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Radio
Transmission
Engineering

VEHICLE RADIOTELEPHONY BECOMES A BELL SYSTEM PRACTICE

During the last quarter century, the motor vehicle has become almost as essential to modern civilization as the home or office, and its various forms—automobile, bus, truck, and trailer—are used during a steadily growing portion of the day and night by a large part of our population. Every indication points to an increase rather than a decrease in its use. As telephone service has become indispensable in home and office, so will it in the vehicles that substitute for them during so much of our time. This need has long been recognized by the Bell System; and for many years studies and tests have been carried on with the objective of extending Bell System service to motor vehicles. With the inauguration of public mobile radio-telephone service in St. Louis* on June 17, 1946, this new extension of the telephone system started its active career.

Mobile radio-telephony is far from new in the Bell System. Some of the earliest studies of radio-telephony were between ship and shore. Commercial ship-to-shore radio-telephony did not come until 1929, however, but it was then rapidly extended to cover fire boats in New York Harbor later in the same year, and to general harbor craft in 1932. With the successful adoption of individual ringing for ships† in 1936, a further step was made toward commercial mobile service to individual vehicles.

Satisfactory telephone communication with motor vehicles in city streets in many ways is more difficult than with ships over water because of the higher noise level and the shielding effects of large buildings. Radio-telephone communication with police patrol cars, however, became a practical reality in 1933, although experimental installations had been made much earlier. Satisfactory transmission was obtained at frequencies below 40 megacycles, but since these police services were essentially private systems, the over-all transmission requirements were not so severe as those for circuits to be connected to Bell System lines for use by the general public. Further studies of radio transmission to motor vehicles in city streets showed that the most satisfactory results are obtained with frequencies in the range between 100 and 200 megacycles, and frequencies of this order were thus requested for these systems.

With the new mobile radio-telephone system, a call may now be set up in either direction between any Bell System or connecting telephone in this country or overseas and the telephone in any subscribing vehicle operating in an area equipped for general mobile telephone service. Besides

*Record, *July*, 1946, *page* 267. †Record, *April*, 1936, *page* 255.

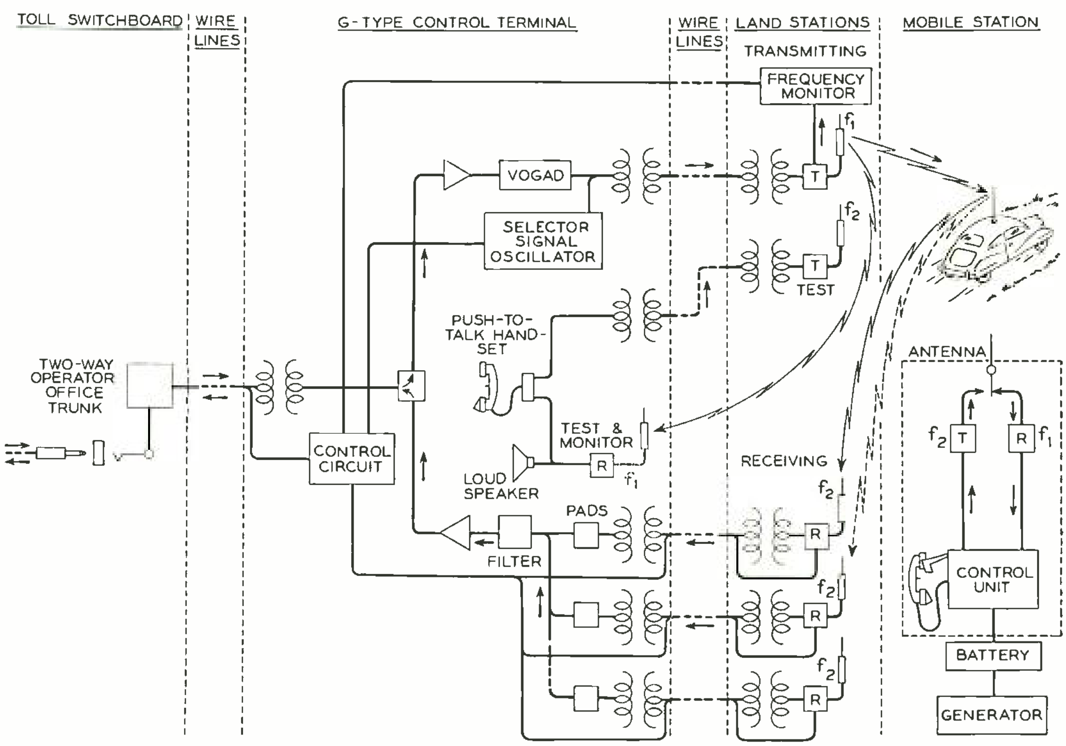
giving communication with motor vehicles, this new service will also be extended to vessels in the local waters; and the service is being extended to vehicles traveling over the major inter-city highways.

Following the method used for coastal and harbor craft telephony,* one or a very few fixed and relatively high-power radio transmitters will be used for sending to the vehicles, while several fixed radio receivers will be used to pick up the calls from the low-power radio transmitters of the vehicles. The fixed receivers are essentially the same as those used in the vehicles. No selective signaling equipment is required at the fixed receivers, however, while each vehicle has a selector, operating in general like that employed in a ship, that rings a bell and lights a lamp only when that particular vehicle is called.

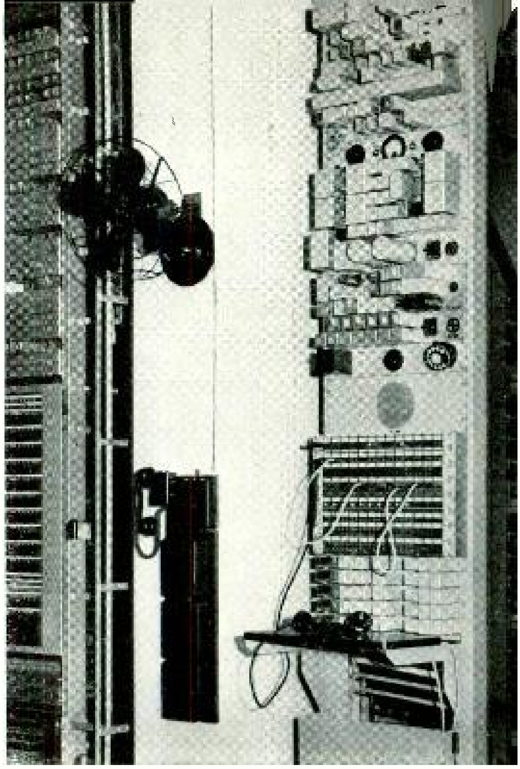
Each mobile station in a vehicle subscribing to this service is assigned a number, which is dialed directly from the mobile service position at the toll switchboard of the city involved. To place a call to a vehicle, a subscriber asks his local operator or dials for the "Long Distance" operator, and then asks for the mobile service operator. He then gives the mobile service operator the number of the vehicle he wants. She, in turn, plugs into the jack of a line to a control terminal after first determining that the line is not busy, and then operates a dial key. As a result of her plugging into the line, plate voltage is applied to the fixed radio transmitter, and, when the transmitter starts, it operates at the correct carrier frequency, and a signal is returned to her indicating that she may dial the desired number.

The signals sent out by the fixed radio transmitter as a result of dialing are detected by all mobile receivers tuned to that transmitter, but will ring a bell and light a lamp only in the particular vehicle called.

*Record, *March*, 1943, *page* 183.



Schematic arrangement of the urban mobile radio system



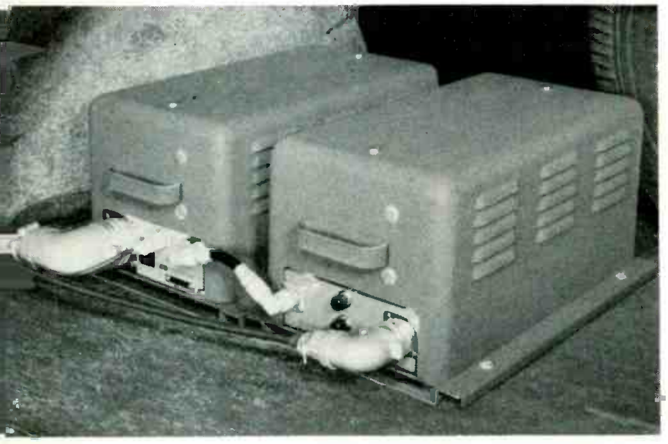
The G1 control terminal used with the St. Louis urban mobile radio system

Anyone near the control unit in that vehicle can then pick up the handset and respond almost as he would to a wire telephone call. The only difference in the talking procedure is that the handset is equipped with a press-to-talk button, which must be held depressed while the person in the vehicle is talking, and released while he is listening. To place a call from a vehicle, the handset is removed and its button depressed for about two seconds so that the mobile transmitter carrier may light the "line" lamp at the mobile service position and the number given to the operator. A call may also be placed from one vehicle to another through the mobile service position and the control terminal.

The major operating units of the system and their locations are indicated in the diagram. A single system as indicated here can handle only one call at a time, and thus it is expected that most of the larger cities will require several such channels as the system grows. From the position of the mobile service operator at the toll switchboard, a wire line runs to the control terminal, which may or may not be in the same building. On the G-type control terminal are mounted: a three-way resistance network for connecting the two-wire circuit from the toll board with the four-wire circuit for radio transmission and reception, transmitting and receiving amplifiers, a vogad in the transmitting path to maintain a uniform speech volume for the fixed radio transmitter, a selective-signaling oscillator, and sundry pads, filters, and repeating coils as indicated in the middle section of the diagram. A test and monitoring receiver and a handset associated with a test transmitter also form part of the control terminal equipment. The vogad, although a modified version of previously existing types, operates in the same general way as that previously described in the RECORD for October, 1938, page 49.

The line from each of the fixed receivers enters the control terminal through a sep-

The half-wave coaxial antenna for the main transmitter of the St. Louis mobile radio system is mounted on a 50-foot pole on top of the telephone building



Western Electric mobile transmitter and receiver mounted in the luggage compartment of an automobile

The vehicle control unit may be mounted under the dashboard or wherever most convenient

arate repeating coil and pad, and then all of the receiving circuits are combined before passing through a filter and amplifier, and thence through the control terminal to the toll switchboard. During a conversation, speech from a mobile station may be received by one or more of these receivers; each will contribute to the total received speech if the signal-to-noise ratio is above a fixed minimum. Although all the operating is done from the toll board, there is always a licensed radio operator near the terminal to make tests when necessary and to carry out any maintenance required.

At the fixed transmitter station of an urban system are the main 250-watt transmitter, a frequency monitor and, perhaps, the test transmitter. The transmitters use phase modulation, and operate in the frequency band from 152 to 162 megacycles. A coaxial transmission line connects the transmitter to a half-wave coaxial antenna, usually mounted on top of a pole installed on the roof of the building.

The frequency monitor gives an alarm at the control terminal if the frequency of the radio transmitter deviates by more than four thousandths of one per cent from its assigned value. An "on frequency" signal from this unit also lights the operator's dial lamp at the toll board to indicate that dialing may be begun, since it shows that carrier is being radiated at the proper frequency by the transmitter, and thus that the circuit is performing satisfactorily. The low-power test transmitter operates at the same frequency as the mobile transmitters, since it is used in testing the fixed receivers.

Sites for the fixed receivers are selected so as to secure good reception from vehicles in any section of the area covered. They may be installed in buildings or mounted in weather-proof cabinets on poles. Their antennas are of the half-wave coaxial type.

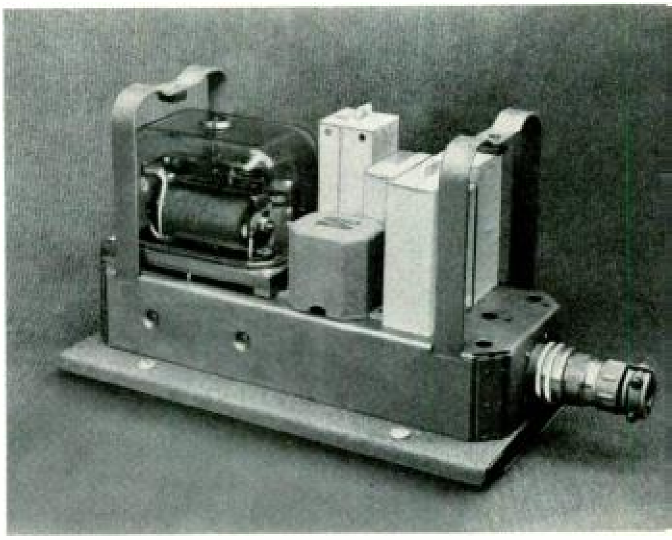
Equipment for the vehicle consists of a small transmitter and receiver, a handset and control unit, and an antenna consisting

A short length of piano wire serves as the antenna for the mobile unit

of a short length of piano wire. When a call comes in, a bell in the control unit rings for about four seconds, and an amber lamp above the handset lights. The lamp will remain lighted until the handset is taken from its receptacle. A green lamp beside the amber one is lighted as long as the power switch is turned on. If the power is left turned on while the driver is away from the vehicle, the lighted amber lamp will indicate that a call has come in during his absence.

The radio equipment is generally provided on a rental basis and maintained by the Telephone Company; however, it may be purchased by the subscriber, in which case he must care for the maintenance. It may be either of Western Electric or non-Western Electric manufacture. In the latter case, a Western Electric 106-A selector set is required. The selector components are included in the Western Electric receiver. More detailed descriptions of the transmitters and receivers employed by the new system will be carried in future issues of the RECORD.

Between the first successful demonstration of some new device or service and its final incorporation into commercial use, there is of necessity a long period while the apparatus and techniques are being tried out and improved. This is particularly true of a Bell System service, since every new device and operating method must work properly with all the telephone instruments, central offices, and circuits in every part of the country. Commercial application of mobile radio-telephony, delayed by the war, now arrives in time to serve the unprecedented increase expected in the use of motor vehicles in the years to come. This service will shortly be available in more and more cities; and as its value becomes more generally recognized, it is expected that subscribers' applications will steadily increase.



The 106-A selector set with cover removed

THE AUTHOR: A. C. PETERSON, JR., received the B.S. degree in Electrical Engineering from the University of Washington in 1928, and in December of that year joined the D & R. With the later consolidation of this department with the Bell Laboratories, he became a member of the Transmission Development Department and in 1940 a member of the Research Department. With these organizations, Mr. Peterson has been concerned with problems dealing with radio transmission and development. During the war he worked on microwave transmission measurements and was a technical consultant to the N.D.R.C. in connection with the development of Loran systems. Since 1945 he has been actively engaged in the development of mobile radio-telephone systems. In 1937 he received the E.E. degree from the University of Washington. He is a senior member of the I.R.E.

Magnetic airborne detector suspended below a plane as used in searching for submarines

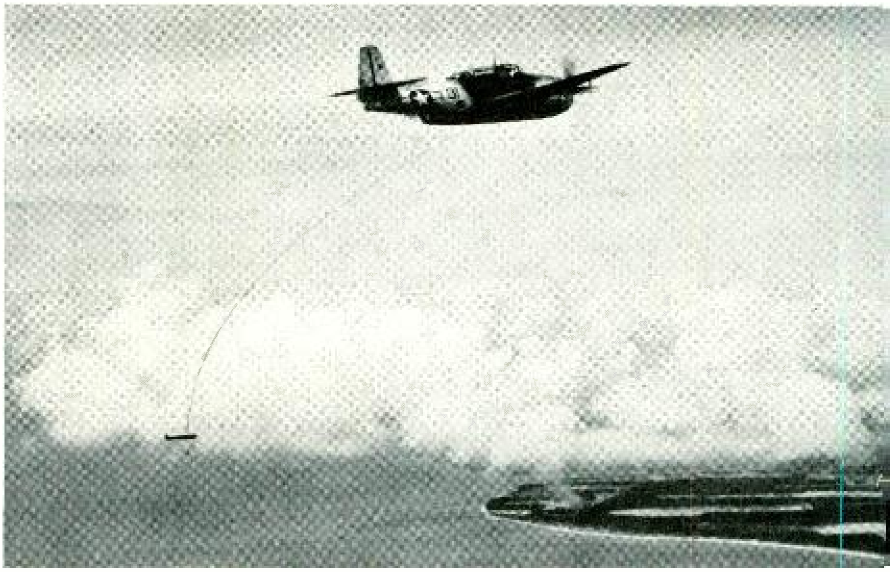


Photo by Bureau of Aeronautics

MAGNETIC PROSPECTING

W. J. SHACKELTON
Transmission Apparatus Engineer

Even before Pearl Harbor, the threat of impending war had stimulated this country to an intensive defense program, and the N.D.R.C. was actively directing scientific development toward devices that would strengthen our military and naval forces. Experience in World War I had shown that the submarine was one of our greatest dangers, and the development of magnetic detectors for locating submerged submarines from aircraft was one of the first projects proposed. Both Bell Telephone Laboratories and the Columbia University Division of the N.D.R.C. were given contracts, and studies were at once initiated. Two methods were tried: one using detecting coils with millions of turns of fine wire, and the other using a magnetometer—a device developed some years earlier for magnetic studies. Systems of both types were built, but after flight testing it was decided that the magnetometer method was the more promising, and the coil method was dropped.

Reduced to its essentials, the magnetometer system employs a small strip of magnetic material of high permeability, which is magnetized to well beyond its saturation point by an a-c winding. With no external field present, or with the magnetometer perpendicular to any existing field, the magnetization in the core changes from saturation in one direction to saturation in the other with the frequency of the exciting current, and the voltages developed across the coil may be analyzed into a series of odd harmonics of the exciting frequency. In the presence of an external magnetic field, however, the alternating magnetization in the core is biased in one direction or the other. As a result, the voltage across the coil contains even as well as odd harmonics, and the magnitude of the even harmonics is proportional to the strength of the external field. If such a magnetometer, held in fixed orientation, is carried through a region where the external field changes, as in the vicinity of a submarine or other mass of magnetic substance, the change in the even harmonics can be detected and observed as a signal on a suitable indicator. A change in the field of the order of one twenty-thousandth part of the earth's field can be recognized in the presence of normal background noise. Prior to the development of the magnetometer, measurements of this sensitivity required magnetometers mounted on a stable base and incorporating quartz-fiber suspensions.

With arborne equipment it is obviously difficult to maintain the magnetometer in fixed orientation, and any change in orientation would give very large signals which would mask those caused by the presence of a submarine. The N.D.R.C. therefore asked the Laboratories to develop practical means for maintaining the magnetometer in a fixed orientation. This work was at once undertaken, and a preliminary model that proved satisfactory on test was shortly turned over to them. The incorporation of the principles of this apparatus into a complete system was then undertaken by the N.D.R.C. itself.

Shortly after this, at the request of the Navy's Bureau of Aeronautics, the Laboratories undertook to produce a commercial design of an airborne magnetic detector in collaboration with the Naval Ordnance Laboratory, which had pioneered in various other applications of magnetic detection devices. As a culmination of this work, the Western Electric Company, under contract to the Bureau of Aeronautics, delivered a quantity of magnetic airborne detectors: the AN/ASQ-3 for heavier-than-air craft, and a number of similar sets known as the AN/ASQ-3A for lighter-than-air craft. The differences in these two systems are required chiefly because of the difference in speeds at which the equipment would be carried. The ASQ-3 equipment gives indications only of those changes in magnetic field that occur rapidly, while the 3A equipment indicates variation regardless of the rate of change.

The magnetometer is least sensitive to angular motions when it is in line with the earth's magnetic field, and it was therefore decided to hold the detecting magnetometer in this position. To maintain such an alignment, two other magnetometers operating through servo mechanisms are used to position an assembly that contains all three magnetometers. This assembly is supported in gimbals in the manner of a marine compass, but it is provided with mechanical drives that, under control of the servos, can rotate it on each of the two gimbal axes. The three magnetometers are all at right angles to each other like the X, Y, and Z axes of a rectangular coördinate system. The magnetometer to be used as the detector, which may be considered as that along the X axis, is held in the direction of the earth's magnetic field while the other two—used for operating the servo motors—are at right angles to it along the Y and Z axes. This right angle position is the most sensitive to angular changes, and thus a very small change in the alignment of the detector magnetometer with respect to the field will cause a signal to appear in one or both of the control magnetometers that can be used to return the assembly to the correct position. The motors, because of the magnetic materials required in their construction, are of minimum size and are placed about two feet from the magnetometers.

The complete magnetometer assembly, including the gimbal mount and the driving motors, is mounted on a framework which must be placed in a position where it will not be unduly affected by the magnetic parts of a plane, such as its engines, guns, and bomb load. On some large planes, such as the PBY patrol bomber, a suitable location was provided in the form of a plywood tail extension. When working with smaller planes it has been necessary to place the unit in a streamlined housing called a bird, which may be carried be-

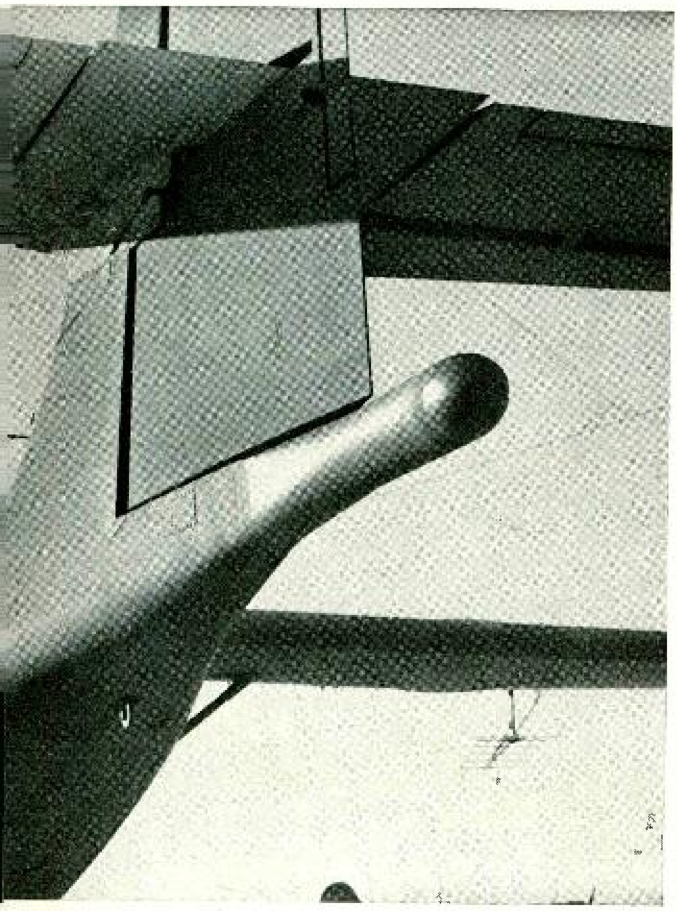


Photo by Bureau of Aeronautics

For some purposes the detector is mounted in a cylindrical extension on the tail of the plane

hind and below the plane by means of a towing cable.

Besides this unit, which is known as the orienting mechanism, an oscillator is required to provide the a-c excitation for the magnetometers, and an amplifier and detector to transform the signals produced by the magnetometers into signals suitable for operating the servos and the indicating and recording instruments. The oscillator and the amplifier detector are mounted on separate chassis in a single case. In addition, a dynamotor unit is required as a power supply, a control unit used in operating the apparatus, a recording meter, and one or two remote indicators.

How extensively magnetic airborne detectors were used during the war and what successes they achieved is still held confidential, but because the distance to which a submarine will cause a detectable change in the earth's magnetic field is limited to a matter of hundreds of yards, such detectors were never considered as primary search devices. The improvement in the submarine situation probably also limited their use.

It had been early recognized that these detectors—perhaps in a somewhat modified form—should have valuable peacetime applications. Their advantages for studies of terrestrial magnetism were obvious. It was also evident that they would greatly facilitate many types of geological surveys, particularly for locating deposits of iron ore. Perhaps of even greater importance would be their use in prospecting for oil. Magnetic surveys as an aid in prospecting for oil had been an established procedure for many years. Oil is generally found in the vicinity of certain types of geological formations, and these formations are of such a nature as to disturb the normal distribution of the earth's magnetic field. Previous methods of magnetic survey, although quicker and less expensive than the usual geological surveys, were very slow and costly compared to aerial magnetic surveys with the new equipment. Although individual magnetic measurements made on the ground with stationary apparatus were more accurate than those obtained from the air, their over-all accuracy for magnetic mapping was considerably less because of the necessity of interpolating between comparatively widely separated measurements, and because of the effects of diurnal changes in the earth's field. The airborne apparatus made a continuous record, and thus showed field values without interpolation along the line of flight. By flying over the same track at different heights, moreover, it was possible to secure a better picture of the changes of geological structure with depth. As a result of these factors, the United States Geological Survey early became interested in these new devices, and soon took an active part in extending their use.

An aerial magnetic survey with this equipment was made on a flight from Florida to Quonset Point, R. I., by Bell Telephone Laboratories and the Naval

Ordnance Laboratory using the 3A equipment. This consisted, however, only of a continuous record of field strength along the track of the flight. A practical aerial survey was made near Boyertown, Pa., by the Geological Survey with the coöperation of the Naval Ordnance Laboratory and Bell Telephone Laboratories. The results were so encouraging that a large-scale aerial survey was made of Iron County, Mich., by the Geological Survey using the ASQ-3. Records were made at three altitudes, and the results obtained were more complete and satisfactory than could have been secured from a year or more of ground surveying.

The Office of Naval Petroleum Reserves also became interested in this apparatus for oil prospecting, and prepared for a survey of Naval Petroleum Reserve No. 4 in Alaska. Preliminary trial flights were made in Oklahoma, and an Alaskan survey was successfully carried out a few months later. In the meantime, the Geological Survey had carried out another survey—this time in the Adirondacks to locate magnetic deposits. In each of these surveys large amounts of magnetic data were obtained in the course of a few weeks of field work. It was further found that with the aid of this new technique, generalized surveys of very large areas became really practical for the first time.

With the ending of the war in both hemispheres, considerable interest is being taken in the new magnetic surveying apparatus. It is still too early to predict the extent and value of future applications, but extensive use of aerial magnetic surveys will undoubtedly be made.

THE AUTHOR: William J. Shackelton joined the Western Electric Company at Hawthorne in 1909. The following year he came to the Physical Laboratory in New York to develop loading coils and to undertake pioneer work in precision electrical measurements. Other apparatus—capacitors, transformers and coils—were progressively added to his responsibility. Studies in the application of magnetic materials and of refinements in the art of precision electrical measurements of impedance, time and frequency occupied much of his attention. In 1928 he was appointed Transmission Apparatus Engineer. During World War II a number of important projects for the Navy were added to his other activities. Mr. Shackelton retired from the Laboratories on December 31, 1945.

A separate index to Volume 24 of Bell Laboratories Record *will be mailed with the April issue to those who received it last year. Others may obtain it upon request. Bound copies of Volume 24 (January, 1946 to December, 1946) will be available in the near future—$2.75, foreign postage 25 cents additional. Remittances should be addressed to Bell Laboratories Record, 463 West St., New York 14, N. Y.*

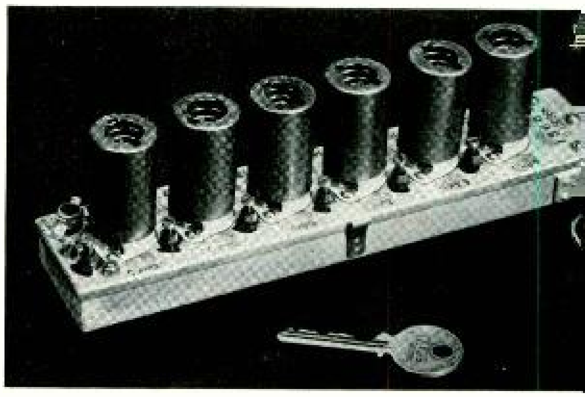
A COMPACT LIGHTWEIGHT AMPLIFIER FOR RADAR

P. L. HAMMANN
Radio Development

All radar receivers employ the superheterodyne principle, and in most equipments initial amplification at the signal frequency is omitted because the extremely high frequencies employed make vacuum-tube amplification impracticable. The converter, most commonly a crystal, is followed by an intermediate-frequency amplifier which provides the major part of the amplification of the receiver. A large amount of amplification is necessary to display the very weak reflected signals, and the amplifier must also handle a frequency band far wider than commonly encountered in communication work. The received radar pulses may be less than a microsecond in length with steep sides which must be clearly defined. This requires I.F. bandwidths up to 10,000 kc for radar receivers in contrast to bandwidths of 10 kc usually employed in communication receivers. Moreover, the signal strength may vary from the weakest echo signal up to the enormously strong signal that reaches the receiver directly from the transmitter during the transmitted pulse. These requirements must be met by a design that is also suitable for quantity production and that can be easily maintained in service by the available technicians.

It has been common practice to divide the intermediate-frequency amplification into two parts: a pre-amplifier of only two or a very few stages, and a main amplifier of many stages. This permits the pre-amplifier to be mounted near the high-frequency converter and thus secure a maximum signal-to-noise ratio, while the main amplifier may be placed at any convenient point. It also permits the main amplifier to be of more or less standard design, and thus to be readily adapted to many different radar systems. An intermediate-frequency amplifier that was designed for this purpose and weighing only nine ounces is shown in the photograph below.

Over-all measurements of the amplifier are 7½ by 2½ by 1½ inches, but these small dimensions were not achieved at the first attempt. They were made possible largely by the development of the 6AK5 vacuum tube already previously described.* Figure 1 shows this amplifier in front of a pre-war amplifier designed for a similar purpose. It was not until the summer of 1942, when a microwave radar for carrier-based aircraft was considered, that it became evident drastic steps would have to be taken to produce a smaller and lighter amplifier. By this time two amplifiers much smaller than the large one of Figure 1 had already been developed. These are shown in Figure 2 at the left of the new amplifier, which was used in several later airborne equipments. The amplifier at the left employs 6AC7 tubes while the middle one uses 717A tubes. In space occupied, these two amplifiers are about alike, but the 6AK5 amplifier is one-quarter their size.



The 6AK5 amplifier

Within its small volume, a voltage amplification of 100 db is obtained with a bandwidth of 3.5 megacycles and a mid-band

*Record, *November,* 1944, *page* 605.

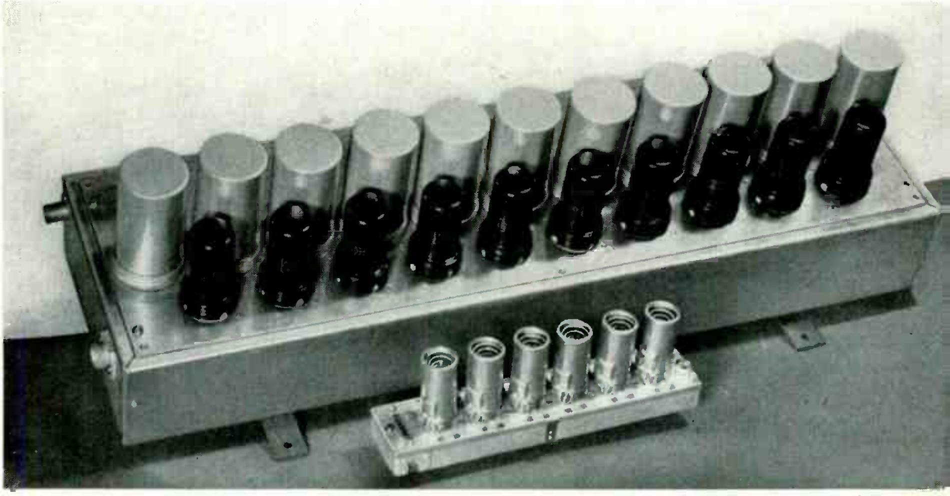


Fig. 1—The 6AK5 amplifier beside a pre-war amplifier designed for the same type of service

frequency of 60 megacycles. Five of the tubes form the amplifier circuit, while the sixth is a detector for converting the 60-megacycle envelope to a video signal. With such a compact arrangement, stability becomes a major factor. That more than adequate stability was obtained is evidenced by the ability of the amplifier to operate satisfactorily without the shielding afforded by the bottom cover.

Several factors contribute to this stability, one being the unusually small physical size of the tuning coils. Only one-quarter of an inch in diameter, these may be seen in Figure 3 mounted vertically along the front edge between each pair of stages, and are marked A in the circuit diagram shown in Figure 4. The coupling condensers, marked D, are the small cylindrical units lying horizontally between stages. Another feature contributing to compactness is the use of silvered-mica by-pass condensers, marked B and C, in the form of small disks soldered into narrow slots punched in the chassis. These features give a compact arrangement with short leads, which contributes to the stability of the amplifier. Considerable attention was also paid to the de-coupling circuits in the power supply network. Too much de-coupling tends to increase the recovery time of the amplifier, while too many components

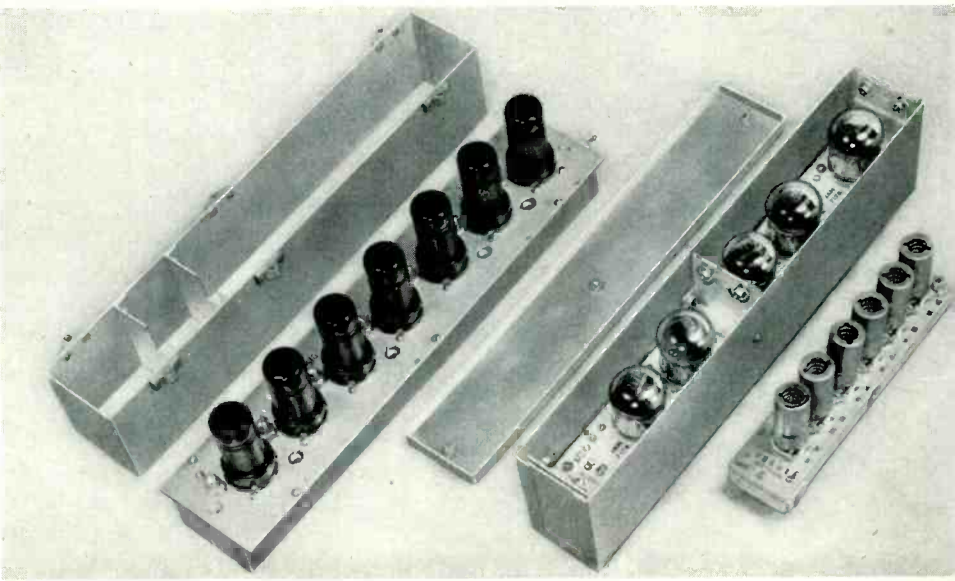


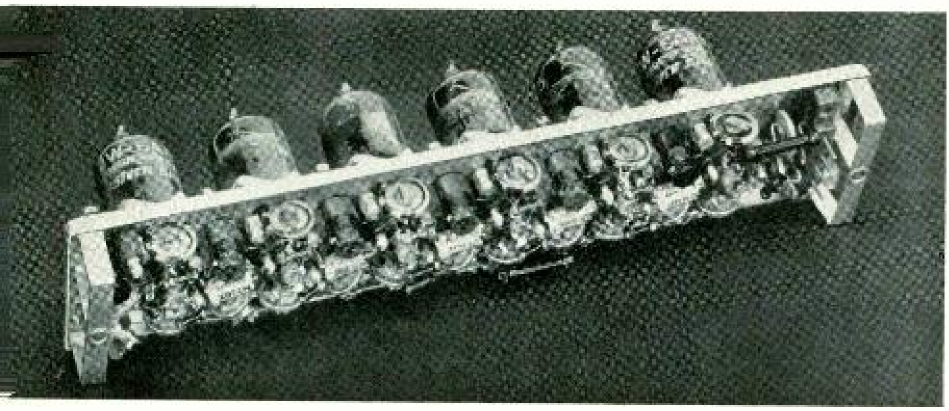
Fig. 2—The 6AC7 amplifier, at the left, and the 717A amplifier, in the center, are both about four times the size of the 6AK5 amplifier shown at the right

had to be avoided in the interest of size and compactness. After extensive experimental measurements, satisfactory de-coupling was secured by four 100-ohm resistors strategically placed in the B+ lead, and a small choke in the heater supply.

Of considerable importance to the user of such apparatus is the amount of maintenance required to keep it in operating condition. In general, a high-gain amplifier of extremely compact design tends to be more difficult to maintain. Considerable effort was expended to make the opposite true of this amplifier. The selection of a single-tuned inter-stage coupling impedance did much to avoid misalignment of the inter-stage circuits, which ordinarily are troublesome to maintain. Such misalignments are commonly caused by the variations in the input and output capacitances of the tubes. Since the tubes contribute about 75 per cent of the total inter-stage capacitance, small variations may cause considerable change in the resonant frequency of the tuned circuit.

Although single-tuned circuits do much to eliminate the troubles caused by variations of the tube capacitances, it is at the expense of the gain and bandwidth obtainable with any given tube. With the design worked out for this amplifier, however, sufficient gain margin is available to compensate for the loss in amplification resulting from misalignment of the tuned circuits, and for tubes of lower mutual conductance. Fortunately, the bandwidth increases with misalignment of the single-tuned circuits, and in general is quite tolerable. To minimize the effects of variations in tube capacitances, every effort is made to keep all the inter-stage capacitances from deviating from their normal value, and the tuned circuits are designed to resonate with tubes of mean capacitance. As a result, any tube conforming to JAN specifications may be installed at random without need of re-aligning and with no apparent degradation in performance.

During the winding operation, the tuning coils are adjusted by a comparison technique to be within a narrow inductance range. Tuning adjustments are provided on the amplifier—by the screws between tubes evident in the headpiece—that may be used



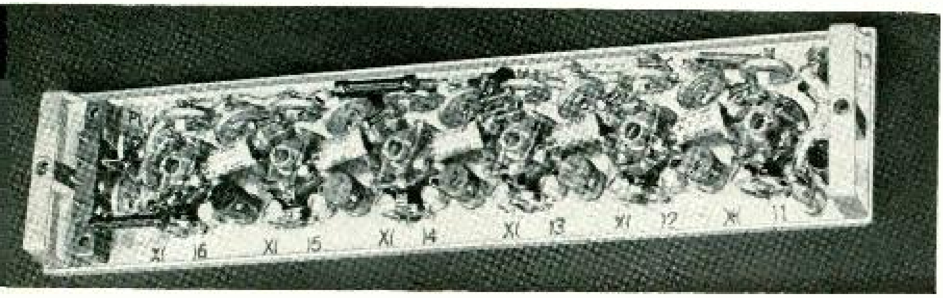


Fig. 3—Small tuning coils and coupling condensers feature the 6AK5 amplifier

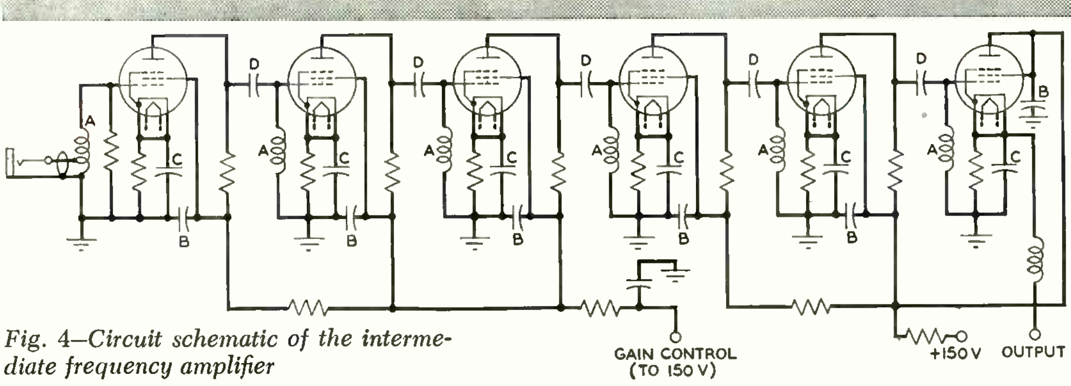


Fig. 4—Circuit schematic of the intermediate frequency amplifier

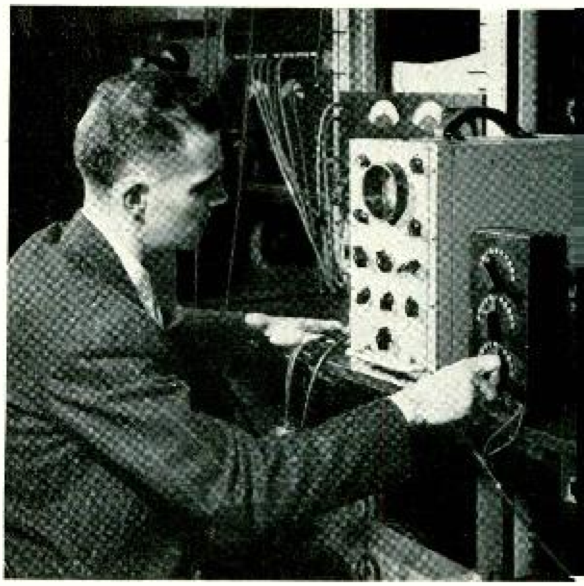
to compensate accurately for variations in the stray capacitances encountered during manufacture. This adjustment should be made with mean capacitance tubes in the sockets. They are then sealed and need not be used thereafter. The range of adjustment is kept small so that tampering cannot misalign the amplifier sufficiently to interfere with satisfactory operation.

At times it is desirable to replace quickly and conveniently various parts of a radio or radar system so as to isolate trouble resulting from the failure of some small component. This is made possible by the mechanical arrangement of the amplifier. Two self-retained screws, one at each end of the chassis, are loosened to remove the chassis from the bottom cover, which in turn is fastened separately to some other part of the radar apparatus. The 50-ohm coaxial input circuit is disconnected by its plug and jack. The two brackets projecting from the lower side of the chassis at each end protect the apparatus while the chassis is out of the bottom cover, and serve as guides in putting it back. Power is connected automatically through a plug and jack when the chassis is pushed into its cover. The receptacle into which the prongs of the plug on the chassis fit is mounted in the cover but is removable from it to permit testing the amplifier when it is out of its cover.

This amplifier has found application in the AN/APS-4 radar* for carrier-based planes, in the Bat radar-directed bomb,† and in other equipments which have not yet been described.

*Record, *September*, 1946, *page* 321. †Record, *April*, 1946, *page* 137.

THE AUTHOR: Paul L. Hammann received his B.S. in E.E. from Kansas State College in 1939. Following a year in engineering research with Phillips Petroleum Company, he joined the Commercial Products Development Department of the Laboratories where he was concerned with high-frequency radio receivers. At Whippany during World War II, he developed radar receivers and other associated microwave components for many radar systems. He participated in the early standardization program of microwave transmission apparatus and spent considerable time test-flying airborne radar systems. At present he is engaged in the development of military radar equipment. Mr. Hammann is a senior member of the I.R.E.



Bernard Ostendorf measures telegraph distortion on the X-75041 *portable set*

A CATHODE-RAY TELEGRAPH DISTORTION MEASURING SET

W. T. REA
Telegraph Transmission Development Engineer

A small portable set for measuring telegraph distortion more accurately and dependably than has been possible before has recently been developed by the Laboratories. Known as the X-75041, it is now in production by the Western Electric Company for the Navy and the Bell System. In addition to its portability and accuracy, one of its features is the use of a cathode-ray tube to indicate the distortion.

An experimental version of this device was constructed in the Telegraph Laboratory in 1938, and was found very useful for accurate measurement of telegraph distortion. This original set included three polar relays and five electronic tubes, and occupied about 30 inches vertically on a 19-inch relay rack. Both commercial a-c power and ± 130-volt telegraph battery were required for its operation.

In 1941, at the request of the Signal Corps, this set was redesigned in more compact form, and was coded the 164A1 telegraph transmission measuring set. One model was supplied for the Signal Corps Laboratory and one was built for our Telegraph Laboratory. This set employed a single polar relay, a 3-inch cathode-ray tube, and nine other electronic tubes, and included a built-in power supply operated entirely from commercial 60-cycle power. Its dimensions were 10 x 16 x 20 inches and it weighed sixty-seven pounds, the framework being of steel because of the shortage of aluminum at that time.

In 1945 orders were received for a number of cathode-ray telegraph transmission sets. To meet additional requirements, the circuit was modified and also arranged for operation at 100 speed as well as 60 and 75, and on polar signals as well as on 60 ma, 20 ma, and inverse neutral signals. The scale was improved and a scale light added. Physical rearrangement reduced the size to 9 x 15 x 16 inches, and the use of aluminum in the case and framework reduced the weight to forty-seven pounds. This is the set that is now in production under the designation X-75041.

The front of this new measuring set, with the cathode-ray scope at the top center, is shown in Figure 1. When the set is operating, the electron beam traces a counter-clockwise spiral on the front of the tube beginning at the top of the outer edge. The rate of describing the spiral is such that at the six possible succeeding transition points of an undistorted teletypewriter character, the cathode-ray beam will have returned to the upper vertical radius. It will be nearer the center of the scope for each succeeding transition, and at the sixth transition position will be just above the central white area on the front of the scope. The intensity of the beam is so low, however, that its position on the face of the scope is invisible except when the polar relay, operated by the telegraph pulses, leaves its mark or space contacts. At these instants, a momentary increase in intensity of the beam causes a dot of light to appear. The beginning of the start pulse will be indicated by a spot of light at the top center of the scale, and if undistorted signals are being transmitted, each succeeding transition will appear on the upper vertical radius.

With distortion present, the transitions will occur earlier or later than their normal times, and will appear on the scope at some other point than the upper vertical radius. The radial scale marked on the front of the scope has one hundred lines with every fifth one heavy, and indicates per cent distortion directly—up to fifty per cent negative at the left and up to fifty per cent positive at the right. A transition appearing ten per cent early, for example, would appear at the right of the center on the second heavy radius from the top.

A block diagram of the essential portions of the circuit is shown in Figure 2. When the start pulse of a teletypewriter character operates the receiving relay, the character timer starts an oscillator and then divorces the control of the oscillator from the action of the relay until near the end of the character. The start-stop oscillator breaks into oscillation without causing a transient, and produces damped sine and cosine waves. After amplification, these cause the beam of the cathode-ray tube to describe the spiral track referred to above. Each time thereafter that the armature of the relay leaves either the M or S contact, a short positive impulse is applied to the intensity control electrode of the cathode-ray tube to give a light spot on the front of the tube. Near the end of the teletypewriter character, the character timing circuit brings the oscillator again under control of the relay, and when the relay operates to marking for the stop pulse, the oscillator, being critically damped, is stopped, and returns to its initial steady-state condition within less than the time of a unit pulse.

Operation of the circuit can be followed with the help of Figure 3. The oscillating circuit consists of a coil L and capacitor C, and when this circuit is oscillating, the voltage at point C varies as the cosine of

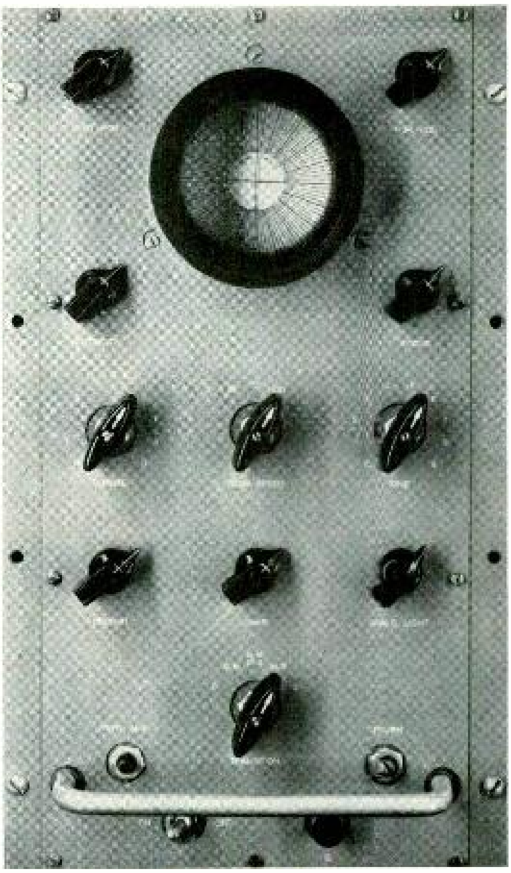


Fig. 1—Front view of the X-75041 telegraph transmission measuring set

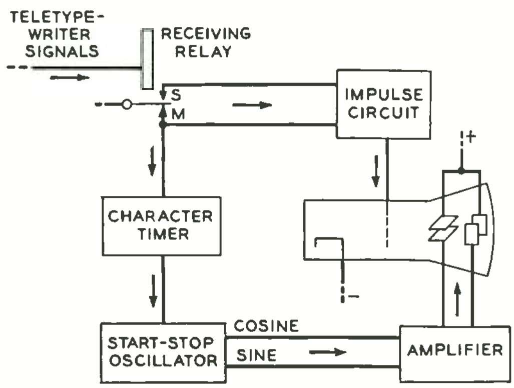


Fig. 2—Block schematic of the measuring set

the oscillating voltage, and that at point S, as the sine. Capacitor C is adjusted to make the length of each cycle equal to one unit of the code at the transmission speed being used. The sine and cosine voltages applied across the two pairs of deflecting plates of the cathode-ray tube give the rotary motion of the beam. Once the oscillation is started it tends to die down because of the resistance in the circuit, and thus the beam follows a spiral rather than a circular path. Vacuum tube element A supplies energy to the oscillating circuit through a transformer, and by adjustment of R1 in its cathode circuit, the amount of gain can be adjusted so that the decrease in the amplitude of the oscillation is such as to bring the spot nearly to the white circle on the scope at the end of the sixth cycle. Vacuum tube B is shunted across the coil L, and when its grid is at a voltage that will permit current to pass, the oscillating circuit is critically damped, and will not oscillate. The oscillator is thus stopped and started by the control of the grid voltage of tube B.

Prior to the receipt of a start pulse, tube C will be passing current, and its cathode will be sufficiently positive to allow tube B of the oscillating circuit also to pass current, and thus the circuit will not be oscillating. C1 will have a small charge on it which will be held constant by diode D as current flowing through R2 tends to raise the voltage on the left-hand plate of C1.

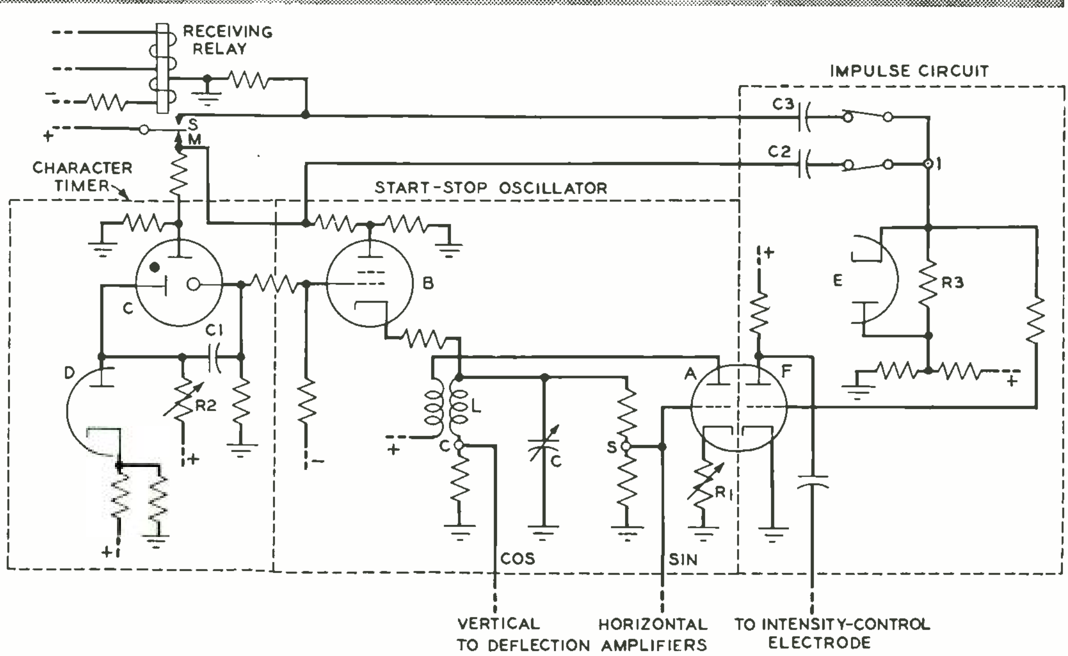


Fig. 3—Simplified schematic of the major sections of the circuit

When the armature of the receiving relay leaves its mark contact, current flow ceases in tube B and thus the oscillating circuit at once begins to oscillate—starting the cathode beam on its spiral course. Current also ceases in tube C, and as a result the voltage on the right-hand plate of capacitor C1 drops, and the voltage on the grid of tube B becomes negative enough to prevent B from passing current when the receiving relay subsequently operates to its mark contact.

The reduction in voltage on the right-hand plate of C1 also reduces the voltage on the left-hand plate, with the result that the voltage on the control plate of tube C becomes so low that tube C also will not pass current when the receiving relay subsequently returns to its mark contact. Capacitor C1 at once begins to charge through the high resistance R2, however, and the voltage on its left-hand plate slowly rises. R2 is adjusted to such a value that the voltage on the left-hand plate of C1 will not reach a high enough value to permit tube C to pass current until shortly before the time for the stop pulse to arrive. On receipt of the stop pulse, tube C at once passes current, and increases the voltage on the grid of tube B so that it also will pass current and thus stop the oscillating circuit. This same cycle will be repeated for each group of telegraph pulses.

Each time the relay armature leaves its mark or space contact during the reception of a character, the cathode-ray beam will be momentarily intensified by the impulse circuit. With the armature on the mark contact, as before the receipt of the start pulse, for example, capacitor C2 will be charged from the positive voltage on the relay armature. When the armature moves away from the mark contact, the voltage on the capacitor drops, thus lowering the cathode voltage of diode E sufficiently to permit current to pass, and a heavy discharge current immediately flows. The rapid decrease in voltage at point 1 due to the condenser discharge is transmitted to the grid of tube F, causing a sudden interruption of current in this tube that intensifies the cathode-ray beam and causes a spot of light to appear on the front of the tube.

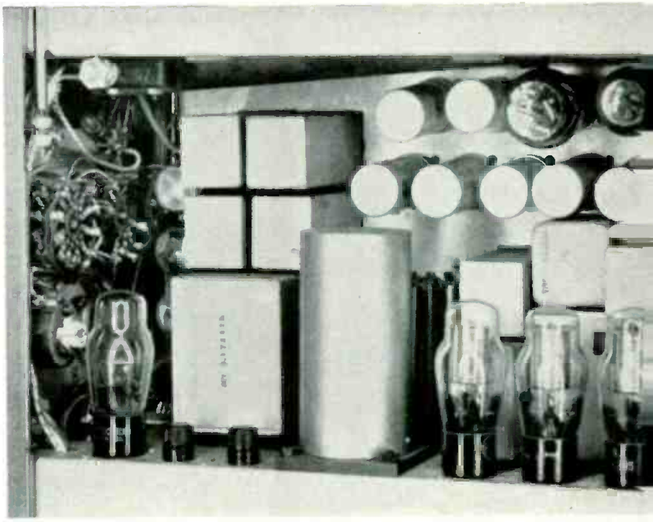


Fig. 4—Side view of set with hinged side lowered

When the armature reaches the space terminal, the cathode voltage of diode E is raised and the tube ceases to pass current. As a result, capacitor C3 can charge only slowly through the high resistance R3. An immediate opening of the space contact due to chatter will not cause another intensification of the cathode-ray beam because insufficient charge has accumulated on C3 to cause any appreciable change in voltage at point 1 as the armature leaves the space contact. During the space pulse, however, capacitor C3 has sufficient time to become fully charged, and thus when the armature leaves the space contact at the next transition, an intensification of the cathode-ray beam will be caused following the same sequence as when the armature left the mark contact. The combination of a diode shunting a high resistance thus makes it possible to secure an intensification of the beam for each regular transition, but not for adventitious transitions caused by chatter.

A rotary switch which opens the connections to capacitors C2 and C3 permits mark-to-space, space-to-mark, or both types of transition to be observed. Another rotary switch changes the constants of the oscillator and character timing circuits for operation on signals at 60, 75, or 100 words per minute.

The power supply circuit employs only a single transformer. This feeds a full-wave positive rectifier and a half-wave negative voltage doubler. The full-wave rectifier supplies plate and biasing voltages for the vacuum tubes, and a portion of its output is regulated and used for the biasing current of the relay. The voltage from the doubler circuit added to that of the full-wave rectifier provides about 1,100 volts accelerating potential for the tube.

Since the X-75041 indicates the displacement of each and every transition from its proper time of occurrence, it may be used to analyze the causes of distortion. It gives, for example, an easily recognizable indication of the effect of gear or shaft eccentricities in a mechanically driven source of signals. In addition, since there is no zero point to which the reading is set during calibration, the device does not conceal its own imperfections. When driven by undistorted signals, it will indicate accurately any internal distortion that may be affecting its normal operation.

THE AUTHOR: W. T. Rea specialized in physics at Princeton University, and received a B.S. degree in 1926. He joined the D & R that year, and worked on the engineering requirements and design of carrier telegraph systems for the next eight years. Transferring to the Laboratories in 1934, he was concerned until 1941 with d-c telegraph systems, telegraph-distortion measuring devices, and teletypewriters. After 1941 he was in charge of a group which originally worked on the application of electronic circuits to telegraph and teletypewriter systems but during the war engaged exclusively in radar development. Since the war, as Telegraph Transmission Development Engineer, he is in charge of the development of telegraph and telephotograph systems. Professional societies Mr. Rea belongs to include the I.R.E. and A.I.E.E.

FOR BACKSTAGE TALK IN COAXIAL CABLES

Telephone people whose business it is to operate and maintain coaxial systems do their talking over independent wire circuits built into the cable along with the coaxial tubes. These circuits, operated on a voice-frequency basis, may extend over hundreds of miles. They are equipped with standard voice-frequency repeaters and are normally loaded at intervals of about 6,000 feet. Loading is provided by the coil assembly unit shown in the picture on the front cover with J. E. Ranges, its designer.

The unit consists of six to twelve molybdenum permalloy-core coils usually of two or more inductance values. The coils are mounted on a dowel and then moisture-proofed, after which the entire assembly is wrapped in paper and muslin as shown.

In a typical set-up a loading unit serves two four-wire circuits for over-all coaxial system maintenance, one two-wire circuit for auxiliary repeater maintenance and a "cableman's talking circuit" with points of connection at convenient intervals along the cable for cable maintenance. Frequently, too, there are several spare circuits which stand by for regular message service.

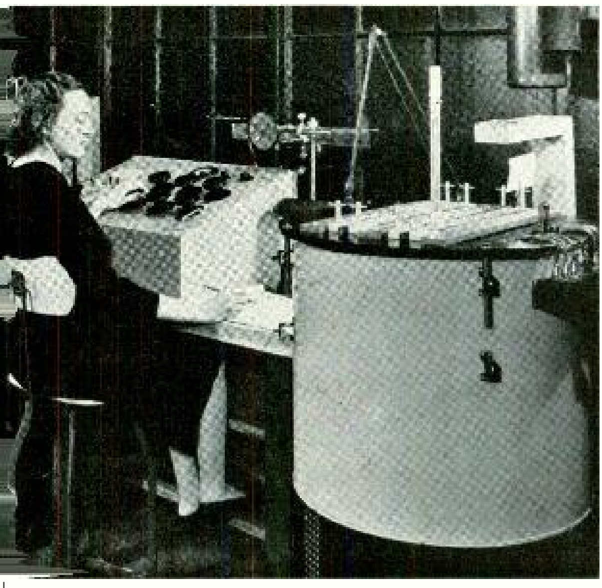
At coaxial splicing points the coaxials must be separated to make room for joint-making tools. This is accomplished by inserting a section of insulated tubing in the cylindrical space inside the coaxial assembly. At loading points the loading coil unit is placed inside this tubing.

H. T. WILHELM
Electrical
Measurements

MEASURING MEGOHMS TO A FEW PARTS IN A MILLION

At the beginning of the war, resistors in the megohm range were not ordinarily measured or certified to better than 250 parts in a million. This is twenty-five thousandths of one per cent, and from most points of view is a high precision, but for many of the networks* used extensively with electrical computers, the ratio of two resistors must be accurate to about a third of this value, or to less than 100 parts per million, if the desired accuracy of fire is to be obtained. Moreover, the ratio must be correct over a temperature range from −40 to +60 degrees C., and thus the variation in ratio per degree must remain constant within one or two parts per million per degree C. A further complication was the wide range of the resistance-temperature coefficients of the deposited-carbon resistors, whose coefficients range from −270 to −370 ppm per degree C. It was therefore necessary to make primary measurements on the deposited-carbon resistors to determine their temperature coefficients within one ppm per degree and to devise simplified measuring techniques of the same order of accuracy for the production routine.

*Record, *December,* 1946, *page* 445.



Production test for resistance and temperature coefficient being made at the Hawthorne plant

Since it is the ratio of two resistors that is of principal concern, it was decided to connect the two resistors to form the AD and CD arms of a bridge for measurement, and to construct a ratio unit having a fixed ratio arm, AB, and an adjustable arm, BC, as indicated in Figure 2. The unknown ratio could then be determined from the setting of the BC ratio arm. The two ratio arms had to be designed so that the desired precision of one or two ppm for resistance ratio would be maintained over a temperature range of several degrees which might be expected in a laboratory.

For the adjustable ratio arm BC, six decade units were employed with steps of 10,000, 1,000, 100, 10, 1, and 0.01 ohms. Most of the resistance of this arm is in the ten 10,000-ohm resistors comprising the largest decade unit, and to secure as great a similarity as possible between the two ratio arms, ten 10,000-ohm resistors identical with those of the adjustable arm were used for the fixed arm AB. Any change in temperature would thus affect both arms in the same way, and although there might be slight changes in absolute value of the resistors of the two arms as the temperature changed, their ratio would remain fixed. The smaller decade units could not be made of the same size of wire, but the wire was made of the same material, and since their contribution is ordinarily less than ten per cent of the total, a slight differential in the change with temperature does not have an appreciable effect on the over-all results. To further limit the effect of changes in temperature on the two arms, the resistors for both are in the same container and are

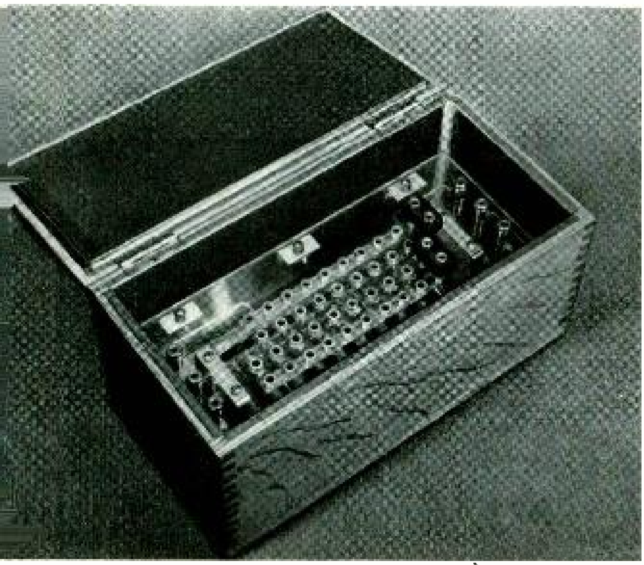


Fig. 1—Terminals and jacks for 10-megohn standard are mounted in a plexiglas plate through which the resistors beneath may be seen

precision bridge, which in turn is calibrated by step-up from a Bureau of Standards 1,000-ohm standard. Substantially this same precision will then hold for other connections. The ten-megohm standard used in the bridge is shown in Figures 1 and 3. These standards, connected in the AD or CD arms, were used for all the primary measurements of the carbon resistors.

The deposited-carbon resistors employed in the computers are sealed in small glass tubes. To facilitate measurement of a number of them over a wide range of temperature, a series of semi-circular grooves of the same diameter as the resistors was cut in two steel plates so that when several resistors were placed in the grooves and the two plates fastened together, each unit—thus subject to similar temperature changes.

With these ratio arms, resistance ratios from 0.000001 to 1.111110 can be measured. In making a measurement, the larger of the two unknown resistors is connected in the AD arm so that the ratio is less than one.

For primary measurements to determine the basic characteristics of the deposited-carbon resistor, two wire-wound adjustable standards* were designed for the AD arm. One consists of ten one-megohm resistors connected to jacks in a top panel made of plexiglas—a transparent plastic with extremely high insulation resistance. The resistors may be connected in parallel, in series, or in various series-parallel combinations by two-pronged plugs. The terminal scheme adopted also permits each unit to be isolated so that its insulation resistance may be measured. So long as the insulation resistance of each unit is high, the resistance of all ten in series is exactly one hundred times that of all in parallel. The other standard is similar, except that ten 0.1-megohm sections are mounted on a larger hard-rubber panel. With all ten units of this standard connected in parallel, the nominal resistance is 10,000 ohms, and the exact value may be determined to high precision by use of the Laboratories' high

*U. S. Patent 2,373,156.

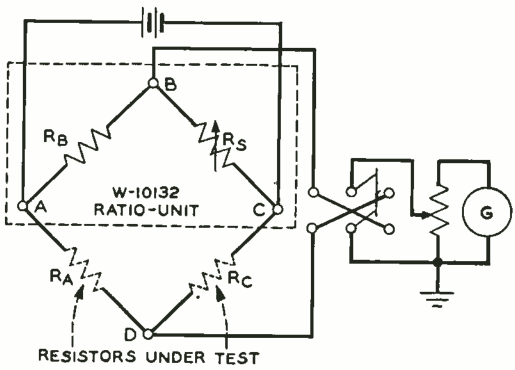


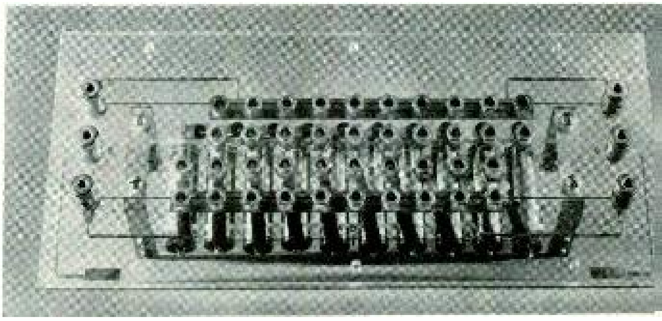
Fig. 2—Bridge circuit for measuring resistance ratios of deposited-carbon resistors

after a suitable equilibrium period—would be at the same temperature as the plates. These plates were massive enough so that changes in temperature occurred slowly, and a copper-wire glass-sealed resistor of the same physical dimensions as the deposited-carbon units was included in one of the grooves for measuring temperature. This assembly was then placed in a test chamber with provision for rapidly circulating air which could be cooled with dry ice or heated with electric heaters. By regulating the heaters and blowers, any desired temperature from −40 to +60 degrees C. could be obtained. The resistance of the copper-wire resistors was measured on a five-dial Wheatstone bridge from which temperatures could be estimated to within 0.1 degree.

By measuring the resistance of these carbon resistors at a series of temperatures over the range from −40 to +60, a temperature-resistance curve could be obtained for each resistor. The temperature coefficient is the slope of this curve. Although the curves are not quite straight, that is, the temperature coefficient does not remain strictly constant over the range from −40 to +60, it was decided that for production purposes it would be satisfactory to determine temperature coefficient from resistance measurements that were made at +30 and +60 degrees C.

The production procedure set up was to determine the resistance and temperature coefficient of each resistor and mark them on the glass container. In making up assemblies, resistors that are to form part of the same network are selected from those having temperature coefficients which are alike within close tolerances—one part per million per degree for some networks. After these units are assembled, their resistance ratios are measured, and padding-out resistors are added in series with the lower-valued ones where necessary to bring the ratios to the desired values. After the network has been sealed in its container, ratios at several temperatures are measured as a final check.

For determining the temperature coefficient in regular production, neither the wire-wound standard in the AD arm nor the metal plates for holding the units was used. Instead a comparison method devised by R. O. Grisdale was adopted. For this method certain deposited-carbon resistors of proved high stability are calibrated as standards and used in the AD arm of the bridge. These standards and the resistors to be measured are mounted in a rack and immersed in an oil bath. Two of these baths are maintained: one at 30 degrees and one at 60 degrees C., and measurements are made first in one and then in the other. One of the advantages of this method is that since the resistors are being compared with a unit of similar temperature coefficient instead of with a wire-wound unit of widely differing temperature coefficient, the actual temperature value is less critical. Vigorous agitation of the oil is required, however, to secure the same temperature for all resistors. From measurements made in these two baths, the temperature coefficient for each unit is deter-



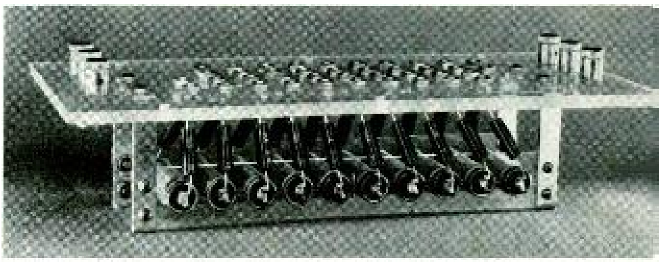


Fig. 3—Chassis of the 10-megohm standard removed from its case. Above, as seen from above; below, as seen from side

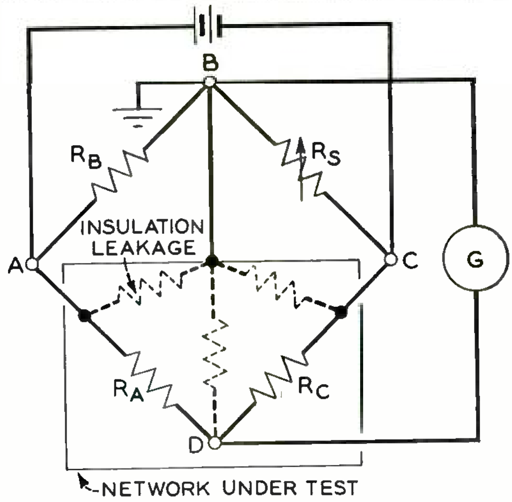
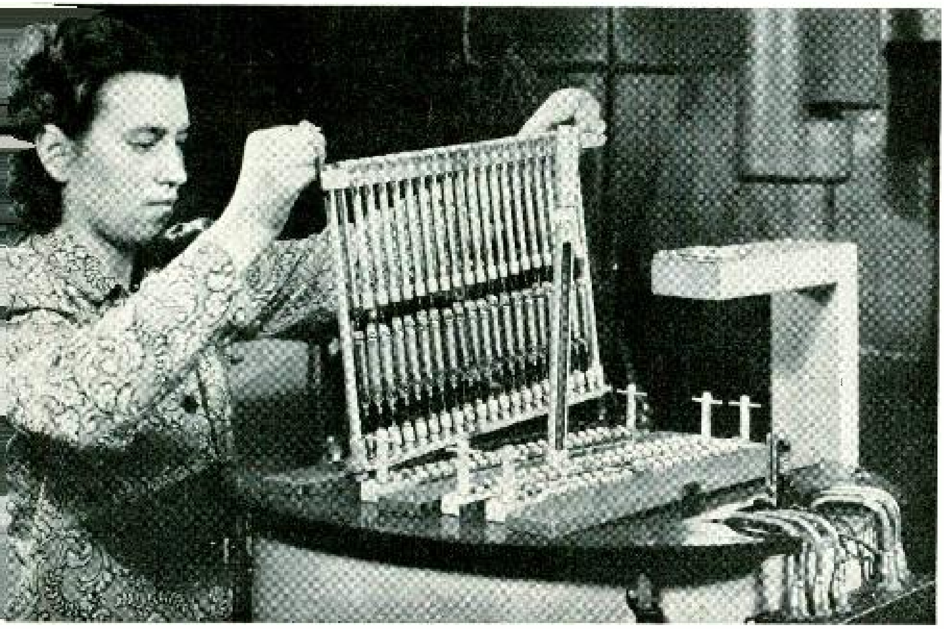


Fig. 4—Bridge circuit of Fig. 1 arranged for direct rather than grounded measurement

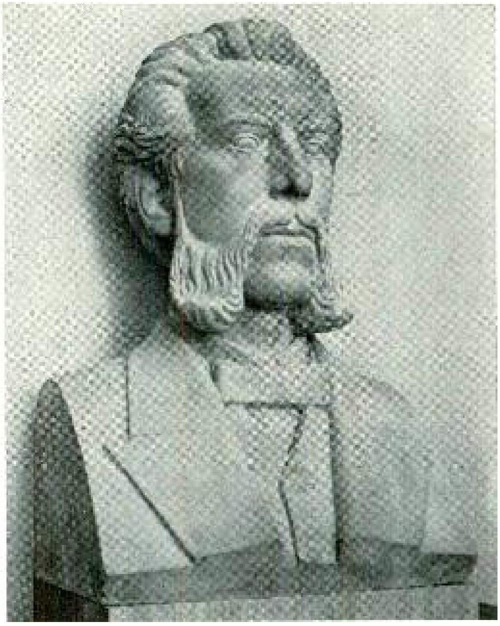


Placing loaded resistance test fixture in constant temperature oil bath at the Hawthorne plant of the Western Electric Company

mined and also its precise resistance at 30 degrees C.

Since for these measurements the resistors are not shielded, the switch in the indicator circuit, shown at the right of Figure 1, is operated to ground the D terminal, and thus grounded measurements are obtained. For the final measurements after the resistors have been assembled in the network cans, however, a direct rather than a grounded measurement is desired. To secure this, the switch is operated to ground the B corner of the bridge, and the enclosing shield of the network is also connected to ground, giving the arrangement indicated in Figure 4. Under these conditions, leakage from the D terminal to the can shunts the galvanometer and has no effect on the measurement. Leakages from A or C to the can shunt the AB or BC arms, but since these never exceed 0.1 megohm, any errors introduced are much smaller than if the leakage shunted network resistors of 1 to 10 megohms.

THE AUTHOR: H. T. WILHELM joined the electrical measurements group of the Laboratories in 1922, but in 1924 left to complete his studies at the Cooper Union Institute of Technology. After graduation in 1927 with a B.S. in Electrical Engineering, he resumed work with his former group. In 1936 he received the E.E. degree from Cooper Union. With the Apparatus Development Department he has been engaged in the design of measuring apparatus including impedance bridges and standards, and in the development of test methods used by the Western Electric Company. During the war period practically all his time was devoted to war projects, among which was the precision ratio bridge described in this issue. Mr. Wilhelm is a member of the I.R.E. and of the A.I.E.E.



BELL CENTENNIAL CEREMONIES AT MURRAY HILL

A heroic size bust of Alexander Graham Bell was unveiled by one of his daughters, Mrs. Gilbert H. Grosvenor, in ceremonies held at Murray Hill on the morning of March 3. Previous to the unveiling, Walter S. Gifford, president of A T & T, extended a cordial welcome to the gathering. Oliver E. Buckley, president of the Laboratories, spoke of Mr. Bell and his scientific descendants, Bell Telephone Laboratories.

Over twenty descendants of Mr. Bell then participated in an "around the nation" talk over a 10,000-mile circuit, the longest land-line conversation in the history of telephony.

As part of the Centennial tribute, President Truman wrote Mr. Bell's two daughters, Mrs. Gilbert H. Grosvenor of Washington, D. C., and Mrs. David Fairchild of Miami, Fla., and hailed Mr. Bell "not only as one of the world's outstanding inventors but as a distinguished citizen giving unstintingly of his heart and talents to the cause of a better world."

"The spirit of service to his fellow-men motivated his entire life," President Truman wrote. "This country is great because men like your father helped make it so. I should like you to know how happy I am, in his Centennial year, to voice our Nation's tribute."

The President's letter was read around the borders of the Nation on the special circuit which encircled all forty-eight states and went through thirty of them. Mrs. Grosvenor, who unveiled the bust of her father, and Mrs. Leonard Muller of Boston, his granddaughter, participated in this conversation, with Mrs. Fairchild joining in from Miami. Others of Mr. Bell's descendants listened over a battery of earphones, and then took their turns at the telephones.

Dr. Buckley called the roll of cities for the demonstration. Cities through which the nation-girdling call passed were New York, Miami, New Orleans, El Paso, Los Angeles, San Francisco, Seattle, Minneapolis, Chicago, Buffalo, Bangor, Boston and again, New York.

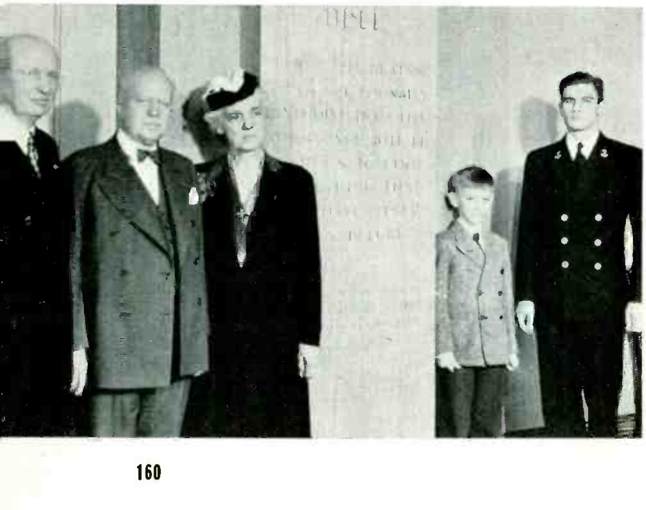
The bust of Mr. Bell shows him as a young man of 29, just at the time he invented the telephone. It is the work of Paul Manship, well-known American sculptor, and is done in terra cotta. Mounted on an eight-foot mahogany pedestal, it stands in the main entrance foyer of the Murray Hill Laboratory. On the pedestal are carved the dates "1847-1947" together with this quotation: "Leave the beaten track occasionally and dive into the woods. You will be certain to find something that you have never seen before." These sentences were taken from Mr. Bell's address to graduates of The Friends' School in Washington in 1914.

After the unveiling ceremonies and demonstration, Mr. Bell's descendants visited various telephone laboratories at Murray Hill. They were guests at a luncheon in the Murray Hill dining rooms, and then they gathered in the auditorium to attend the premier showing of "Mr. Bell," a centennial motion picture depicting highlights in the inventor's career.

Among the direct descendants of Alexander Graham Bell attending the observance of his 100th birthday anniversary were, left to right, front row: Gilbert M. Grosvenor, Helene Muller, David Muller, Martin G. Myers, Gardiner H. Myers, Walter K. Myers, 2nd, and Joseph P. Blair, 2nd, all great-grandchildren; second row, Edwin A. G. Blair and Joan G. Blair, great-grandchildren; Mrs. Gilbert Grosvenor, daughter, Mrs. Walter K. Myers, granddaughter, and Helen R. Grosvenor, great-granddaughter; rear, Cabot Coville, Jr., Hugh Bell Muller and Gilbert G. Coville, great-grandsons; Melville Bell Grosvenor, grandson; Midshipman Alexander Graham Bell Grosvenor, great-grandson; Mrs. Leonard Muller

At the Centennial ceremonies. Left to right, Oliver E. Buckley, President of the Laboratories; Walter S. Gifford, President of A T & T; Mrs. Gilbert Grosvenor, a daughter of the inventor; Gardiner H. Myers and Midshipman Alexander Graham Bell Grosvenor, great-grandsons

Martin G. Myers, a great-grandson of Alexander Graham Bell, receives from Mr. Gifford a model of the liquid telephone transmitter. Others, left to right, are David Muller, Gardiner H. Myers, Walter K. Myers, 2nd, who are also great-grandsons of Mr. Bell, and Dr. Buckley



eated in adjacent telephone booths, Mrs. Leonard Auller, left, a granddaughter of Alexander Graham Bell, and Mrs. Gilbert Grosvenor, a daughter, converse with each other over a 10,000-mile nation-girdling telephone circuit. Other Bell descendants also participated in the conversations

As the three generations of Mr. Bell's family, twenty-two in all, arrived at the Murray Hill grounds, they were met by C. D. Hanscom, usher, and A. R. Brooks and F. L. Hunt, who were their guides for the day. They were received by Mr. and Mrs. Gifford and Mr. and Mrs. Buckley.

After the unveiling ceremony, the Bell family visited laboratories in three groups. Mr. Brooks guided one group, Mr. Hunt a second, on a tour of Murray Hill, while L. S. O'Roark took the four small great-grandsons in tow and provided them with suitable entertainment consisting of a movie by J. J. Harley, a magnet show by R. A. Chegwidden and an exhibition of liquid air by J. T. Bell.

The younger members of Mr. Bell's family, those of preparatory school and college age, found in their tour of the Laboratories a great deal of interest. They witnessed the extrusion of rubber-covered wire in the rubber laboratory where A. R. Kemp spoke to them on the importance of synthetic rubber research to telephony; they saw hot molten metal compounded and poured into sand molds in the shape of bells marked "1847-1947 Bell Centennial," which they later received as souvenirs of their trip to the metallurgical laboratories. Their interest in the growing of synthetic crystals was particularly marked. They also witnessed the breaking of a cross-arm in the Outside Plant laboratory, where R. A. Haislip spoke to them on various projects under way for telephone plant improvement. After luncheon, Harvey Fletcher gave a demonstration of stereophonic music in the Arnold Auditorium. Mr. Bell's family are represented at the United States Naval Academy, Colby Junior College, Amherst, Sarah Lawrence College, Harvard University, and at Phillips Exeter, Landon, and Fessenden Schools.

Arrangements for the around-the-country telephone circuit which was used during the ceremony were made by I. E. Lattimer of Long Lines who coördinated the work of men in the control room. In this connection, Mr. Lattimer was aided by I. W. Whiteside of the Plant Department and a group of New

F. S. Malm describes the products developed in the rubber laboratory

Jersey Bell men who set up the telephone receivers for each chair at the ceremony and for the extra circuits that went to New York. Press releases for newspapermen were prepared by Wesley Fuller, who was responsible for newspapermen and photographers.

L. B. Cooke planned the over-all set-up for recording the proceedings, the tie-in with the local telephone circuits and, together with J. P. Maxfield, laid out the pick-up equipment, which was installed by W. W. Grote. Mr. Grote was also responsible for contact between the pick-up point and the recording rooms. Recordings were made at both Murray Hill and New York. L. Vieth and H. A. Henning supervised the recording at Murray Hill, where the program of the entire ceremonies was recorded by A. C. Kane, G. R. Yenzer, and J. Z. Menard.

The round the country telephone conversation, piped to 180 Varick Street from Long Lines Headquarters, was recorded by E. V. Kuzela and W. R. Goehner under the supervision of H. W. Augustadt.

As Plant Operations Manager at Murray Hill, A. F. Leyden was responsible for arrangements in the foyer, telephone and power facilities for the demonstration, and for the luncheon which was attended by the Bell family, together with executives of The American Telephone and Telegraph Company, Bell Telephone Laboratories, and other Bell System companies. Assisting Mr. Leyden, under T. J. Crowe, were P. Venneman for building services, A. J. McGuinness, power, D. R. Pope of the Building Department Shop, and under P. V. Brunch, R. L. Towne, who was responsible for engineering the plans for the installation of equipment in the foyer.

The centennial party had luncheon in the Murray Hill service dining room where F. E. Dorlon was assisted by Marjorie Forrest in the planning and serving of the meal, and by Otto Mohni, chef, and Charles Erb, baker, in its preparation. Floral arrangements were made by Miss Forrest.

General arrangements were under the direction of R. K. Honaman, Director of Publication, assisted by L. S. O'Roark.

E. W. Adams Dies Suddenly

Edgar W. Adams, General Patent Attorney of the Western Electric Company, died suddenly at his home in Montclair on March 10, the day before his sixty-third birthday. Mr. Adams joined the Bell System in 1912 and, with the exception of two assignments in Europe for Western Electric, he was continuously concerned with Laboratories patent matters. He became Assistant General Patent Attorney in 1927 and then was General Patent Attorney from 1937 to 1945, when he went to Western Electric in the same capacity.

Plant Costs per Telephone

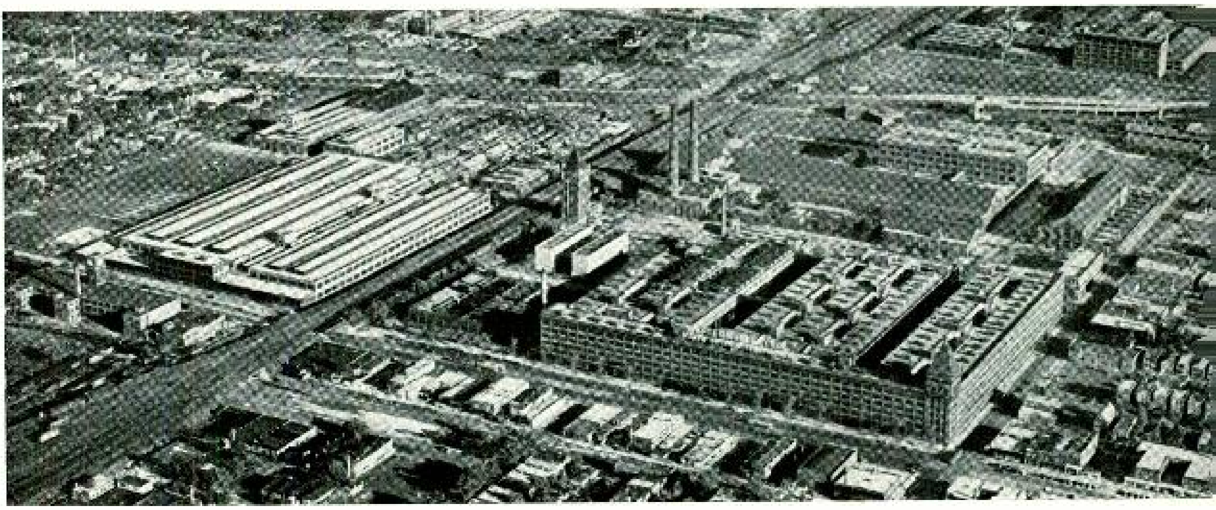
The total cost of the Bell System plant amounts today to about $245 per telephone of which only $16 or 6.5 per cent is for the telephone itself, according to the annual report of the A T & T. On December 31, 1946, plant cost per telephone was distributed between the various classes of plant as follows:

Items of Plant	Amount	Per Cent of Total
Telephone Instruments	$ 16	6.5
Lines and Equipment between telephones and central offices..	90	36.7
Switchboards and Equipment in central offices	71	29.0
Toll and Long-Distance Lines...	37	15.1
Land, Buildings and other Plant	31	12.7
Total	$245	100.0

$2,150.00 Contributed to the Red Cross

Members of the Laboratories contributed $2,150.00 to the Red Cross 1947 Fund, according to D. D. Haggerty, Chairman of the

The casting of small souvenir bells, given to the inventor's descendants present, was described by E. E. Schumacher, Research Metallurgist of the Chemical Laboratories



Western Electric Plants and Their Principal Products

HAWTHORNE WORKS (ABOVE)

Chicago and Cicero Plants—Dial central office equipment, combined sets, other station apparatus, wire, cable and pole-line hardware.

Lincoln, Neb.—Dial central office equipment.

St. Paul, Minn.—Combined sets and central office equipment scheduled for production.

KEARNY WORKS

Kearny, N. J.—Manual local and toll central office equipment, crossbar toll, wire, cable and carrier equipment.

Haverhill and Lawrence, Mass.—Coils and transformers.

Roselle, N. J.—Switchboard power equipment.

Passaic, N. J.—Switchboard apparatus and factory cabling.

Newark—Warehousing, equipment engineering and drafting.

Queensboro Works, Long Island—Telephone booths and woodworking.

POINT BREEZE WORKS

Baltimore and Dundalk, Md.—Rubber-covered wire, cords, coaxial cable, switchboards and station protection apparatus.

ALLENTOWN AND BETHLEHEM, PA.

Scheduled for production of vacuum tubes, crystals and other electronic devices now being manufactured in the Tube Shop, New York.

BUFFALO

Scheduled for production of switchboard cable and wire products.

RADIO SHOPS

Burlington, N. C.—Vehicular radio broadcasting equipment, sound systems and hearing aids.

Winston-Salem, N. C.—Radar and coils.

Kearny—Sound-powered equipment, sonar and radios.

Bayonne—Radar; Jersey City—Radios and radar; and Passaic—radar.

Welfare Fund Committee. The amount, however, is but a part of the over-all amount contributed by Laboratories members, a large number of whom made contributions directly to their local Red Cross Chapters.

G. A. Kelsall at Newark College

G. A. Kelsall, who retired from the Laboratories in 1945 after forty years of service, has been named a special lecturer in the mathematics department of the Newark College of Engineering. Dr. Allan R. Cullemore, president of the college, announced Dr. Kelsall's appointment on February 13. E. C. Molina, retired, is also a special lecturer at that college.

National Service Life Insurance

Most World War II veterans recognized the need for protection from war hazards and took out life insurance for the first time while they were in the Armed Forces. Upon return to civilian life the continued need for insurance is not so obvious to many. Yet we are informed 94,000 more people were killed in accidents in the United States between Pearl Harbor and V-J Day than were killed in service. Life insurance is generally recognized as the surest and safest way to provide for the payment of a specific sum for future delivery to one's self or to one's dependents at the time of their greatest need.

Broadcasting an "Adventures in Science" program from Bell Telephone Laboratories on March 8 were R. Karl Honaman, director of publication of the Laboratories; Edward Oates, CBS producer; and Watson Davis, director of Science Service. Subjects were Dr. Bell's invention of the telephone, mobile radio, rural carrier and rural radio. The program was broadcast over a network of seventy-three stations

National Service Life Insurance is now very much like ordinary commercial insurance except that premiums are twenty to thirty per cent less. If you served in the Armed Forces, you may apply for N.S.L.I. on a term basis even though you are now out of service and did not take out such insurance while in uniform. If you had term insurance and have since discontinued it, you have until August 1, 1947, to reinstate your term insurance without a physical examination upon payment of two monthly premiums. If your term insurance is still in force it may be converted to permanent insurance available in the following forms: (1) Ordinary Life; (2) 20-Payment Life; (3) 30-Payment Life; (4) 20-Year Endowment; (5) Endowment at age 60; and (6) Endowment at age 65. Even if you have already converted your insurance, you may still select any of the new types. For an additional premium your insurance will provide a disability payment, which benefit cannot be obtained at all in most major commercial insurance companies. The new insurance now provides unrestricted choice of beneficiary. Settlement may be made in a lump sum or choice of three monthly installment options.

Since the amount and type of insurance needed depends largely upon the financial and family status of the individual, veterans would do well to become fully informed regarding insurance before coming to any definite conclusions as to their insurance needs and the plan best suited to their individual cases.

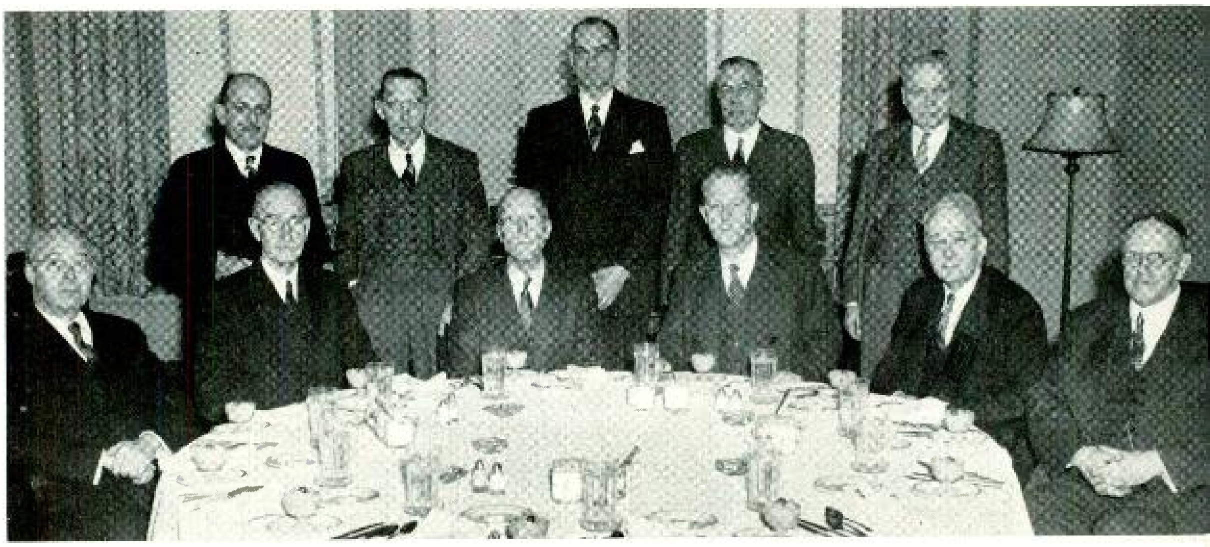
Questions concerning N.S.L.I. and requests for forms for reinstatement, conversion, or payroll deduction should be referred to the Personnel Department—Extension 226 at the Murray Hill Laboratories or Extensions 109 or 898 at West Street.

Frank B. Jewett Fellowships

Award of seven Frank B. Jewett fellowships for research in the physical sciences was announced recently by the American Telephone and Telegraph Company which founded the grants three years ago upon the retirement of Dr. Jewett. Two of the 1947-48 fellowships have been awarded to scientists holding similar grants for 1946-47 to enable them to continue their current research projects. Two of the recipients are chemists, two physicists, two mathematicians, and the seventh is an aeronautical engineer.

Recipients of this year's awards are: Dr. M. G. Ettlinger of California Institute of Technology and Austin, Texas, who is also a 1946-47 Fellow; Wallace D. Hayes of California Institute of Technology and Palo Alto, California; Paul Olum of Harvard University and Winchester, Mass.; Aadne Ore of Yale

Radio Transmission Engineering furnished a laboratory to make the Honaman broadcast more vivid. Doren Mitchell of that group made Bell's harmonic telegraph "ping," while Joe King, the Columbia announcer, watched



At the luncheon given to R. S. Hoyt honoring his completion of forty years of service with the Bell System. Standing, left to right, G. W. Gilman, A. G. Chapman, O. J. Zobel, W. L. Casper and Harry Nyquist. Seated, Lloyd Espenschied, O. B. Blackwell, Mr. Hoyt, the guest of honor, A. B. Clark, Thomas Shaw and K. S. Johnson

University and Oslo, Norway; Dr. Alfred Schild of the Carnegie Institute of Technology and Pittsburgh; Dr. Robert L. Scott of the University of California and Santa Ana, California, also holder of a 1946-47 fellowship; and Edwin H. Spanier of the University of Michigan and St. Paul, Minn.

Purpose of the fellowships is to stimulate and assist research in the fundamental sciences and particularly to provide the holders with opportunities for individual growth and development as creative scientists. The awards carry an annual stipend of $3,000 to the holder and $1,500 to the institution at which the recipient elects to do research.

Dr. Martin G. Ettlinger, of Austin, Texas, is at present investigating the chemistry of cyclopropene and dicyclobutane derivatives at the California Institute of Technology as a Jewett Fellow for 1946-47. He received his bachelor's degree from the University of Texas in 1942 and his master's from the same university in 1943. In 1946 he received his doctorate in chemistry from Harvard University. Dr. Ettlinger plans to continue his present research studies in chemistry.

Wallace D. Hayes, of Palo Alto, California, is a graduate student at the California Institute of Technology, where he expects to receive his doctorate in physics in June of this year. In 1941 he received his bachelor's degree and in 1943 his degree as aeronautical engineer from the same institute. Mr. Hayes plans to carry on an investigation into problems of transonic and supersonic fluid flow.

Paul Olum, of Winchester, Mass., is a graduate student at Harvard University. He received his bachelor's degree from Harvard in 1940, his master's from Princeton in 1942, and expects to receive his doctorate from Harvard in June 1947. A mathematician, Mr. Olum proposes to carry on his research in the field of algebraic topology.

Aadne Ore, of Oslo, Norway, is at present an F. E. Loomis Fellow at Yale University, where he expects to receive his doctorate in the spring of this year. He carried on his undergraduate studies at the University of Oslo and received his master's degree in physics from Yale in 1946. As a Jewett Fellow, Mr. Ore plans to carry on theoretical studies of combinations of electrons and positrons.

Dr. Alfred Schild, of Pittsburgh, is a member of the Department of Mathematics of the Carnegie Institute of Technology. He received his bachelor's degree in 1943, his master's in 1944, and his doctorate in 1946 from the University of Toronto. A physicist, Dr. Schild will study relativistic field theories in quantum mechanics.

Dr. Robert L. Scott, of Santa Ana, Cal., is engaged in research in chemistry at the University of California as a Jewett Fellow for 1946-47. He received his bachelor's degree from Harvard in 1942, his master's from Princeton in 1944, and his doctorate, also from Princeton, in 1945. Dr. Scott plans to continue his studies relative to the thermodynamics of solutions.

Edwin H. Spanier, of St. Paul, Minn., is a Rackham Predoctoral Fellow at the University of Michigan. In 1941 he received his bachelor's degree from the University of Minnesota and in 1945 his master's from the University of Michigan. A mathematician, Mr. Spanier will engage in research in the homotopy classification of continuous mappings.

PIONEERS' CENTENNIAL OPEN HOUSE

Frank B. Jewett Chapter of the Telephone Pioneers celebrated the Alexander Graham Bell Centennial by holding open house at both the West Street and Murray Hill laboratories on the evening of March 3. About 1,800 pioneers and members of their families attended the parties. The evening's entertainment at both locations included buffet dinner, a trip through the laboratories, the new motion picture, "Mr. Bell," and the Telephone Hour. In addition, there was a demonstration at Murray Hill of stereophonic music, under the direction of Harvey Fletcher, and at West Street, of the Voder, Vocoder, and Visible Speech, with talks by S. S. A. Watkins and H. W. Dudley.

P. W. Spence, chairman of the Pioneers' entertainment committee, was in general charge of the evening's program, with subcommittees headed by J. A. St. Clair and R. J. Nossaman responsible for arrangements at West Street and Murray Hill. Many other members of the Pioneers also worked effectively to make the evening a success; and the Pioneers are greatly indebted to the Plant Department, especially to G. F. Fowler and Elizabeth Ink of West Street, and I. W. Whiteside and F. E. Dorlon of Murray Hill

REPORT OF EMPLOYEES' BENEFIT COMMITTEE

The "Plan for Employees' Pensions, Disability Benefits and Death Benefits," which provides for payment of definite amounts to employees when they are disabled by accident or sickness, and when they are retired from active service and to their qualified beneficiaries in the event of death, is administered by a committee consisting of R. L. Jones, Chairman, A. B. Clark, M. J. Kelly, D. A. Quarles and G. B. Thomas, and as alternate members J. W. Farrell, W. Fondiller and M. R. McKenney. J. S. Edwards is Secretary and K. M. Weeks is Assistant Secretary.

Retirements and Deaths

Fifty-one members of the Laboratories were retired with pensions during the year. Of these, twenty-five had reached the age of sixty-five and were retired in accordance with the Retirement Age Rule and thirteen were unable to continue working because of disability. As of the close of 1946, there were 220 retired employees receiving service pensions, twenty disability pensions and two special pensions, or a total of 242.

Eleven active members of the Laboratories, ten retired employees, three employees on military leave of absence and one employee on disability leave died during the year. Payments to their qualified beneficiaries were authorized as provided in the Plan or in the special authorities granted the Committee by the Board of Directors. A death benefit under the Plan was also granted to the dependent beneficiary of a former employee who died as a result of an illness incurred while he was an employee.

Accidents and Sickness

The gratifying downward trend in the occurrence of accidents noted in 1945 has continued during 1946. There were 129 accidents during the year, 16 per cent fewer than in 1945. Of these, only 58 were lost-time cases as compared with 84 for 1945. Accident benefit payments and accident medical expenses during 1946 decreased 21 per cent relative to payroll as compared with 1945.

As compared with 1945, the frequency of benefit sickness absence in 1946 increased 15

Statement of Benefit Payments Under the "Plan for Employees' Pensions, Disability Benefits and Death Benefits"

Pension Trust Fund	1945	1946
Disbursements by Trustee for Service Pensions	$ 324,012.96	$ 393,417.30
Payments by the Company		
Disability Pensions	11,978.25	16,310.76
Payments After Death of Retired Employees	9,797.82	15,023.69
Accident Benefits and Related Expenses	34,385.86	23,756.31
Sickness Disability Benefits	270,379.44	295,152.12
Sickness and Accident Death Benefits	33,413.43	63,025.00
Total Benefit Payments	$ 683,967.76	$ 806,685.18

Status of Pension Trust Fund as Reported by Bankers Trust Company, Trustee

	1945	1946
Balance in Fund—Beginning of Year	$15,503,283.45	$18,036,793.76
Additions to Fund During Year		
Payments Into Fund by Company	2,283,181.00	2,432,033.00
Interest Revenue, Including Gain or Loss on Investments Disposed of	574,342.27	541,071.52
Total Additions	2,857,523.27	2,973,104.52
Disbursements for Pensions During Year	324,012.96	393,417.30
Net Increase in Fund During Year	2,533,510.31	2,579,687.22
Balance in Fund—End of Year	$18,036,793.76	$20,616,480.98

per cent, and its duration in relation to working time increased 23 per cent. Next to service pensions, sickness benefit payments are the largest single item of expense, and were actually 9 per cent more than in 1945.

In addition to sickness benefits under the Plan, other payments, charged to departmental expense and totaling $489,908, were made to employees for absence on account of sickness. These payments covered the first week of absence of employees eligible to sickness benefits under the Plan, sickness absences of one week or less duration, and sickness absences of employees with insufficient service to be eligible to sickness benefits. Excluding all benefit absence cases, sickness absences amounted on the average to 2.47 cases per employee.

Where need of special assistance beyond that provided in the Plan existed, supplementary payments or special pensions, amounting to $26,676, were paid to 36 employees, 9 retired employees, the beneficiaries of 7 deceased employees and the widow of 1 retired employee.

Leaves of Absence

Of the 1,055 military leaves of absence granted during the war years, only 95 were active as of the close of 1946. However, there were on leave of absence 101 employees who were going to school under the GI Bill of Rights and Public Law No. 16.

Benefit Plan Amended

The Benefit Plan was amended effective January 1, 1946, and notice of the amendments and a new Plan booklet were distributed to all employees at the beginning of 1946. Effective August 1, 1946, the Board of Directors authorized the Committee to grant to an employee or his qualified beneficiary special benefit payments to offset the deduction made under Section 8, Paragraph 27 of the Plan from his disability pension, disability benefit or death benefit because of governmental payments of the same general character, payable because of former military service.

(Signed) J. S. Edwards, *Secretary*
Employees' Benefit Committee

News Notes

W. H. Doherty and E. G. Shower visited Columbia University to discuss operation of the radio-frequency power amplifier associated with the Columbia cyclotron.

J. F. Morrison discussed with FCC engineers in Washington the use of a new power monitoring device for FM broadcast stations.

A. K. Bohren was at Burlington on various projects recently.

J. B. Bishop selected *Western Electric FM Broadcast Transmitters* as the subject of his address before the Detroit section of the Institute of Radio Engineers.

H. T. Budenbom, J. F. P. Martin, R. R. Hough and R. Hammell attended a conference at the Bureau of Ships in Washington regarding high power X-band TR tubes. Mr. Budenbom also attended a meeting of the RMA Waveguide Committee in New York at which he was appointed a member of the Sub-committee on Connector Standardization. During February he also visited Massachusetts Institute of Technology.

R. A. Cushman visited the Burgess Battery Corporation at Freeport, Illinois, recently.

W. H. C. Higgins, R. R. Hough and J. C. Crowley visited the Kuthe Laboratories in connection with an Army project. Mr. Higgins, Mr. Hough, W. C. Tinus, H. G. Och and A. C. Currie discussed the same project with Army Ordnance and Army Ground Force representatives in Washington.

R. H. Ricker, F. Lohmeyer and J. B. Nordahl studied the use of radio in freight classification yards and other services at the Selkirk Yards of the New York Central Railroad near Albany.

E. L. Nelson, H. B. Fischer and R. H. Ricker discussed shop problems on the production of mobile radio-telephone equipment at Burlington and Winston-Salem.

H. A. Baxter and F. E. Nimmcke visited the Acme Company, Cleveland, and the Palmer-Bee Company, Detroit, to discuss parts for radar equipment. Mr. Nimmcke, W. Stumpf and W. C. Dorgan conferred in Washington with representatives of the Bureau of Ordnance.

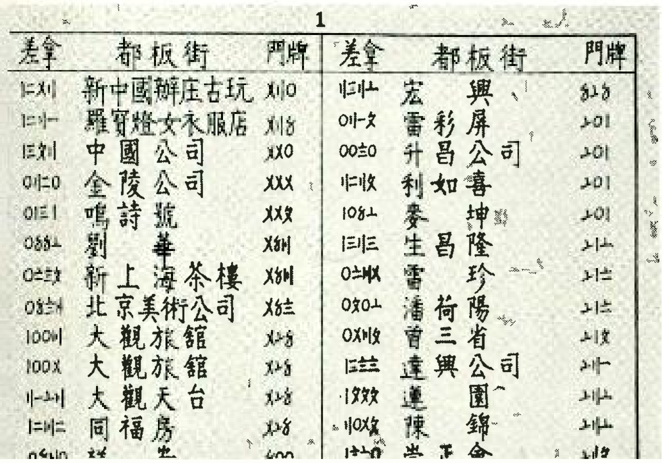
C. W. Ramsden studied modulation network problems at New London.

O. B. Cook and J. J. Harley visited the General Machine Products Company at Philadelphia in connection with the manufacture of cable lashers. Mr. Cook also witnessed an installation of lashed cable in the New Jersey Bell Telephone plant.

T. T. Robertson and W. Stumpf participated in discussions with the Air Material Command at Wright Field, Dayton, on drawings and specifications pertaining to Army Air Force procurements.

San Francisco's Chinese Directory

A page from the Chinese Telephone Directory of the Pacific Telephone and Telegraph Company, used in San Francisco's famous Chinatown, is shown in the accompanying illustration. In the box at top of page (left) the three columns are headed "Telephone Number," "Dupont Street" (the old name of Grant Avenue which the Chinese still use), and "Street Number." The first listing, directly beneath the box, reads: "1242—New China Curio Shop—420." The Chinese directory is hand-lettered, and is for the 2,100 tele-



A portion of the first page of the Chinese telephone directory used in San Francisco

phone subscribers served by China central office. There are 2,700 telephones in the area which has a population of about 13,000. The Chinese operators know by heart the names, addresses and telephone numbers of all subscribers listed in the directory. Each operator can locate subscribers whether asked for in English or in any of the five Chinese dialects used in Chinatown. The dialects are the Som Yup, Soy Yup, Heong Sow, Gow Gong and Aw Duck.

News Notes

J. F. Chaney, E. W. Conger and J. M. Maxey, accompanied by P. J. Moynihan of Western Electric, visited Distributing Repair Shops in Atlanta and Chicago.

H. L. Rosier witnessed tests of equipment for the Bureau of Aeronautics at the Naval Auxiliary Air Station at Charleston, R. I., from February 6 to 20. He was later joined by D. E. Bilton and R. C. Newhouse who also witnessed some of the tests.

W. H. MacWilliams and R. A. Devereux conferred at the Bureau of Ordnance in Washington on a naval project.

J. W. Smith, C. R. Taft, R. J. Philipps and N. W. Bryant went to the submarine base at New London to discuss a naval project.

N. Botsford, A. J. Christopher and L. H. Whitman went to Hawthorne to discuss subset components.

R. R. Hough spoke before the Rotary Club of Morristown for a second time on his trip in 1944 to England and the Continent for the "Buzz" bomb project. In his first talk he was not free to disclose, as he did in his second, the use of radar in tracking buzz bombs for fire control. A. L. Johnsrud assisted Mr. Hough by showing a British motion picture of buzz bombs and by projecting slides on the operation of radar for fire control.

G. F. J. Tyne, at Winston-Salem, discussed coils for the rural power-line carrier system.

E. B. Wood conferred with engineers at Point Breeze on cord manufacturing problems.

J. H. Bower visited the Burgess Battery Company at Freeport, Illinois, in connection with special batteries.

H. Peters and W. J. King discussed silicone rubber for use in high-voltage connectors with the General Electric Company, Pittsfield, Mass.

O. C. Eliason studied air-conditioning problems at the Illinois Bell in Chicago.

N. Insley visited the General Electric at Cleveland and the Sylvania Electric at Salem, Mass., in regard to switchboard lamps.

H. M. Knapp and D. C. Koehler, at Hawthorne, were concerned with the design and use of pretensioned springs for the UB relay.

S. A. Schelkunoff's discussion on *Concerning Hallen's Integral Equation for Cylindrical Antennas* appeared in the March, 1947, *Proceedings of the Institute of Radio Engineers.*

J. B. Johnson is the author of *A Cathode-Ray Tube for Viewing Continuous Patterns* which was published in the *Journal of Applied Physics* for November, 1946. In the same issue is a paper by G. K. Teal, J. R. Fisher and A. W. Treptow, *A New Bridge Photo-Cell Employing a Photo-Conductive Effect in Silicon, Some Properties of High Purity Silicon.*

W. G. Shepherd spoke on *Reflex Oscillators* recently at Carnegie Institute of Technology, at the University of Illinois and at the University of Minnesota.

O. E. Buckley, on February 20, visited the Wisconsin Telephone Company in Milwaukee where he addressed the supervisory staff on the work of the Laboratories. With W. C. Bolenius, president of the Wisconsin Company, he also visited the plant of the A. O. Smith Corporation in Milwaukee. On February 21, at the Hawthorne Works of the Western Electric Company, he was entertained by Mr. Levinger at a lunch at which he addressed the executive group.

A. B. Clark participated in *The Business Forum* presented over Station WMCA on March 4 by the Commerce and Industry Association of New York with D. F. G. Eliot, vice-president of Western Electric, and C. W. Phalen, vice-president of the New York Telephone Company. Subject of the broadcast was *The Man Who Gave Wings to Words.*

H. N. Wagar discussed filled coils and U and Y relays during his visit to Hawthorne.

C. W. McWilliams and T. H. Guettich conferred at Hawthorne on engineering questions in connection with a new multi-contact relay of the card-release type.

E. D. Mead and J. M. Melick discussed design problems of machine accounting apparatus at the Teletype Corporation in Chicago.

A. C. Keller spoke on *Submarine Detection by Sonar* at a joint meeting on February 13 of the A.I.E.E. Basic Science and Communications Groups and the New York Section of the Institute of Radio Engineers.

W. W. Werring attended a meeting in Philadelphia of the Impact Section, Committee E-1, of the American Society for Testing Materials.

H. Fletcher attended a meeting of the Committee on Hearing of the National Research Council Division of Medical Sciences.

R. R. Stevens and G. F. Schmidt assisted the Western Electric Company in Burlington with problems concerning the production of carbon microphones.

T. H. Crabtree, at Burlington, consulted members of the Shop regarding the present and new production of hearing aid amplifiers.

W. L. Tuffnell, A. F. Bennett, W. H. Edwards, H. I. Beardsley and C. L. Krumreich conferred with Western Electric engineers on the new telephone set and handsets at the Archer Avenue plant in Chicago.

F. S. Corso witnessed the manufacture of plastic and fiber parts for hearing aids at the Formica Insulation Company in Cincinnati, the Erie Resistor Company in Erie, Pa., and the General Industries Company in Elyria.

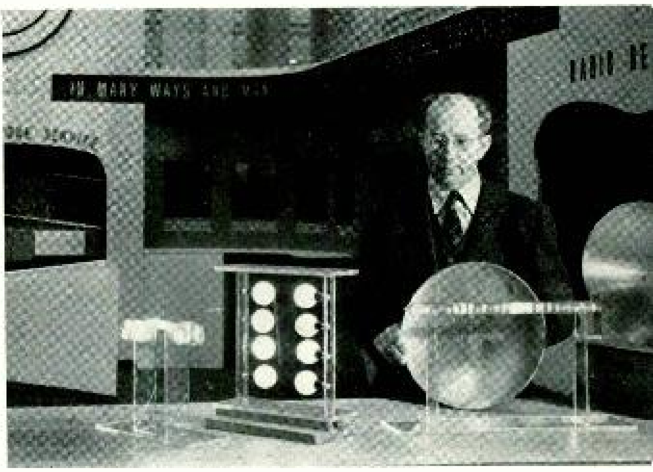
At a dinner tendered him, D. H. King was "crowned" in honor of his 25th service anniversary by L. N. Hampton. Left to right: A. I. Crawford, O. A. Shann, Mr. Hampton, Mr. King, A. F. Bennett and P. Neill. The crown was created for the occasion by C. L. Krumreich of Station Apparatus Development

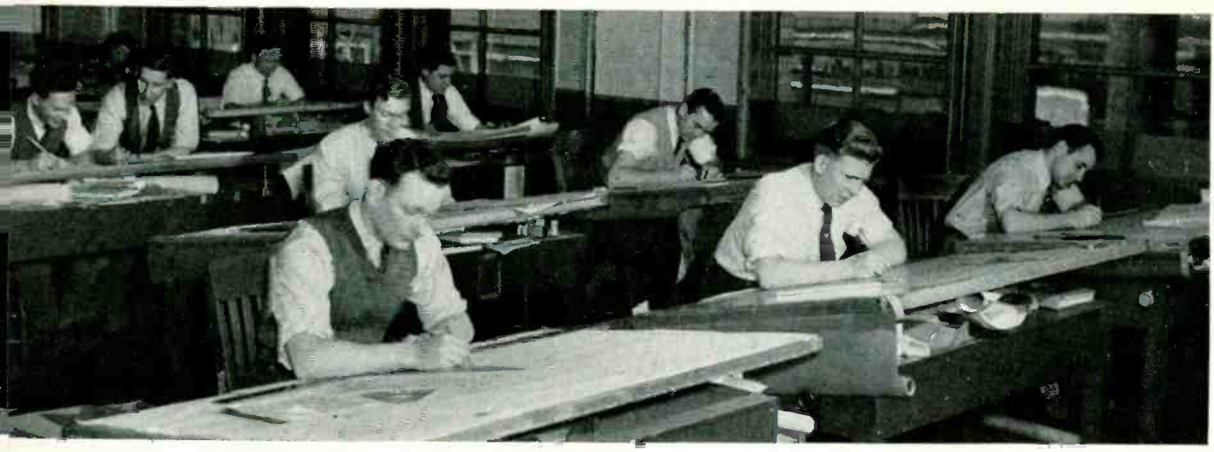
J. M. Rogie and F. S. Wolpert went to the International Resistance Company, Philadelphia, to discuss tone control switches and potentiometers for hearing aids.

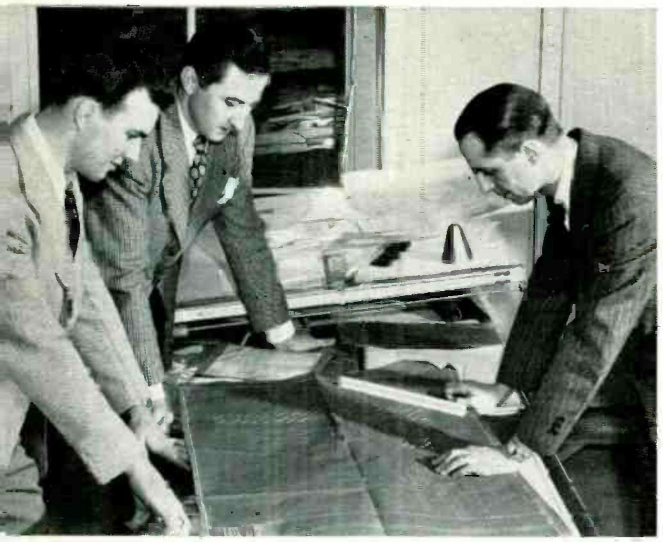
J. W. Tukey spoke on *Linearization of Solutions in Supersonic Flow* before the Hydrodynamics Section of the American Physical Society.

A. C. Millard traveled to Detroit for the meeting of Committee B-18 on Nuts, Screws, Bolts and Rivet Proportions of the A.S.A.

A popular feature of the A T & T exhibit at the Radio Engineering Show of the I.R.E. at Grand Central Palace was equipment for microwave experiments provided by the Laboratories. Henry Kostkos of Publication designed the experimental set-up and supervised its installation



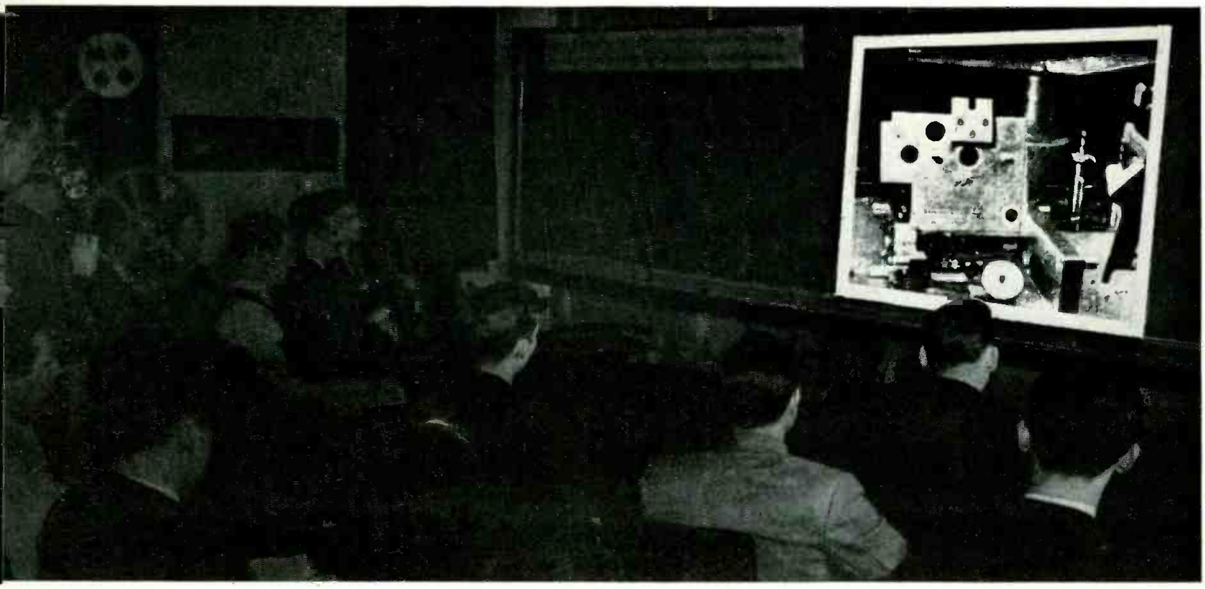




DRAFTING ASSISTANT COURSE

Thirty-one veterans of World War II are now enrolled in the Drafting Assistant Course. In this program, which was instituted by the Personnel Department and is presented in collaboration with the drafting departments, the student learns the fundamentals of drafting and mechanical design through two years of practical training in the drafting room together with in-hours classroom instruction in allied technical subjects. This program was suspended during the war and was resumed last fall for the benefit of the returned veterans.

←R. C. Benkert and M. C. Nielson discuss a drawing with their supervisor, J. W. Mackay, in the Apparatus Development Department drafting room at Murray Hill



←A few of the students at work in the Systems Development Department drafting room at West Street. Front row: G. J. McArdle, C. H. Dalm, J. A. Ceonzo; second row: J. B. Kennedy, J. M. Marko; third row: C. H. Kennedy, R. H. Funck, G. J. Thiergartner; fourth row: R. J. Seymour

J. A. Seifert (center), instructor, checks a layout→ of a disk cam, one of the classroom problems, with G. Chabra and T. B. Horton

R. C. Fremon lectures on vacuum tube amplifiers during a course in Communications

←Sound movies are used by W. G. Stephens to illustrate a lecture on jigs and fixtures in the course in Materials and Processes. The picture on the screen shows a drill jig from a film made by Film Productions Company

I. E. Seaman (right) of Commercial Products→ Development Drafting, Whippany, and A. T. Jensen, his supervisor, discuss a work project assignment

Present at "Dave" Haggerty's fortieth service anniversary luncheon were Mrs. Christine Smith, K. B. Doherty, Mr. Haggerty, G. B. Thomas, C. H. Achenbach, Morton Sultzer and J. S. Edwards

News Notes

W. KALIN reviewed problems on hearing aid transmitters in Burlington.

J. M. RICHARDSON presented a paper *Representation of Stress and Strain in the Case of Finite Deformation* at a Brown University Seminar.

ELIZABETH ARMSTRONG spoke on *Crystallography of the Forms of Silica* before the Queens Mineralogical Society.

K. K. DARROW selected *Nuclear Energy* for his topic when he addressed the Deal-Holmdel Colloquium on March 7 at Deal. Dr. Darrow recently prepared a new article on *Physics* as his first contribution to the Encyclopaedia Britannica for its 1947 revised printing.

R. M. BOZORTH has written the article on *Magnetism* for the 1947 printing of the Encyclopaedia Britannica. This same article appears in the January issue of the *Reviews of Modern Physics*.

E. E. SCHUMACHER, J. H. SCAFF, R. A. CHEGWIDDEN and G. A. ASHWORTH conferred at Hawthorne on various problems related to the current supply stringency in certain magnetic materials.

AMONG THOSE who attended the American Society for Testing Materials meeting in Philadelphia were R. C. PLATOW, R. BURNS, W. G. PFANN, H. PETERS, K. G. COUTLEE, H. A. BIRDSALL, A. R. KEMPF, F. S. MALM, J. R. TOWNSEND, E. E. SCHUMACHER and J. R. BOETTLER.

J. H. SCAFF has been appointed to the membership and the program committees of the Institute of Metals Division of the A.I.M.M.E.

A. H. WHITE, P. P. DEBYE, DOROTHY DODD, MILDRED HOOGSTRAAT and E. K. JAYCOX attended the Optical Society of America meetings in New York.

A. R. KEMP and G. N. VACCA participated in a quality assurance conference on wire at Point Breeze, where they later considered various problems related to rubber-covered wires.

M. D. RIGTERINK and G. T. KOHMAN visited the A. D. Little Company in Cambridge to discuss a new process for forming ceramics to close dimensional tolerances.

G. T. KOHMAN gave a lecture-demonstration on *Ceramics in Communication* before the Morris County Engineers Club. He was assisted in the demonstration by J. W. POLLIO.

April Service Anniversaries of Members of the Laboratories

40 years

K. B. Doherty

30 years

Amelia Blauvelt
Eginhard Dietze
Anthony Grieco
C. D. Jones
G. H. Keillen

25 years

H. H. Abbott
E. G. Andrews
F. W. Cunningham
R. C. Field
Coke Flannagan
L. A. Kille
Newton Monk
Cornelius Tanis
Daniel Wallace

20 years

O. J. Barton
Stephen Bobis
Manfred Brotherton
B. B. Cahoon, Jr.
W. B. Carmichael
W. J. Connell
W. C. Ellis
J. R. Flegal
A. A. Hauth
G. A. Head
R. B. Hearn
Marie Kirchmann
L. N. St. James, Jr.
E. O. Widmer

15 years

H. M. Owendoff
H. J. Ulrich

10 years

Margaret Brownlie
E. E. Francois
J. D. Lawson
J. S. McCarthy
J. C. Morris
W. W. Van Roosbroeck

M. D. Rigterink has accepted an appointment to the Advisory Committee for the Signal Corps Ceramic Research Program at the School of Ceramics, Rutgers University.

A. C. Walker and W. G. Straitiff spent a day in Allentown in connection with the growing of crystals. In the evening Mr. Walker spoke on *The Growing of Crystals* before the Western Electric Allentown group.

F. B. Llewellyn spoke on *Television Antennas, Propagation, Coaxial Cable and Microwave Relay Links* before the New Jersey Division of the A.I.E.E. New York Section.

B. A. Fairweather and D. B. Penick spent some time at the Chattanooga carrier station, checking the performance of an initial installation of program branching point equipment for type-K carrier systems.

Watching Charles Erb make his famous pies and pastry in the Murray Hill kitchen brought back to Otto Mohni, the head cook, memories of his boyhood in Switzerland. It particularly reminded him of a little old baker who vended his crisp, sweet bread by cart and was the joy of children in the surrounding hillsides. When he began telling "Charlie" the story, they found that they had grown up in the same vicinity at about the same time

H. W. Hermance, G. H. Downes and E. G. Hilyard made studies in Chicago of atmospheric contamination in central offices.

R. D. Heidenreich spoke on *Electron Microscopy* before the New Brunswick section of the American Chemical Society at Rutgers University, New Brunswick.

"The Telephone Hour"

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

April 7	*Maggie Teyte*
April 14	*Fritz Kreisler*
April 21	*Gladys Swarthout*
April 28	*Jascha Heifetz**
May 5	*Lily Pons*

*Broadcast from Hollywood.

C. J. Calbick attended a conference on *Electron Microscopy* at the University of Toronto.

L. C. Roberts conducted tests in Atlanta of telegraph operation over the type-K systems equipped with the new program equipment.

W. E. Campbell participated in a meeting at the Bureau of Standards at which a test procedure for spreading instrument oils was determined.

S. B. Williams spoke on *Relay Computers* at the March 12 Symposium on *Electromechanical Computing Devices* held at Columbia University under the auspices of the A.I.E.E. Basic Science Group.

L. R. Montfort participated in performance tests of the Barnstable-Nantucket microwave radio relay system.

W. D. Moeder and F. B. Combs discussed sonar problems in Washington with the Bureau of Ships. They also inspected sonar installations at the submarine base in New London, Conn. Mr. Moeder and R. E. Carpenter observed sonar operations during a two-week visit to the Navy Sector Base, Key West.

R. L. Jones has received the following letter from Charles R. Denny, chairman of the Board of War Communications:

"With the signing of an Executive Order by the President, the Board of War Communications is officially abolished, and the Board wishes to take this occasion to extend to you its sincere gratitude and commendation for your service as a member of one of the committees* whose assistance made the work of the Board possible. . . ."

"The Board relied for its successful functioning upon voluntary service such as yours. It had no paid personnel, no funds, no appropriation. Travel and other expenses were paid by the individual committee members themselves or by the companies, agencies or associations they represented.

"We shall always look back upon our association with you with pleasure and satisfaction. Please accept this expression of our appreciation."

*Committee II—Aviation Communication.

WHAT'S NEW

K. E. Gould Returns From Japan

K. E. Gould has returned to the Laboratories after seven months of service with the Civil Communications Section of General MacArthur's headquarters in Tokyo. Dr. Gould, who had been a member of the Bell System group in Japan, requested by the Army to assist in rehabilitating Japanese communications, was responsible for the direction of all Japanese communications research in governmental agencies such as the Ministry of Communication, in educational institutions and in private industry. Among his responsibilities were decisions as to permissible types of research in Japanese laboratories and guidance of the development program to provide more effective service, particularly in the telephone system.

During his stay, Dr. Gould spoke before the Science and Culture Association on *The Engineers' Place in the Sun* and before the Institute of Electrical Communications Engineers on *Some Practical Aspects of Communications Research*. He also had occasion to visit several universities where he became acquainted with a number of Japanese scientists who are prominent in academic circles.

Brigadier General S. B. Aiken, Signal Officer of the U. S. Army, is shown above presenting Dr. Gould with a Certificate of Appreciation from the War Department prior to his return from Japan.

Army personnel in Alaska observe operation of the M2 tracker during M9 field maneuvers at Task Force Frigid where the temperature is below minus forty. H. W. Benfer of Whippany took the photograph during a recent trip he made to Task Forces Frost in Wisconsin and Frigid in Alaska as a technical observer for the United States Army

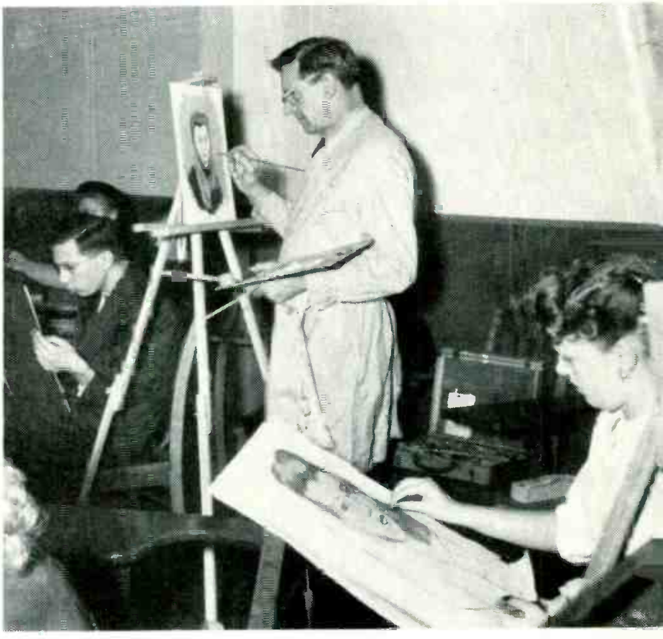
Ruth Vieweger of General Methods Department was responsible for compiling and editing the telephone directory recently distributed by the Laboratories. Deadline for listings in the directory was January 1 after which copy was prepared for printing. Miss Vieweger, a member of General Methods since 1940 also has charge of its service work

Bon voyage luncheon for W. E. Campbell who recently flew to his homeland, South Africa. Clockwise, A. N. Holden, W. D. Rigterink, J. R. Townsend, Mr. Campbell, E. J. Murphy, G. K. Teal, G. T. Kohman, B. S. Biggs, U. B. Thomas and D. A. McLean

A section of the sketching group during a class in Building T held under the auspices of the Bell Laboratories Club. Left to right, Norma Malecki, Homer Dudley, Alice Loe, C. O. Richard and the model. The photograph below and to the right shows R. W. King and Miss Malecki

Sir James Chadwick, Nobel Laureate, Visits Murray Hill

Sir James Chadwick, a Nobel laureate and a member of the United Nations Atomic Energy Commission, toured the Murray Hill laboratories recently. It was his second visit to Bell Laboratories, his first having been in connection with radar early in the war. Sir James was one of Rutherford's earliest and most eminent collaborators in the pioneering work on the transmutation of the elements during the twenties and the early thirties. In 1932 he identified the free neutron and demonstrated its character as a material particle of about the same mass as the proton, and thus provided the basis for the contemporary theory of the nucleus for many modes of transmutation and for the fission of uranium. Soon after this he became professor at the University of Liverpool, where, after a period of seven years devoted to war work, he has lately resumed his researches.



Right in his element (and looking it) is A. B. Conner of General Service. Occasion for this double row of smiles was a monthly conference of assistants to supervisors. Left to right, standing: Doris Middleton, Miriam White, Lillian Sangberg, Marion Ahrens, Ruth Meyerhoff, and seated, Eleanor Hill, Jean Wilson, Rosemary McKay and Joan Pisano

News Notes

George Risk was in Chicago to discuss mobile radio matters with the Galvin Corporation.

George Risk and A. E. Ruppel visited the RCA Camden Plant to discuss problems concerning general mobile radio-telephone equipment.

R. V. Crawford, with representatives of the A T & T and C & P Companies, went to Washington in connection with a demonstration of mobile radio-telephone equipment for the FCC.

R. C. Shaw and R. J. Kirscher are authors of *A Coaxial-Type Water Load and Associated Power-Measuring Apparatus* published in the January, 1947, issue of *Waves and Electrons.*

Bell Laboratories' location scenes were made at Murray Hill by Wilding Pix Incorporated for four Western Electric motion pictures featuring telephone subscribers' instruments, quartz crystals, vacuum tubes, and precision measurements. H. J. Kostkos was technical advisor.

T. N. Pope was elected Assistant Treasurer of the Army Signal Association at a regular dinner meeting held on February 24, 1947, at Fraunces Tavern, New York City. During the meeting General A. Van Fleet talked on *Personnel in the Armed Forces,* and the motion picture "Jimmy" was shown. "Jimmy" is the name given to the statue of Mercury which was "liberated" by the British in Italy during the war and is now prominently located at Fort Monmouth. It has been presented as a symbol of appreciation of the co-operation and aid given by the American Signal Corps to the Royal Signals of the British Army during World War II.

D. C. Smith, J. H. Gray, F. V. Haskell and E. F. Vaage witnessed installation tests at Newburgh on toll cable.

A Bell Laboratories display of quartz and synthetic crystals was exhibited for a month, ending March 18, at the Museum of Natural History, Minerals Section, in New York City.

W. C. F. Farnell went to the Edison Institute, Dearborn, Michigan, at the request of the Michigan Bell Telephone Company as advisor on Bell System exhibits at the Institute.

William Fondiller has been appointed a member of the Committee on Research of the Department of Electrical Engineering, Columbia University.

Spring ties interest these men at West Street. Besides the customers she waits on over the counter Vicki La Barbera of the Club Store also maintains stock control and takes care of telephone orders

H. S. WERTZ and J. E. CASSIDY were at the Patent Office in Washington during February in connection with patent matters.

R. P. CHAPMAN, a Staff Assistant in the Methods Department, and W. B. GROTH, a Technical Assistant in Systems Development Department, recently received degrees from evening colleges. Mr. Chapman was awarded a B.S. degree in Economics from New York University, while Mr. Groth received a B.E.E. degree from City College.

W. S. ENO was recently elected to the Board of Education in the township of Springfield, N. J., and C. S. KNOWLTON reëlected to the same board.

E. G. CONOVER and G. W. LEES, JR., reviewed new developments in material handling equipment at the annual Materials Handling Exposition held in Cleveland.

C. A. CHARITY visited E. L. Wilbur, Curator of the Frick Chemical Laboratory at Princeton University, to observe the operation of their glass washing equipment.

H. J. DELCHAMPS spoke on *Apparatus Drawings, Standards and Specifications* before a number of engineers at Kearny who had less than two years' E of M Department experience.

K. K. DARROW delivered the Norman Wait Harris Foundation Lectures at Northwestern University under the title *Atomic Energy;* the series comprised four lectures. He has been elected a vice-president of the International Union of Pure and Applied Physics.

J. P. MAXFIELD and W. J. ALBERSHEIM are authors of a paper on *Acoustic Constant of Enclosed Spaces Correlatable With Their Apparent Liveness* in the February *Journal of the Acoustical Society*. Other papers by Laboratories men in the same issue are *Factors Governing the Intelligibility of Speech Sounds* by N. R. FRENCH and J. C. STEINBERG; *Short Duration Auditory Fatigue as a Method of Classifying Hearing Impairment* by M. B. GARDNER; *Temperature Coefficient of Ultrasonic Velocity in Solutions* by G. W. WILLARD; and *Measurements of Ultrasonic Absorption and Velocity in Liquid Measures* by F. H. WILLIS.

F. H. HEWITT visited Hawthorne in connection with studies on No. 1 and No. 5 crossbar systems.

F. W. CLAYDEN and R. E. COLEMAN obtained resistance data on step-by-step solderless banks at a step-by-step office in Jacksonville.

J. J. KUHN was reëlected to the Elizabeth Board of Education for a second term.

OBITUARIES

DONALD M. TERRY, February 17

Donald M. Terry of Transmission Development had been a member of the Laboratories since graduating from Ohio State University in 1920. His early work was on fundamental carrier research and on the development of picture transmission apparatus. He played a responsible part in the first public demonstration of the picture transmission system in 1924 in Cleveland. Subsequently he worked on the development of automatic control of transmission level for carrier telephone lines, including, for type-J carrier telephone systems, the difficult problem of regulation under sleet storm conditions. During World War II Mr. Terry was associated with the development of the AN/TRC-6 radio set which was later used in the European theater.

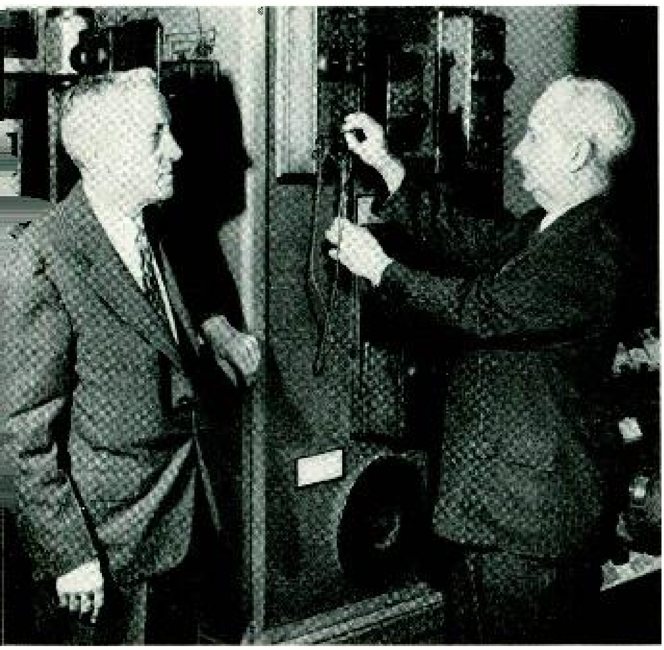
Mr. Terry held office in the Ohio Society of New York and in the Ohio University Club of New York, but he was best known as a boy leader in various churches and clubs in Brooklyn and New York. His funeral service was a remarkable gathering of men and women from all walks of life, many of whom had grown up under his leadership during the twenty-five years or more of his activities in boy guidance and young adult counselling.

D. M. TERRY
1899-1947

GEORGE THOMPSON
1869-1947

GEORGE THOMPSON, February 27

Mr. Thompson, who retired in 1932 after thirty-four years of service, was a member of the Systems Development Department's circuit group. Since that time he had been active in church and civic affairs in his local community of Mt. Vernon, having served for seven years as an elected member of the Board of Education and having taught a bible class in the First Methodist Church.



W. C. F. Farnell (left), Consulting Historian, and J. T. Lowe, Curator of the Bell System Museum

L. J. STACY at New Brunswick investigated ringing conditions on rural telephone lines exposed to inductive interference.

A. C. GILMORE discussed problems at Hawthorne concerning the No. 5 crossbar.

Engagements

*Anne Bahlav—Haig Casparian
*Marie Callaghan—Clement J. Thall
*Rosemary Fitzgerald—Malcolm T. MacEachen
*Frances Fitz-Patrick—*Eugene Flannery
*Gloria Greaver—Andrew Morrison
*Dorothy Johanson—Richard Chalcraft
Mabel Jones—*W. E. Evans, Jr.
*Eileen Kemmler—Samuel Zurich
Peggy McCarthy—*Charles W. Muccio
*Doris Middleton—Raymond Hitchen
Muriel Patterson—*G. F. Brown, Jr.
*Antoinette Romano—Frank Di Tommaso
Julie Viele—*M. E. Hines
*Grace Wielar—Daniel J. Gillen

Weddings

*Mechalina De Meo—Daniel Lawlor
Millicent Keiffer—*C. G. Matland
*Helen Lordan—Arthur M. Ryan
Sara Mallery—*Lt. R. D. Horne, Jr., U. S. Army

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

F. F. LUCAS presented a lecture before the Columbia Chapter of the American Society for Metals on March 11 in Columbus, Ohio.

H. M. PRUDEN and E. M. STAPLES spent two weeks at Chicago, South Bend, Toledo, Cleveland and Pittsburgh testing the control units for the airlines radio wire network.

W. W. BROWN discussed operators' chairs with Western Electric Company engineers at Hawthorne and with the U. S. Rubber Company at Mishawaka, Indiana.

R. H. MILLER visited the Western Electric and the Illinois Bell in Chicago, in connection with the introduction of No. 4 crossbar for New York and Chicago.

O. J. MORZENTI and E. T. BALL, at Philadelphia, discussed No. 5 crossbar for Media, Pa.

W. J. RUTTER visited Norristown, Pa., in connection with toll switchboard development.

G. H. KLEM participated in the installation and test of trial equipment for plane communication between Chicago and Pittsburgh.

R. A. HAISLIP attended the Chief Engineers' Conference on February 25 and 26 at Absecon, N. J.

C. D. HOCKER attended the Spring Meeting of the A.S.T.M. at Philadelphia.

A. P. JAHN was recently appointed Chairman of Subcommittee XV, of the American Society for Testing Materials Committee A-5. This subcommittee is concerned with exposure testing and inspection of bare and metallic-coated iron or steel wire and its products. In this capacity, he recently attended the Spring Meeting of the A.S.T.M. held in Philadelphia.

T. A. DURKIN and C. C. LAWSON, at Point Breeze, discussed wire manufacturing.

"Your Telephone Has a Nervous System, Too"

Pictured in the advertisement at the right is a series of line-link bays in MUrray Hill 6, the first of Manhattan's full-size crossbar offices. Soon after the cutover, which was in July, 1938, Rosenfeld's Fred Kollatz, accompanied by Publication's P. C. Jones, took a complete set of pictures whose eye-appeal has brought them continued popularity.

MUrray Hill 6, although it is only one of several at 227 East 38th Street, is still quite an office. Its 10,190 lines serve 22,000 telephones, about as many as are in Quincy, Mass., which has a population of 78,000. Several famous firms are served by MUrray Hill 6; among them New York Central, Railway Express Agency, the Commodore and Roosevelt Hotels, and B. Altman and Company.