems.

U. B. Thomas has been elected secretary of the newly formed Battery Division of the Electrochemical Society.

W. E. Campbell visited the Franklin Institute in Philadelphia as a member of the American Petroleum Institute Committee guiding a project for the measurement of viscosity by means of a torsionally vibrating crystal. He also read a paper, *The Influence of Adsorbed Moisture Films on the Coefficient of Static Friction Between Lubricated Surfaces,* at the annual meeting, December 3 to 5, of the American Society for Mechanical Engineers at Atlantic City.

W. Orvis and J. Z. Takacs participated in conferences at the Erie (Pa.) Resistor Corporation on problems of molded cases for hearing aids.

J. C. Steinberg attended the Fall Meeting of the Acoustical Society of America, held on December 12 and 13 in Los Angeles. He also visited the U. S. Navy Electronics Laboratory on December 15 in San Diego.

L. A. Meacham, R. L. Carbrey and S. E. Michaels visited the Radio Corporation of America Laboratories at Princeton, where Mr. Meacham presented a paper on *Pulse Code Modulation* before the Princeton Section of the Institute of Radio Engineers.

A. J. Christopher and M. Whitehead were in Indianapolis regarding a quality survey at the P. R. Mallory Company on capacitors.

J. A. Becker and P. P. Cioffi attended the Round Table Conference of Catholic Scientists at Fordham in December.

C. A. Webber and O. C. Eliason attended conferences with Telephone Company representatives in Philadelphia and Chicago in connection with air filtration for central offices.

"It says 'The Laboratories will be closed this year on February 14 for the observance of St. Valentine's Day'"*

At Winston-Salem, V. I. Cruser, H. B. Fischer and F. B. Combs reviewed the mobile radio telephone program; F. E. Gissler, production problems on mobile radio receivers; H. Morrison, radar equipment; J. R. Haveland and F. A. Goss attended a conference to exhibit radar equipment to representatives of aircraft manufacture; H. A. Stone, pulse networks; and P. V. Koos, microwave radio equipment.

*It's Saturday!!!—and leap year, too!

E. E. ALDRICH visited Haverhill regarding inspection of transformers.

E. B. WOOD and D. R. BROBST participated in a survey of switchboard cable at the Western Electric Company Tonawanda plant.

A. C. PEYMAN visited Burlington on the design of a new transmitter.

G. W. RUST, F. A. THIEL, J. M. PEABODY, and L. N. HAMPTON installed Model No. 2 of the KS-13834 perforator in the No. 5 crossbar office in Media.

J. D. TEBO visited the Westinghouse Electric Corporation Publications Department in Pittsburgh in connection with special problems.

A. C. KELLER delivered the second, and E. I. GREEN the third lecture in the Out-of-Hour Lecture Series. Mr. Keller's lecture, *A New General Purpose Relay for Large Scale Production,* was delivered on December 8 at West Street and on the 10th at Murray Hill. Mr. Green's topic was *Principles and Trends in Communication Measurements.* He spoke on January 12 at West Street and on the 15th at Murray Hill.

THE MANUFACTURING RELATIONS GROUP at the Burlington Radio Shop were entertained at a Christmas Dinner and Dance by K. O. THORP, H. A. DOLL, R. V. LOHMILLER, H. C. JAMES and C. C. WILLHITE.

J. T. MULLER presented a paper on *Transients in Mechanical Systems* at the annual convention, December 4 to 6, of the Society of Experimental Stress Analysis.

Engagements

*Anne Bookless–Daniel J. Madden
*Margaret Boyce–Alford A. Hanel
*Jean Brzezinska–Eugene Czajkowski
*Kathleen Garrett–Frederick P. Vanacore
Betty Johnson–*Bert Meyer
*Helen Karban–John A. Smith
*Catherine Loeffel–James Bellotti
Winifred Mackie–*Francis X. J. Sullivan
Jean Mosier–*Fred Herr
Ethel Schreiner–*Robert Sherman
*Audrey Schumacher–*William R. Carolan
Gladys Stout–*Helmut E. Schrank
*Virginia Thrall–Charles J. Radl
*Irene Walsh–Joseph F. Leahy, Jr.

Weddings

Ruth Barham–*Nelson E. Wallin
Elizabeth Thomson–*Edwin R. Weir

*Members of the Laboratories. Notices of engagements and weddings should be given to Mrs. Helen McLoughlin, Room 803C, 14th St., Extension 296.

R. T. STAPLES RETIRES

Robert T. Staples of Transmission Apparatus Development retired on January 31 following forty-one years of service. After attending Virginia Polytechnic Institute, Mr. Staples, in 1906, joined the Long Lines office in Philadelphia. Shortly thereafter he enrolled in the Western Electric student course in New York, which covered telephone manufacturing activities. He then was assigned to tests on keys, switches and miscellaneous apparatus in the Physical Laboratory. Later he became active in designing paper and mica condensers for equipment used in the first transcontinental telephone line and apparatus used in World War I communicating equipment. Since 1924 he has been engaged in developing cords, wires, and cables. He was associated with the development of fast dyes for cords and cables and in the application of washed cotton to replace silk in central office apparatus and wiring. During World War II he was active in the development of special cables and cords for the Armed Forces.

News Notes

AT HAWTHORNE, H. A. FREDERICK, H. O. SIEGMUND, D. D. MILLER, C. W. MCWILLIAMS, H. N. WAGAR, V. F. MILLER and T. P. FARKAS discussed spring relay developments; Mr. Frederick, J. J. KUHN, D. H. GLEASON and C. C. BARBER, the new design of crossbar switch for future production; C. A. COLLINS and A. S. KING, problems concerning equipment for community dial offices; and R. BLACK, die cast parts. At the Indiana Steel Products Company, Valparaiso, Indiana, Mr. Black discussed magnets for a new microphone.

The Proceedings of the Institute of Radio Engineers for December carries articles by J. O. MCNALLY and W. G. SHEPHERD on *Reflex Oscillators for Radar Systems;* C. C. CUTLER, A. P. KING and W. E. KOCK on *Microwave Antenna Measurements;* and A. G. FOX on *An Adjustable Wave-Guide Phase Changer.* In the *Waves and Electrons Section* of the same issue is an article by P. H. SMITH on *"Cloverleaf" Antennas for F. M. Broadcasting.*

F. E. DORLON attended the opening in Chicago on November 24 of the new Bell System Cafeteria, largest and most modern of its kind in the Chicago area.

The Laboratories team at the Chatham Road plant of Western Electric Radio Shops in Winston-Salem came out on top in the first half of play in the Bowling League there. With a record of 21 wins and six defeats, they nosed out the second-place team, which posted 19 victories and eight losses. In the picture are: Bowling, H. G. Boyles, captain; standing, left to right: R. P. Kennedy, A. F. Jacobsen, V. J. Vierling, A. C. Jackson and R. G. Wellborn. Members of the team not present when the picture was taken are: R. C. Snook and L. W. Pray

News Notes

H. A. HILSINGER discussed production problems on radar equipment in Boston at the Doelcam Corporation.

R. K. HONAMAN and W. KEISTER visited Schenectady and consulted with the General Electric Publicity Staff regarding technical publications.

H. J. KOSTKOS conferred with the staff of the Museum of Science and Industry and members of the Illinois Bell Telephone Company on the development of new Bell System exhibits. He also discussed the revisions of exhibits for the Franklin Institute in Philadelphia with the Bell of Pa. These problems are handled by a Bell System Science Museum Committee. Mr. Kostkos is in charge of the design and development of display mechanisms.

E. VON DER LINDEN and R. W. BURNS observed new methods of testing subscriber dials from the test desk during a visit to the Wildwood, New Jersey, office.

W. G. SCHAER and W. K. ST. CLAIR, together with Western Electric engineers, conferred with engineers of The Chesapeake and Potomac Telephone Company at Baltimore, in connection with problems in engineering combined toll and DSA boards.

R. H. MILLER and F. W. WHITE visited the New York Telephone Company offices at Albany, regarding the engineering of the A4A toll switching system for Albany.

E. L. RUDD, together with engineers from the Western Electric Company, visited Boston and Providence, on the proposed use of vertical busbars instead of cable in the battery distribution to various floors of the building.

S. C. DEL VECCHIO was in Philadelphia at the Race Street toll office and W. C. ROUSE in Richmond, Virginia, in connection with the trial installation of tone signaling equipment at these locations.

F. W. TREPTOW attended a Quality Assurance Conference on the 755 P.B.X. at the Western Electric Company, Baltimore.

M. A. FROBERG and D. E. TRUCKSESS conducted noise tests on the power equipment at Buffalo.

C. A. SMITH visited the Wisconsin Telephone Company, the Illinois Bell Telephone Company and Northwestern Bell Telephone Company to discuss application of voice repeaters.

KENNETH BULLINGTON is the author of a paper on *Radio Propagation at Frequencies above 30 Megacycles* in the *Waves and Electrons Section* of the November *Proceedings of the Institute of Radio Engineers.*

O. H. COOLIDGE gave the opening lecture, *Transmission Line Theory,* of a six-lecture symposium on telephone and radio transmission under the auspices of the Milwaukee Section of the Institute of Radio Engineers.

N. MONK, H. S. WINBIGLER, W. H. EVANS, J. MALLETT, J. L. LINDNER and R. S. TUCKER have been making tests between New York and Buffalo in coöperation with the New York Telephone Company and the New York Central Railroad, looking forward to a provision of passenger telephone service.

"The Telephone Hour"

NBC, Monday Nights, 9:00 p.m.

February 9	*Gladys Swarthout*
February 16	*Jascha Heifetz*
February 23	*Ferruccio Tagliavini*
March 1	*Bidu Sayão*
March 8	*John Charles Thomas*

J. C. Bain visited the Brooks and Perkins Plant in Detroit for discussions on the manufacture of equipment in magnesium alloys for military applications.

H. C. Fleming made field tests on new type current supply at Atlanta and at unattended repeater stations along the K2 carrier route toward Chattanooga.

RECENT DEATHS

Frank B. Livingston, January 2

A member of Outside Plant Development Department, Mr. Livingston died suddenly at the Murray Hill Laboratories. His Bell System career began in 1912 in the student course at Hawthorne after his graduation from Kansas State College with a bachelor of science degree in electrical engineering. Following a year's training in Chicago and Kansas, he chose lead-covered cable development as his field and continued in it throughout the rest of his career. In 1933 he received the degree of electrical engineering from his alma mater. He had an important part in the developments which led to more than tripling the number of wires in a cable, and he participated in the development and evaluation of alloy sheaths. During World War II, Mr. Livingston made important contributions to the development of radar cable. After the war he returned to a study of special problems in connection with textile insulation and cable sheaths.


O. D. M. Guthe
1880-1947


W. A. Southwick
1889-1948


J. A. Frey
1882-1947


F. B. Livingston
1891-1948

Olaf D. M. Guthe, December 16

After 40 years of Bell System service, Mr. Guthe, a member of the Patent Staff, was retired in December, 1945. He came to this country from Sweden in 1903 and three years later joined the New York and New Jersey Telephone Company as a draftsman. Transferring to the Western Electric at West Street he did similar work until 1913, when he joined the Patent Department. He was successively patent draftsman, chief patent draftsman and office manager until 1920. For two years he handled foreign patents, and in 1923 began the patent work on telephone systems which he continued until his retirement. This included such apparatus as step-by-step, panel, cöordinate and crossbar; circuits and equipment for dial systems; and station apparatus.

William A. Southwick, January 5

At the time of his retirement in June of last year, Mr. Southwick had completed 34 years of service. He had joined the student course at Hawthorne after receiving his B.S. in electrical engineering from the University of Maine and had transferred to the Hawthorne division of the Apparatus Development Department upon completing the course. There he was engaged in the development of quadded cables and in the improvement of their transmission qualities until 1928, when he went to Kearny in the Outside Plant Development Department. For the next two years he was concerned with the development of protective coverings for buried cables. Transferring to Point Breeze in 1930, he remained there until his retirement, engaged in the development of modern toll cables designed for carrier operations.

Joseph A. Frey, December 22

Mr. Frey retired from the Laboratories in 1933 after 31 years of service. His first work with the Western Electric Company in the Cable Department was followed by ten years of switchboard installation work in the New England territory. He was then assigned to the Engineering Department and later to the Local Systems laboratory, where he was largely engaged in wiring circuits. At the time of his retirement he was in charge of the power supply for the Local Systems laboratory.

New York World Telegram

"Sweep Hand" Boys Make Daily Pilgrimage to Their Shrine

The "Sweep Hand" Boys at 195 Broadway

In a feature story, "They're Men Who Know What Time It Is," in the *New York World Telegram* for December 23, Ed Wallace, a staff writer, said:

"The ordinary man experiences no difficulty setting his watch. It calls for no trance-like preoccupation, no particular stance. If his watch is wrong, he sets it right—up or back.

"The same does not apply to the Sweep Hand Society, a fraternity of men who make humble pilgrimage each day to 195 Broadway, their national shrine.

"In the window of the A T & T building, Fulton and Broadway, is the world's most accurate public clock. Hundreds of men visit the block between 12 and 2 p.m. each day. They are the sweep hand boys, a brotherhood bound together by an almost demented desire to know what time it is.

"Men with sweep second-hand watches have become a peculiar cult. On lower Broadway some of them had rather have the right time than their lunch. When they owned ordinary wrist watches, they were never worried. With sweep hand watches, time has become a pleasant obsession.

"Twenty-four hours a day people check their watches with the electric clock, built by research physicists of Bell Telephone Laboratories, correct within 5/100th of a second. Men with ordinary watches glance, set, then hurry along. Give or take 30 seconds, they don't care.

"A Sweep Hand Boy comes to a full halt, then takes a solid, unhurried position squarely in front of the clock. Then the ritual begins. If his watch is a few seconds off, he sets it ahead a minute, then stops the sweep hand on 12.

"Then the trance begins. With wrist held precisely centered with the pivot of the big clock, finger on the stem of his watch, the sweep hander waits, quivering and alert, for the second hand of the clock to reach 12. Then, click! He has the correct time, within the limits of his own coördination. . . ."

Magazines Carrying Laboratories Technical Advertisements

American Scientist
Army Ordnance
Broadcasting*
Bulletin of the American Ceramic Society
Chemical Engineering
Civil Engineering
Communications
Electrical Engineering
Electrical World
Electronics†
F-M and Television†
Industrial and Engineering Chemistry
Instruments
Journal of Applied Physics
Journal of Chemical Education
Journal of Engineering Education
Journal of the Franklin Institute
Mechanical Engineering
Ordnance
Popular Mechanics
Popular Science Monthly
Proceedings of I.R.E.†
Radio Craft
Radio News
Review of Scientific Instruments
S.A.E. Journal
Science
Science News Letter
Science Teacher
Scientific American
Scientific Monthly
Telephony
Tele-Tech†
Telegraph and Telephone Age
U. S. Naval Institute Proceedings

*Joint Laboratories-Western Electric advertisements only.
†Laboratories or Joint Laboratories-Western Electric advertisements, in alternate issues.