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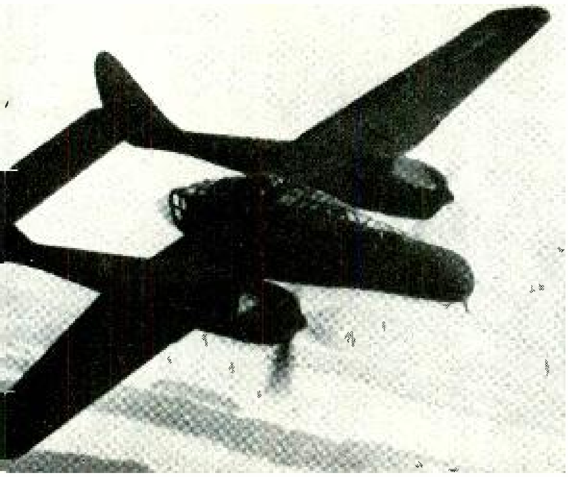


J. B. MAGGIO
Transmission
Development

RADAR EYES FOR THE BLACK WIDOW

Night fighters came into prominence during the blitz against Britain, and were in effective use throughout the war. Radar apparatus of various types was used for locating targets and tracking them until they could be seen and destroyed. For the U. S. Army Air Forces' P-61, the Black Widow night fighter, similar radar equipment was also used, but it was felt that the fighters would be more effective if the radar equipment could automatically track the target so as to supply data to a lead computer, thus permitting the guns to be aimed and firing started before the plane was actually seen. To meet these objectives and to obtain other improvements, the Laboratories developed the AN/APG-1 radar. With this equipment, the intercepting plane can automatically track a target and properly aim its turret guns so that firing may be begun as soon as the target has been identified as a foe, and brought within the desired range. Accuracy of fire is considerably better than that of manually operated turret guns. Guided by his radar, the pilot may also maneuver to bring his fixed guns to bear on the target.

Two different functions are provided by the APG-1 equipment: that of searching the area ahead of the interceptor for targets, and that of automatically tracking a specific target both in range and direction. A cathode-ray scope and a range meter are mounted at both the radar operator's and the pilot's positions, and at the pilot's position, shown in Figure 1, is also a meter to indicate the rate at which the target is being overtaken. During searching no indication is given on either of the pilot's meters, and on his scope appears only a horizon display that indicates the position of the plane relative to the actual horizon. On the radar operator's scope, however, appear indications of the range and azimuth of all targets within range of the instrument.

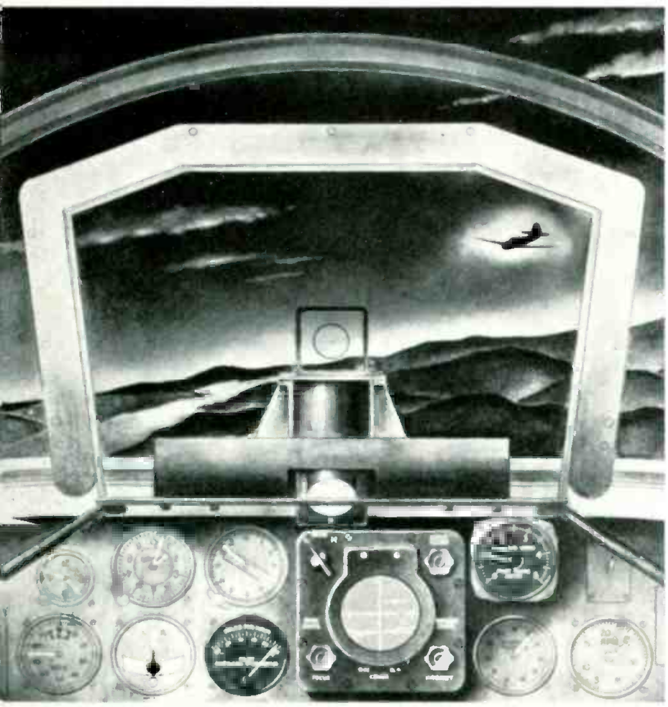


Fig. 1—At the pilot's position are three instruments used with the radar tracking equipment, which are retouched on the above illustration to make them more conspicuous. These include: the cathode-ray scope at the center, an overtaking speedometer located at its lower left, and a range meter at its upper right

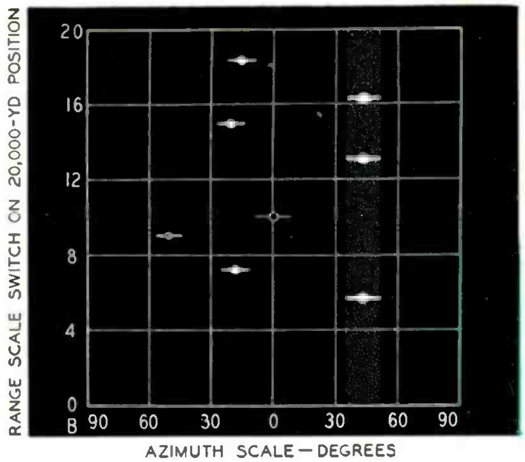


Fig. 2—Appearance of the radar operator's indicator during automatic search

Under the search condition, the radar operator's scope gives type B presentation, range being indicated by distance above the base-line, and azimuth by distance to the left or right of the central line marked zero azimuth. The appearance of the scope under typical searching conditions is indicated in Figure 2. The direction in azimuth in which the antenna is pointing at any instant is indicated by a faint vertical band, and targets appear as bright irregular dots at their proper range and azimuth. The band moves slowly back and forth across the face of the scope, and for each transit requires about four seconds. As the band moves, the target indications fade slowly, and have not completely disappeared by the time the band reaches them on its next transit. Elevation indication is not provided on this indicator, but the output of the interceptor's interrogation equipment may be displayed on the indicator so that friendly targets can readily be identified.

When the operator wishes to track a specific target, he grasps a manual sighting control, shown at the lower right of Figure 3. This is a movable pistol-like grip connected to vertical and horizontal servo systems for positioning the antenna. A trigger in the handle disables the automatic scanning circuit, and allows the antenna to follow the motion of the hand control. The operator moves the control in azimuth to the position where the target was noted while searching, and elevates and depresses the hand control until the target is seen at maximum intensity, which indicates that the antenna is centered on the target in elevation. A movable electronic range marker is then brought into superposition with the target indication on the oscilloscope, and its controlling knob and the manual pointing control are released. The system thereupon automatically tracks the target in range, azimuth, and elevation.

As soon as the automatic tracking operation is initiated, circuits are put in operation that provide the pilot with meter indications of the range to the target being tracked and the rate of change in range in miles per hour. This lets him know how fast he is overtaking or falling behind the target, and enables him to approach it at the optimum tactical rate. An indication of the target's position in both azimuth and altitude relative to the plane's axis is given on his scope also, in addition to the horizon line. The target appears as a short horizontal line with a dot in the middle giving the appearance of a single-engine airplane. The length of the wings varies in inverse proportion to the range to the target so that as the target is approached, the wings grow wider. A pair of short vertical lines on the target-elevation axis indicates the optimum range for the fixed guns. For "tail-on" interceptions, the pilot maneuvers so as to bring the winged spot to the cross-hairs, and then approaches the target until the wings on the indicator touch the vertical lines. He may then open fire with his fixed armament, having pointed his fixed guns at the target without visual contact. The appearance of the pilot's scope under these conditions is shown in Figure 5. The slope of the horizon display shows that the plane is banking to the left, and the depression of the horizon display below the horizon-elevation axis at the azimuth axis shows that the plane is climbing.

After the radar operator has initiated automatic tracking, he may change his indicator to another type of display wherein a wandering circle, shown in Figure 4, indicates the azimuth and elevation angles of the target, which is at the center of the circle. Azimuth is given to left or right as before, but vertical distance now indicates elevation instead of range.

The antenna is mounted just inside the nose of the ship, as shown in Figure 6. A small dipole is mounted at the focus of a parabolic reflector, and its currents are phased in such a way that the axis of the radiated beam diverges slightly from the axis of the reflector. This dipole is rotated by a small motor at 4,000 rpm, and thus the axis of the radiated beam rotates at high speed around a narrow cone. Radiation from the dipole is greatest along the axis of the radiated lobe. With increasing angle from the lobe axis, radiation decreases

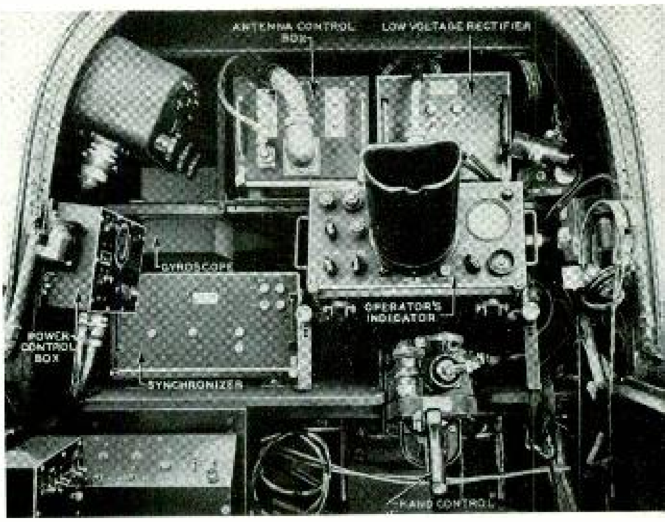


Fig. 3—Radar operator's position showing his radar control unit and oscilloscope near right center with the manual scanning control beneath it

slowly at first and then cuts down sharply. As a result, there is only a small circle in space from which effective echoes can be received. Since the axis of the beam rotates around a small cone, however, the total area scanned by the beam in one rotation of the dipole is the circle swept out by the effective area of the lobe as it rotates.

The scanning procedure when the reflector is stationary is indicated in Figure 7, where the central dot represents the axis of the reflector, the heavy circle represents the path of the axis of the radiated beam as the dipole rotates, and the shaded areas—shown only for four positions of the dipole—show the effective area covered by the beam when the dipole is in these four positions. One complete rotation of the dipole

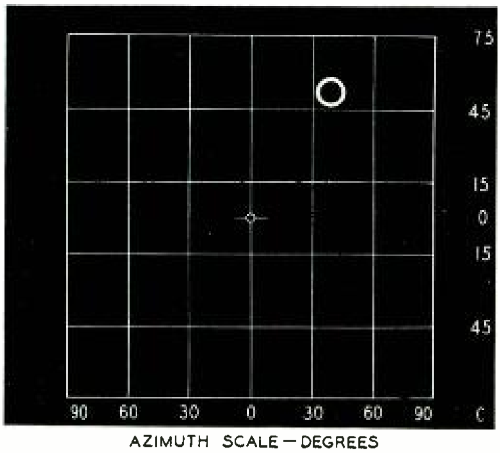


Fig. 4—The radar operator's scope employs C presentation during automatic tracking with a bright circle surrounding the target's position

covers the area within the dotted circle.

Under searching conditions, however, the reflector is moving laterally, back and forth, and thus the circles of coverage, all shown within the dotted circle of Figure 7, move continuously, but relatively slowly, as the dipole rotates. As each pulse leaves the dipole, the electron beam of the oscilloscope, which is being slowly carried across the zero range-line of the scope, but in back and forth oscillations in phase with the position of the radiated lobe, is deflected rapidly upward but at very faint intensity. For each revolution of the dipole, twenty-four pulses are sent out, and the twenty-four pulses for the overlapping rotations thus appear on the scope as a faint vertical band 15 degrees wide—the width covered by the dipole in one rotation. When a target sends back a reflected pulse, the electron beam is intensified, and thus in its vertical travel will appear bright at a point corresponding to the range of the target.

After a target has been selected and automatic searching is stopped, the servos that control the vertical and horizontal motion of the reflector for searching are put under control of the echoes from the target in such a way as to hold the reflector on the target at all times. With the reflector centered on the target, the axis of the beam, where the radiated power is greatest, makes a circle around the target as the dipole rotates. At all positions of the beam, therefore, the reflection from the target under these conditions is always the same, since it is that corresponding to the intensity of the beam at the same angular distance from its axis. The rectified pulses are thus equal amplitude pulses of direct current, and under these conditions both the horizontal and vertical drive motors of the reflector are held inoperative.

Connected to the motor that rotates the dipole is a two-phase 66-cycle generator, and the output of this generator is connected to two phase detectors: one controlling the vertical and the other the horizontal drive of the reflector. The envelope of the rectified echo pulses is also carried to these two phase detectors. When the reflector is not exactly centered on the target, the received echoes will vary in magnitude at a 66-cycle rate as the dipole rotates, and thus their envelope will be a 66-cycle sine wave. The phase detectors controlling the drive motors compare the phase of this envelope with the output of the two-phase generator connected to the dipole drive, and are so arranged that when a phase difference is found, the reflector will be driven in a direction to center it on the target. By these means, the reflector is held centered on the target in spite of all evasion efforts that may be made by the target.

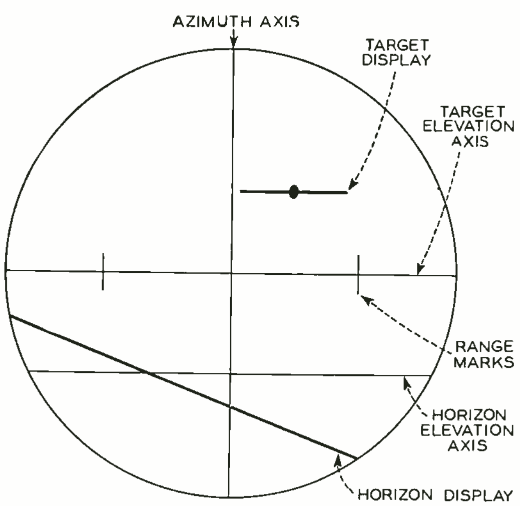


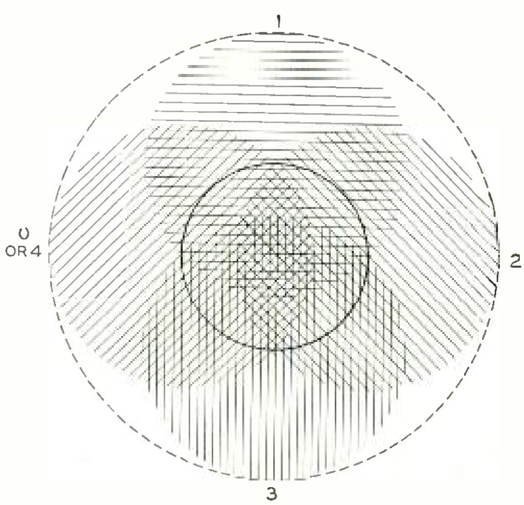
Fig. 5—Appearance of pilot's cathode-ray scope during automatic tracking

In this description of how the antenna is held pointed at the target during automatic tracking, it has been tacitly assumed that echoes from only one target are being received. Since the radiation from the rotating dipole covers an appreciable angle from the axis of the reflector, however, there may be other targets within this area that send back echoes, and thus means must be provided to insure that the echoes from only the target selected will guide the positioning of the antenna. This is accomplished by range tracking, which is one of the novel features of the AN/APG-1.

The rectified echo pulses are passed through a delay network, tapped at three points corresponding to delays of 1, 1.25, and 1.5 microseconds. In Figure 8, the pulses from these three taps of the delay circuit are indicated in their relative positions on a time axis. T_0 on this time axis represents the time a pulse leaves the antenna, and T_x, which is a variable time after T_0, is the time the echo pulse is received. Connections from the three taps on the delay network are carried to three gate circuits which, under control of a range pulse, will pass echo pulses only for 0.75-microsecond interval after the range pulse is received. This open-gate period is indicated on Figure 8 by the band below the time axis. If it occurs at the time indicated, the full pulse from the 1.25-microsecond tap will be passed by its gate, while the other two gates will each pass only two-thirds of their pulses.

At the time automatic tracking is started, the range pulse is set by the radar operator so that its mid-position occurs at a time corresponding to the range of the target selected plus a 1.25-microsecond delay as indicated in Figure 8. Thereafter, it is adjusted automatically by the relative amounts of the echo pulses passed by the A and B gates. If the range to the target decreases, for example, T_x on Figure 8, and thus the three pulses, will shift to the left relative to the open-gate period. As a result, more of the B pulses and less of the A pulses will be passed. These A and B pulses are compared in a differential integrator circuit, and their difference shifts the time of the range pulse so that it will occur earlier. When the A and B pulses passed are again brought to an equality by this shift of the range pulse, correction ceases. Should the range increase, a correction in the opposite direction would take place. By

Fig. 6—The radar antenna consisting of a rotating dipole in the center of a parabolic reflector is mounted in the nose of a ship



. 7—Scanning pattern caused by rotation of dipole en the reflector is fixed

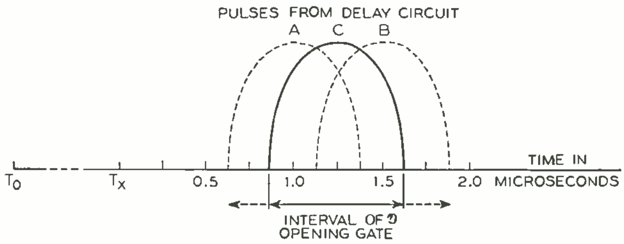
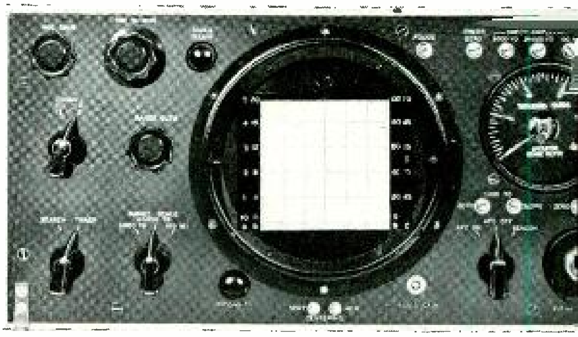


Fig. 8—Range tracking is secured by variable time gates controlling the passage of the pulses

this means the gates are kept in a time position to pass the full pulse from the 1.25-microsecond tap on the delay circuit, and this pulse is used to control the directional scanning as already described.

Echo pulses from targets at all other ranges are not passed by the gates, and only the pulse from the selected target can operate the directional tracking control. Since the range voltage that controls the time of the gate is automatically held to correspond to the correct range, it is also used to operate the range meters at the pilot's and radar operator's positions, and its differentiated value is used to operate the pilot's overtaking speedometer.

The APG-1 radar was given prolonged and exhaustive tests by the Army Air Forces, and its performance was found highly satisfactory. Arrangements were being completed for putting this radar equipment into operation in the Pacific theater when the Japanese war ended.



Radar operator's control unit for the AN/APG-1

THE AUTHOR: J. B. Maggio was graduated in 1935 from Cornell University with the degree of E.E., and received a master's degree in communications at Harvard University in 1936. He joined the Systems Development Department of the Laboratories that summer, where he was associated with the development of repeaters for carrier telephone systems until 1940. During the latter part of 1940 and 1941 he designed receivers for sonar equipment, but from then until V-J day, he designed airborne radar equipment for fire control and for blind bombing. At present he is developing short-haul microwave systems for television.

G. DEEG, JR.
Chemical
Laboratories

DIFFUSION OF WATER THROUGH PLASTICS

Rapid strides in the development of synthetic resins have produced a great variety of new plastics. To meet the diversified requirements of the communications field, it is necessary to evaluate these new products for intended applications. Among these is the use of plastics as impregnants, coating or molding material to protect condensers, crystals or coil assemblies from the deleterious effects of even small amounts of moisture. The relative protection afforded by a plastic can be predicted by permeability or diffusion data.

The results of diffusion tests have been available for a large number of these materials but they could not be compared on a common basis because of indeterminate or unreported variables. Lack of information concerning the composition of the materials tested also limited the value of much of the published data. To supplement these results and permit a study of some of the factors that govern permeability in plastics, further investigations were undertaken by the Laboratories on a number of materials.

Diffusion constants were obtained by determining the rate at which moisture passed from water in a shallow dish through a membrane of the material into the drier atmosphere of a desiccator in which the dish was placed. The desiccator contained phosphorus pentoxide or calcium chloride to absorb the moisture. The dish was 2 in. in diameter and ½ in. deep. It was filled with water to within one-quarter of an inch of the under surface of the specimen which was clamped air-tight onto the dish. To prevent leakage, silk gaskets coated with polyisobutylene were placed on each side of the specimen and stop-cock grease was applied to its exposed edge. Corrosion of the dish, which was made of aluminum, was prevented by applying several coats of an alkyd varnish to it and baking each coat thoroughly to remove volatile constituents.

From the loss of weight of the cell per unit time, the diffusion constant D was calculated by Fick's law $D = NX/At(p_1 - p_2)$, where N is the grams of water that penetrate a cross-sectional area A in square centimeters through a thickness X centimeters in t hours. The difference in pressure of the water vapor on the two sides of the plastic $p_1 - p_2$ was assumed to be 23.75 mm. of mercury for phosphorus pentoxide and 23.50 mm. for calcium chloride, at 25 degrees C., the temperature at which the tests were made. The constant D thus shows the number of grams of water per hour that will pass through a cube of the plastic, one cm. on a side when the vapor pressure difference is one mm. of mercury.

To be certain that the specimen was in equilibrium with respect to sorption, each test was continued until a constant value of D was obtained. This required from three days to several months, depending on the thickness, water sorption and permeability of the specimen. The desiccant had to be renewed frequently and the number of aluminum dishes per desiccator limited to avoid transferring excessive amounts of moisture. None of the materials tested was totally impermeable to water vapor. The constant D was found independent of the thickness of the specimen, which is in agreement with Fick's law. It was also found that diffusion constants of typical unplasticized plastics varied more than a thousandfold. The lowest value, 0.1 x 10^{-8}, was obtained with phenol formaldehyde resin and the highest, 114 x 10^{-8}, with unplasticized cellulose acetate. Values for other frequently used plastics were polyethylene 0.2, polystyrene 3.5, polyvinyl acetate 30, ethyl cellulose 77, all multiplied by the factor 10^{-8}.

In compounds made by combining two polymers, the relative concentration of the components changed the rate of diffusion. The value of D for a compound consisting of a copolymer of 87 per cent polyvinyl chloride and 13 per cent polyvinyl acetate was 1.1 x 10^{-8}. For the chloride alone it was 0.5 and for the acetate it was 29.9 x 10^{-8}.

Unplasticized cellulose derivatives are generally very permeable to water vapor, undoubtedly because of the numerous unesterified hydroxyl groups in the cellulose structure. The more complete the acetylation of the cellulose, the less the permeability. Values of D vary from 52 x 10^{-8} for cellulose acetobutyrate to 114 x 10^{-8} for cellulose acetate, Figure 1.

Plasticizers may change the permeability considerably. Dibutyl phthalate in ethyl cellulose increased the diffusion constant from 77 x 10^{-8} without plasticizer to 118 x 10^{-8} when it became 45 per cent of the compound, Figure 2. A plasticizer may also decrease the permeability. This is illustrated by adding di-monophenyl phosphate to ethyl cellulose. Increasing the content of this plasticizer from 5 to 45 per cent decreased the value of D from 77 to 22 x 10^{-8}.

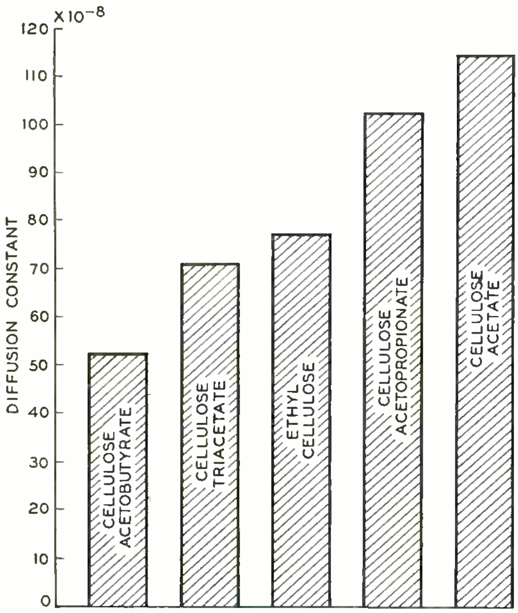


Fig. 1—Unplasticized cellulose derivatives are generally very permeable to moisture

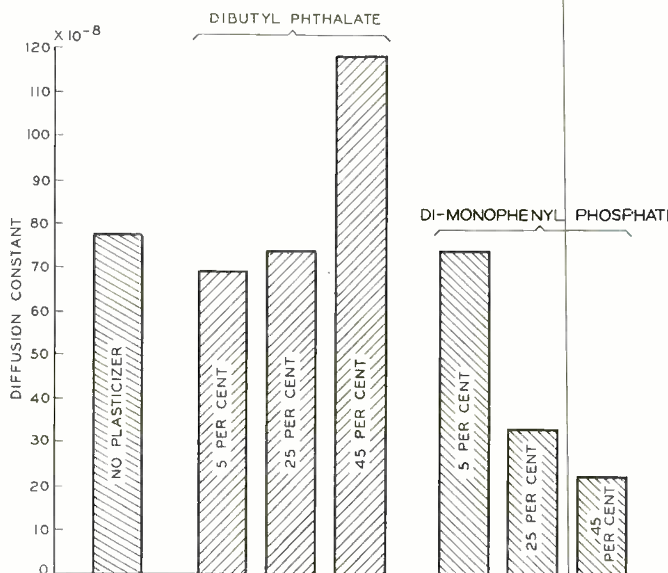


Fig. 2—Plasticizers may increase or decrease the permeability of ethyl cellulose to water vapor

In the polyvinyl 95 per cent chloride 5 per cent acetate series, Figure 3, the diffusion constants vary considerably for the equivalent amounts of plasticizer as also did those for the polyvinyl chlorides when modified by incorporation of different plasticizers. The relative rate at which the plasticizer itself transmits water and its degree of compatibility with the resin or polymer probably are important factors.

Adding wax, an incompatible hydrophobic constituent, to an ethyl cellulose compound reduces the permeability, but these systems are not always stable. The diffusion constant of a composition containing 22 per cent of wax steadily decreased, over a period of two months, Figure 4, with visual evidence that the wax was being forced to the surface of the specimen to form a continuous layer.

Fillers also affected the rate of moisture diffusion through plastics. Ethyl cellulose compounds that contained 44 per cent whiting had about two-thirds of the permeability of the same compounds without filler. The plasticizer-resin ratio was constant in the filled and unfilled compounds. This is a greater reduction than would be obtained on the assumption that the inert whiting only displaced the water diffusing constituents in proportion to its volume in the compound. This discrepancy may be attributed to the blocking action of the non-permeable filler which effectively increases the diffusion path. On the other hand, the incorporation of a water sorbing filler in a resinous composition may produce the opposite effect. Whereas bakelite resin alone has a constant of 0.1 x 10^{-8}, the permeability of a composition that contained 50 per cent wood flour increased thirtyfold. Whether a particular filler will increase or decrease the permeability of a compound to water depends on the moisture sorption and diffusion characteristics of the filler relative to that of resin.

The method of preparing samples also may affect the diffusion constant. A cast film of unplasticized cellulose acetate is more permeable to water than a molded one. The permeability also may vary with the solvent used. When molding a material like bakelite, which contains a considerable amount of compressible filler, improper application of heat and pressure produces an internally porous film that will give erroneous results. Moreover, brittle materials such as polystyrene may change during test by crazing and consequently give an increased rate of diffusion.

The diffusion constant is independent of the vapor pressure differential according to Fick's law. Therefore, the same value should be obtained whether a sample is tested with a pressure differential at a low or high relative humidity, *i.e.*, the humidity

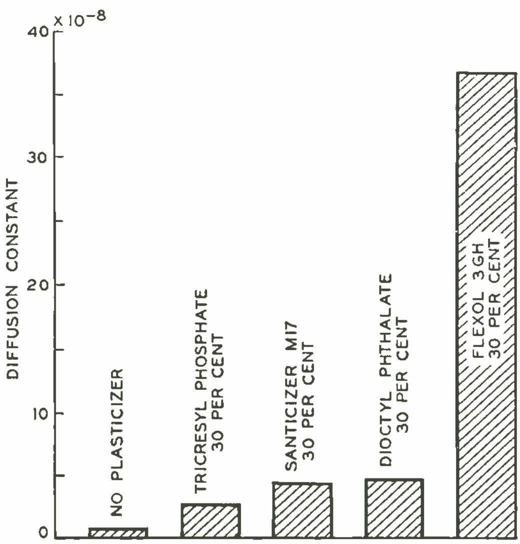


Fig. 3—Some plasticizers change the permeability of plastics to moisture more than others

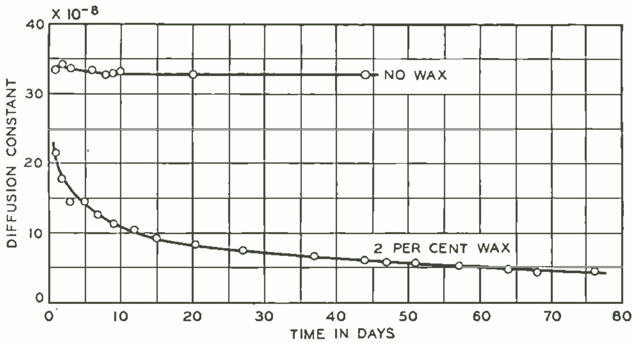


Fig. 4—Adding wax reduces the permeability of ethyl cellulose compounds to water vapor

conditions chosen to obtain p_1 and p_2 should not affect the result. To check this deduction, tests were made with water or calcium chloride in the cell, and saturated salt solutions outside it to establish the humidity conditions. The data revealed that the departure from Fick's law is in some way related to the sorption characteristics of the diffusion specimen.

Results on polyvinyl chlor-acetate, a compound of 87 per cent polyvinyl chloride and 13 per cent polyvinyl acetate and on

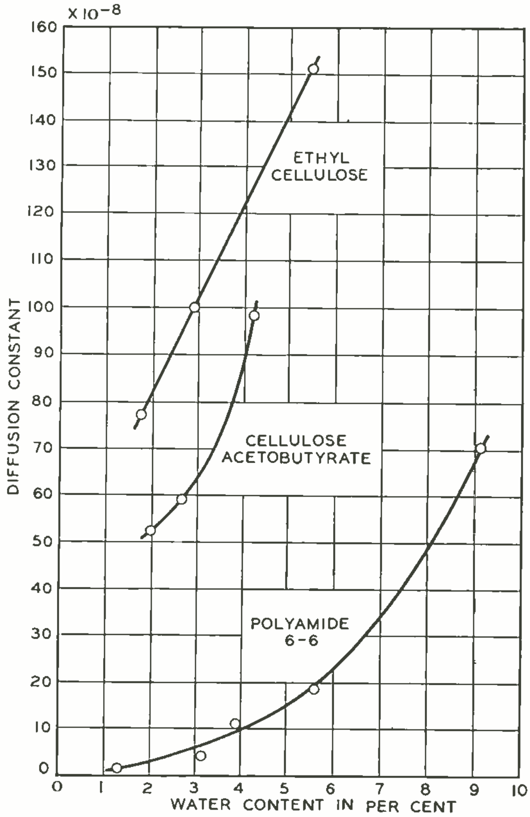


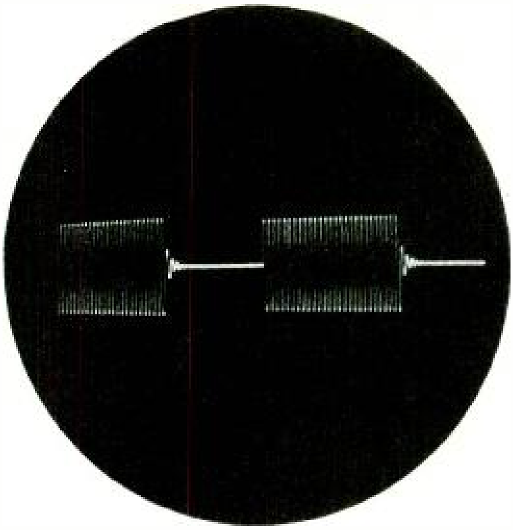
Fig. 5—The diffusion constant increases with water content in some plastics

polystyrene, materials which sorb little or no water, indicate the validity of Fick's law for compositions of this type because practically the same constant is obtained regardless of the humidity range used in the test. Polymethyl methacrylate and polyethylene sebacate, which sorb less than 2 per cent of water at saturation, illustrate a slight departure from the law. For materials that sorb considerable water, such as polyvinyl acetate, polyamide or most cellulose derivatives, various diffusion values are obtained which differ too widely to be expressed by an average. The results on polyamide show that modification of Fick's law to include the effect of water sorption is necessary. The arbitrary selection of any given humidity range and comparison of all data on the basis of Fick's law otherwise would be misleading in the case of moisture-sorbing systems.

The effect of moisture content on the rate of diffusion of several plastics is indicated in Figure 5. For these curves the water contents at the vapor pressures were calculated from equilibrium sorption data by assuming a linear vapor pressure gradient across the specimen.

These experiments show some of the factors that have to be considered when the diffusion of moisture through a plastic is important. They do not present detailed engineering data on the materials tested nor pass on their relative merits for any particular application. The choice of specimen thickness and other factors must be determined by the design under consideration and where it is to be used. In addition, many plastics are available in a wide variety of formulations, permitting the engineer substantial latitude in choice of materials for his particular requirements.

THE AUTHOR: George Deeg, Jr., was graduated from the Pratt Institute School of Industrial Chemical Engineering in 1925 and spent the four succeeding years with the Brooklyn Union Gas Company as chemist on corrosion problems. He entered the Laboratories in 1930. After several years' experience in corrosion and wood preservation studies, he joined the plastics group in 1935. Since that time Mr. Deeg has been engaged in the development of test methods and the evaluation of plastic materials for Bell System applications. He has supplemented his work at the Laboratories with courses at Brooklyn Polytechnic Institute.



L. A. MEACHAM
Transmission
Research

TIMER FOR RADAR ECHOES

In radar, the distance to a target is measured by determining the length of time between the transmission of a pulse of microwave energy and the reception of its echo from the target. The "timepiece" for measuring this very brief interval is known as the radar range unit.

For every pulse sent out—and there are hundreds of them per second—the range unit ticks off a time interval corresponding to the setting of its controls, and marks the end of this interval by generating a sharp "range pulse." When used with the common P.P.I. (Plan Position Indicator) type of radar, the succession of these range pulses appears as a circle on a fluorescent screen, along with the map drawn by the radar echoes. Such a presentation is illustrated in Figure 1. The range of a selected target may be measured by turning a knob on the range unit until the circle passes through the image of the target. The time interval indicated by this circle is then equal to the round-trip travel time of the pulse, and the corresponding range may be read in yards from the calibrated dial associated with the range knob.

Many kinds of radar have been required to meet a wide variety of military needs, and likewise a number of different types of range unit have been needed. An effort was made early in the war, however, to develop a timer of high accuracy that might be adapted to more than one project in the interests of economy and ease of training the personnel. The result is the range unit described in this article. Its accuracy has made it particularly suitable for radars intended for the control of gunfire. At sea it has served aboard vessels of many classes, from submarines to battleships, contributing to the accuracy of torpedoes, anti-aircraft fire, and the big guns of main batteries. In the air it has been a component of some of the bombing radars, while ashore it has supplied its range information to anti-aircraft gun directors.

In early radars, the pulses had been

transmitted at perfectly regular intervals under the synchronizing control of a stable oscillator, and the oscillator wave had been conveniently available for timing the target echoes. Later, to reduce possible interference between nearby radar equipments, and for other reasons, it was found desirable to vary the period between successive transmitted pulses either by changing the frequency of the controlling oscillator (thus destroying its usefulness as a time base), or in many cases by introducing random fluctuations in the timing of pulse emissions. being stopped and reset to wait for the next transmitted pulse.

The general method chosen had been used previously at lower speeds for measuring telegraph distortion. It required an oscillator that could be started and stopped suddenly enough to allow the independent time measurements to be made in terms of cycles and fractions of cycles of the resulting trains of oscillations. How this method was applied is shown schematically in Figure 2 and illustrated by wave form sketches in Figure 3. Corresponding letters in these

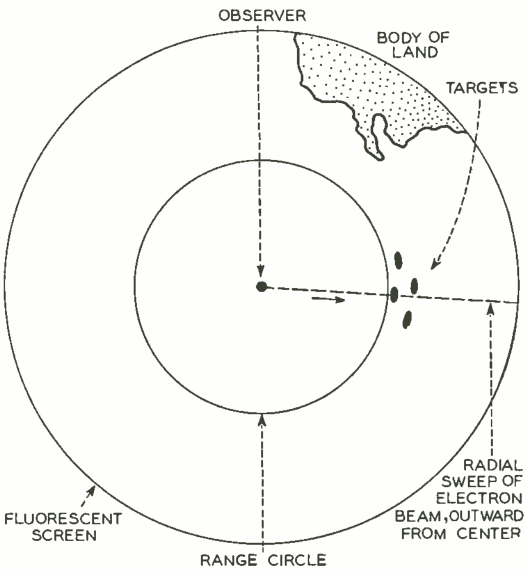


Fig. 1—In a typical cathode-ray display using a radial sweep, the radius of the "range circle" corresponds to the time interval marked off by the range unit

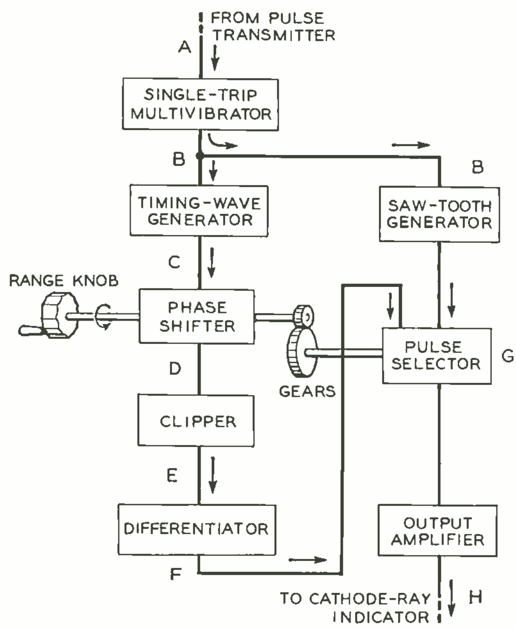


Fig. 2—Block diagram of range unit

As a result, the requirement was placed on this range unit that it must be "asynchronous." That is, it must not depend upon uniformity in the time of occurrence of the outgoing pulses. Whereas the range unit of the early synchronous radar had resembled a continuously running clock (with the outgoing pulses leaving "hourly on the hour," so to speak), the asynchronous range unit was required to function like a stop watch, being started by a transmitted pulse, ticking out its accurate time interval, and later illustrations associate each wave with the part of the range unit in which it is found.

Input A is a series of pulses obtained from the radar transmitter at times t_0, t_0', etc., each pulse triggering an independent operation of the "single-trip multivibrator." The square-wave output B of this multivibrator controls the intermittent operation of the oscillator or "timing-wave generator," starting the sinusoidal timing wave C at time t_0 and quenching it thoroughly soon after t_{max}. In most applications, the interval from t_0 to t_{max} is of the order of 300 microseconds, and that from t_0 to t_0' may have any value greater than 500 microseconds. A minimum time of 200 microseconds between t_{max} and t_0' is needed for the range unit to settle down before the next impulse from the transmitter.

The frequency of the timing wave is 81.96 kc. This wave is passed through a special "phase shifter" which, when a control shaft is turned, changes the phase of the timing wave continuously. If this control is set at the point of zero phase shift, the output of the phase shifter has the same wave form as the original timing wave shown in line C. For other settings, the phase of the wave in each train is advanced or retarded, as illustrated for a shift of about 270 degrees by the solid trace of line D. In this line the wave for zero shift is also shown (dotted) to facilitate comparison. When seen on an oscilloscope synchronized with the outgoing pulses, the cycles of the phase-shifted timing wave appear to move toward the right or left as the control shaft is rotated clockwise or counterclockwise, in much the same fashion as the spiral seems to move on a rotating barber pole. Cycles appear and disappear at the beginning and end of the recurrent wave train just as turns of the spiral do at the ends of the pole. The wave progresses one complete cycle for each turn of the shaft—the total angular phase shift being equal to the total angular mechanical displacement.

After amplification, the phase-shifted wave is converted into a square wave E by a clipper-limiter circuit that effectively transmits only a thin horizontal slice of the wave, taken near its center line. This square wave is then "differentiated" by passage through a small capacitor into a resistance load, and becomes a series of positive and negative timing pulses indicated on line F. Only the positive pulses are used. These are spaced a little over 12 microseconds apart, and represent range intervals of precisely 2,000 yards.

As the phase-shifter control is turned, these pulses, seen on an oscilloscope as before, appear to move along the time axis of the oscilloscope pattern. With each complete turn of the phase-shifter, every pulse except one moves smoothly over to occupy the position previously held by its neighbor; this excepted one shrinks and vanishes as it runs off the end of the train, and a new pulse is formed at the opposite end. If a particular one of the pulses is selected for attention, it may be moved at will to any position from within a microsecond after t_0 to t_{max}, and its time with respect to t_0 may always be known by the total amount the control shaft has been turned away from a zero position that had been calibrated previously.

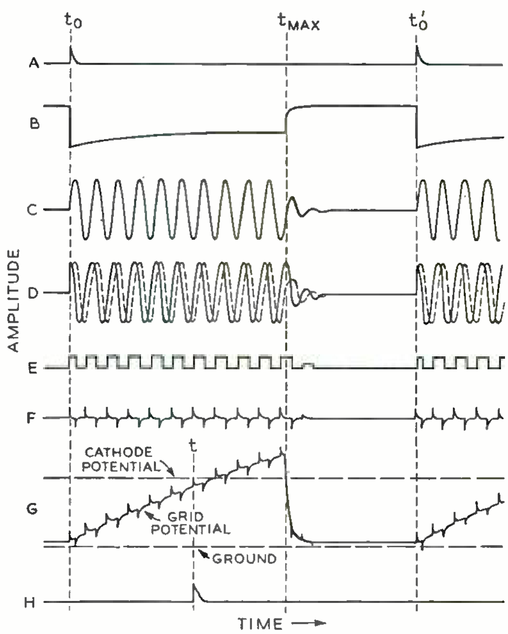


Fig. 3—Wave forms of voltages in the circuit of Figure 2

To the "pulse selector" is assigned this task of picking out a particular pulse, following it wherever in the train it is moved by the phase-shifter, and using it to trigger the desired range pulse. This it does with the aid of a saw-toothed wave, generated by slowly charging and rapidly discharging a capacitor under control of the square wave of line B. The timing pulses F are superimposed on the saw-tooth, as shown at G, and this combination is applied to the grid of a vacuum tube. The cathode potential of this same tube, which is also indicated on line G, is obtained from a potentiometer, the moving arm of which is geared to the range control that also drives the phase shifter. At the start of each rising saw-tooth, the grid potential is far enough below this cathode potential so that the tube passes no plate current; but at the instant one of the timing pulses extends above the "cut-off" value (just below the cathode potential), the tube becomes conducting. The first small flow of plate current is used to trigger a multivibrator-like circuit, labeled "output amplifier" in Figure 2, which delivers a single range pulse, line H, at time t, and then blocks to prevent the transmission of any more than the one timing pulse until the following microwave pulse leaves the radar transmitter.

The potentiometer mentioned above is carefully designed, and is geared to the shaft of the phase-shifter in such a way that the cathode potential is changed by the difference in height between the successive pulses on the sloping line while the pulse train is being phase-shifted the horizontal distance between pulses. If the control, for example, were set so that a range of 10,000 yards was indicated, the cathode potential would be such that the sixth pulse (counting one at approximately zero range) triggered the range pulse. If the control were now turned in a direction to increase the range, this sixth pulse would move to the right up the sloping line, and the cathode potential would rise with it. The range pulse would thus always be triggered by

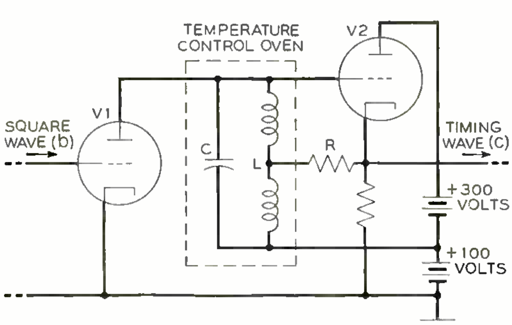


Fig. 4—Simplified schematic of timing-wave generator

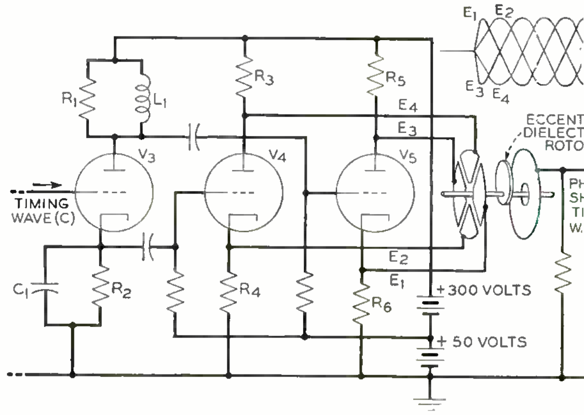


Fig. 5—Simplified schematic of phase shifter and wave forms of potentials applied to the disc sectors (d-c omitted). This is accomplished with negligible distortion, even in the first cycle

this same pulse, which would become the seventh, eighth, ninth pulse, and so on, as a greater and greater range was indicated. In this way the range pulse, at time t, may be set accurately to occur at any time interval after t_0, from less than a microsecond to the maximum range value that is near t_{max}.

For the sake of picturing the over-all operation, some important features new to the electron art have been skipped over quickly. The almost instantaneous starting of the timing wave at full amplitude and steady-state frequency is accomplished by means of the circuit shown schematically in Figure 4. In its rest condition between measurements, triode V1 passes a steady plate current through the tuning inductor L. At time t_0, the tube is suddenly made non-conducting by the negative square pulse applied to its grid. The current through the inductor, unable to stop suddenly, and unable to flow through V1, proceeds to charge the tuning capacitor C. It can be shown that the circuit is then in the same instantaneous condition it acquires at one point in each cycle of steady-state oscillation. Thus the suddenly started oscillation continues as though it had been going on indefinitely. The voltage across the tuning elements is applied to the grid of the cathode follower V2, which acts as a buffer amplifier; it provides a low-impedance replica of the timing wave for use by succeeding circuits. The oscillating frequency of the L-C resonator is made very stable with the aid of temperature control, and low-loss elements are employed. To keep the amplitude approximately constant throughout each wave train, even the slight dissipation in these elements is neutralized by introducing a corresponding amount of power from tube V2 through the resistor R.

At the time t_{max}, V1 is restored to its conducting state, whereupon its low plate impedance damps the oscillation within a few cycles, and the steady flow of plate current is reëstablished.

The problem of shifting the phase of an intermittent wave, with negligible distortion of its form throughout the steady-state period, is also a novel one. As shown in Figure 5, the timing wave is applied to the grid of a tube V3 having resistance and capacitance in its cathode circuit and resistance and inductance in its plate circuit. By properly proportioning these elements, the wave form of the plate potential may be made accurately the derivative of the cathode potential, and the steady-state amplitudes may be made equal. Then, since the cathode potential is a close replica of the wave on the grid, and can be represented by $E \sin\omega t$, starting at $t=0$, the plate potential turns out to be $E \cos\omega t$, jumping to its initial peak value within a small fraction of a microsecond after $t=0$.

The operation of V3 may perhaps be understood more readily by imagining R_1 and C_1 to be omitted. In this case the cathode circuit would be like that of an ordinary cathode follower, with the cathode potential E_k closely following the grid potential, and the cathode current having the value E_k/R_2. The plate current I_p is equal to the cathode current. Passing through the inductance L_1, this would produce a plate potential $E_p = -L_1\, dI_p/dt = -(L_1/R_2)dE_k/dt$, which is thus shown to vary as the derivative of the cathode potential. Similar reasoning leads to the same derivative relationship if R_1 and C_1 are used while L_1 and R_2 are omitted. To avoid practical disadvantages in either of these simple schemes, it was found desirable to use a combination of four elements, as indicated.

With the aid of two inverter tubes, V4 and V5, four waves are thus produced, E_1, E_2, E_3, and E_4, equal in amplitude and spaced accurately 90 degrees in phase. These are connected to four sectors of a circular metal disc, insulated from one another. All of these sectors have capacitive coupling to a separate continuous disc, parallel to the sectored one. By rotating an eccentric flat slab of insulating material (having a dielectric coefficient different from that of air) between the sectored and the unsectored discs, the four small coupling capacitances are varied, and by properly shaping the eccentric slab, the output wave picked up by the unsectored disc of this phase shifter may be made to vary linearly in phase and have constant amplitude. The over-all accuracy is ± (15 yards + 0.1 per cent of the measured range).

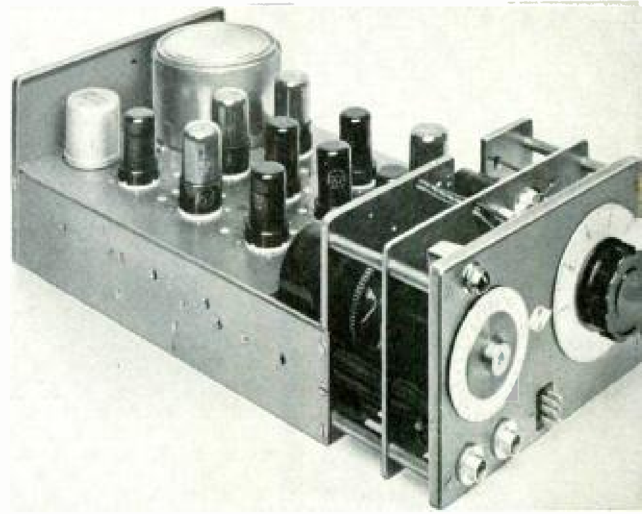


Fig. 6—This "brass model" of the range unit built as the first step in the development operated with the required precision in a complete radar

Figure 6 shows the "brass model" of the range unit—built in the laboratory as the first step in development after a "breadboard" version. An indication of the urgency attending its construction is the tin can used to house the temperature control oven, shown at the rear right of the range unit. Two dials were used to display the range setting, one calibrated with ten yards per division, from zero to 1,000 yards, and the other with a thousand, up to 45,000 yards. In manufacture, this eleven-tube circuit has been given several different physical forms to suit various applications. The range dials are generally replaced by counters resembling those of automobile mileage indicators, illuminated for use in darkened surroundings. In some models, shafts extending from the rear of the unit allow it to be driven by an automatic tracking device, and also provide for transmitting the range information directly to a gun-laying computer.

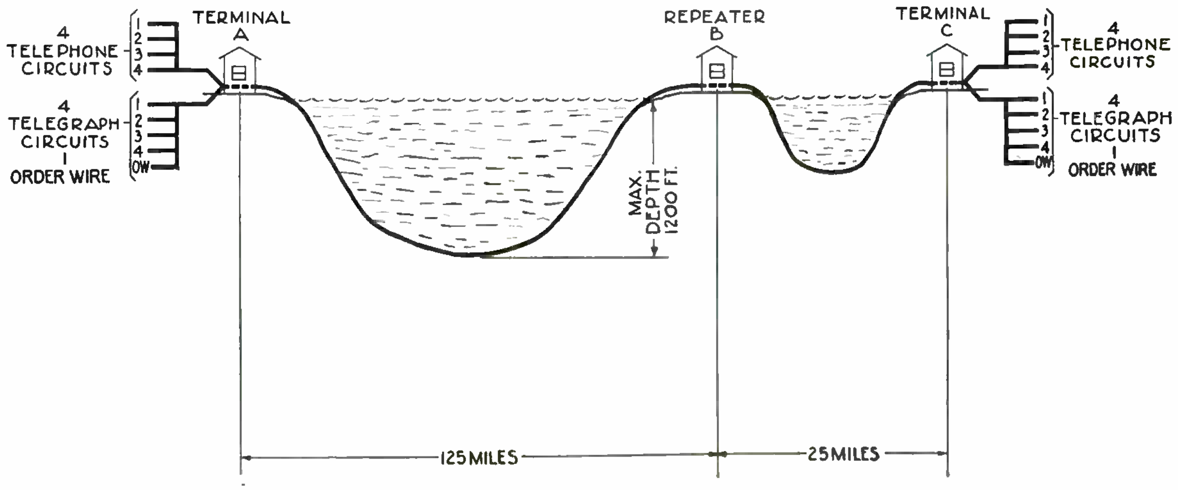
THE AUTHOR: L. A. MEACHAM received the B.S. in E.E. degree from the University of Washington in 1929. The following year he pursued graduate studies at Cambridge University in England, where he received the Cambridge "Certificate of Research" in 1930. That year he joined the Laboratories, and until 1940 worked on the development of precision oscillators and other devices related to standards of frequency. In 1939 Mr. Meacham received the Eta Kappa Nu Recognition of Outstanding Young Electrical Engineers for his "distinguished research in the generation of constant-frequency currents and his participation in the cultural life of the community." During 1940 and 1941 his efforts were turned to the application of electronic techniques to telephone switching problems. From that time until nearly the end of the war he was engaged in radar development, and he has since been concerned with pulse modulation systems of multiplex telephony.

VOCAL CORD VIBRATIONS UNAFFECTED BY HELIUM GAS

A lecture audience can always be counted on for a laugh when the speaker fills his throat and mouth with helium and talks. His manly tones are replaced by a comedy falsetto, only to resume their original quality as the helium is replaced by air. The helium gas, of density about one-seventh that of air at a given pressure, raises the resonance frequencies of the throat, mouth, and nose cavities by a factor of about 2.6, so that they act like cavities of less than half normal size. However, motion pictures taken at 4,000 per second of the vocal cords in an atmosphere of helium show that the cord vibrations are relatively independent of the acoustic load formed by the cavities.

The effect of density on acoustic resonance is further illustrated by the observation that the speech of men working under pressure, such as divers and caisson workers, sounds unnatural when they are supplied with a mixture of helium and oxygen instead of air. The use of helium in this case tends to reduce the occurrence of bends.

Studies of the speech mechanism are part of the research program of the Laboratories, since the transmission of speech is a basic function of the Bell System. A thorough understanding of the interactions between the cavities of the vocal tract and the vocal cords is of importance in evaluating methods of speech transmission.



W. F. MALONE
Systems
Development

A SUBMARINE CABLE CARRIER FOR FOREIGN WAR SERVICE

During the darkest period of the war, when Axis drives had nearly severed the east from the west, an urgent need arose for a submarine cable system to link two strategic points in the hands of our Allies. Through the Treasury Department, an order was placed for such a system on the International Standard Electric Corporation. Since urgent military necessity required that the cable system be engineered and manufactured in the United States, arrangements were made to have the Laboratories undertake the over-all design of the system, and the detailed design and manufacture of the terminal and repeater equipment.

Two sections of cable would be required: one 125 miles long and the other 25 miles long—with terminal equipment at both ends and repeater equipment on an island at the junction of the two cables. The terminal equipment should provide four telephone circuits and four telegraph circuits, and in addition a telegraph orderwire circuit from the repeater station to each terminal.

The best solution appeared to be a carrier-frequency cable of the solid insulation coaxial type, similar to that installed between Key West and Havana in 1930.* This had a tape stranded central conductor and a return conductor consisting of flat tapes wound over the outer surface of the insulation. Such conductors give more efficient transmission than other forms. The 1930 cable was insulated with paragutta, a thermoplastic insulation of very good electrical characteristics. Materials for manufacturing this type of cable, however, were not available in this country.

Short lengths of carrier-frequency submarine cable had been made by a number of manufacturers in this country, in particular by the Simplex Wire and Cable Company, using vulcanized rubber insula-

*Record, *May*, 1931, *page* 412.

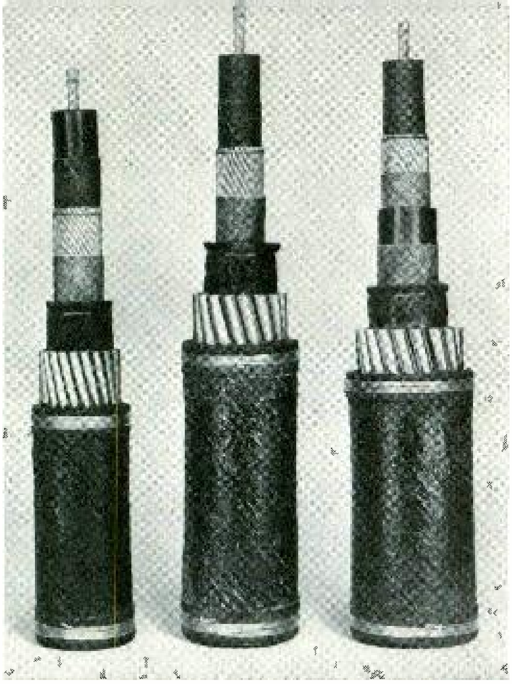


Fig. 1—The three types of submarine cable employed. At the left is the deep-sea cable; in the middle is the intermediate cable; and at the right is the shore-end cable

tion, wire-stranded central conductors, and a return conductor consisting of a large number of wires laid on the insulation. Other forms were proposed by various manufacturers, but they did not appear to have over-all advantages. Rubber insulation is not nearly so good as paragutta electrically, and wire conductors are not so efficient as the tape form used in 1930 cable. The best proportions for such a cable, however, were decided in the course of a joint development program by the Simplex engineers and the Laboratories. The Simplex Company would make up perhaps a twenty-foot sample according to our specifications, and then one of their engineers would bring it with him under his berth in a sleeper to New York. The transmission characteristics would be measured at the Laboratories, and the next step agreed upon. Arriving at a suitable design was a matter of some difficulty, since, to furnish the required number of circuits, it was necessary to work toward proportions that were close to the limit of what could be done with a mechanically practicable size of cable.

As finally designed, three types of structure were used to make up the complete submarine cable. These are shown in Figure 1. That at the left is a deep-sea cable with smaller armoring than the others, since at great depths mechanical injury is less likely. It is used over the middle section of the 125-mile cable. For the middle section of the 25-mile cable, and for intermediate sections between the deep-sea section and the shore end of the longer cable, the intermediate type shown in the middle of Figure 1 is used. This differs from the deep-sea type chiefly in having heavier armor. For both shore ends of both cables, the type shown at the right is used. Like the intermediate cable, this also has heavy armor, and in addition it has a layer of thermoplastic material to protect the insulation from oil. During manufacture, the Laboratories made the transmission measurements involved in acceptance tests.

Like all long submarine cable projects, the equipment was designed to fit the characteristics of the cable. In this case, it was practicable to use Spiral-4 equipment* for the telephone circuits and packaged equipment† for the telegraph and order-wire circuits—all modified somewhat to meet the changed conditions. The Spiral-4 system uses the same frequencies in each direction of transmission because it operates on a four-wire basis, that is, a separate pair of wires is used for each direction of transmission. The submarine cable, however, has but one pair of conductors, and thus two-way transmission had to be obtained by subjecting the messages in one direction to modulation as a group so that they could be transmitted over the cable at higher frequencies. This group of frequencies is demodulated at the receiving terminal before entering the Spiral-4 equipment. New modulators and demodulators were designed for this purpose. Amplifiers were provided to take care of the high attenuation of the cables, and directional filters were provided to separate the frequencies for the two directions, and also to separate the telephone circuits from the telegraph circuits. Ringer and testing equipment were also provided. The equipment designed especially for this system was made at Bell Telephone Laboratories, while the standard equipment was fur-

*Record, *December,* 1943, *page* 168.

†Record, *March,* 1946, *page* 97.

nished by the Western Electric Company.

At the top frequency, the attenuation over the 125-mile cable circuit is about 90 db. The signal level at the ends of the sections of the cable is extremely low, and a number of precautions had to be taken to reduce the effects of noise. One was to divide the equalization between the two terminals, which resulted in an improved signal-to-noise ratio. Another was to use batteries for the power supply instead of an a-c source as is used with Spiral-4. Each battery has its own rectifier for charging, and in addition, each has a spare rectifier. At the terminals, these rectifiers operate from 115-volt, 60-cycle power supply taken either from commercial lines or from an emergency gas-engine-driven generator. Gas-engine-driven generators alone are used at the repeater station.

The telephone and telegraph equipment at the two terminals occupies five bays, as shown in Figure 2. From left to right, these are the telephone high-group bay, the telephone low-group and channel bay, the signalling bay, the test and order-wire bay, and the telegraph bay. At the repeater station, two bays house all the necessary telephone and telegraph equipment. The cabinets for this equipment are of sheet steel construction, 7 feet high, and have full length front and rear doors.

Because this equipment was to be installed in remote locations and operated by those not familiar with Bell System design, the instructions for operation and maintenance were prepared in unusual detail, and comprise two large volumes. In addition, large photographs of the equipment with foreign-language descriptions were fastened to the inside of the front door of each cabinet. The apparatus numbers which appear on the wiring diagrams were stamped on the inside of the rear doors opposite the apparatus for identification purposes. To assure the equipment would operate satisfactorily, the complete system was set up in the Laboratories, and over-all tests were made using networks to simulate the two sections of the cable. These measurements matched with slight variation the calculated results made at the start of the

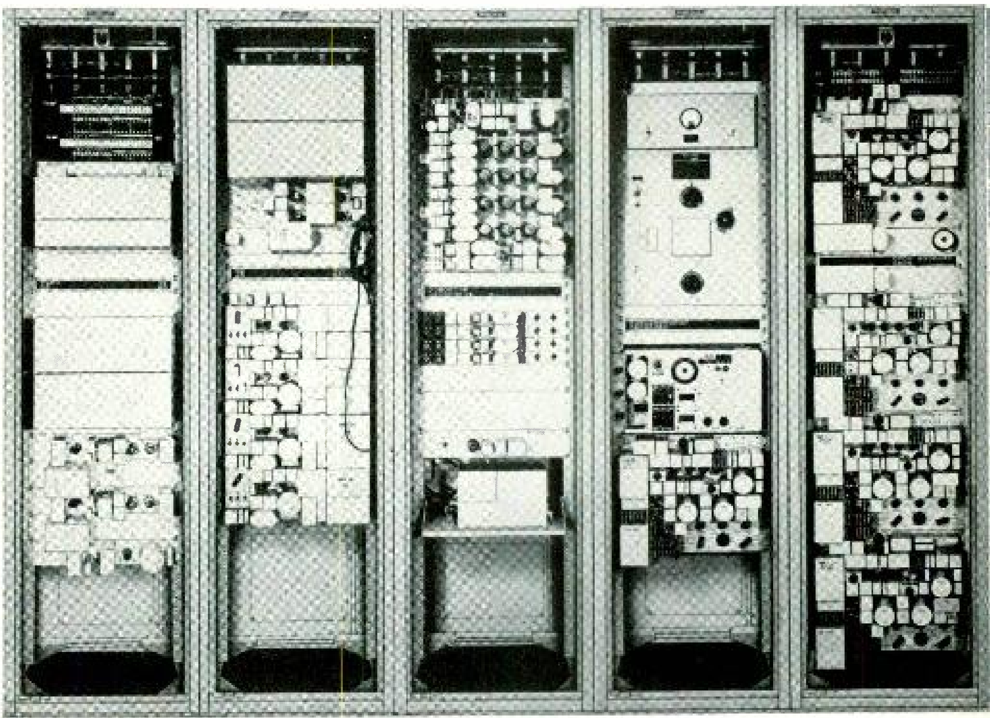


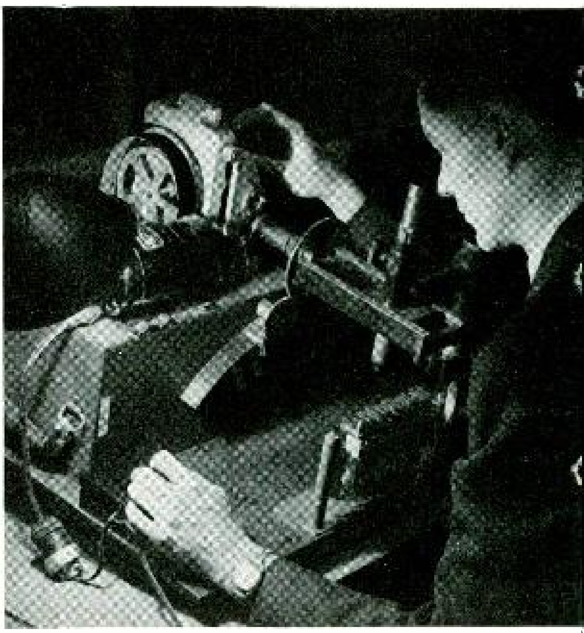
Fig. 2—The five bays of telephone and telegraph equipment employed at the two terminals

job. The 125-mile section of this system is about the same length as the cable between Key West and Havana, which has the distinction of being the longest carrier telephone cable circuit that is in existence without intermediate repeaters.

THE AUTHOR: W. F. MALONE joined the Engineering Department of the Western Electric Company in 1917, where, in the Systems Drafting Department, he engaged in the preparation of drawings and specifications for the first panel dial offices. In 1923 he transferred to the Equipment Development Department and for the next eight years prepared manufacturing information for models and trial installations of new equipments. During this time he was responsible for supervising the installation of the Key West-Havana submarine cable and the transatlantic radio control equipment at 24 Walker Street, New York. Since then he has been engaged in developing equipment for carrier telephone circuits over cable pairs, various types of key telephone systems, and is, at the present time, developing equipment that is associated with crossbar switching systems. During the war he developed equipment for air raid defense and the equipment described in this issue of the RECORD.

GUN DIRECTOR MECHANISM MOVES MICROSCOPE FOR CROSSBAR SWITCH MEASUREMENTS

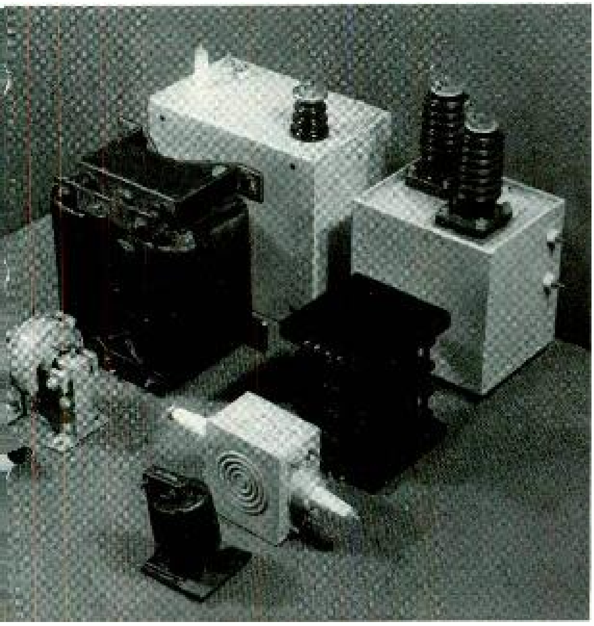
With a traveling microscope, R. E. Coleman, Jr., of Bell Telephone Laboratories, measures the positions of springs on a vertical unit of a telephone crossbar switch before and after exposures to extreme dryness and humidity. Measurements on twenty-four units involved 48,000 hand-made revolutions of the microscope lead screw with 2,400 pauses to read the scale for distance. To reduce this laboi, Coleman geared the microscope to a precision mechanism (shown by his right hand) which once formed part of a wartime gun director. Driven by the electric motor, the device swiftly moves the microscope to within one-thousandth of an inch of the desired mark. A push button under his left hand starts and stops motor. The counter, which is shown at the center, records the number of revolutions of the lead screw and hence the distance traveled.



E. E. ALDRICH
Transmission
Apparatus
Development

CHARGING CHOKES IN PULSE GENERATING CIRCUITS

A new application for power retardation coils arose, during the war, from their need in pulse generating circuits developed for radar systems. Power retardation coils are used chiefly as the series elements of "LC" filter circuits to suppress the ripple or noise from d-c circuits. A typical circuit of this type is shown in the center of Figure 1, with the input voltage wave at the left and the output at the right. In this example, the input is obtained from a single-phase full-wave rectifier and thus consists of a series of half-cycle sine waves, which are smoothed by the filter to d-c with a low amplitude ripple. In a pulse-generating circuit, the action resembles the reverse of the filtering action referred to above, since in a pulse circuit a d-c voltage is applied across the input terminals of a coil-and-condenser combination and a pulsating voltage is obtained across the output terminals. An important difference between these two circuits is that the filter circuit operates under steady state conditions while the pulse circuit may be considered as operating under a controlled transient condition.



A simple type of pulse circuit, which differs from the filter circuit of Figure 1 only in the addition of a synchronous switch, is shown in Figure 2. If the switch is left open and a d-c voltage, E_{dc}, is applied to the input terminals of the circuit, the voltage across the condenser will be as shown in the middle diagram. If the switch is adjusted so that it closes at the instant the condenser voltage reaches a maximum and opens as soon as the condenser has been discharged, the voltage across the condenser will be as shown in the lower diagram. This is essentially the action obtained in a pulse-generating circuit of the "resonance" charging type. The magnetic* type of pulse generator is also used extensively in radar work, and although in operation it differs somewhat from that of a resonant charging type of generator, they both use retardation coils which perform similar functions in their respective circuits.

To make use of these pulses in a radar system, it is necessary, for reasons which are beyond the scope of this article, to modify the above circuit by connecting a transformer in series with the condenser and replacing the condenser by a network. From a circuit standpoint, this will not appreciably affect the voltage across the network provided the input impedance of the network at the pulse frequency approximates that of the condenser it replaces, and the input impedance of the transformer is low compared to that of the choke at this frequency. These characteristics are obtained in the design of the apparatus, and the circuit becomes that shown in Figure 3.

*Record, *December*, 1946, *page* 450.

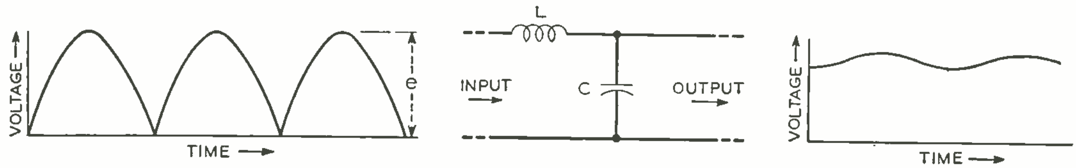


Fig. 1—An "LC" filter circuit, middle, with the input wave, left, and the smoothed output, right

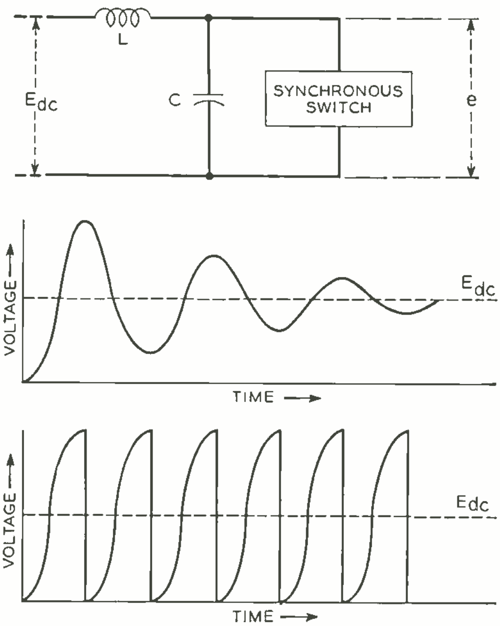


Fig. 2—A simple pulse circuit, top; the output when switch is open, middle; and with switch opening and closing, bottom

The voltage across the network remains as shown in the lower diagram of Figure 2.

Because the circuit is in resonance, the voltage across the network rises to a value practically twice that of the d-c voltage supply. Since one end of the charging choke is connected to the network, it must follow the network voltage, whereas the other end, being tied to the d-c supply, remains at the supply potential. This results in a sine wave of voltage across the coil that is cut off at the middle of each half cycle by the closing and opening of the switch. The network charging current, which is the same as the choke current, is a sine wave interrupted at the end of each half cycle, and is zero at the time the switch closes, since at this time the network is fully charged. During the time the switch is closed, the charging choke is connected across the d-c voltage supply, and if this condition existed for any appreciable length of time a large current would build up in the coil. The switch remains closed for only a few millionths of a second, however, and since a choke tends to resist any sudden change in current through it, the current remains very close to zero. The current through the charging choke and the voltage across it are shown graphically in Figure 4. The switch closes at point x, and remains closed until the voltage across the coil has reached the d-c supply voltage, E_{dc}, at which point the switch opens again and the cycle is repeated.

The d-c voltages required for the operation of the radar circuits for which charging chokes were designed ranged from 1,200 to 13,000 volts and, as previously explained, these are doubled in the pulse circuits. Thus these coils not only operate at high voltages to ground but also have high voltages across the windings as well as superimposed direct currents in their windings. The pulse rates ranged from 200 to 10,000 pulses per second, and some of the circuits were required to be operable at more than one pulse rate.

For a power filter choke, it is usually sufficient to specify only the minimum inductance. Since a pulse-generating circuit, on the other hand, operates at a pulse rate equal to twice the resonant frequency of the "LC" circuit, the inductance of a charging choke is required to be held within limits of ± 5 per cent. A power filter choke generally operates at low flux densities and therefore has comparatively low core losses so that the greater portion of the heating is caused by the losses in the copper. Because of the space and weight requirements, the higher frequency of operation, and the high voltages under which a charging choke is required to operate, it is designed to have core losses equal to or greater than the copper losses in order to achieve minimum size and weight for the allowable temperature rise. Some radically different designs resulted from these requirements, including the use of 0.006-inch-thick permalloy laminations in the cores. Due to the high operating voltages, particular attention was given to the winding insulation in order to eliminate the harmful effects of corona.

Several types of construction are represented in the charging chokes designed for radar circuits, the choice having been governed by requirements as to currents, voltages, size, weight, moisture resistance, etc. These included open type coils with "Flexseal" treatment, air-insulated coils with self-supporting duolateral windings, and oil-insulated types with either paper-filled or duolateral windings. Some of the types of construction are shown in the illustration on page 241. The weights of these coils vary from 6 ounces to 40 pounds. Several thousand of the various types were manufactured for the Armed Forces during the war by the Western Electric Company and its subcontractors.

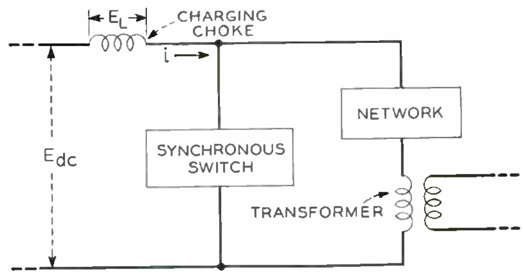


Fig. 3—As modified for use in radar circuits, the condenser of the pulse circuit of Figure 2 is replaced by a network, and a transformer is added to supply the output

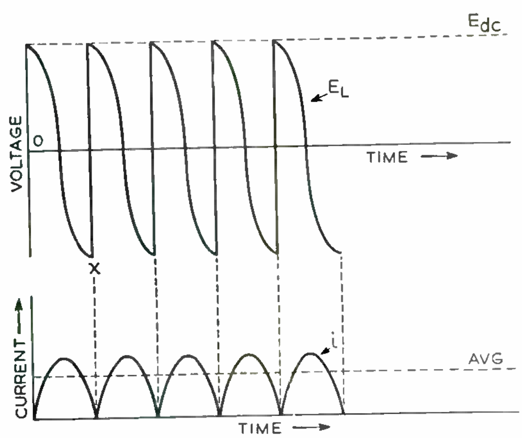
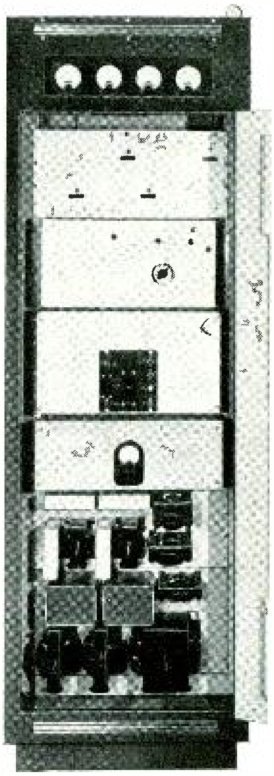


Fig. 4—Current through charging choke and voltage across it when a synchronous switch is operating

THE AUTHOR: E. E. ALDRICH received a B.S. degree in Electrical Engineering from M.I.T. in 1927 and joined the Technical Staff of the Laboratories in 1930. Since then he has been with the Transmission Apparatus Development Department where he has been chiefly concerned with the design and development of networks, transformers, and repeating and induction coils. During the war he devoted his time to the development of power transformers and charging chokes for radar, and communication equipment for the Armed Forces. Since the close of the war he has been engaged in the design and development of pulse transformers for use in radar, pulsed communication systems, and television circuits.

FIXED STATION TRANSMITTERS FOR MOBILE RADIO TELEPHONE

A. E. HARRISON
Specialty
Products
Development



Since radio transmitters in vehicles equipped for radio telephone service must be of low output in the interest of economy, reasonable battery drain, size and weight, their range for dependable transmission is relatively short. Satisfactory service with such limited range is achieved by installing receiving sets at a number of carefully selected locations throughout the area served. For transmission to the mobile units, however, size and weight of the transmitter are not determining factors. The "land" stations for the mobile service, therefore, have been engineered on the basis of using one, or two, transmitters of much larger output. Preliminary studies indicated that an output of 250 watts would be adequate, and that a transmitter of this size could best be provided by using an exciter similar to the mobile transmitter which would drive a 250-watt radio-frequency amplifier. Such a combination with the addition of power supply and control equipment comprises the 540A transmitter.

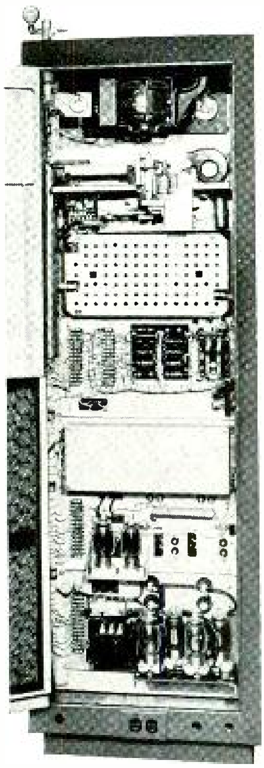
As finally arranged, the 540A transmitter consists of seven units assembled in a steel cabinet with front and rear doors shown in the accompanying illustrations. The upper unit is a meter panel, and is mounted behind glass above the top of the front door so that the faces of its four meters will be visible when the door is closed. The other units, from top to bottom, are the 250-watt 137A amplifier, the 40A radio transmitter, the 575A control panel, the 2A frequency monitor, the 24A low voltage rectifier, and the 25A high voltage rectifier.

The 40A transmitter is quite similar electrically to the 38B transmitter designed for vehicular use, but modifications were incorporated to make it suitable for relay rack mounting. In addition, the dynamotor was removed, and heater type tubes were substituted for the filamentary type throughout the set. Whereas the 38B, with the help of its dynamotor, was operated from the 6 or 12-volt car battery, the 540A is operated from the 60-cycle a-c commercial supply through its two rectifier units. It can be controlled from a remote operating point to the extent that both tube filament and high-voltage supplies are under control of the central-office operator. The 2A frequency monitor, which is mounted in the transmitter cabinet, is used to transmit an alarm over a telephone line extending back to the control point should the transmitter carrier-frequency deviate beyond the specified tolerance. As already described,* this monitor affords an indication that the transmitter is in opera-

*Record, *April,* 1947, *page* 137.

tion at its proper frequency and thus that it is available for handling traffic.

Included in the cabinet of the 540A transmitter are two blowers: one for cooling the tubes in the power amplifier, and the other for circulating air through the entire cabinet. Air is taken through a filter in the rear door and is exhausted through the top of the cabinet. Both this rear door, which gives access to all wiring, and the front cover on the 40A radio transmitter unit are equipped with safety interlocks to render the set inoperative when either the rear door is opened or the cover removed from the 40A. No such protection is provided for the front doors since, with the exception of the 40A, none of the front panels has points of dangerous voltages.



Considerable attention has been paid to the development of mechanical and electrical arrangements which will insure reliable service. Xenon gas-filled rectifier tubes, for example, are used instead of the mercury vapor tubes commonly employed. Mercury vapor tubes become inoperative at temperatures below freezing, while the gas-filled tubes remain operative at temperatures of 40 degrees below zero. Another frequent cause of trouble in service is high resistance contacts in variable elements of the tuning circuits. In this transmitter, an output circuit was designed in which there are no moving contacts carrying radio-frequency currents. This careful attention to all factors affecting operation has resulted in a transmitter that will furnish reliable service continuously under the wide variety of conditions encountered in Bell System service.

THE AUTHOR: A. E. Harrison graduated from the University of Colorado with the degree of B.S. in E.E. in 1931, and spent the next three years as radio technician for the American Airways and the Denver Police Department. In 1934 he joined the U. S. Department of Commerce as Airways Engineer, and engaged in developing radio aids to navigation. During 1941 he was with the Aeronautical Radio, Inc., Washington, D. C., coördinating engineering for the domestic airlines, and was also Secretary of the Radio Technical Commission for Aeronautics. Later, attached to the Joint Radio Board in Washington, he was consultant for the Navy on aircraft radio equipment. In 1942 he joined the Laboratories Technical Staff, first working on the development of very-high-frequency airborne radio communication equipment and subsequently of ultra-high-frequency airborne communication equipment for the Navy. Since the end of the war he has been developing fixed station radio transmitters for the Bell System urban and highway radio telephone service.

NEWS AND PICTURES OF THE MONTH

This Croix de Guerre avec Palme was recently received by Lt. Col. Frank A. Parsons from the Belgian Government. It was awarded to him on May 2, 1946, for the part he played during World War II in the liberation of Belgium. Colonel Parsons also holds the French Croix de Guerre as noted in the RECORD *for September,* 1946

Pulse Code Modulation

A radically new technique which promises freedom from noise and interference in long-distance telephone communication was described by W. M. Goodall in a paper presented before the Union Radio Scientific International on May 5 at Washington, D. C. Known as PCM, for pulse code modulation, it is a method of transmitting the human voice by various patterns, or codes, of electrical signals. Each pattern conveys certain information about the voice at a particular instant and from a succession of such patterns an entire conversation can be reconstructed.

The conversions from voice to pattern and back from pattern to voice—known as the coding and decoding processes—are accomplished electronically at almost unbelievable speeds. If enough patterns are used, these conversions can be made with incredible fidelity and so smoothly that the human ear is completely unable to detect the processing.

Although the new system is expected to be used primarily as an adjunct to the telephone network, it can also be used to transmit radio programs, pictures and teletypewriter signals.

A description of the basic principles of PCM will appear in an early issue of the RECORD.

L. F. Morehouse, 1874-1947

Lyman F. Morehouse, who retired from the A T & T in 1939, died on May 1. Born on October 21, 1874, he was graduated from the University of Michigan in 1904, where he remained for two years as professor of electrical engineering. In 1934 his Alma Mater honored him with the degree of Doctor of Engineering.

Dr. Morehouse joined the Western Electric Company in 1906 and was soon sent to Europe as its Transmission Engineer. He returned in 1909 and was transferred to the A T & T as Equipment Engineer concerned with the development of central-office equipment, making many valuable contributions in this field. When the D & R consolidated with the Laboratories in 1934, he became Assistant Director of Systems Development. A year later Dr. Morehouse went to London as Technical Representative in Europe of the A T & T and the Laboratories. He retired from the Bell System in 1939. During World War II he was associated with the O.S.R.D.

Third in a series of Laboratories PBX pictures to be published in the RECORD *is this trio of operators and their supervisor, Dorothy Carlson, standing, of Murray Hill. Left to right, the operators are Paulina Ryan, Mary McKay and Margaret Kerrigan*

E. J. Kane Goes to Western

E. J. Kane, Switching Development Engineer, has been appointed Patent License Engineer of the Western Electric, reporting to Vice-President Best. After graduation from Brooklyn Polytechnic Institute in 1921, Mr. Kane entered Equipment Development where he worked on step-by-step, panel and No. 1 crossbar systems. In 1941 he was appointed Switching Development Engineer. During the war, his department was responsible for the development of flight trainers for the Navy and pre-production engineering of ship radars. Since the war, Mr. Kane has been responsible for the switching laboratories, for performance phases of switching apparatus, and for various current developments. He received the degree of Bachelor of Laws from Fordham in 1929 and was admitted to the New York State Bar in 1930.

J. M. Hayward Receives Legion of Merit

In a recent ceremony at Fort Slocum, New York, Colonel John M. Hayward, of Station Apparatus Development at Murray Hill, received the Legion of Merit Award from Colonel G. A. McHenry of the Air Corps. The citation reads as follows: "As Chief, Technical Data Laboratory, Headquarters, Air Technical Service Command, from January, 1943, to September, 1945, Colonel Hayward created and supervised the activities of a unit dealing with the compilation, verification and coördination of highly important flight data, technical information and engineering evaluations of domestic and foreign aircraft and equipment. Colonel Hayward's noteworthy attainments and his exemplary devotion to duty reflect great credit upon himself and the Army Air Forces."

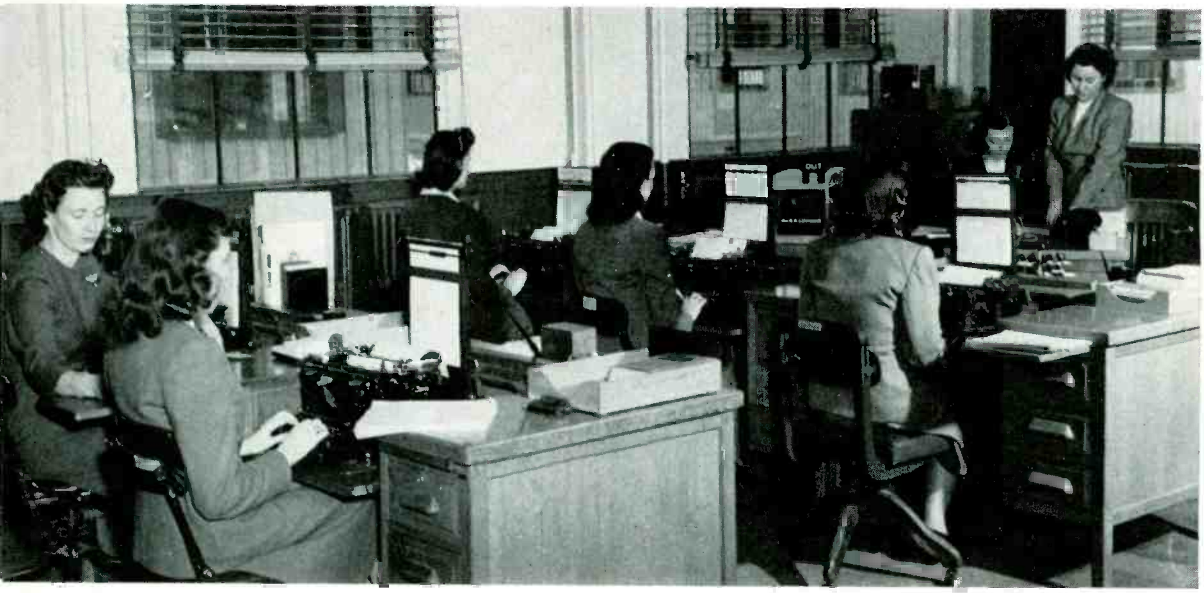
Army Signal Association Meets at Fort Monmouth

The First National Convention of the Army Signal Association was held at Fort Monmouth on April 29. Following a business session, the delegates were given the opportunity to see a great many excellent exhibits of the latest in communication, electronic and photographic developments for the Armed Forces. In addition to the exhibits which proved most interesting, an overseas teletype conference was demonstrated consisting of about 25,000 miles of circuit that included Tokyo, Japan, Frankfort, Germany, and several other stations. R. D. Parker, recently retired from the Laboratories, was one of the conferees at Tokyo.

A banquet, sponsored by the New York Chapter No. 1 and attended by about 500 delegates and members, was held the evening preceding the convention at the Pennsylvania Hotel. As President of the New York Chapter, Brig. Gen. Carroll O. Bickelhaupt of the A T & T welcomed the guests. The retiring Chief Signal Officer of the U. S. Army, Major General H. C. Ingles, and the new Chief Signal Officer, Major General Spencer B. Akin, were guests of honor and attended

During the First Quarter of 1947 the United States Patent Office Issued Patents on Application Filed by the Following Members of the Laboratories

H. L. Barney	T. L. Dimond	A. C. Keller (2)	L. A. Meacham	J. W. Rieke
A. C. Beck	W. A. Edson	W. M. Kellogg	E. D. Mead	V. L. Ronci (2)
J. A. Becker (2)	F. S. Farkas	A. R. Kemp	O. R. Miller	A. L. Samuel (2)
B. S. Biggs	C. E. Fay	A. P. King	H. Morrison	J. C. Schelleng
A. R. Bonorden	C. B. H. Feldman	N. Knapp, Jr.	J. F. Muller	R. W. Sears
A. E. Bowen (2)	T. R. Finch (2)	P. V. Koos	O. Myers (2)	R. B. Shanck
O. E. Buckley	H. T. Friis	J. A. Krecek	R. C. Newhouse	W. Shockley
H. T. Budenbom	E. M. Fry	E. Lakatos	R. S. Ohl	G. K. Teal
A. J. Busch	M. S. Glass	W. V. K. Large	B. M. Oliver	F. M. Thomas
D. M. Chapin	H. W. Goff	C. A. Lovell	C. V. Parker	E. J. Walsh
H. Christensen	W. M. Goodall	A. N. Luce	D. B. Parkinson (2)	E. F. Watson
J. E. Clark	P. L. Hartman (2)	T. A. Marshall	J. R. Pierce (2)	C. A. Webber
C. A. Dahlbom	J. R. Haynes	W. P. Mason (6)	J. A. Potter (2)	J. W. West (3)
J. W. Dehn	R. E. Hersey (2)	R. F. Massonneau	R. K. Potter	W. Whitney
C. Depew	C. N. Hickman	R. C. Mathes	J. B. Retallack	A. S. Windeler
W. A. Depp (2)	E. W. Houghton	D. A. McLean (2)	F. W. Reynolds	W. R. Young, Jr.
E. Dickten, Jr.	P. A. Jeanne	J. O. McNally	C. D. Richard	



Whippany has a new stenographic department with hectograph and TWX facilities under the supervision of Harriet Filmer, who is also supervisor of secretarial services. Members of the stenographic group shown are, left to right: Dorothy Clothier, Ann Riley, Betty Engstrom, Ruth Soranno, Marie Dempsey, Ruth Leonard, to whom these girls report, and Mrs. Filmer

both the banquet and the convention. Eighteen members of the Laboratories attended the banquet in New York, and the following attended the Monmouth session: W. O. Arnold, E. W. Conger, W. H. Edwards, L. L. Glezen, W. W. Maas, T. A. McCann, L. Pedersen, T. N. Pope, W. J. Smith, Morton Sultzer, W. P. Turpin and R. C. Winans.

News Notes

Dr. Vannevar Bush, President of the Carnegie Institute of Washington and a Director of the A T & T, visited the Laboratories on March 19 and again on April 16.

GENERAL review conferences, held in Chicago with Hawthorne engineers, were attended by A. F. BENNETT, R. BOWN, R. M. BURNS, A. B. CLARK, H. A. FREDERICK, A. G. GANZ, F. J. GIVEN, W. C. JONES, A. C. KELLER, M. J. KELLY, W. H. MARTIN, R. G. MCCURDY, D. A. QUARLES, H. O. SIEGMUND and E. B. WOOD.

WILLIAM FONDILLER spoke on *Industrial Research in Electrical Communication* before the A.I.E.E. Student Chapter at the College of the City of New York.

D. A. QUARLES attended a Board of Directors' meeting of the A.I.E.E. in Worcester, Mass. He also attended a meeting of the Committee on Electronics of the Joint Research and Development Board in Washington.

M. B. LONG was one of the six vice-presidents elected for a two-year term, beginning July 1, by the Telephone Pioneers of America.

R. K. POTTER appeared on WCBS-TV, the Columbia Broadcasting System's New York Television Station, where he demonstrated and explained Visible Speech, using the newly developed playback device.

HARVEY FLETCHER, at the invitation of the Institute of Radio Engineers, gave a demonstration lecture on *The Pitch, Loudness and Quality of Musical Tones* using the tone synthesizer at a joint meeting of the Montreal Section of the I.R.E., A.I.E.E., and the Engineering Institute of Canada on March 13 at Montreal. At the invitation of the Royal Canadian Institute,

"The Telephone Hour"

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

June 9	*Bidu Sayão*
June 16	*Gladys Swarthout*
June 23	*Olga Coelho, Andres Segovia*
June 30	*Maggie Teyte*
July 7	*Nelson Eddy*

he gave the same lecture at a joint meeting of the Toronto Section of the A.I.E.E. and the Royal Canadian Institute on March 15 at the University of Toronto. A. R. Soffel, S. Balashek and P. B. Oncley accompanied Dr. Fletcher as his assistants.

A. N. Holden addressed the New York Mineralogical Club at the Museum of Natural History in New York on *Growing Crystals From Solutions*. The Laboratories recently exhibited real and synthetic crystals at that museum.

C. E. Shannon spoke before the Mathematics Colloquium at Harvard University on *The Transmission of Information*. He repeated the talk before the Colloquium of Applied Mathematics at Brown University.

W. L. Bond and Elizabeth Armstrong attended a meeting of the Crystallographic Society at Annapolis. Mr. Bond gave two papers, one entitled *An Alignment Chart for the Polarization Correction in the Equi-Inclination Weissenberg Method;* and the other, *Making Crystal Plates for Piezoelectric Research*.

Dr. Armstrong gave a talk on *The Vocational Opportunities for Students Majoring in Geology* on April 21 at Barnard College of Columbia University.

W. A. MacNair, C. H. Townes, E. J. Murphy and L. H. Germer attended meetings of the Metropolitan Section, American Physical Society, at Columbia University.

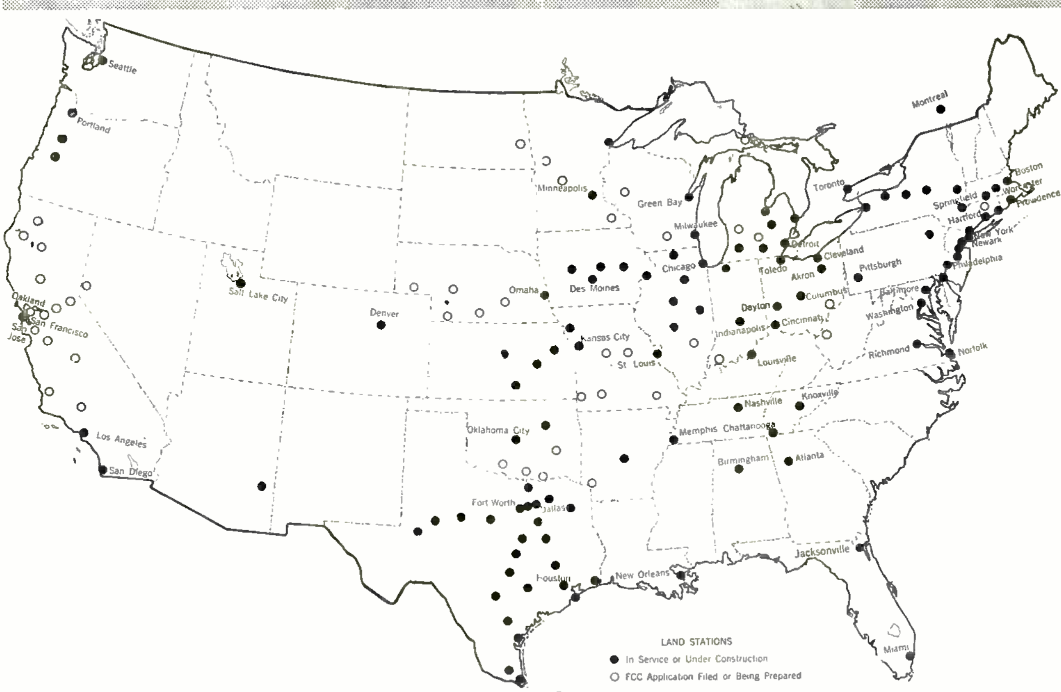
K. K. Darrow recently went to Philadelphia, where he attended the American National Conference on the United Nations Educational, Scientific and Cultural Organization and prepared a report on the proceedings of its Division of Natural Sciences. Dr. Darrow has been appointed to the United States Committee of the International Union of Physics.

E. C. Wente attended a meeting of the Board of Editors of the I.R.E. in New York.

W. A. Munson, F. M. Wiener and J. E. Karlin discussed electro-physiological measurements with Dr. J. E. Hawkins at the Merck Chemical Laboratory in Rahway.

H. W. Hermance, C. W. Mattson, A. J. Engelberg and O. C. Eliason participated in a coöperative study in Chicago of atmospheric contamination.

F. S. Malm, H. Peters and C. M. Hill visited the Vulcanized Rubber and Plastics Company at Morrisville, Pa., to discuss hard rubber problems.



Scope of the present Bell System's mobile radio telephone service

"At Lunch"

A birthday party for Margaret Schiehser, ready to open her present, is the occasion for this happy gathering. Clockwise around the booth, the girls are Virginia Ahearn, Mary Mallard, Mrs. Schiehser, Edna Buckner and Margaret Haunfelder

A trio, formerly of the Club Store staff, enjoy luncheon get-together where G. J. Wolters is giving his order to their favorite waitress, while S. M. Ray and C. R. Schramm enjoy ribbing him

R. C. PLATOW and W. ORVIS discussed adhesives at the Armstrong Cork Company in Lancaster, Pa.

C. S. FULLER spoke before a panel on new non-metallic materials at the Chicago Production Conference. Mr. Fuller's topic was *New Non-Rigid Plastics*. He also visited Hawthorne for discussions on plastic problems.

J. LEUTRITZ, R. BURNS, C. J. FROSCH, C. S. FULLER, G. DEEG and I. L. HOPKINS attended the A.S.T.M. meeting in Cincinnati at which Mr. Leutritz presented a paper on *The Effect of Fungi on Plastics*.

D. H. WENNY, JR., I. V. WILLIAMS and J. R. BOETTLER spoke on modern fabrication methods at the Deal-Holmdel Colloquium held at Holmdel on April 3. Their talks covered die-casting, precision-casting, permanent-mold casting and centrifugal casting. At the May 2 colloquium, also at Holmdel, RALPH BOWN discussed *Research Topics*.

F. G. FOSTER has been made a fellow of the New York Microscopical Society, an affiliate of the New York Academy of Sciences.

HARVEY FLETCHER visited the Physics Department at Rutgers University, New Brunswick, where he attended a meeting of the Advisory Board of the Research Council. He also attended the National Academy of Sciences meetings in Washington.

THE FOLLOWING engineers attended meetings of the American Mathematical Society and the Institute of Mathematical Statistics at Columbia University: H. W. BODE, R. M. BOZORTH, D. L. DIETZOLD, R. W. HAMMING, L. A. MACCOLL, B. MCMILLAN, C. E. SHANNON, W. A. SHEWHART, J. W. TUKEY and O. J. ZOBEL. Mr. Bozorth presided at the May 3 session, which was devoted to the *Solid State*.

J. R. TOWNSEND has been elected Chairman of the Board of Review of the American Standards Association.

A. R. KEMP selected *Recent Trends in Rubber and Plastics* as the topic for his talk before the Monmouth County Section of the American Chemical Society on April 10 at the Squier Signal Laboratory, Fort Monmouth.

← *Apparatus Development Department engineers who frequently go to lunch together are, left to right, E. S. Savage, W. H. Sellew, and A. B. Reynolds, who continued their lunch undisturbed by the Laboratories cameraman, Jack Stark*

R. M. Burns traveled to the Pacific Coast in March. Dr. Burns conferred with engineers of The Pacific Telephone and Telegraph Company in Los Angeles and San Francisco and of The Mountain States Telephone and Telegraph Company in Boise, Idaho. He also visited the California Institute of Technology, Stanford University and the University of California at Berkeley. At the Western Metal Congress at Oakland he spoke on *The Theory of Corrosion and Protective Coatings.*

C. H. Townes spoke on *Microwave Spectroscopy* at the Physics Colloquium of Columbia University and at the Joint Physics Colloquium of Duke University and the University of North Carolina at Duke University.

Among the Laboratories engineers who attended the American Chemical Society national convention at Atlantic City were R. B. Gibney, S. O. Morgan, W. McMahon, L. Egerton, W. G. Straitiff, C. J. Frosch, C. S. Fuller, F. H. Winslow, J. H. Heiss, Jr., G. H. Williams, B. A. Stiratelli and J. B. DeCoste.

G. T. Kohman and W. G. Straitiff attended a conference at Allentown on growing crystals. Mr. Kohman and M. D. Rigterink discussed silica gel with members of the Davison Chemical Corporation in Baltimore. They also attended the annual meeting of the American Ceramic Society at Atlantic City with A. W. Treptow, J. R. Fischer, W. F. Jannsen and J. F. Potter.

A. M. Clogsten spoke on *A Type of Electron Motion in Crossed Electric and Magnetic Fields and Applications* on April 30 at Murray Hill at a conference of the Electron Dynamics Research Group. At the same conference, A. T. Nordsieck gave a talk on the *Theory of the Traveling Wave Amplifier for Large Signal Amplitudes.*

U. B. Thomas, Jr., and G. S. Phipps visited the National Battery Company at Depew, N. Y., where they discussed lead-calcium grids for storage batteries. Mr. Thomas presented a paper, *The Oxidation of Metals,* of which W. E. Campbell was co-author, at the Spring Congress of the Electro-Chemical Society in Louisville.

"At Lunch"

The girls at this table in one of the restaurants well patronized by Laboratories people are, left to right: Vivian Kilpatrick, General Service; her sister, Mildred Kilpatrick, Personnel; Margaret Wardlaw, Systems Development; and Joyce Thompson, Staff Department

K. F. Rodgers of the Transmission Apparatus Development Department, and his wife, formerly Allegra Hamilton of the Laboratories, relax with an after-luncheon smoke in a nearby restaurant

Here a table of engineers crowd a fireplace → corner in one of the more popular restaurants. Clockwise they are B. F. Lewis, Switching Apparatus; S. P. Shackleton, Systems Development; R. W. Hamming (hidden), Research; and J. L. Sherry, Apparatus Staff

J. C. OSTEN attended the Paint and Varnish division meeting of the American Chemical Society in Atlantic City.

V. J. ALBANO presented a paper on *Electro-Chemical Factors in Underground Corrosion of Lead Cable Sheath* at the Chicago convention of the National Association of Corrosion Engineers. Others attending included K. L. MAURER, R. POPE, H. M. TRUEBLOOD and A. MENDIZZA.

J. H. HEISS, JR., attended a meeting of the Office of Rubber Reserve Research Group in Washington, where he presented a paper on *Molecular Weight of Microgel*, of which W. O. BAKER was co-author.

C. S. FULLER spoke on *Behavior of Polymers in the Solid State* at a symposium arranged by the Polytechnic Institute of Brooklyn.

B. D. HOLBROOK and S. C. HIGHT conferred on radar in Washington with members of the Naval Research Laboratory and the Bureau of Ordnance.

W. SHOCKLEY attended the conference held at Princeton University on the program for the Brookhaven Laboratories, Long Island.

J. R. HAYNES spoke at Rutgers University to the Physics Seminar on *The Print-Out Effect and Its Use in the Study of the Motions of Electrons in Silver-Halide Crystals in an Electric Field.*

G. E. MOORE visited the General Electric Company in Schenectady.

A. H. WHITE was in Toronto on April 25-27 visiting the University of Toronto.

J. D. H. DONNAY, professor of crystallography and mineralogy at The Johns Hopkins University, spoke on *Twinning in Crystals* on May 2 in the Arnold Auditorium.

W. L. BOND and G. C. DANIELSON attended a one-week course on *Diffraction and Spectrometry* sponsored by the North American Philips Company. Morning lectures were given by outstanding authorities and afternoon sessions were devoted to laboratory work.

J. R. ERICKSON was technical advisor on studio scenes for a Western Electric picture being made in Chicago featuring telephone subscribers' instruments.

H. F. HOPKINS and N. R. STRYKER presented a joint paper entitled *A Proposed Loudness Efficiency Rating for Loud Speakers and the Determination of System Power Requirements for Enclosures* at the Society of Motion Picture Engineers' meeting in Chicago.

L. VIETH, F. S. CORSO, J. R. POWER, W. KALIN, J. M. ROGIE, R. E. PRESCOTT and T. H. CRABTREE were in Burlington in connection with the manufacture of hearing aids and other specialty instruments.

G. F. SCHMIDT was in Burlington concerning problems on the hand-held lip microphone.

F. F. ROMANOW attended a meeting in Washington of the American Standards Association Subcommittee devoted to *Fundamental Sound Measurements.*

W. L. TUFFNELL, D. T. EIGHMEY and W. G. TURNBULL, at Archer Avenue, Chicago, discussed handset problems and attended a quality survey on the new operator's telephone set.

Retirements

Recent retirements from the Laboratories include A. W. HORNE, with 46 years of service; C. D. DUSHECK, 44 years; J. M. FINCH, 36 years; RUDOLPH SLOVENZ, 27 years; WALTER CLARNER, 26 years; and S. A. HENSZEY with 24 years of service.

J. M. FINCH

S. A. HENSZEY

JAMES M. FINCH

After attending Columbia University, Mr. Finch joined the Installation Department of the Western Electric Company in 1910. The following year he transferred to the Chemical Laboratories of the Engineering Department to work on chemical development and control of insulating materials. Mr. Finch has been concerned with the development of electrical insulating papers, sheet insulating materials, including phenol fibre and vulcanized fibre, plastic films, textiles and enameled wire.

His work on insulating paper for the conductors in lead-covered cable promoted the gradual change and improvement in this insulating material from the original manila hemp fibre to the present paper which consists largely of wood pulp and is a stronger paper of better electrical characteristics and of longer life than the earlier version. Similarly, Mr. Finch participated actively in the development of capacitor paper from the days when 0.5 mil linen base paper was the best available material to the present time when 0.2 mil Kraft tissue is becoming available. This development has permitted the design of our present-day small size capacitors. Mr. Finch's contributon to paper technology includes the development of tests for wet strength, edge tear, and thickness, all of which were subsequently adopted by the American Society for Testing Materials and the Technical Association of the Pulp and Paper Industry.

Samuel A. Henszey

Mr. Henszey joined the Installation Department of the Western Electric Company in 1923 as an employment interviewer. In 1928 he transferred to the Headquarters Department at 195 Broadway and was responsible for personnel services. Eleven years later he was assigned to the Telephone Sales Department in charge of a group editing supply information for the A T & T Technical Information Letters sent to operating companies. Mr. Henszey came to the Laboratories in 1942 and since then had been in charge of the Men's Division of General Employment.

Charles D. Dusheck

Mr. Dusheck of Equipment Development started as a draftsman at the old Clinton Street, Chicago, plant of the Western Electric Company in 1902 where Messrs. Gray and Barton were still active. Except for a brief period with the Wisconsin Telephone Company, he remained with the Western Electric Company or the Bell Telephone Laboratories until his retirement. In 1913 he came to New York to work on the Newark semi-mechanical and early full mechanical panel installations, becoming a circuit drafting supervisor in 1920. In 1927 he was made supervisor of all Systems drafting. Since 1939 he had been engaged in general equipment standards engineering work.

Rudolph Slovenz

Mr. Slovenz came to the Laboratories as an instrument maker in 1920. Five years later he was assigned to the precision shop and since that time had specialized in tool and die work. The more important projects with which he was associated included television apparatus used in the 1927 and 1929 demonstrations, high-speed motion picture cameras and, during the recent war, molding dies for making plastic details.

Walter Clarner

Mr. Clarner joined the Laboratories in 1920 as a millwright in the old Building Shop. In later years he was assigned to duties in the Building Operation Department.

C. D. Dusheck

Rudolph Slovenz

Walter Clarner

A. W. Horne

Arthur W. Horne

The first seventeen years of Mr. Horne's telephone career was with the New England Telephone and Telegraph Company. In 1917 he joined the Signal Corps and saw service overseas. Returning to the New England company for a short period, he then came to the Western Electric Engineering Department to work on line finders and district selectors for the panel system. Between 1920 and 1923 he was in Omaha and Seattle on the initial installation of panel equipment in these two cities. The next two years he was engaged in field inspection work in the eastern part of the country. Since 1925, with what is now the Switching Development Department, he has been concerned with circuits that are associated with senders, decoders and markers.

The Bridge Club Takes Its Game Seriously

This foursome, arranging cards just picked from the board, was entirely unaware that a photograph had been taken. Left to right, they are T. L. Tanner, R. W. DeMonte, T. J. Grieser and C. M. Morris

Isolde Graham, second from the left, studies her hand while her opponents, Marguerite Johnston and Molly Radtke, extreme left and right, await her bid. Mrs. Graham's partner is Florence Costello

News Notes

M. H. Cook attended general review conferences at Hawthorne and visited the University of Illinois at Champaign.

J. T. Caulfield visited the Naval Air Test Center at Patuxent, Maryland.

J. H. Cook made a short visit to the Douglas Aircraft Company, Santa Monica, California.

R. W. Benfer related his recent experiences with Task Force Frigid at Fairbanks, Alaska, in talks before the Whippany Camera Club and the New York "N" Club.

H. A. White spent two weeks at the Radio Shops in Winston-Salem.

V. I. Cruser's visit to the Harris-Seybold Company, Cleveland, concerned antenna problems.

H. A. Baxter, B. H. Nordstrom and P. H. Thayer discussed Navy equipment at the Palmer-Bee Company in Detroit. Mr. Baxter conferred on radar components at the Gorham Manufacturing Company located in Providence, Rhode Island.

F. W. Kausch, E. P. Furst and G. T. McCann have returned from Burlington, where they assisted in the preparation of manufacturing drawings for 10-kw and 3-kw frequency modulation broadcast transmitters.

F. E. Nimmcke and J. H. Hershey were at the Navy Bureau of Ordnance in Washington for radar discussions.

G. R. Benson, J. F. Brennan, A. G. Costellano and J. J. Simon are assisting in the preparation of manufacturing drawings of airborne radar equipment at Winston-Salem.

H. C. Lloyd, M. N. Yarborough, F. L. Langhammer and E. L. Bright have been spending considerable time at Winston-Salem on an airborne radar project. Mr. Yarborough, Mr. Langhammer and F. C. Willis participated in discussions on the antenna for that project at the Brooks and Perkins Company in Detroit. Mr. Willis was also in Dayton for a conference with the Air Matériel Command on various radar equipment.

P. W. Blye participated in the March 5 Science Forum broadcast over Station WGY, Schenectady. His topic was *What's News on the Party Line*. Science Forum programs help to acquaint the radio public with the achievements of modern research and engineering, and to promote on the part of laymen listeners an interest in scientific endeavor.

Beatrice Koukol and her partner, W. L. Gaines, appear to be down at this point. H. H. Felder, left watches closely as his partner, G. H. Downes, lead

W. H. DOHERTY presented a paper on *Western Electric FM Broadcast Transmitters* during the Broadcast Engineering Conference at Atlanta, sponsored by the Georgia School of Technology, the Georgia Association of Broadcasters and the Atlanta section of the Institute of Radio Engineers.

K. K. DARROW was in Washington to attend meetings of the National Research Council Committee on International Scientific Unions, the National Academy of Sciences and the American Physical Society, and in Philadelphia, meetings of the American Philosophical Society. In a broadcast on May 3 on the *Adventures in Science* series of the Columbia Broadcasting System, his topic was *The Meeting of the American Physical Society*. Dr. Darrow has been appointed a member of the Visiting Committee, Physics Department, of Union College and of the National Research Council, Division of International Relations.

Edna Aamodt, having taken a trick, studies her opponent, L. C. Roberts. Her partner is C. L. Dellwater; her other opponent, B. B. Mann, extreme right

C. H. WILLIAMS spoke on *Radar* before the Lions Club at Mine Hill, N. J.

O. H. DANIELSON and F. C. MASEK conferred on a Government project at the Watson Laboratories, Eatontown, N. J. They also visited the plant of the Reeves Corporation in New York with W. C. TINUS in connection with the manufacture of a Navy project.

F. W. CUNNINGHAM and J. F. MORRISON attended committee meetings and technical sessions of the Radio Manufacturers Association Annual Spring Meeting, held from April 28 to 30 at Syracuse.

S. E. MILLER is the author of *Considerations in the Design of Centimeter-Wave Radar Receivers* in the April, 1947, *Proceedings of the Institute of Radio Engineers*.

AT THE ACOUSTICAL SOCIETY OF AMERICA meeting, May 8 to 10 in New York, HARVEY FLETCHER, Program Chairman, presented a paper *An Institute of Musical Science—A Suggestion*. A demonstration of electronic instruments, many of them experimental or home workshop projects, was given by various engineers including L. A. MEACHAM, J. E. KARLIN, R. N. LARSON, R. H. NICHOLS, JR., P. B. ONCLEY, J. R. ANDERSON and C. D. LINDRIDGE.

D. W. BODLE was in Atlanta recently in connection with the natural lightning studies the Laboratories is conducting in coöperation with the Long Lines Department on the Atlanta-Birmingham "A" cable.

T. C. Rice, extreme right, has just taken a trick and is now leading. His partner is N. C. Brower; his opponents, W. F. Brown, extreme left, and A. A. Catlin, opposite

F. F. LUCAS attended the President's Conference on Fire Prevention held at the Departmental Auditorium in Washington.

AT THE WASHINGTON MEETING of the American Physical Society, papers presented by members of the Laboratories were: *On the Dissociation Energy of CO* by H. D. HAGSTRUM; *Surface State and Space Charge Layers in Semi-Conductors* by JOHN BARDEEN; *Electrical Conductivity of Alkaline Earth Oxides* by D. MACNAIR and A. H. WHITE; *Electrical Conductivity and Thermionic Emission of Oxide Coated Cathodes* by N. B. HANNAY; *A Survey of the Theory of Bubble Pulsations* by CONYERS HERRING and *The Positive Ion Transient in Townsend Discharge Tubes* by R. R. NEWTON.

W. K. OSER observed a demonstration of the production and utilization of Fiberglas during a conference of the wire and cable industry at the Huntingdon, Pa., plant of the Owens-Corning Fiberglas Corporation.

June Service Anniversaries of Members of the Laboratories

35 years

Stephen Gasparick
C. S. Gordon
R. H. Kreider
J. T. Lowe

30 years

R. E. Collis
H. F. Dodge
D. K. Gannett
L. H. Germer
H. W. Goff
F. W. Hecht
J. B. Johnson
A. L. Johnsrud
R. W. King
L. A. Leatherman
J. W. Schmied
G. B. Thomas

25 years

W. J. Abbenseth
W. C. Babcock
E. C. Blessing
L. H. Campbell
W. E. Cantwell
E. G. Conover
P. G. Edwards
J. M. Eglin
J. S. Elliott, Jr.
E. W. Flint
R. L. Hastings
A. A. Heberlein
Norman Insley
A. G. Jensen
John Maas
P. E. Mills
E. L. Norton
P. S. Olmstead
H. L. J. Siedentop
D. O. H. Weston
M. L. Wilson

20 years

Ruth Aitken
H. A. Blake
J. E. Conwell
V. A. Douglas
A. M. Doyle
S. L. Eppel
T. G. Fischer
E. J. Fogarty
Mary Gregory
O. D. Grismore
W. G. Gustafson
W. M. Hill
Jacob Jacobsen
M. E. Maloney
H. G. Och
E. G. Olsen
J. R. Power
J. W. Quinn
W. C. Schmidt
W. F. Simpson
H. L. Stark
P. W. Swenson
R. L. Tambling
E. F. Vaage
Adele Vieta
George Wascheck
S. D. White

10 years

Robert Beattie
E. B. Cave
Chapin Cutler
J. J. Dowd
M. W. Dring
A. C. Ekvall
R. S. Graham
G. E. Helmke
R. H. Kendall
C. L. Krumreich
Helen Lordan
Elsie Melroy
B. C. Meyer
L. P. Newby
James Paterson
T. C. Rehm
B. H. Simons
B. Stiratelli
W. T. Wichman

R. C. Platow and D. J. Maccia attended a meeting in Philadelphia of the A.S.T.M. committee on adhesives. Mr. Platow is chairman of this committee.

J. M. Dunham conferred with engineers of the James R. Kearney Corporation in St. Louis regarding fuses for the M1 carrier system.

R. H. Colley, C. H. Amadon and G. Q. Lumsden attended the annual meeting of the American Wood-Preservers' Association held in Portland, Oregon. They also visited offices of Associated Companies and wood preserving plants at Spokane, Seattle, San Francisco, Los Angeles and Denver.

C. D. Hocker attended the meeting of Committee D-7 on Wood Poles of the A.S.T.M. held in Chicago.

D. C. Smith and C. D. Hocker were at Massachusetts State College, Amherst, Mass., in connection with the study of squirrel damage to cable sheath.

F. V. Haskell conferred at Camden with engineers of the O & E and the New Jersey Bell Telephone Company on problems involved in lashing aerial cable.

The Laboratories were represented in interference proceedings at the Patent Office in Washington by W. L. Dawson before the Primary Examiner.

A. P. Jahn recently made an inspection of the wire specimens undergoing atmospheric corrosion tests for the A.S.T.M. at Bridgeport, Sandy Hook, State College and Pittsburgh.

A. G. Hall visited Hawthorne in connection with the manufacture of cable containing video circuits.

J. W. Schmied and R. Marino were in Chicago during April in connection with interference proceedings.

H. S. Wertz appeared before the Primary Examiner at the Patent Office relative to an application for patent.

L. S. Inskip with F. R. Arnoldy of A T & T recently visited Wichita and Denver regarding a study of station protection in those areas.

P. A. Jeanne attended a meeting in Pittsburgh of the A.I.E.E. subcommittee which was devoted to power system grounding methods.

E. C. Molina spoke on *Some Applications of Probability Theory in Engineering* before the A.I.E.E. Basic Science Group in New York.

P. B. Drake visited the Taft-Peirce Company in Woonsocket, Rhode Island, in connection with newly developed accounting apparatus.

Henry Kostkos completed an exhibit of electronic tubes at the Edison Institute, Dearborn, Michigan, at the request of the Michigan Bell Telephone Company. This addition of about one hundred tubes to the ones that had been previously presented by the Bell System makes this one of the most complete collections in the country. Mr. Kostkos met with representatives of the Bell Telephone Company of Canada in Toronto to aid them in planning their exhibits for the Canadian National Exhibition, which will be held in Toronto during the months of August and September.

C. W. SPENCER gave instructions in adjusting special equipment at the Taft-Peirce Company in Woonsocket, R. I.

R. A. SYKES, at Hawthorne, assisted the Western Electric Company in the preparation of a motion picture on *Crystals*.

R. T. STAPLES visited the Boston Insulated Wire and Cable Company regarding various cable problems.

J. C. STEINBERG and G. E. PETERSON visited the University of Michigan at Ann Arbor from April 28 to May 2 in connection with the visible speech development program.

G. D. EDWARDS spoke on the *Future of Quality Control* at the annual meeting of the Delaware Quality Control Society held in Wilmington on May 1.

R. I. WILKINSON discussed *Adventures With Statistics in the Jungle Air Force, From Fiji to the Philippines* at a Newark meeting of the Society for Statistical Quality Control.

A. J. BUSCH participated in a conference in Philadelphia on the No. 5 crossbar.

S. KING spent three weeks in St. Louis testing the urban mobile radio telephone installation.

F. F. SIEBERT made a trip to Cleveland in connection with design questions on battery charging motor generator sets.

J. M. DUGUID and V. T. CALLAHAN went to Lansing, Michigan, on acceptance tests of new diesel alternators. They also attended a conference on diesel alternator production and development problems in Detroit.

J. A. WATTERS and A. J. PASCARELLA reviewed patching trunk facilities at the Philadelphia No. 4 Toll Office.

S. A. SCHELKUNOFF was the speaker at a conference of the mathematics research group on April 2 at Arnold Auditorium, Murray Hill. His talk was in two parts, the first titled *Practical Applications of Electromagnetic Theory*, and the second, *The Wave Perturbation Method of Solving Linear Differential Equations*.

D. P. LING was the guest pianist during the noon hour program on March 27 of the Murray Hill Chorus.

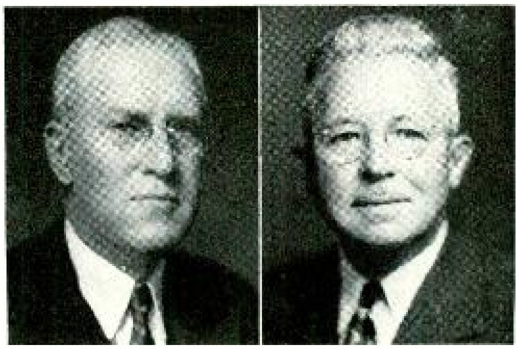
R. J. SHANK has left the Laboratories to accept a position in the Research Department of the Hughes Aircraft Corporation. His associates, who have worked with him on coaxial and television problems during his entire stay in the Laboratories, presented Mr. Shank with a set of tennis rackets on March 28 at a farewell luncheon in his honor.

C. T. BOYLES, a member of the executive committee of our Photographic Forum, has been elected president of the Metropolitan Camera Club Council. Eighty-one member clubs are affiliated under the Council, one of whose duties is the administering of trophies that are valued at more than $2,000.

Obituaries

ARTHUR C. GARRECHT, May 4

Mr. Garrecht, a former member of Switching Apparatus Development who retired in 1940 after twenty-nine years of service, began his career in the Bell System as a die and tool maker in the Manufacturing Department of Western Electric. He remained there, advancing through various tool drafting and tool inspection work, until Manufacturing was moved to Hawthorne. He then joined the machine switching group at the time when the call distribution system was being developed. Here he worked on calling dials and later on apparatus for panel and crossbar dial systems, specializing in the design of panel drives, gear train devices and lubrication systems.



A. C. GARRECHT 1880-1947 — H. W. MACDOUGALL 1882-1947

HARRY W. MACDOUGALL, May 3

Mr. MacDougall, formerly of the Patent Staff, retired in 1944 after forty-two years of service. A native of Chicago, he had joined the Western Electric Company there and later came to New York, where he was engaged successively in circuit design for manual, toll and panel systems. Transferring to the Patent Department, he prepared patent applications and assisted in other patent activities relating to panel systems until 1929, when he began patent work on sound picture developments. From 1937 until his retirement, he did similar work in connection with automatic telephone systems. Mr. MacDougall was a member of the Patent Law Association.

A double quartet from the Murray Hill Chorus presented a noon-hour concert of folk music on May 7. They were accompanied by Capitola Dickerson, who also sang Negro spirituals. Standing, left to right: R. N. Larson, W. E. Mathews, Margery McHale, Ann Codington, Phyllis Taylor, Frances Tracy, F. L. Crutchfield and William Vierling

Over 800,000 New Telephones Added

More than 800,000 new telephones were added to the Bell System's network in the first quarter of 1947, bringing the total in service to just over 26,500,000. Demand for service, however, continued at a high level during the period, keeping the number of unfilled applications for telephones close to 2,000,000.

In the first three months of the year, Bell companies connected 1,402,000 telephones. Disconnections, at the lowest rate since 1926, totaled 591,000, leaving a net gain of more than 811,000 telephones in service.

Western Electric Company shipments to operating companies during the quarter were approximately or fully equal to the programs: dial lines, 380,000; manual positions, 1,119; exchange cable, 10.1 billion conductor feet.

Engagements

*Josephine Angelo—V. P. Candio
*Rosemary Jaeger—H. W. Saundry
*Marion Reich—Edmund Wright, II
Joan Ritner—*F. G. Higbie
*Joan Thomas—*Harry A. Helm
*Frances Truzzolino—John Kaufmann
*Stella Ulias—Edward Soltysik
*Jeannette Warnetzka—C. G. Renz

Weddings

*Betty Buser—L. B. Boutillette
*Josephine Capozzoli—H. S. Hansen
*Virginia Essenson—Donald Groth
*Mary Jane Fay—J. J. Reynolds
*Helen Ives—Stewart Quick
*Barbara Losey—Richard D. Lewis
*Caroline Meehan—J. C. Jones
*Jean Nally—A. S. Force
*Helen Powers—J. J. Freeman
*Mildred Swanson—R. E. Mattison
Henrietta Wagg—*R. C. Shaw

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

Housing in the Summit Area

M. B. Long addressed a special meeting of the Summit Chamber of Commerce on April 28. The meeting was called by the Chamber for the purpose of discussing the city's need for additional facilities and improvements to take care of expanding community growth. Mr. Long spoke on the subject of housing, stating that during the past year and a half, some 600 families of Laboratories people had moved into the Summit area, but that only a small fraction of those who desired to live in Summit itself had been successful in finding homes. He also indicated that when the new Murray Hill buildings are completed, the Laboratories' staff at that location will be increased by more than 1,200 members.

H. E. Hill to Command Reserve Battalion

Lieutenant Colonel Henry E. Hill of Switching Research has been assigned to the 362nd Ordnance Battalion, Organized Reserve, Morristown, according to General Courtney H. Hodges of the First Army, and has been approved as the commanding officer of that unit.

Called to active duty in December, 1940, Colonel Hill served overseas for three years in the Central Pacific Theater as Executive Officer and Commander of the 46th Ordnance Battalion. He returned in December, 1945.