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A NEW YEAR GREETING

Fellow-Members of the Laboratories:

As 1947 draws to its end, we can look back on it as a year of outstanding progress. Enthusiasm combined with hard work has produced imposing results. Projects interrupted by the war have been pushed to completion. Projects started since the war are now coming through. The birth rate of new ideas has been high, and the further we go the more opportunity looms ahead.

But we are not content with what we have done, and enter 1948 with a determination to mark the year with accomplishments that will surpass anything we have done in the past.

My grateful appreciation goes to all the members of our Laboratories family who have worked together so harmoniously and successfully, and my best wishes are for a New Year as happy as it is sure to be productive.

Oliver E. Buckley

POWER LINE TREATMENT FOR THE M1 CARRIER TELEPHONE SYSTEM

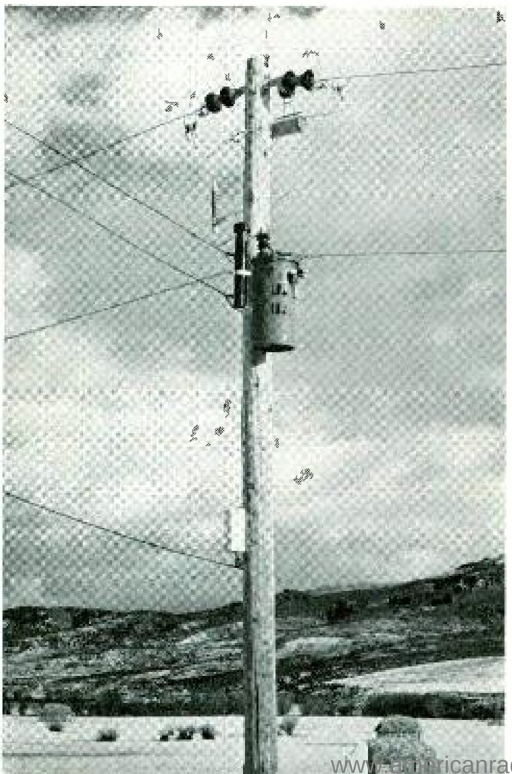
J. M. DUNHAM
Protection
Development

Power lines over which M1 carrier systems* are operated usually start from a sub-station and extend with branches and sub-branches through their service territory to supply power to the scattered customers. For the most part, the lines are single phase with a multi-grounded neutral, and operate at about 7,200 volts, 60 cycles. Transformers near the customers' houses reduce the 7,200 volts to the usual 120-240 voltage for lighting and power, but unfortunately, these transformers have a high attenuation for the M1 carrier-frequency currents. The simple expedient of plugging a suitable carrier-telephone set into a 120-volt outlet in the house thus cannot be utilized. A different method of coupling the telephone to the 7,200-volt line is required.

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

The coupling device employed consists of a high-voltage capacitor connected in series with a coil which is grounded, as shown in Figure 1. Telephone carrier equipment is connected across this coil. At power frequencies, the impedance of the capacitor is about 1.5 megohms, whereas that of the coil is about 3 ohms. Thus the normal 60-cycle voltage on the coil is only a small fraction of a volt. Abnormal voltages, which would otherwise appear across the coil if the capacitor failed or if the coil winding developed an open, are prevented by protector blocks across the coil and a high-voltage fuse in series with the capacitor, which insure prompt clearing of a damaged capacitor or the by-passing of an opened coil. A switch is provided in the coupler box which by-passes the coil and protector blocks, so that the blocks may be safely removed for inspection or the coil may be replaced. The coupling capacitor and 1-ampere fuse are shown in Figure 2, and a typical pole installation for a subscriber is shown on this page. The coupler box is shown in Figure 3. The coils shown in Figure 1 are in the larger of the two cans immediately above the terminal strip, while most of the other apparatus of the unit consists of filters.

The coupling capacitor consists of an oil-impregnated paper capacitor unit con-



Typical pole installation at the end of a carrier section showing a tap choke at upper right to block the carrier from the line beyond this point. A fuse and coupling capacitor are at the upper left, and a coupling unit below all the power equipment. The power transformer with lightning arrester mounted on it is at the level of the neutral wire tained in a glass tube about 16 inches long and 2 inches in diameter. It has a capacitance of 2,000 $\mu\mu$f, and a maximum rated 60-cycle operating voltage of 8,700, but it must withstand impulse tests at 95,000 volts to conform with A.I.E.E. standards for this type of power equipment.

Efficient transmission of carrier over the power line requires proper terminations at the ends of lines and choke coils at taps to reduce reflection losses. Early field tests indicated the approximate inductances that should be used for the chokes. Three types of coils are specified: isolating, tap and transmission chokes. Although both the isolating chokes and tap chokes are for blocking carrier-frequency currents, the former has an inductance of 10 mh, while the latter has an inductance of 2.5 mh. The higher inductance of the isolating choke makes it suitable for use as part of a sectionalizing network to separate two adjacent M1 carrier systems. The 2.5 mh choke is used on branch lines which do not serve subscribers. The transmission chokes have inductances of 0.3 and 0.6 mh, and are used on branch lines serving subscribers.

Since all of these chokes operate at 7,200 volts to ground and carry the power-line current, they must meet the same requirements as similar power-line equipment for short-circuit currents, temperature rise due to load currents, and protection against lightning voltages. These requirements tend to conflict with those for carrier frequencies. Large current-carrying and heat-dissipating ability, for example, conflict with the objective of low winding capacitance. This imposed rather severe design problems. The three types of chokes are de-

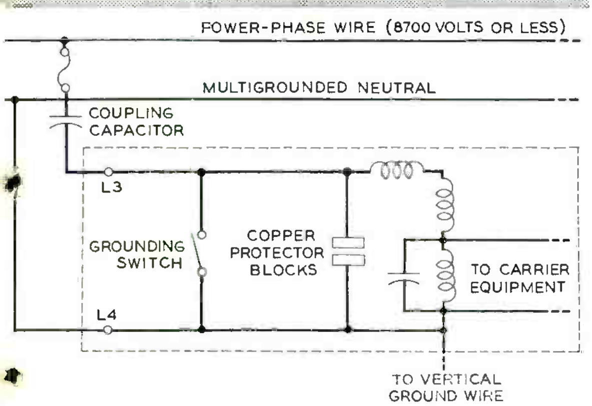
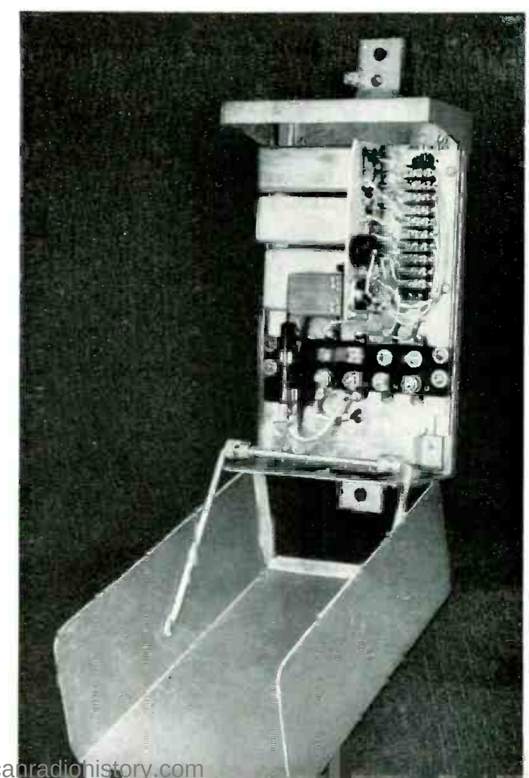


Fig. 1—Circuit schematic of the 60-cycle section of a coupling unit

Fig. 2—Coupling capacitor and fuse used for connecting low-voltage carrier circuits to the high-voltage power lines

Fig. 3—One of the coupling units used for connecting carrier subscribers to the power line. The coils shown in Figure 1 are in the larger of the two cans that are immediately above the terminal strip



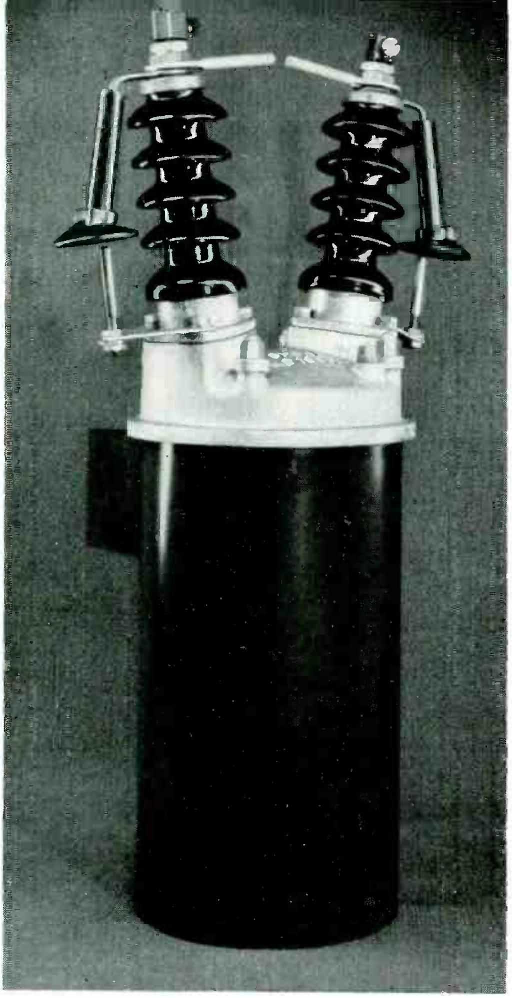


Fig. 4—An isolating choke coil for the M1 carrier system

signed to withstand 500 amperes short-circuit current. Suitable gaps are provided on the coils for lightning protection.

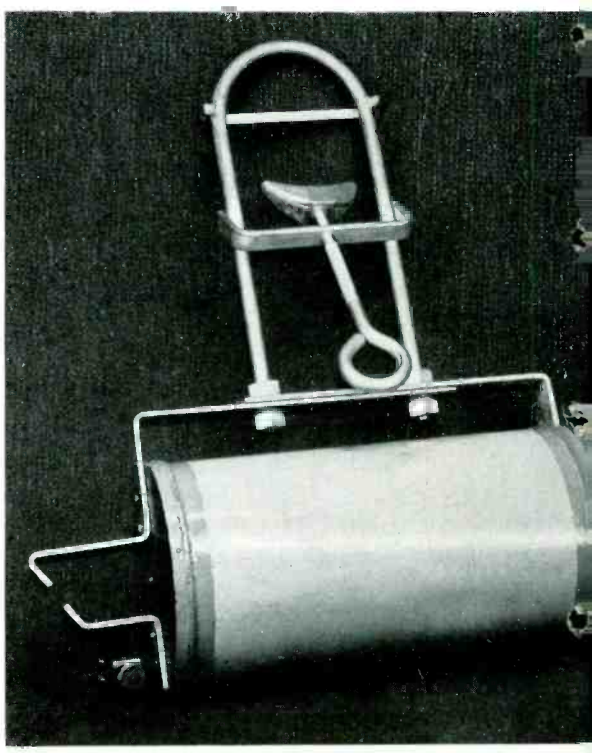
The rated continuous power-line load current for the isolating chokes is 10 amperes, and they will carry up to 15 amperes continuously without undue heating. This choke coil is mounted in an oil-filled steel tank having two high-voltage porcelain bushings, as shown in Figure 4. The assembled coil, which weighs sixty pounds, is mounted on the power pole and connected in series with the power line.

The tap choke and the two transmission chokes are not oil-filled; they are rated at 4 amperes, but will carry up to 7, 9 and 10 amperes, respectively. A coil of this type with supporting clamp is shown in Figure 5. It is suspended by means of its clamp from a pin-type power insulator. The coils are designed for hot-line mounting; that is, they can be put in place with an insulated hot-line stick and connections made without interrupting the 7,200-volt circuit.

Where load currents at either end of a carrier section exceed 15 amperes, two isolating chokes may be connected in parallel. Tap chokes are not operated in parallel because 2.5 mh is about the minimum inductance which will effectively block these carrier frequencies. If tap lines have currents greater than 7 amperes, therefore, an isolating choke can be installed in place of the tap choke.

Some rural power lines are equipped with automatic reclosing circuit-breakers to restore service on the line following trouble, and the winding of the operating solenoid is connected in series with the line. These coils insert a large loss in the line at carrier frequencies, and so, when there are circuit-reclosers in a carrier section, it is advisable to by-pass the solenoid coil with an impedance that is low at carrier frequencies, but high compared with the coil impedance at power frequencies. The by-passing unit, designed for mounting inside the oil tank of

Fig. 5—A tap choke with its protecting gap at the left and its supporting clamp above



the circuit recloser, has a maximum impedance of 50 ohms at carrier frequencies.

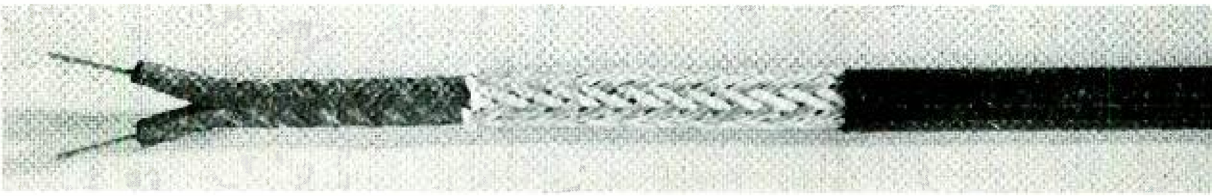
In applying the M1 carrier telephone system to a rural power line, the equipment mounted on power-line poles is installed by power linemen, except the common terminal and cabinet, which are installed by telephone linemen after power-line equipment connections have been made. Since telephone linemen must have access to the coupler boxes on the pole, they are located at least 40 inches below any power-line equipment. Drops are run from these boxes to the subscriber premises where standard station protection, as used for voice-frequency subscribers, is installed.

The choke coils were designed by S. G. Hale and are being manufactured by the Western Electric Company. The coupling capacitor now being used, shown in Figure 2, was designed by the Sprague Electric Company to meet requirements set up for the M1 carrier telephone system. Specifications and acceptance test requirements for the coupling capacitor were prepared by J. R. Weeks, Jr., and C. C. Houtz.

THE AUTHOR: J. M. Dunham received a B.E.E. degree from Ohio State University in 1924. After two years with the Commonwealth Southern Corporation he joined the D & R, where he worked on low-frequency induction as a member of Project Committee 2J of the Joint Subcommittee on Development and Research, Edison Electric Institute and Bell System. During World War II, he was associated with the development of radar equipment for certain fighter planes. Subsequently he has been concerned with the power-line equipment and protection features involved in adapting rural power lines for M1 carrier and also with low-frequency inductive coördination problems.

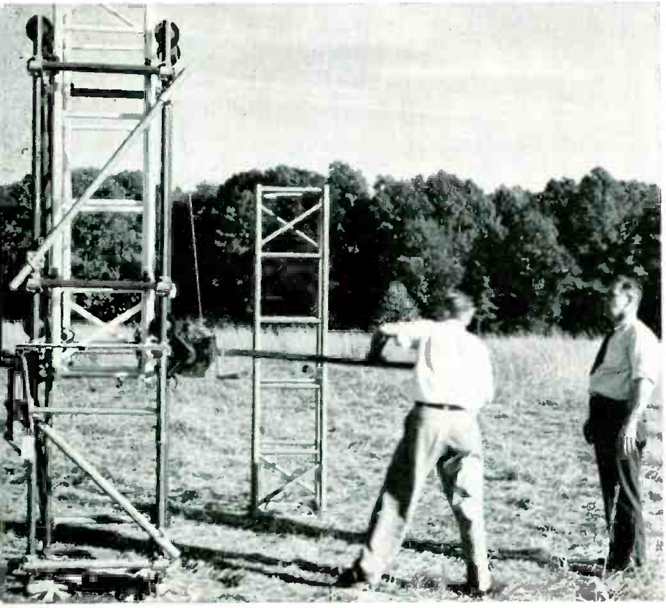
UNDERGROUND DISTRIBUTION WIRE

Among the more recent plant developments is this new UG distribution wire designed for burying in the ground. Perfected by the Laboratories and now used by a number of Bell companies, the wire consists of a pair of sixteen-gauge copper conductors covered with rubber insulation, over which is a braided steel wire armor. The outside jacket is of neoprene. The increased tensile strength of the wire results in fewer breaks and, with the armor acting as a shield against lightning, no separate shield wire is necessary. The armor and jacket provide additional protection against cutting and crushing during installation and in service. This new wire is used in place of open wire or cable in rural areas where soil conditions permit. It is also excellent in outdoor locations where tree interference exists. W. K. Oser of Outside Plant Development was the engineer on this project.



PORTABLE MICROWAVE TOWER

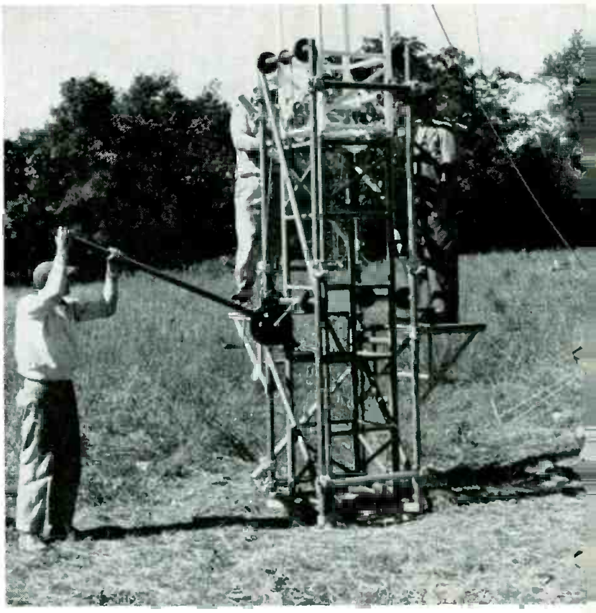
Since microwaves follow a line-of-sight path, one of the preliminaries to setting up a system is to assemble a set of topographic maps and pick out a series of suitable hill-tops. But there might be a steel silo or



With the tackle fastened to the bottom of the lowest section, and with a long lever on the winch handle, the whole tower is lifted. The method of placing each section in the hoisting yoke is shown on the cover of this issue

water tank right in line; and in the plains country there are no hills to give a view along the radio path. So, as a preliminary to laying out the Chicago-New York radio relay system, the Laboratories have developed a tower for quick erection and a microwave transmitter and measuring receiver to go with the tower. With this outfit, the path can be surveyed by radio waves.

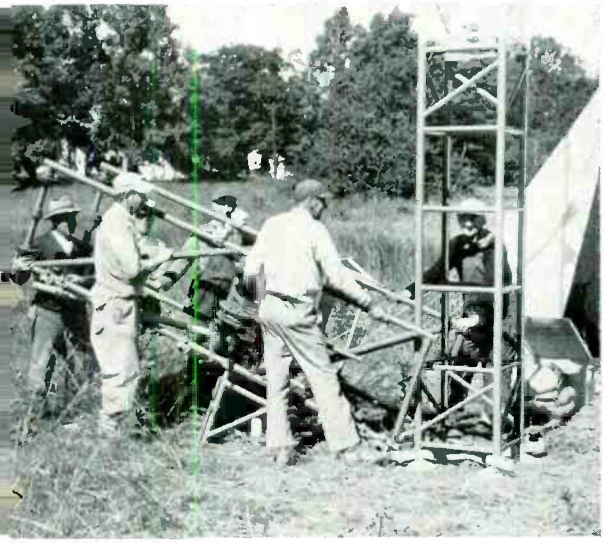
Noteworthy advantage of these towers over any heretofore built is that the erecting crew work entirely at, or very near, ground level; thus professional riggers are not required and the hazard of working far above ground is eliminated.



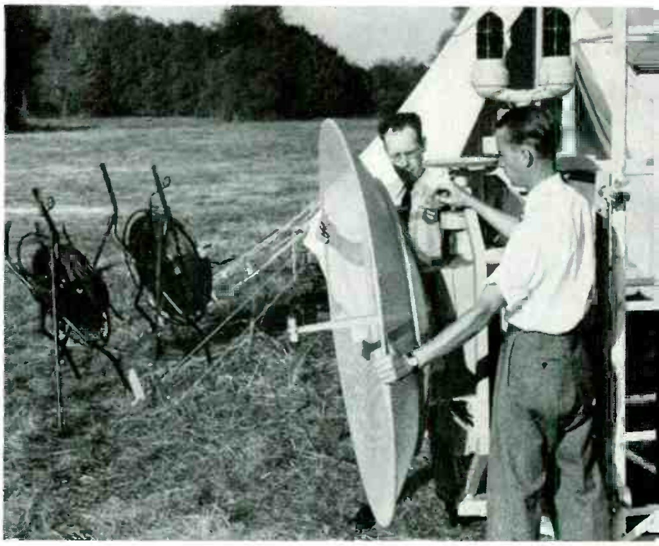
The tower is lowered onto the added section and bolted to it; tapered bushings in the ends of the pipes hold the two sections in alignment. As the tower goes up, additional guys are added every six sections

First step in putting up the tower is to level off a few square feet of firm soil, then lay down a base plate and set on it the erection frame seen in accompanying illustrations. Inside the frame is placed the top section of the tower. It carries a communication antenna and its lead-wire; a pair of pulleys carrying a loop of light steel cable, and four guy cables.

Probably the first section will be lifted



After the tower is high enough, the erection frame is removed



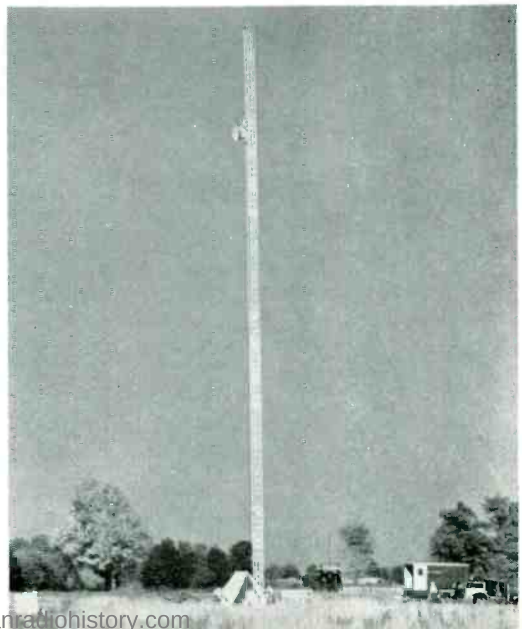
The receiver and its radiator are mounted on a carriage which rolls on either of two faces of the tower

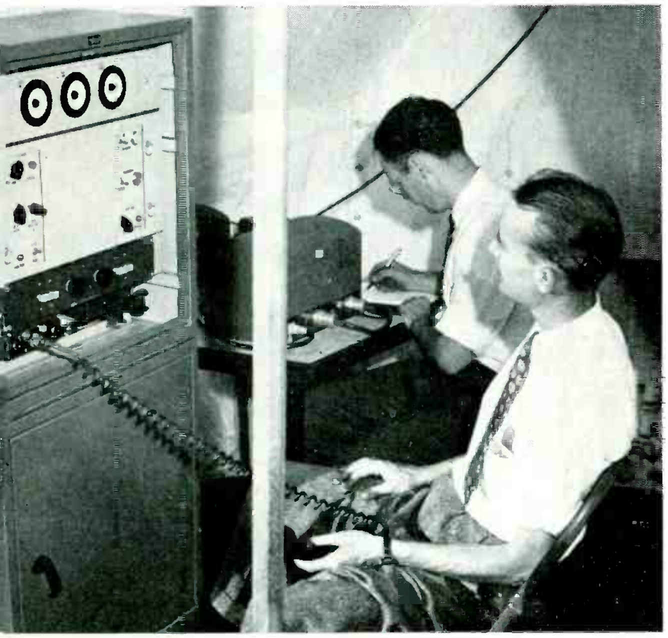
by hand, and the second section placed under it. But from then on, as shown in the illustration on the cover of this issue, a hoisting yoke is fastened to the bottom of each section and the whole tower is raised vertically upward. Guy anchors are placed, unless trees are available, at a distance from the tower suited to the final height, and a workman at each point tends a winch to pay out the guy cable as the top of the tower rises. When the tower has been lifted high enough, the erection frame is opened; and another section is put on the base plate. The tower is then lowered an inch or two until tapered bushings have engaged the ends of the four uprights; then the two sections are solidly bolted together and the hoisting yoke is shifted to the bottom in readiness for another lift.

As the tower goes up, additional guys are added every six sections (48 feet). When the desired height is reached—which may be as much as 200 feet—the erection frame is removed; a rolling carriage is put in

With all connections made, the receiver starts on its dizzy voyage. Left to right, G. H. Baker, G. M. Phillips and H. G. Fisher

The "dish" can be oriented in azimuth and elevation. Transmission is measured at various heights to determine a clear path





Microwave measuring equipment and antenna controls, left; on the table is the v.h.f. communication set

place on one side of the tower framework, and a hand-operated hoisting drum is attached. The microwave transmitter (or receiver) is attached to the carriage and two electrical cables are connected to it. With the winch, the carriage is raised while the two cables are being paid out from their reels. When the desired height is reached, the inboard ends of the cables, which have been stowed inside the reels, are unrolled and led to the apparatus shown in the illustration at the left.

Electrical equipment consists of a microwave oscillator with antenna at one end of the path to be surveyed, and a receiver-detector-meter set at the other end. To line up the transmitting and receiving antennas, each is provided with two motor drives; one can swing the "dish" through 180 degrees in azimuth and the other through 5 degrees in elevation. There is a two-way radio communication set similar to those used for mobile radio. Power for all equipment, including night lights for airplanes, comes from duplicate gasoline alternators at each end, which deliver 115-volt, 60-cycle, a-c.

The tower was designed by R. R. Andres and A. H. Lince of Transmission Equipment under the supervision of T. J. Grieser. The electrical system was designed by G. M. Phillips and G. H. Baker of Transmission Engineering under the supervision of J. M. Barstow.

High-frequency induction furnace in the Metallurgical Laboratory at Murray Hill. O. J. Barton is shown removing slag and cleaning out the crucible after pouring a heat in preparation for the next experimental melt

N. MONK
Radio
Transmission
Engineering

TELEPHONE SERVICE FOR TRAINS

On August 15, Bell System radio telephone service became available to passengers on certain trains of the Baltimore & Ohio and Pennsylvania Railroads operating between New York and Washington. This radio extension of telephone service—being operated only experimentally at the present time—has been made feasible by the recent installation of the urban mobile radio system* in many of the larger cities. The same mobile receivers and transmitters are used, and all calls pass through the mobile service operators in the city nearest the train when the call is made.

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

On the Baltimore & Ohio Railroad, the equipment is installed in the club car on the "Royal Blue," which makes one round trip between the above points daily. On the Pennsylvania Railroad, it is located in the club car on both the northbound and southbound "Congressional Limiteds." Since these cars return northward on the "President" and southward on the "Speaker," the service will be available on these trains also in the directions indicated, as well as on the "Congressional Limited" in both directions. In the vicinity of New York, calls are completed through the Newark mobile service operator. After the train passes out of range of the Newark station, the calls are handled through Philadelphia, Baltimore, or Washington as the train passes into the areas within the range of these stations. Since, at the time the service was inaugurated, no one radio frequency was used for urban mobile service at all four of these cities, each train is provided with two sets of radio equipment so that communication can be established on either of two channels as desired.

A small compartment or booth for the passenger is provided on the train to reduce room noise and insure privacy, as shown in Figure 1. It contains a wall type subscriber set and a writing shelf for the convenience of the user. An attendant provided by the railroad handles the calls

Fig. 1—William R. Triem, General Superintendent of Telegraph of the Pennsylvania Railroad, placing a call from the telephone booth on the lounge car "John Adams" with the recently installed mobile radio telephone apparatus

with the aid of the cabinet shown in Figure 2, which is called Control Unit B. On its face, this unit has a lock to prevent unauthorized use of the equipment, a key to select either of the two channels available, and a three-position switch to permit the attendant to talk to a mobile operator or to the occupant of the telephone booth, or to connect a call through to the booth. In addition, there are a number of supervisory lamps and buttons for turning the transmitter on and for signaling the booth. The relays required for the switching operations are mounted in Control Unit A, which is installed with the radio equipment.

Fig. 3—Train telephone operator, Miss Helen K. Reese, at the control point for the mobile radio telephone service in Pennsylvania lounge car "John Adams." At her right is the Control Unit B shown in Figure 2. The window just to the right of the handset mounting opens to the telephone booth on the other side of the wall

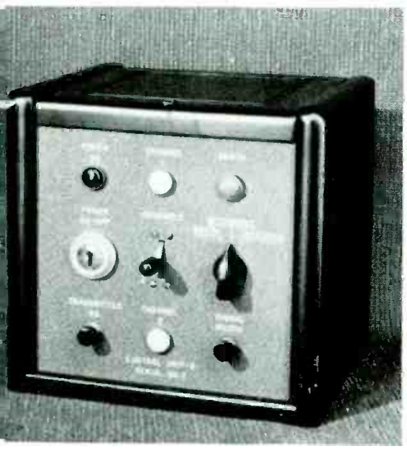
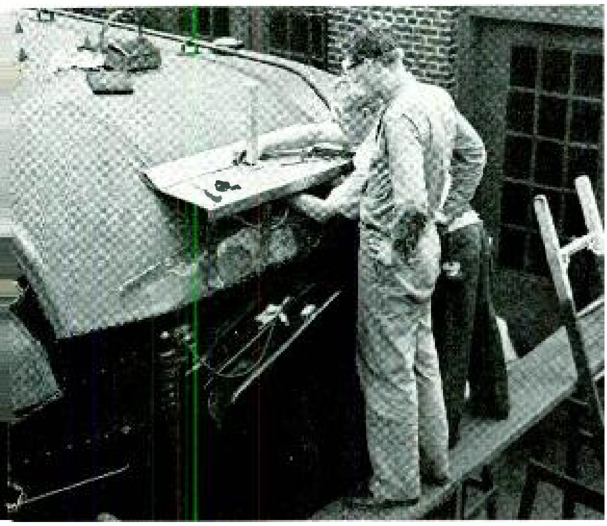


Fig. 2—Control Unit B used by the operator for mobile telephone service on railroad trains

Fig. 4—A. S. Hunt, Chief Engineer of Communications and Signals of the B. & O., talks over the attendant's telephone in the lounge car of the B. & O.'s "Royal Blue"

In the usual mobile system, the handset in the vehicle is equipped with a button which is pressed for talking and released for listening. This permits a single antenna to be used both for transmitting and receiving; the antenna is switched to either the transmitter or receiver by the action of the press-to-talk switch. Since only one person or a very few people use the equipment in each mobile installation, they soon get accustomed to operating the press-to-talk switch.

For train telephone service, on the other hand, those using the telephone will for the most part not be familiar with press-to-talk operation, and thus the equipment on the trains has been modified to permit the handset to be used in the ordinary way. This is accomplished by using two antennas—one at one end of the car for the transmitter, and one at the other end



'ig. 5—*Installing one of the antennas on the Pennsyl- ania Railroad lounge car "John Adams." J. L. Lindner, 'ell Telephone Laboratories, at the left, and G. E. 'oldner of The Diamond State Telephone Company*

for the receiver—and connecting a filter in the receiving path to provide a large loss to frequencies from the transmitting antenna. The filter consists of sections of coaxial conductor and operates in accordance with principles already described.*

Standard mobile 38C radio transmitters† and 38A radio receivers‡ operating from 12 volts d-c are employed on the trains, there being two transmitters and two receivers on each car. The 12-volt source in each installation is supplied by the railroad from a specially installed 12-volt storage battery. This battery is charged when not in use from the regular 32-volt car battery through suitable voltage dropping and regulating equipment. The 12-volt battery is connected to the radio equipment through a small power panel which contains a disconnect switch and fusing equipment. A large part of the design work for the circuits and equipment was carried on by H. S. Winbigler, while the two control units together with the power panel and coaxial filter previously mentioned were produced in the Graybar-Varick Model Shop under the direct supervision of C. P. Bartgis.

A block schematic of the arrangement employed in each car is shown in Figure 6. The radio sets, filter, power panel, and Control Unit A are mounted together. On the Baltimore & Ohio Railroad, these units are contained in a built-in compart-

*Record, *December*, 1937, *page* 118. †*September*, 1947, *page* 330. ‡*October*, 1947, *page* 376.

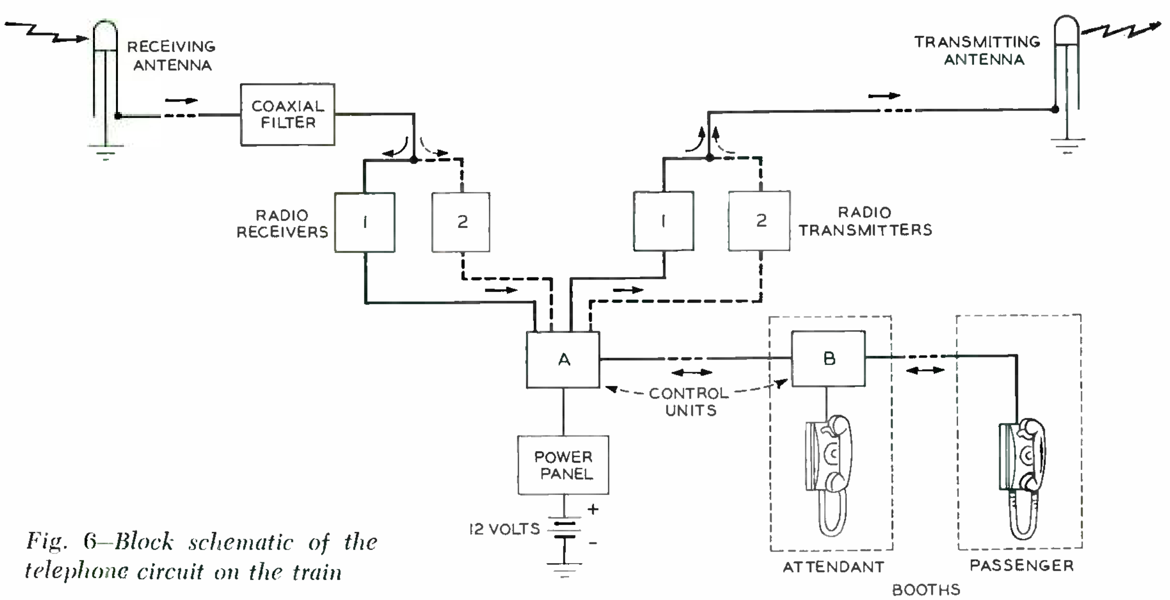


Fig. 6—Block schematic of the telephone circuit on the train

ment next to the passenger booth. On the Pennsylvania, a special equipment cabinet is mounted in the interior of the car near the attendant's position, as shown in Figure 7.

The operation of the telephone service on the Baltimore & Ohio Railroad is under the supervision of The Chesapeake and Potomac Telephone Company of Baltimore, while that on the Pennsylvania is handled by The Bell Telephone Company of Pennsylvania. Since the trains lie over at night in yards outside the territories of these companies, maintenance assistance is being furnished by several other Bell System operating companies.

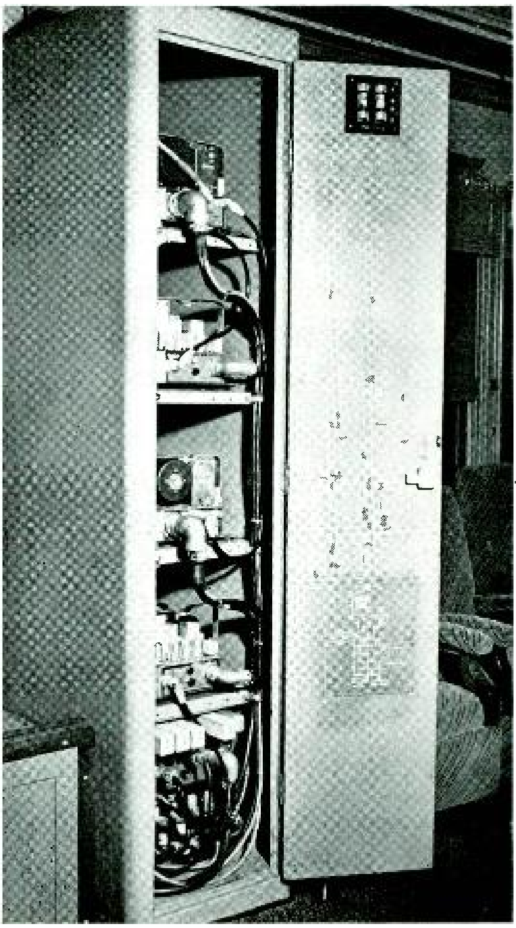
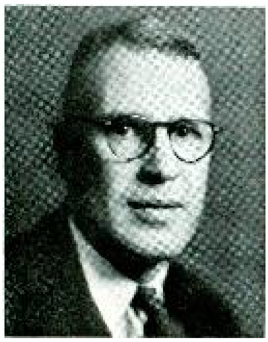


Fig. 7—Transmitters, receivers, and power supply for the mobile telephone equipment on Pennsylvania Railroad trains are installed in a single cabinet

THE AUTHOR: Newton Monk interrupted his college work at Harvard to spend two years with the Signal Corps during World War I. After graduating with an A.B. degree in 1920, he entered the Harvard Engineering School, from which he received the B.S. degree in Communication Engineering in 1922. He then joined the Department of Development and Research of the American Telephone and Telegraph Company, where his early work was concerned with interference prevention investigations. Later he became interested in carrier development, and continued this work after transferring to the Laboratories in 1934. Just prior to World War II, he devoted most of his time to applying carrier equipment to railroad communication systems. During World War II he was active in the development of voice-frequency and carrier systems for the Signal Corps. Since the war, he has been in charge of a group developing radio for railroads and airplanes.



E. S. WILLIS
Transmission
Networks
Engineering

A NEW CRYSTAL CHANNEL FILTER

Since their development in the years before the war, broadband carrier systems have come steadily into more extensive use, and modifications have been made in their circuits and apparatus as advances in the art have made them desirable. One such advance was the wire-supported, hermetically sealed crystal* unit replacing the previous clamp-type construction. These new units are not only more economical in the space they require, but also they can be more precisely adjusted for effective inductance and resonant frequency. It was these features that offered an opportunity to develop a new channel filter† of reduced size that could be produced in relatively large quantities more economically than the original design. These new 219-type channel filters, such as shown in Figure 1, require less than two-thirds as much mounting space as the earlier 75-type filters.

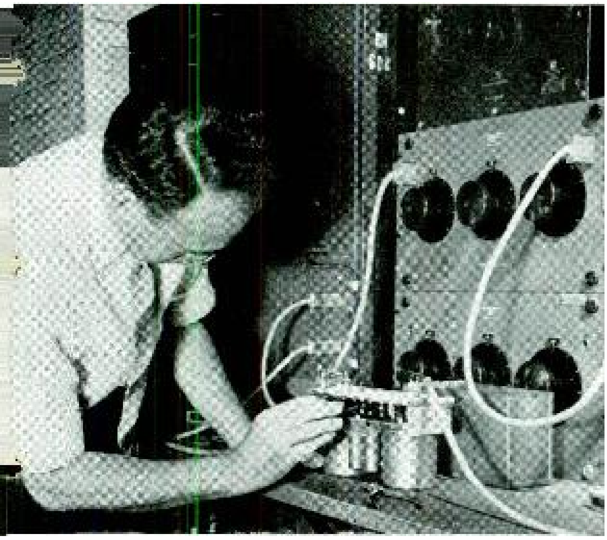
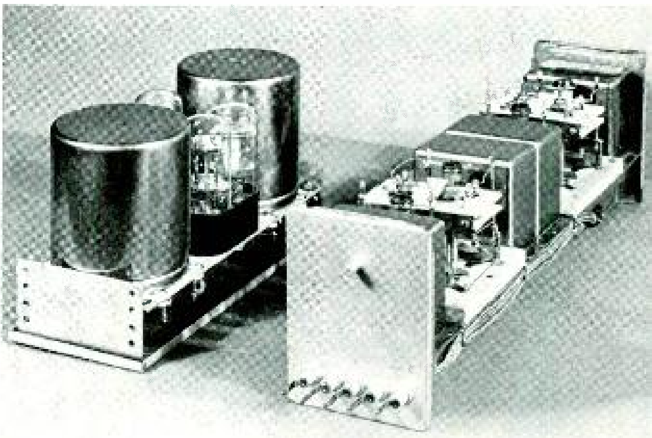


Fig. 1—The author making adjustments of one of the new filters

More compact than the earlier design, the configuration of the new filter also requires fewer coils and capacitors. This type of filter is critical of adjustment, and the desired performance is realized only if the electrical characteristics of the component elements are maintained close to their theoretical values. Hence, it is only with the development of the more precise wire-supported crystal unit replacing the clamp-type crystal unit that it has been possible to utilize this type of filter configuration. The new filter consists of only one lattice-type section in contrast to two in the earlier

Fig. 2—The new 219-type filter, at the left, requires only two-thirds the mounting space of the former 75-type filter shown at the right



*Record, *April,* 1945, *pages* 140 *to* 144.
†Record, *October,* 1938, *pages* 62 *to* 70.

design. The four coils used in the old filter are replaced by two less expensive coils in the new design, and four of the capacitors are omitted. These differences, and the resulting decrease in size, are evident in Figure 2, where the new filter is at the left and the old one at the right.

In the 75-type filter there was one crystal connected electrically in each of the four branches of each filter section, and thus eight crystals in all. The two crystals in the series branches of one section, however, had the same resonant frequency. This was

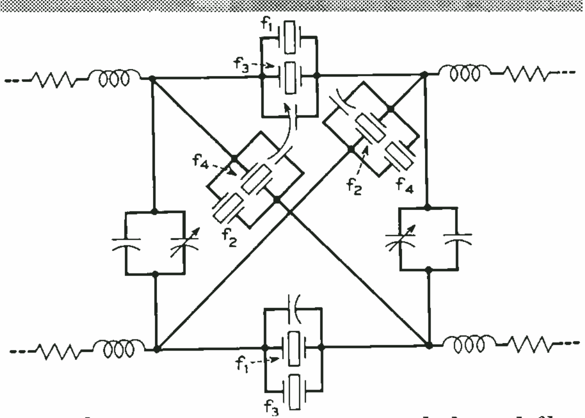
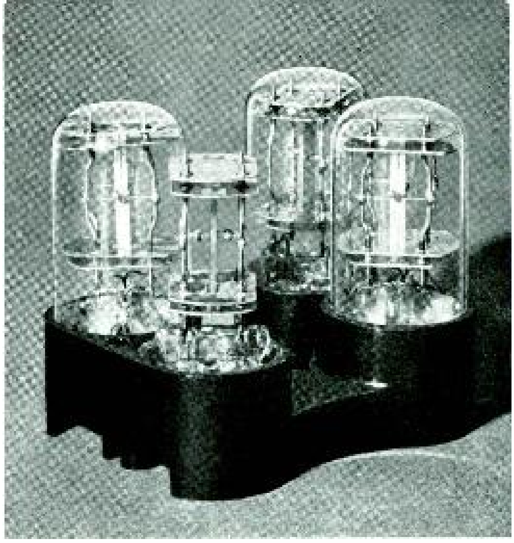
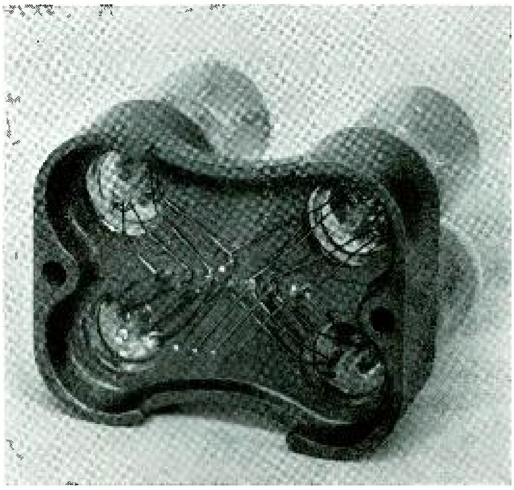


Fig. 3—Schematic of the 219-type crystal channel filter

also true of the diagonal branches of the same section, but the series branch resonance differed from the diagonal branch resonance, and the resonances for the corresponding arms of the two sections differed. Four resonant frequencies were thus required for the two sections. Since the coating on each side of the crystal plate was divided into two parts, and thus each plate became electrically two crystals vibrating in unison, only four plates were required in each filter to provide the eight crystals required in the electrical design. Likewise, the new filter also employs eight crystals with four resonant frequencies. In effect, it incorporates the two lattice sections into one by connecting two crystals in parallel in each of the four branches, as shown in Figure 3. The two crystals of each sealed crystal unit are connected in different lattice branches, as indicated by the markings f_1, f_2, f_3 and f_4 of Figure 3, where





Figs. 4 and 5—The four glass-sealed crystal units are cemented into a rectangular molded base. The eight elements of these units forming a filter are interconnected in the base to two input and two output leads

the two crystals of the same unit are separated to bring them into the branches of the filter into which they are connected.

The four glass-sealed crystal units that provide the basis of the lattice structure are mounted at the corners of a rectangular molded base, as shown in Figure 4. Four leads from each unit pass through the base and are interconnected, as shown in Figure 5. In Figure 6, where the same frequency markings are used as in Figure 3, the interconnections are shown schematically. Two input and two output leads are brought out from the interconnected points. The molded base of the crystal unit is fastened, in turn, to one side of a metal plate forming the chassis of the filter, as shown in Figure 7.

On the other side of the plate are mounted the capacitors and resistors associated with the crystal units. As will be noticed from Figure 3, there are three adjustable capacitors: a double capacitor adjusting the capacitances in one series and one diagonal branch differentially, and two single capacitors—one at the input and the other at the output of the lattice. These are the three elements mounted on the upright base, as evident in Figure 7. The fixed capacitors and the resistors associated with the coils are mounted on the bottom of the chassis.

The inductances shown at the ends of the filter in Figure 3 are air-core coils mounted in the cylindrical copper containers, evident in Figure 7. The high coil-impedance called for by the filter design requires that the parasitic capacitances between the windings, and between the windings and case, be kept as small as possible. This is accomplished by winding the coils in four sections, as shown in Figure 8.

A reactance-frequency diagram for the filter is shown in Figure 9, where the reactancé of the series branches is shown solid and that for the diagonal branches, dashed. The pass-band for the filter spans the region where the reactances of the series and diagonal branches are of opposite sign, which is indicated by the heavy line along the axis of zero reactance.

A lattice-type filter section is a "bridge" circuit, as indicated in Figure 10, and when the reactances of all branches are alike, both in magnitude and sign, the bridge is balanced, and no energy from the input gets through to the load. Over the pass-band this balance never exists, as evident from Figure 11, but beyond the pass-band it exists whenever the reactance of the series branches equals that of the diagonal branches in magnitude. In the attenuating region, the reactances are always alike in sign, as evident from Figure 9. In this latter diagram, the series and diagonal branch reactances are shown equal except for a short distance just beyond the pass-band, but if the curves had been drawn to a larger scale, the two reactances would be seen to cross and recross each other—never departing very much, but exactly alike only at isolated points. At each crossing point there is a peak of attenuation due to balance of the bridge circuit, while between peaks the attenuation depends on the separation of the curves of reactance for the series and diagonal branches, the greater the separation, the lower the attenuation.

Very precise adjustment of the induc-

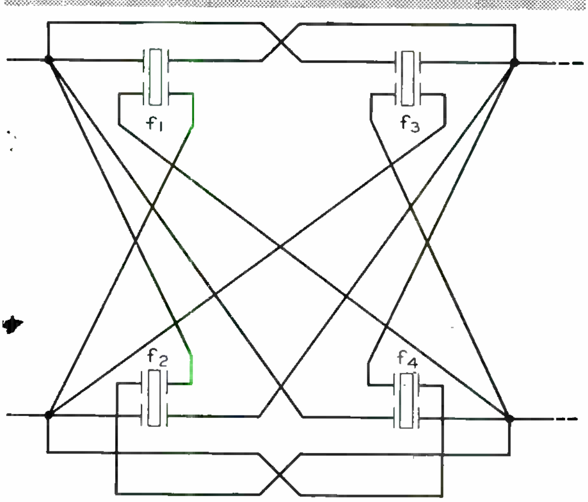


Fig. 6—Interconnections for the eight elements of the four crystal units incorporated in the filter. Frequency markings are the same as in Figure 3

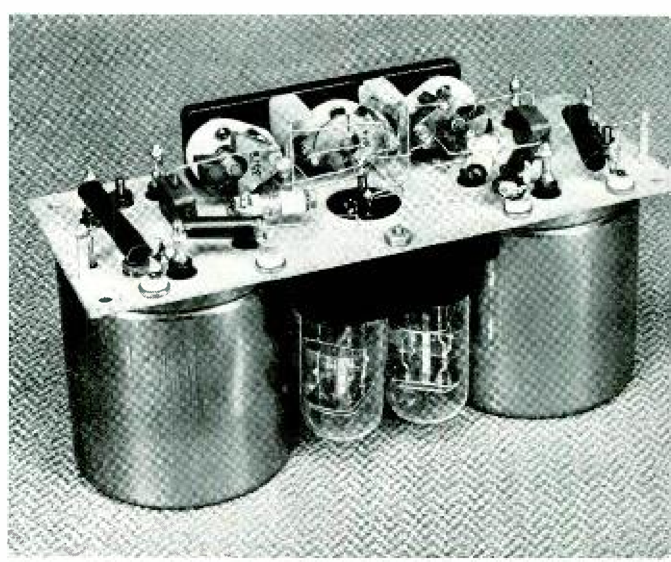


Fig. 7—The 219-type filter showing capacitors and resistors associated with the crystals and coils of the filter. The coils for the input and output of the filter are in the cans at each side of the crystal units

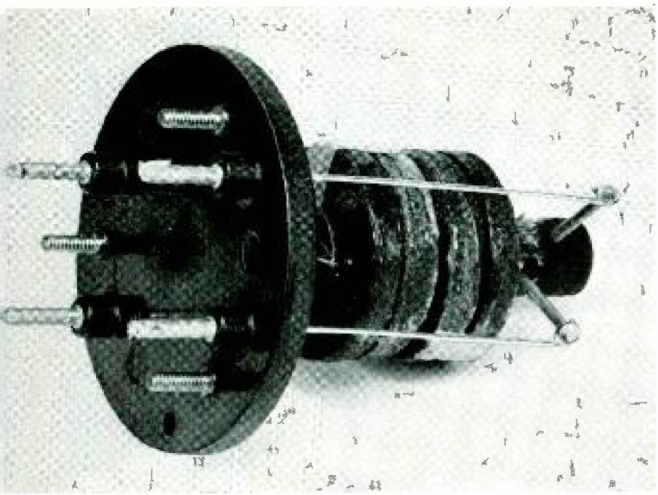


Fig. 8—To reduce parasitic capacitances, the air-core coils are wound in four sections

tances and resonant frequencies of the crystal units is required to accurately control the location of these crossings and the separations of the two reactance curves. The required accuracy could not be attained with the clamp-type crystal units; hence, it was not until the wire-supported crystal unit was developed that this compact type filter design could be utilized.

In referring to the "bridge" balance of the four reactance branches, only reactance was mentioned because the arms are predominantly reactive. Associated with each of these reactances, however, there is some dissipation, and to obtain a high peak loss in the filter at a definite frequency, there must be a balance of the conductances of these four branches as well as of their reactances. Conductance unbalance of these branches in the attenuating region of the filter will degrade filter performance to the same extent as reactance unbalances. Whereas the tuning of the differential condenser balances these reactances at one frequency, no means is provided for balancing the conductance component. Extreme care must be exercised, therefore, to keep these four branches alike. Even though the crystal units are surrounded by dry air and enclosed in sealed glass containers, it is still necessary to protect the filter against atmospheric conditions of high relative humidity. A trace of salt or other contamination across the terminals in the molded base of

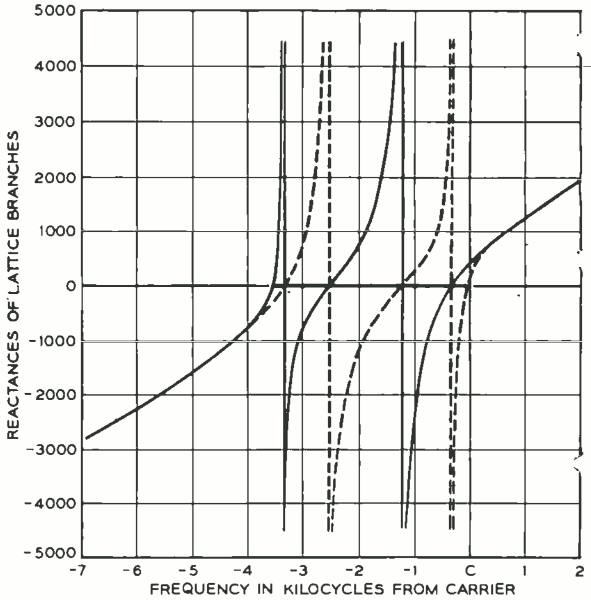


Fig. 9—Reactance-frequency characteristic for the 219-type crystal channel filter

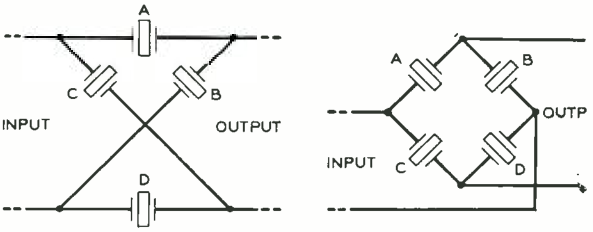


Fig. 10—The four branches of a lattice-type filter, shown at the left, form a bridge circuit as indicated at the right

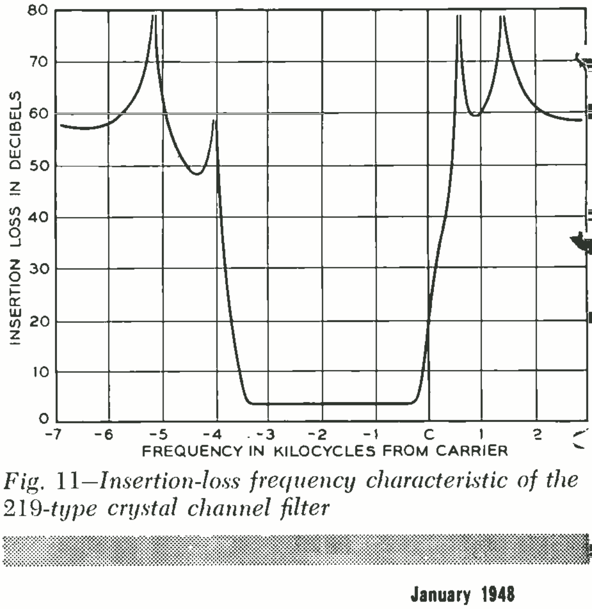
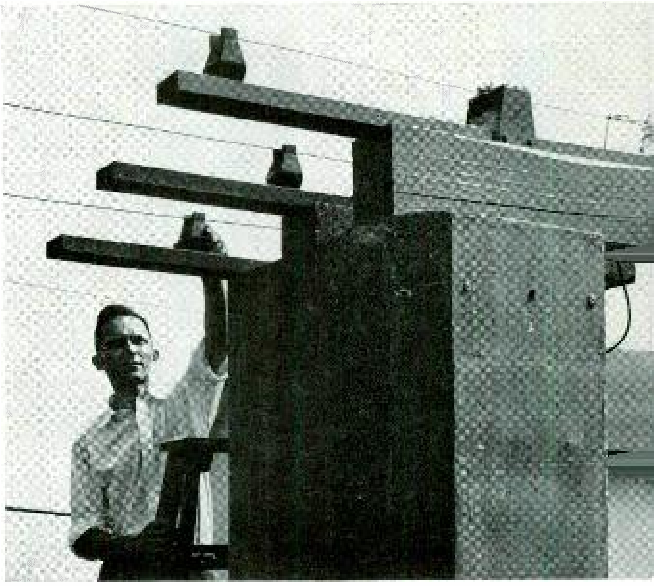


Fig. 11—Insertion-loss frequency characteristic of the 219-type crystal channel filter

the crystal units or across the ceramic in the air capacitors will make the insulation resistance highly sensitive to the moisture in the adjacent air and may result in large conductance unbalances in the lattice. To guard against this condition, only homogeneous low-loss materials are used for the insulating materials within the lattice structure. The insulating parts assembled in the filter are kept clean, and the filters are adjusted, tested and sealed hermetically when surrounded by an atmosphere in which the relative humidity is not greater than 40 per cent.

The 219-type crystal channel filter is the first commercial application of lattice-type filter circuits in which more than one crystal unit is used in each branch of the lattice. The economies it permits in space, material and labor are very desirable in view of the increasing use of broadband carrier systems in the telephone plant.

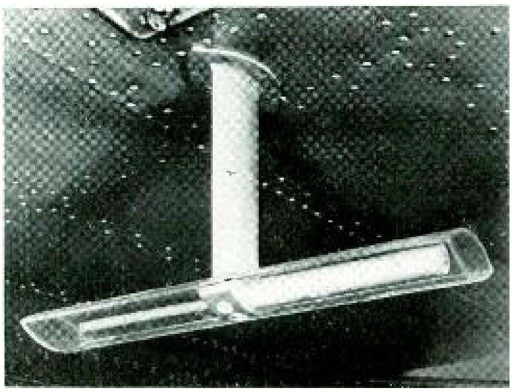
THE AUTHOR: E. S. WILLIS joined the Technical Staff of the Laboratories in July, 1927, after receiving the degree of M.A. from the University of Missouri. Since then he has been engaged in the development of various types of transmission networks, such as electric wave filters and equalizers. He had an active part in the first use of quartz crystal elements as applied to various types of filter circuits. In the past few years he has been chiefly engaged with problems associated with the crystal channel filter for broadband carrier systems. Recently, this work has involved the application of synthetic crystal units to filter circuits.



At the Chester field laboratory, J. H. Shuhart is preparing a test of various line-wire materials to study their fatigue properties under vibrations induced by winds

HISTORIC FIRSTS: RADIO ALTIMETER

While struggling with the problems of long-distance telephone lines during the early teen-age years of this century, Bell System engineers were considerably hampered by the reflection of electrical waves at impedance irregularities along the line. These electrical echoes proved serious obstacles, particularly to the application of repeaters, and for a long time limited their use in circuits. The objectionable characteristics of echoes on telephone lines was intimately associated with the distance between the points of origin and reflection. In fact, the effect of the echoes in producing a "humpy" impedance-frequency curve had been used by telephone engineers to measure this distance, and thus locate the position along the line of a defective loading coil or other "irregularity."



One of the antennas used with the terrain clearance indicator. These antennas were attached to the under side of the plane as shown —one to transmit and one to receive

The work that had been carried on, and the precision and beauty of the reflection phenomena, suggested to Lloyd Espenschied that electrical reflections had merit in their own right, and that they could be put to more positive use. One of the early applications that occurred to him was as a warning and safety system for railways. His proposal was to send an electric wave along the track ahead of the locomotive. A broken rail or another train would form an impedance irregularity that would reflect the wave, and the arrival of the reflected wave at the locomotive would not only give warning of danger ahead, but would permit the distance to the danger to be determined and the train automatically controlled. A patent on such a system was applied for in 1919, and patent No. 1,517,549 was granted in 1924. Among the early ideas entertained at the time was that of the use of a frequency-swing oscillator and beat-frequency reception for indicating the distance — principles later used in the radio altimeter.

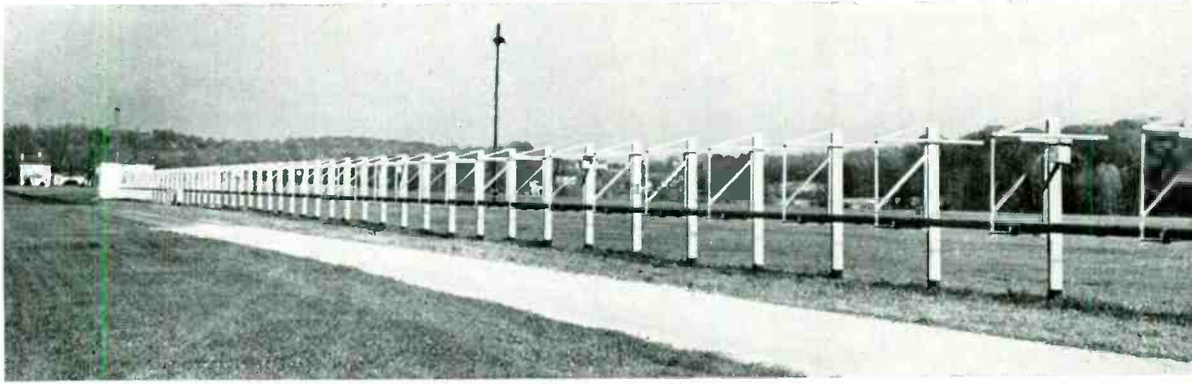
A number of allied and modified systems were devised in the immediately following years, but meanwhile the airplane was rapidly assuming an important position in the transportation field, and an electrical reflection system that would give an airplane a continuous indication of its height above ground seemed highly desirable. Barometer readings, the only indications of distance available for this purpose heretofore, gave the height above sea level, and thus were of little use when the elevation of the land beneath the plane was increasing rapidly, as when the plane was approaching a chain of mountains or a city with tall buildings. Espenschied therefore proposed an electrical reflecting system for use by airplanes using radio instead of rail transmission. At that time, however, 1926, a really practical terrain clearance indicator could not be built, largely because suitable radio instrumentalities were not available. It was felt that vacuum tubes capable of operating at frequencies some fifty times higher than existing commercial tubes could handle would be required before a satisfactory system could be built.

Although altitude determination was considered at various times following Espenschied's first suggestion, it was not until 1930 that patents were applied for, and it was not until June, 1936, that patents 2,045,071 and 2,045,072 were granted to Espenschied for an airplane radio altimeter. Considerable commercial interest was aroused, and in the following year a group of Laboratories' engineers headed by R. C. Newhouse undertook to develop commercial apparatus for Western Electric.

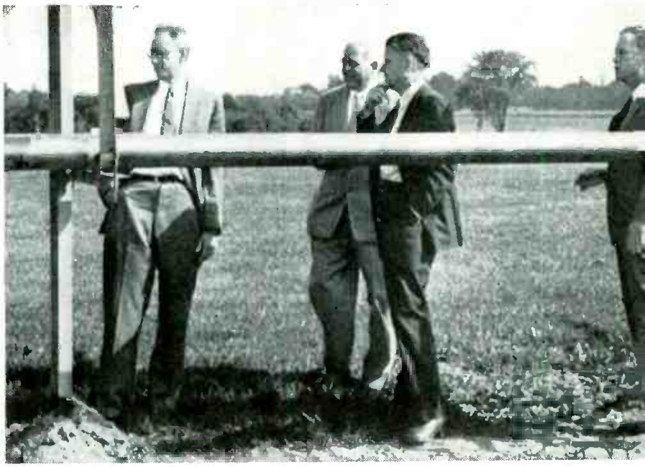
In 1938, a number of demonstration flights were made, culminating on October 8 and 9, 1938, in a joint demonstration* for the press by the Laboratories, the Western Electric Company, and the United Airlines. During one of the early flights, it was noticed that in addition to height above ground, variations in the wave pattern on an oscillograph gave indications of the character of the reflecting surface beneath. This suggested a still wider field of use, and proposals were made that similar apparatus, designed to project the beam ahead, could be used to give warning of approaching aircraft, mountains, or other obstructions. Experiments of this nature were carried out this same year in New York harbor. In the avalanche of war developments that shortly followed, these and other suggestions were used by the Laboratories in their many radar projects.

*Record, *November*, 1938, *page* 84.

NEW WAVEGUIDE TUBE AT HOLMDEL



To study microwave propagation through circular waveguides, it is necessary to begin with a waveguide which is as nearly straight as possible. So Radio Research constructed this copper tube, shown above, 1,200 feet in length, on supports which permit its accurate alignment. At the lower left, A. P. King closes line short-circuiting switch which disconnects the line beyond the switch. The other view shows R. Bown, H. T. Friis, M. J. Kelly and A. B. Clark inspecting line



AUTOMATIC SWITCHING FOR PRIVATE-LINE TELETYPEWRITER SERVICE

W. M. BACON
Telegraph Development

In the years before the war, a number of private-line teletypewriter systems had grown to considerable size—some of them spanning many states or even the entire country. A case in point is the Republic Steel Corporation. Its main office is at Cleveland, where it also operates steel mills, but it has other plants and offices extending from Boston to San Francisco and from Buffalo and Detroit to Birmingham and Houston. Since about 1925, these offices and mills had been linked for teletypewriter communication through a system of private lines, which in more recent years had been augmented by TWX service.* Switching was all done manually, however. A message from Chicago to New York, for example, would first go to an operator in Cleveland who would establish manually a connection to New York. Twenty-six private-line teletypewriter circuits were in use, and traffic over these circuits was extended by TWX service to points all over this country.

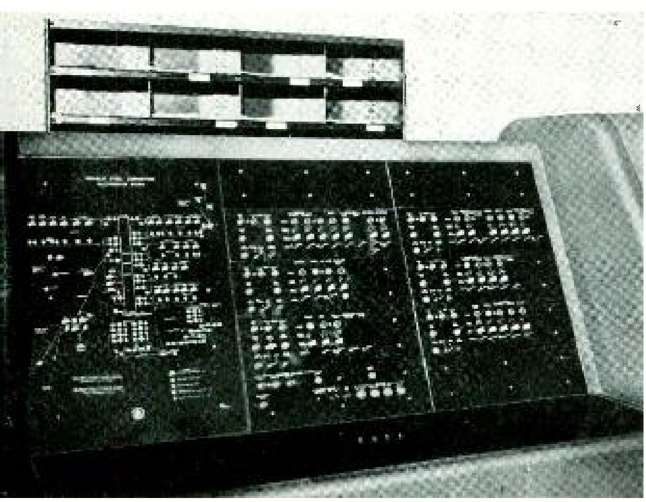


Fig. 1—The control panel for the private-line teletypewriter network at the Cleveland office of the Republic Steel Corporation

About 1940, it was felt that faster and more economical service could be secured by the use of automatic switching, and after an extensive analysis by the Bell System, the 81B1 teletypewriter private-line switching system was decided upon. The original installation was completed in October, 1941, just in time to handle the rush of war business. Besides greatly increasing the speed of service, this new system made it possible to reduce the number of private-line teletypewriter circuits from twenty-six to thirteen. Seven of these thirteen are connected to the automatic system, and each of the circuits serves a number of receiving and sending stations.

In fundamental principles, this type of automatic private-wire teletypewriter switching differs basically from telephone switching. With the latter, the complete communication path between the originating and called stations must be idle before a connection can be established and the transmission of intelligence begun. When the paths are not idle, repeated time-absorbing attempts using expensive facilities must be made to reach the called station. In the teletypewriter system, however, once a message has been perforated in a tape and this tape placed in a transmitter, no further action by the sender is required for the transmission of the message. The sender's transmitter sends the message to the switching center as soon as the path to the center is available. At the switching center, facilities are provided to receive and sort the messages and to store them until the outgoing path to the called party is free. In this manner, messages are carried as far on their way to the ultimate receiver

*Record, *September,* 1936, *page* 7; *October,* 1937, *page* 34.

as idle facilities permit before they are delayed to wait for a free path.

At the switching point, Cleveland for the Republic Steel Corporation, a group of crossbar switches* is provided that has incoming circuits connected to their horizontals and outgoing circuits to their verticals, so that any two circuits may be connected together. Director and sequence circuits, consisting chiefly of relays, control the operation of the crossbar switches. Local teletypewriter transmitters and receivers are associated with the crossbar switches to handle messages originating or terminating at the switching office and for certain supervisory services, but the major unit of the switching system is the 14-D reperforator transmitter, which will be described in more detail in a subsequent article. In brief, this unit consists of a combined typing reperforator and a transmitter. The former perforates a tape in accordance with the received signals and at the same time prints the message on the tape, while the latter receives the tape punched by the receiver and retransmits the message, including the last character punched. Between the receiver and transmitter are facilities for storing tape.

Incoming messages for passage through the switching system arrive at one of these machines, and a tape is punched as a message comes in. The first two characters of the message will be a code indicating the ultimate destination, and the last two characters indicate a disconnect. The transmitter forwards this code to the control circuit of the crossbar switches, pauses until it has been notified that the connection has been made, and then transmits the message.

Fig. 2—General view of Republic's teletypewriter operating room

Each outgoing circuit has two verticals on the crossbar switches, and each vertical is connected to the receiving side of a reperforator transmitter. If one of these is receiving, a message from the incoming side of the office will be connected to the other, which will punch a tape and store it. This makes that message available for transmission as soon as the outgoing line is free, and permits the incoming line to send its following messages to other outgoing lines that may be ready to accept them, thus speeding up trans-office transmission. During traffic peaks a back load of messages may accumulate awaiting transmission, and these will be sent out in approximately the order in which they were received as the outgoing line becomes available, thus keeping the outgoing lines in use continuously. Each reperforator transmitter and its mounting arrangement can store about seventy-five feet of tape, which corresponds to about 1,500 words. Since the ordinary messages and orders run from fifty to three hundred words, ample storage is thus provided to carry the system over any ordinary peaks of load.

Besides its reperforator transmitter, each incoming circuit has a receiving teletypewriter that can be connected to the circuit in place of the reperforator transmitter

*Record, *July,* 1937, *page* 338.

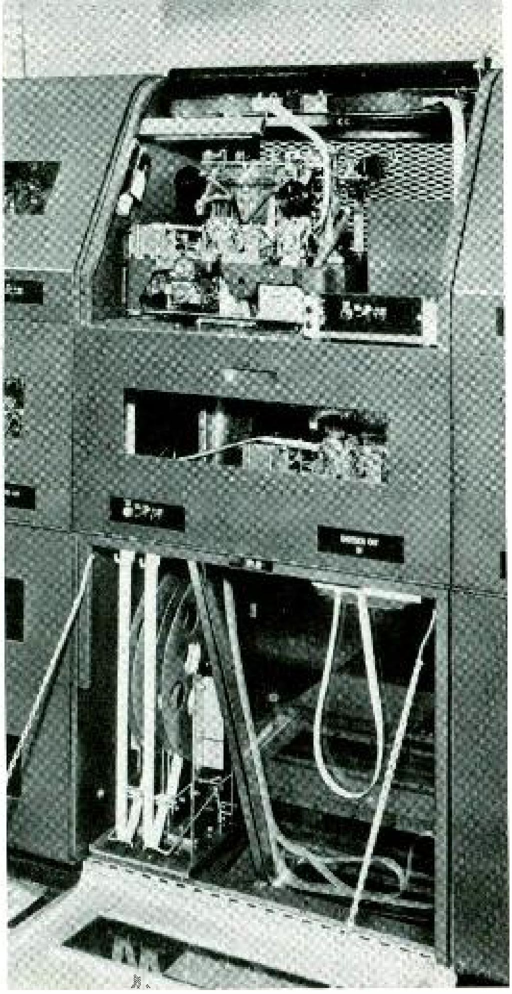


Fig. 3—Each cabinet houses two reperforator transmitters with tape storage space in the lower section

when the message is for the local office. When the reperforator transmitter recognizes by the code of a message that it is for that office, it operates relays to disconnect itself from the circuit and to connect in the receiving teletypewriter.

The transmitters at the distant stations are under control of the switching office, which automatically starts those on any given line in turn by start patterns of teletypewriter characters sent from the switching office. Arrangements are also provided to start these transmitters by the manual operation of keys at the switching office.

One of the fundamental principles of this type of teletypewriter switching is that no message shall be lost or delayed more than a few minutes. Provisions are made, therefore, for taking care of such errors as incorrect or missing switching codes that otherwise might seriously delay the delivery of a message. Whenever a director circuit detects an incorrect code, that is, one for which there is no station, it sends the message to an intercept circuit. This circuit passes the message to a typing reperforator near a supervisor's desk. The supervisor determines the correct destination, either from the contents of the message or by questioning the sender. She then places the proper code at the head of the tape and starts it again on its way.

There are occasionally times when a particular plant or office, perhaps because of holidays or other such circumstances, is not able to receive messages. To take care of such situations, keys at the control board may be operated to permit messages to any station on an outgoing circuit to be directed to a willful intercept circuit. This includes one or more reperforator transmitters which will store all messages received until they can be transmitted to their destination. When this time comes, the messages are automatically transmitted through the crossbar switches in the usual manner.

The control panel from which the willful intercept is controlled is the nerve center for the entire system. It has lamps to indicate what machines are sending, what circuits are busy or idle, and all the many things that those responsible for the operation of the system should know. From here also is controlled the order in which the various stations on a single circuit are allowed to transmit. The control panel for the Cleveland office of Republic Steel is shown in Figure 1.

A general view of the teletypewriter operating room in Cleveland is shown in Figure 2. In the left foreground are the receiving teletypewriters that receive messages for the Cleveland office. To the right of these are machine cabinets containing the reperforator transmitters on the receiving circuits. As shown in Figure 3, each cabinet has two reperforator transmitters with storage spaces for their tapes. Next to the right is the control panel and then the reperforator transmitters on the outgoing circuits. In the cabinets at the rear are the crossbar switches and the various relay control circuits. At the right are order writing and originating machines where messages from

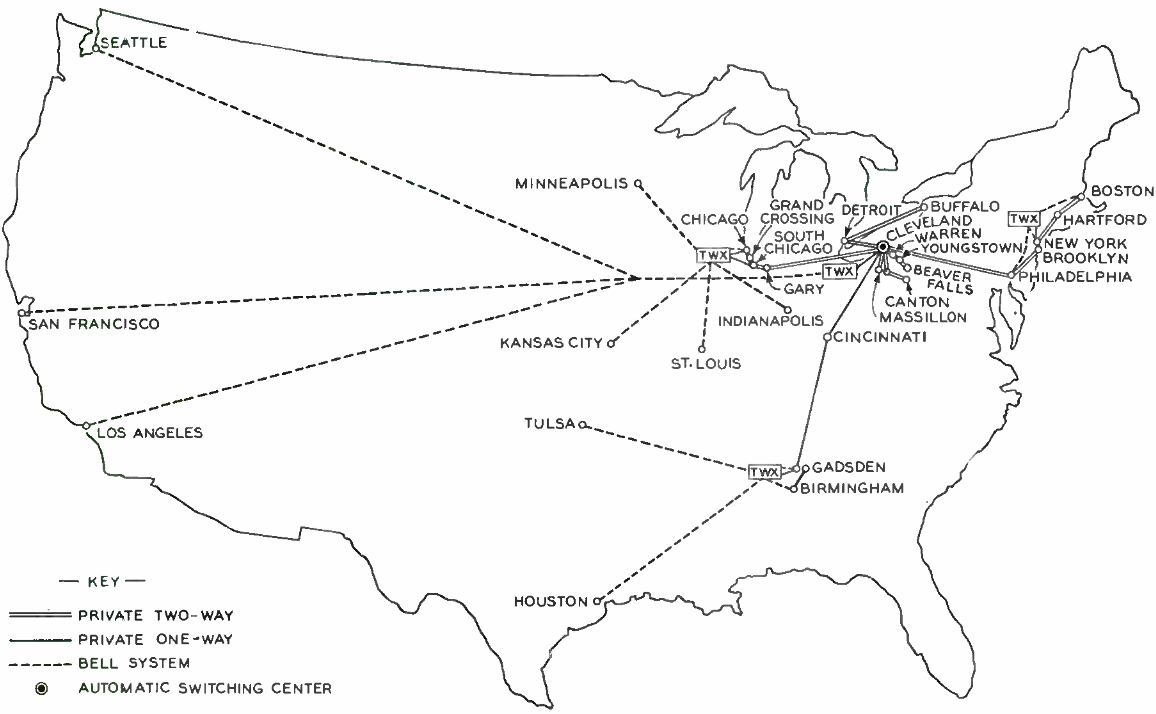


Fig. 4—Republic Steel Corporation's private-line teletypewriter network. It consists of six main duplex circuits and a single circuit to Gadsden, Alabama

the Cleveland office are originated. The supervisor's desk where the intercepted messages are handled is at the rear of this group just in front of the relay cabinets.

The complete teletypewriter network of the Republic Steel Corporation is shown in Figure 4. There are six main duplex circuits, each with a number of stations connected to it and one single circuit to Gadsden, Ala. At Cleveland, Chicago, New York, and Gadsden, the network is associated with the Bell System teletypewriter service, and messages to offices not on their private-line network are transmitted over the TWX.

THE AUTHOR: W. M. Bacon, after graduating with the E.E. degree from Cornell in 1930, joined the D & R and was concerned with teletypewriter development problems. This work was continued with the Laboratories telegraph facilities group after the 1934 consolidation, and has involved maintenance, repair, and installation methods and procedures as applied to teletypewriters. From 1938 to the present time, he has been engaged in the development of private-wire teletypewriter systems, including full automatic and manual switching systems. During the war years he was engaged in developing teletypewriter cipher arrangements for the Armed Forces.

WAVEGUIDE HYBRIDS

W. A. TYRRELL
Waveguide Research

In the past fifteen years, the waveguide has been developed from an electrical curiosity to an important medium for microwave transmission. Progress was especially rapid during the war years, since many of the most important developments in radar would have been virtually impossible without waveguides. It is now possible to judge with some perspective the rôle that waveguides will play in communications developments of the near future. Hollow-pipe guides do not assume a thoroughly practical form until the wavelength is shorter than about thirty centimeters. At this upper limit, the waveguide has supplanted coaxial cable in some instances. For shorter wavelengths, it becomes increasingly attractive, so that at ten centimeters it is the preferred medium for the efficient, shielded transmission of wave power, and at three centimeters it is almost exclusively used.

Although the earliest work emphasized waveguides as a form of transmission line for radio waves, it was apparent from the outset that waveguide structures would be required also to serve as numerous basic electrical components. At low frequencies, these components include such elements as coils, capacitors, resistors, transformers, relays, and switches. It was soon found that waveguide counterparts of these low-frequency elements could be constructed to operate in the microwave region. To the uninitiated, the electrical behavior and physical form of these new components appear novel and even revolutionary.

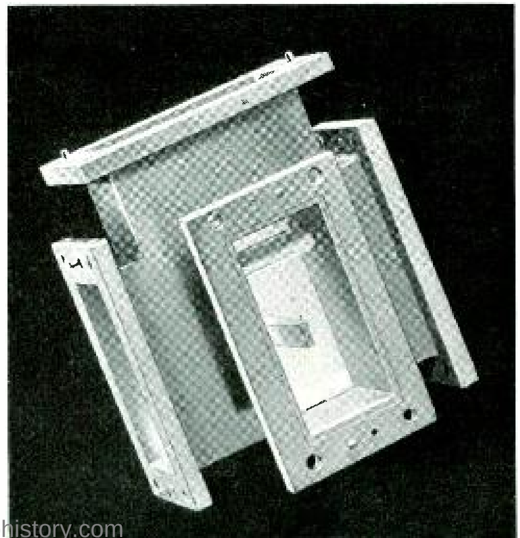
The investigation of waveguide transmission and of related circuit elements, as carried on by Dr. G. C. Southworth and his associates, opened up vistas of a radically new communications art for the Bell System. Expanding effort in microwave research and development is now bringing about a reduction to practice. The engineering of waveguide components, for example, is already sufficiently far advanced to permit construction of a microwave circuit between New York and Boston in a manner only dreamed of ten years ago.

One of the waveguide components which is finding a wide variety of uses is the four-arm junction shown in Figures 1 and 2. If wave power is sent into this junction from the ARM S, Figure 2, half of the power flows into each of the ARM 1 and ARM 2, with no power appearing in the ARM P. Conversely, if waves are sent into the junction from the ARM P, the power is again equally divided between ARM 1 and ARM 2, with none flowing into the ARM S. Thus, ARM S and ARM P are balanced with respect to each other, provided ARM 1 and ARM 2 are terminated in a symmetrical manner. Since the junction provides balance reminiscent of the familiar hybrid coil, it is called a hybrid junction.*

The features just described, depending upon the combination of geometrical symmetry with the polarization properties of rectangular waveguide, are inherent in the

*The term "Magic Tee," which has also been applied to this construction, is felt to be a misnomer.

Fig. 1—One form of waveguide hybrid



junction by itself. An important refinement is realized, however, when reactive tuning, as exemplified by the metal post and rod in Figure 2, is associated with the junction. These added elements improve the impedance match of the junction to each of the four arms, and thereby automatically bring about a high degree of balance between ARM 1 and ARM 2.

A qualitative explanation of the hybrid junction can be arranged to bring out some of the more important aspects of modern waveguide theory and practice. It will be recalled* that radio waves can be freely propagated within any conducting tube, so long as the wavelength is shorter than a cutoff wavelength determined by the cross-sectional size and shape of the pipe. There is, indeed, an infinitude of transmission modes, corresponding to different patterns of lines of force, which can be established and maintained for wave transmission, and thus an infinitude of different cutoff wavelengths. For reasons of simplicity, however, waveguide developments have so far been confined almost exclusively to the mode of longest cutoff wavelength, the so-called dominant wave, in pipes so proportioned that no other mode can be freely sustained. Also, for practical reasons, only circular and rectangular shapes are in common use. In Figure 3, lines of electric intensity in the dominant wave are shown for tubes of circular, square, and oblong cross-section. A close resemblance to radio waves in free space is evident.

There is an important difference between symmetrical and nonsymmetrical pipes, however, with respect to the permissible orientation of the plane of polarization. Patterns are shown in Figure 3 for both vertical and horizontal polarization. In the circular and square pipes, the configuration may have any orientation, depending upon the manner in which the waves were initially launched. In an oblong pipe, however, the cutoff wavelength corresponding to the cross-polarized oscillation can be depressed below the operating wavelength, and only the fixed orientation shown can be freely transmitted.

An oblong shape is thus preferred whenever there is any chance that the polariza-

*RECORD, *May*, 1936, *page* 283.

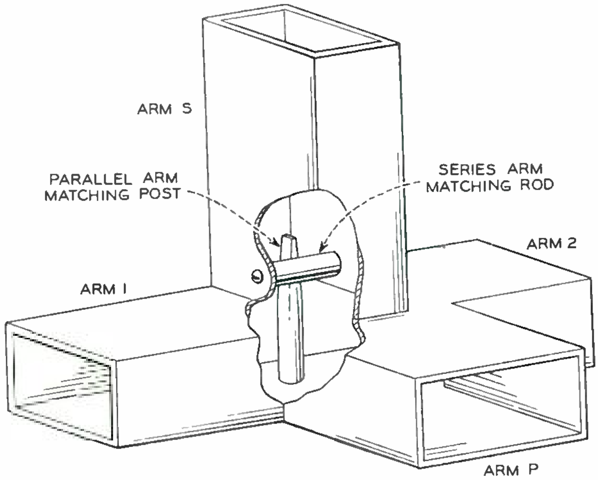


Fig. 2—Perspective cut-away view of waveguide hybrid showing "rod" and "post" used in impedance matching

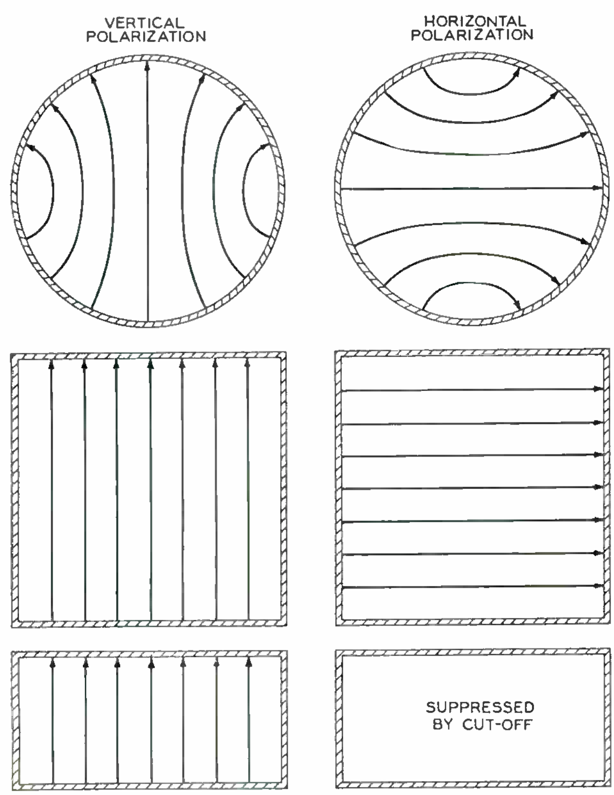


Fig. 3—Electric field configuration in circular, square, and oblong guides

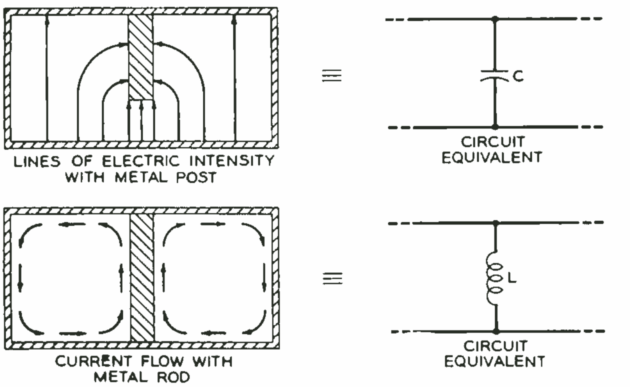


Fig. 4—A "post" at the upper left is equivalent to a shunt capacitor, while a "rod," lower left, is equivalent to a shunt coil

tion may be rotated in an uncontrolled fashion. Experience has shown that unavoidable irregularities or deliberate distortions, such as bends, do tend to rotate the plane of polarization in circular waveguides to such an extent as to interfere seriously with the normal operation of the system. For the most part, therefore, waveguide components have been developed with rectangular guide. Best results are generally obtained when the proportions of the cross-section lie in the vicinity of 1 by 2, with the larger inside dimension equal to about three-quarters of a wavelength.

Waveguide studies are greatly facilitated by the close analogies that can be established with conventional transmission line circuits. Just as the waveguide itself is representable as a transmission line, so also can waveguide components be replaced for analytical purposes by equivalent networks of impedance elements in association with sections of line. For the simpler waveguide structures, the equivalent networks are obvious upon inspection or can be readily derived from elementary consideration of electric fields and currents within the configuration. This is true, for instance, of the post and rod already shown in the hybrid junction. As indicated in Figure 4, the metal post concentrates the electric field between itself and the nearby wall of the guide, and is equivalent to a capacitance placed in shunt across a transmission line. With the metal rod, on the other hand, the principal effect is to provide paths for conductive current flow between the connected walls of the guide, with a resulting increase in magnetic flux and flux linkages, and thus it is like an inductance in shunt across a line. Provided that reasonably good conductors have been selected for the post and rod, their resistance components can be neglected except in extreme cases.

For more complex waveguide structures, accurate representation in terms of equivalent networks can often be reached only after considerable study. This is true of the hybrid junction. For a first approach to this subject, equivalent network analysis is not well suited. Instead, use can be made of

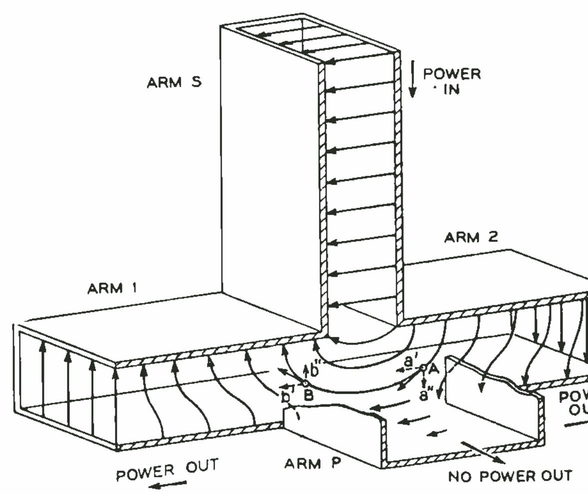


Fig. 5—Electric field at a hybrid junction with power flowing in through ARM S

analogies with optics. Here the principal concern is with the spreading of a wave front from one portion of the structure to the others. In a straight section of guide, the wave fronts are plane; distribution of the electric field has been indicated in Figure 3. In the vicinity of a severe discontinuity such as an abrupt junction, there is local distortion, wave fronts become curved, and the field may follow a complicated distribution. An accurate knowledge of this distortion is not essential, however, in deriving important properties of the hybrid junction.

Figure 5 shows what happens when a

wave front spreads into a hybrid junction from the ARM S. Lines of electric intensity are drawn in several successive positions of the wave front. To show why no power flows into the ARM P, the electric intensity in a typical position of the front is indicated vectorially at two points A and B symmetrically disposed with respect to the center of the junction. At A, the local field has components a' toward the left and a″ downward, while at B the components are b' toward the left and b″ upward. From symmetry, the magnitudes of the respective components at A and B are equal. Thus, the downward and upward intensities a″ and b″ cancel, or, more precisely, they induce equal and opposite voltages in the ARM P wave front as a whole, therefore, no power flows into the ARM P, and the power which is transmitted through the junction must appear in ARM 1 and ARM 2, and from symmetry, in equal amounts. It will be noticed that at points equidistant from the junction, the polarities of the electric intensity are reversed in ARM 1 and ARM 2. With respect to phase, at least, the ARM S acts as a transmission line connected in *series* with the line corresponding to ARM 1 and ARM 2.

What happens when a wave front spreads into the junction from the ARM P is shown in Figure 6. With respect to flow toward the ARM S, the lines of electric intensity are seen to be directed so as to create only a cross-polarized wave in the ARM S. As in

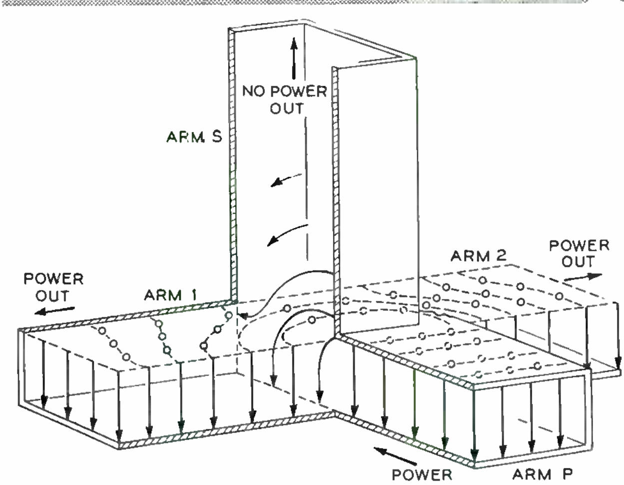


Fig. 6—Electric field at hybrid with power flowing in through ARM P

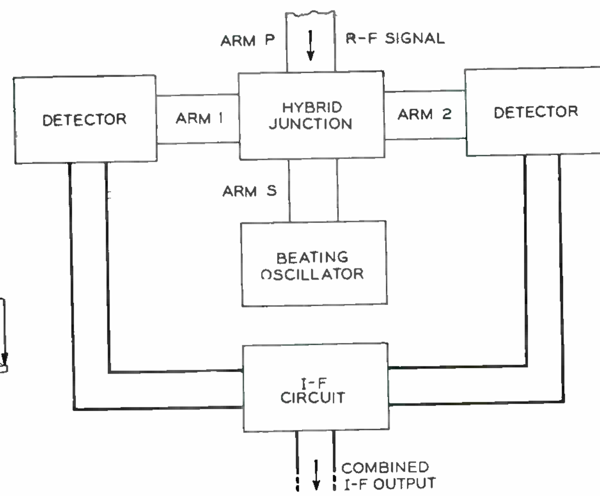


Fig. 7—Use of a waveguide hybrid junction with a balanced converter

as the wave front spreads into that arm. The intensities a' and b' reinforce each other and tend to produce in the ARM P a cross-polarized wave. If the ARM P guide is correctly proportioned, however, the cross-polarized wave cannot be freely propagated. This shows that no power flows into the ARM P as a result of the electromotive force exerted at A and B. All other points in the wave front can be grouped in pairs, symmetrically located with respect to the junction center, and the same conclusion holds for each pair of points. From the previous case, there are, in planes off-center from the junction, additional components arising from the curvature of the lines of force, but these are cancelled by the mirror image components on the other side of the junction center. With properly proportioned guide for the ARM S, therefore, no power flows into it from the ARM P. This conclusion is in harmony with the reciprocity theorem for electrical networks; if no power can be transmitted from ARM S and received at ARM P, then no power can flow the other way when the positions of

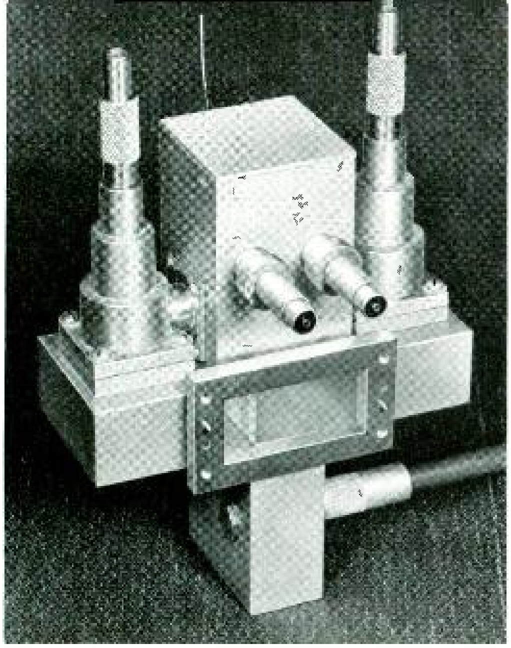


Fig. 8—A balanced converter for the microwave system between New York and Boston

transmitter and receiver are interchanged.

Figure 6 also indicates how power from the ARM P spreads into ARM 1 and ARM 2. With complete symmetry prevailing in these arms and their terminations, the power is equally divided between them. Here the geometry does not act to reverse the polarity of lines of force, and at equal distances from the junction, voltages in ARM 1 and ARM 2 are in phase. From this consideration, the ARM P is regarded as analogous to a transmission line connected in *parallel* across a line corresponding to ARM 1 and ARM 2.

To reveal clearly the balancing and power dividing properties of the hybrid junction, the picturization of wave propagation has been simplified by neglecting waves reflected from various parts of the junction. On account of the sharp geometrical discontinuities involved, field patterns in the region of the junction are in reality very complicated, corresponding to the superposition of waves bouncing back and forth within this region. All reflected components are symmetrical or paired with respect to the center, so that they are incapable of disturbing the balance or power division. The presence of reflections does, however, lead to a serious impedance mismatch of the device to the individual arms. These mismatches can be eliminated by incorporating within the junction tuning elements, such as the rod and post visible in Figure 2. From an optical point of view, they are regarded as sources of additional reflections whose amplitudes and phases are such as to bring about cancellation of the original reflections. In terms of network analysis, the rod and post are equivalent, as has been pointed out, to a coil and capacitor, and are disposed so as to tune out the reactance associated with the equivalent network of the junction. By a proper choice of tuning elements, effective neutralization of reflections can be obtained over a remarkably broad band of frequencies. Other tuning means, metal plates for example, can be used in place of the rod and post. The particular combination shown, developed by C. F. Edwards, is being widely used.

When the hybrid junction has been matched by reactive tuning, it exhibits the further customary property, that of balance between ARM 1 and ARM 2. If power is caused to flow into the junction from ARM 1, a hasty analysis of wave-front propagation leads to the conclusion that the power will be divided in some fashion among the other three arms. This is indeed true. The use of matching reactors, however, automatically brings about a balance between ARM 1 and ARM 2, so that power flows only into the ARM S and ARM P and is, moreover, evenly divided between them. This behavior, while not obvious from an optical standpoint, is a necessary consequence of the law of reciprocity.

Hybrid junctions have been built from various sizes of guide for use at frequencies in the vicinity of 4,000, 6,000, 9,000, and 24,000 megacycles per second. Constructed with reasonable care, they provide an isolation of 35 to 40 decibels between the ARM S and ARM P, and satisfactory impedance matching over frequency bands as wide as twelve per cent. If unusual pains are taken to secure a geometrically symmetrical junction, the balance is improved to 50 decibels or more.

The hybrid junction can be used in the same way as its low frequency counterpart, the hybrid coil. The junction has, in addition, many diverse applications in microwave systems and in laboratory measurements, so that it already occupies as important a position in centimeter wave techniques as does the hybrid coil in low-frequency practice. New uses are constantly being discovered in which advantage is taken of the balance, power division, and phasing afforded by the junction.

Perhaps the most important use so far found for hybrid junctions is in the balanced converter. Since this was also one of the earliest applications, it has been brought to an advanced stage of development. The general principles underlying the operation of the balanced converter or first detector are shown in the block diagram of Figure 7. Two detectors, in this case point-contact silicon rectifiers, are used as terminations for ARM 1 and ARM 2 of a hybrid junction. The beating oscillator power is introduced from the ARM S, and the signal input from the ARM P. With this arrangement, half of the signal power and half of the beat frequency power are developed in each rectifier. The 180-degree phase shift between the signals in ARM 1 and ARM 2 by the nature of the series connection persists in the intermediate-frequency voltages developed at the two rectifiers. By combining the two intermediate-frequency signals with proper phasing, however, all of the intermediate-frequency power can be made available in a single output.

An important advantage afforded by such a balanced detector is the isolation achieved between the signal line and the local beating oscillator. If care is taken to build a truly symmetrical structure and to use rectifiers which are as nearly identical as possible, this uncoupling corresponds to the balance between the ARM S and ARM P of the hybrid junction. Another advantage is that the same intermediate-frequency phasing which combines the two intermediate-frequency signals additively causes noise contributions from the beating oscillator to be cancelled. For these and other reasons, the balanced converter is considered the most efficient and desirable microwave detector now available. A specific construction developed by C. F. Edwards is illustrated in Figure 8. This is the converter that is now being used in the microwave repeater system between New York and Boston, described in the last issue of the RECORD.

THE AUTHOR: WARREN A. TYRRELL received a B.S. degree from Yale in 1935 and a Ph.D. degree in Physics in 1939. Upon graduation he joined the Technical Staff of the Laboratories and was assigned to the waveguide research group. During the war he developed a number of components for use in Navy radar systems. Since the war, Dr. Tyrrell has continued his work on waveguides at the Holmdel Laboratory in New Jersey, and is engaged in the application of waveguide techniques to measurements on dielectric and metallic material.

VOLUME 25—INDEX AND BOUND COPIES

A separate index to Volume 25 of BELL LABORATORIES RECORD *will be mailed with the January issue to those who received it last year. Others may obtain it upon request. Bound copies of Volume 25 (January, 1947 to December, 1947) 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.*

MODELS 65 AND 66 HEARING AIDS

J. R. POWER
Telephone
Instruments
Development

An ideal hearing aid would have the highest acoustic performance that the ear could appreciate and be small in size and weight. These two major objectives, however, tend to oppose each other; the highest performance, including high gain and power output, tends to require more apparatus and thus larger size and weight. Since the Laboratories has always considered that high quality was the primary factor, Western Electric hearing aids have led the field in performance ever since the first 220-pound set of 1923. Size and weight reductions have come steadily, but they have depended on the development of materials and techniques that would permit the two objectives to be more effectively reconciled. Advances since the war greatly helped in this direction, and following the 64-type hearing aid, which came out immediately after the war, the Laboratories has developed the Models 65 and 66 hearing aids. These achieved greater convenience and a much smaller weight than previous designs —six and eight ounces, respectively, including batteries—and the 66 equals the high performance of the best previous aids.

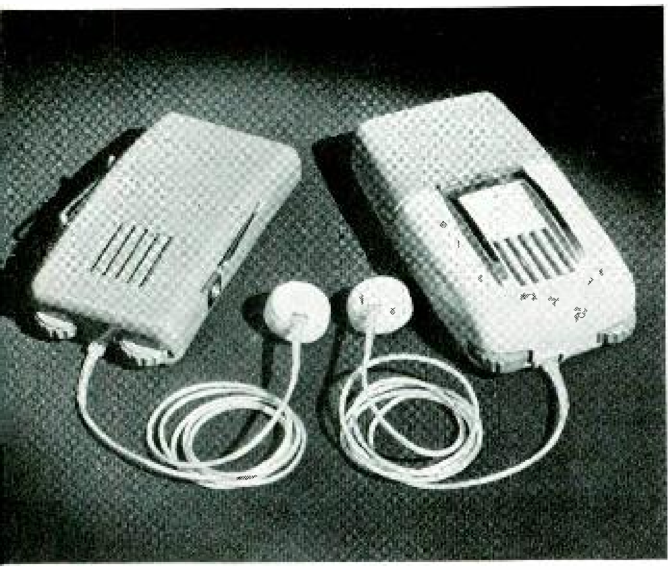


Fig. 1—The Model 66 *hearing aid at the right, and the smaller Model* 65, *at the left*

In attaining excellent performance with very small size and weight, dependability in service has not been sacrificed. The components selected for the sets meet requirements of stability and ruggedness that assure they will stand up under conditions of use. In addition, many special measures have been taken to protect the components against the adverse effects that are encountered with moisture and dirt.

One of the innovations of the new development is the provision of two sets rather than a single set. In designing previous sets for the highest practical quality, the Laboratories has recognized that the user with only a small hearing loss was wearing an aid that had much more gain and range than he needed. The provision of two sets meets this situation, since one of them is designed to provide the best possible hearing for anyone with a correctable hearing loss, while the other, smaller and with less gain and power capacity, will satisfactorily serve the great majority of those requiring a hearing aid.

These two new sets are shown in Figure 1. Each consists of a plastic case housing the transmitter, amplifier, battery, and controls, to which a No. 724-type midget receiver and cord is attached. The Model 66 case is in either two tones of gray or flesh color, while the Model 65 is either dark gray or flesh. The microphones for both sets are of the crystal type, and each has a three-stage vacuum-tube amplifier with a volume control and also a tone control that may be used to suppress the lower frequencies of background noise. The amplifier circuit for the Model 66 set is shown in Figure 2. The amplifier for the Model 65 has no feedback, and some of the capacitors and resistors have also been omitted.

This protected network principle is applied throughout the set. For the Model 66, all circuit elements between the first and second vacuum tubes are assembled in a compact, self-supporting group molded in a block of wax to form a moistureproof and tamper-proof network. Interconnections are made by wires that are parts of the elements, thereby reducing the number of joints required. Many of the connections are welded instead of soldered. The circuit elements between the second and third stages are treated in a like manner.

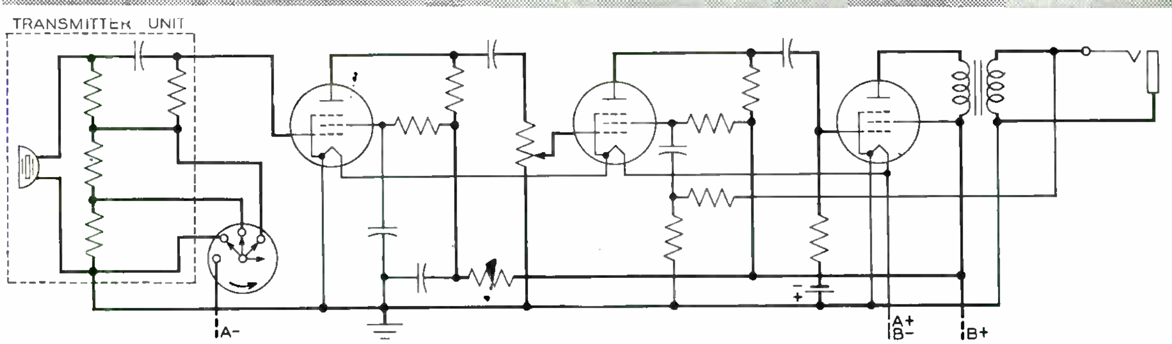


Fig. 2—Amplifier circuit for the Model 66 hearing aid. That for the Model 65 is similar with fewer capacitors and resistors

A cross-section of the crystal microphone is shown in Figure 3. It is sealed by a plastic-coated metal-foil membrane across its face, and by closing other potential points of moisture leakage with moistureproof plastic cement. Microphones for both sets are of essentially the same construction, but that for the Model 65 is somewhat smaller than that for the Model 66. The capacitor and resistors of the tone control network are housed in the microphone case. This not only protects these high-impedance elements from moisture but also shields them electrically.

In the Model 65 set, this principle is extended. The entire amplifier—vacuum tubes, capacitors, and resistors—is wired together by the element's own leads, and is then molded in wax to protect it from dirt and moisture. The resultant package is 1⅝ by 1½ by ⅜ inches. In case of failure of any of

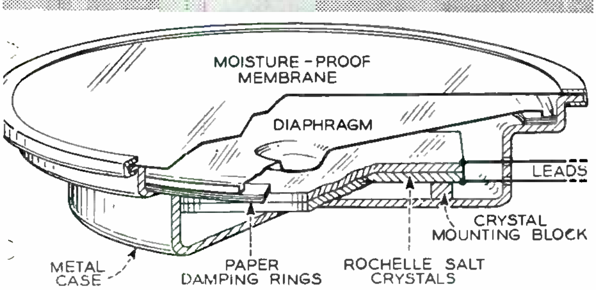
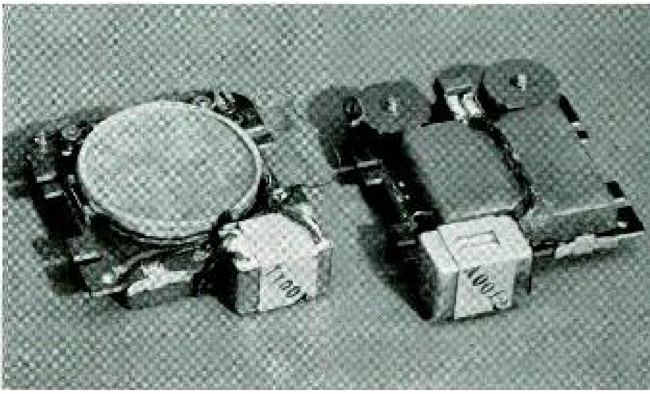


Fig. 3—Cross-section of the crystal microphone

Fig. 4—Chassis for the Model 65 hearing aid



the elements, the entire network is replaced. The complete chassis for the Models 65 and 66 sets are shown in Figures 4 and 5.

One of the distinguishing features of both sets is the absence of distortion and a minimum of noise due to clothing. If adequate precautions are not taken, the noise of clothing rubbing against the set, which reaches the microphone either as mechanical vibration or as airborne sound, may so mask the useful sounds that the value of the hearing aid is seriously impaired. In the new hearing aids, it has been reduced at its source by the avoidance of any sharp corners or projections on the case, and by making the case of a material that has a very low coefficient of friction. In addition,

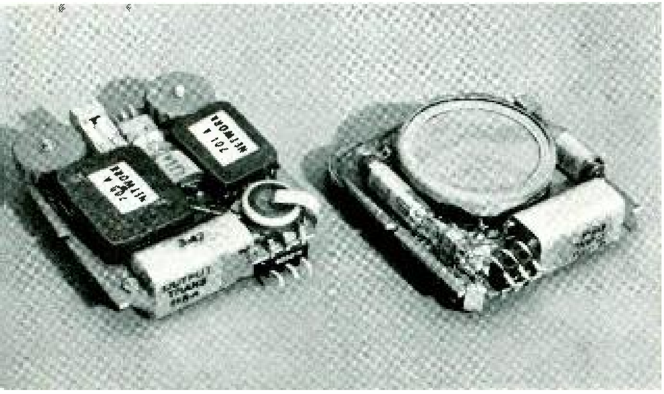


Fig. 5—Chassis for the Model 66 hearing aid

the microphone is protected by a resilient mounting against any mechanical vibration that may be generated.

Besides providing two sets—one for those needing considerable aid and the other for those requiring only a moderate amount—a further division of the range is provided by additional options in the size of the battery (in the Model 66) and the type of the receiver used. There are three 724-type receivers, the A, B, and C. Their characteristics are shown in Figure 6. The 724C has a flat characteristic extending from below 200 to over 4,000 cycles. The 724B gives greater output, but its response falls off above 3,000 cycles. The 724A has the same frequency range as the 724B, but has a high output peak at about 1,200 cycles which is helpful in some extreme cases. Only the 724B and 724A receivers are applicable to the Model 65 set, but all three may be used with the Model 66, as may also the 725 bone-conduction receiver.

When used with its self-contained 22½-volt B battery and with the wide-range 724C receiver, the Model 66 aid is capable of increasing the sound intensity reaching the ear by 55 db and of producing a sound pressure in the ear of 116 db above the minimum pressure that can be heard by a normal ear. The frequency range under these conditions is from 250 to 4,000 cycles. Within this range, the response is uniform within ±6 db. This flat response may be changed to one that rises toward the high frequencies at either 5 or 10 db per octave by turning a three-position tone control switch. Another control permits adjustment of amplifier gain over a 40 db range.

A special feature of the design of the Model 66 set is that the battery compartment may be detached and replaced by a small adaptor from which a cord extends to an external battery case. This permits the use of higher voltage, or of larger, more economical batteries, when desired. By taking advantage of this feature, amplification and sound pressure may be increased 4 db by using a 30-volt external B battery. These characteristics may also be increased 7 db by substituting the high-efficiency 724B receiver for the 724C. This latter method entails some sacrifice of high-frequency response. In extreme cases, both of these substitutions may be made with a resultant amplification of 66 db, and the maximum sound pressure level of 129 db. This pressure is about the maximum that the ear can tolerate.

With the Model 65 aid, a 15-volt B battery is employed, and when using a 724B-type receiver, which is recommended in most cases, the acoustic amplification is 50 db and the maximum sound pressure in the ear is 115 db above normal threshold. The effective frequency range is from 700 to 3,200 cycles, but even at 300 cycles, the response more than meets the requirements of the American Medical Association. Within the effective range, the response is normally quite flat, but may be tilted to slope upward toward the high frequencies at either 4 or 8 db per octave. Somewhat different gain and frequency characteristic is

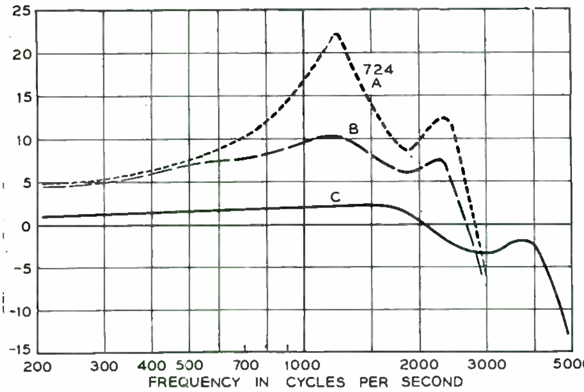


Fig. 6—Characteristics of the 724A, 724B, and 724C receivers for hearing aids

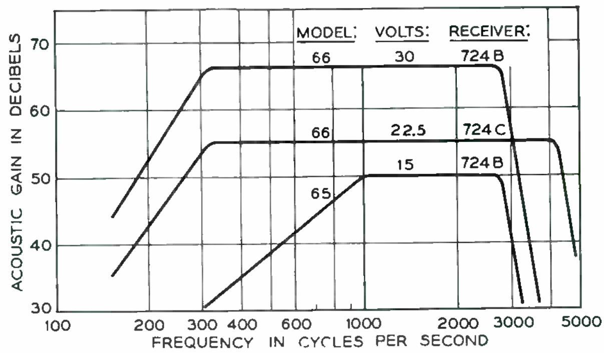


Fig. 7—Gain-frequency characteristics of various arrangements of the Models 65 and 66 hearing aids

possible by using the 724A receivers. Overall characteristics for the most commonly used combinations of the two sets are shown in Figure 7.

These two hearing aids thus complement each other. The Model 66 has the superior acoustic performance that is required by those who have a severe hearing loss or who want exceptionally good acoustic quality. On the other hand, the Model 65 is smaller and therefore more convenient to wear. The reduced size causes no loss in dependability. Its acoustic characteristics are of good quality and are entirely adequate for the majority of hard-of-hearing people. By offering the choice of either of these two sets, Western Electric is carrying out its long-established policy of rendering the greatest possible assistance to any person who is hard of hearing.

THE AUTHOR: J. R. POWER received a B.S. degree in Electrical Engineering from Carnegie Institute of Technology in 1927. Entering the Apparatus Development Department of the Laboratories that same year, he engaged in the development of special motors and generators for use primarily in sound pictures. In 1935 he transferred to work on acoustical problems connected with noise conditions in the telephone plant and offices. Later he spent some time on the preliminary development of a new telephone ringer. This was interrupted by work on high power auditory systems for the Government. Since the end of the war, he has been engaged in the development of hearing aids, audiometers, and artificial larynges.

NEWS AND PICTURES OF THE MONTH

EUROPE AND THE MARCONI CONGRESS

W. H. Doherty
Radio Development Engineer

"Congresso Internazionale per il Cinquantenario della Scoperta Marconiana della Radio," was the announcement spelled out by banners stretched across the streets of Rome as engineers and physicists from many countries gathered there in late September to honor the name of Guglielmo Marconi. The tenth anniversary of Marconi's death was the fiftieth anniversary of the pioneering experiments of this brilliant and energetic Italian in wireless communication.

Sponsoring the Congress was the National Council of Research, whose fine headquarters building near the University of Rome was the scene of the technical sessions. My assignment was to represent the Laboratories and to give a paper dealing with our contributions to the design of modern broadcast transmitters.

Mouromtseff of Westinghouse, Zworykin of RCA, and Bolt of MIT were other Americans participating as the Congress commenced on a Sunday afternoon with ceremonies in the *Campidoglio,* or state capitol. Among the many foreign scientists I met for the first time were Smith-Rose from England and Strutt from Holland, whose names are familiar to all radio people through their many publications.

The papers presented during four days of technical sessions covered a wide field, including acoustics, wave propagation, circuit theory, vacuum tubes, communication systems, aural broadcasting, and television. Numerous Italian papers testified to a lively scientific endeavor in that country despite the present difficult economic conditions; while the importance assumed by microwave papers was in line with the technical trends of the times. Indeed, Marconi himself had been an enthusiast over centimeter waves, and no one a generation ago envisioned more clearly than he the vast possibilities for their practical use.

With all the art treasures and historic monuments Rome has to offer, the delegates welcomed a program arrangement that left time for sightseeing, though in a visit of ten days one could only glimpse briefly the "high spots" of the Eternal City. The management of the Congress arranged for splendid side trips to Villa d'Este at Tivoli, with its beautiful fountains and gardens; to the picturesque ruins of Ostia, ancient Roman port at the mouth of the Tiber; and to Castelgandolfo, papal summer residence, for an address by Pius XII and a personal introduction to the pontiff for each member. An evening concert provided by the Italian broadcasting organization and an inspection tour of the international radio transmitting station of Italcable at Torrenova rounded out a busy week. The Torrenova plant, a great communications center almost completely destroyed by the Germans, is being rebuilt and equipped with the most modern long-wave and short-wave radio telephone and telegraph equipment for European and overseas transmission.

After the close of the Congress on October 5, I spent a month visiting industrial and university laboratories and radio stations in Switzerland, France, Holland, Belgium, Luxembourg, England, and Ireland. An outstanding affair I attended in London, attracting the general public from all over England, is Radiolympia. Resumed this year, after a lapse of eight years, this exhibition of radio products of all kinds drew half a million spectators in ten days, a remarkable show of interest for these hard times. Improvements in radio technique, stemming from the intensive war effort in England and America in electronics, are plainly seen in these products; and all

The photograph at the head of the page shows the author (right) and V. I. Enders of Alpine Western Electric, Switzerland, returning from a sail on the Lake of Zurich.

WESTERN ELECTRIC-BELL LABORATORIES DEVELOPMENT CONFERENCES

To review the progress of development and manufacturing of wire, cables and cords, a conference of engineers and executives of the Laboratories and the Western Electric Company was held at the Point Breeze Works in October. This was the first in a series of similar conferences to discuss joint development and manufacturing problems. The second was held at the Kearny Works on December 10 and 11 and dealt with the development and manufacturing of transmission apparatus.

Under the general direction of M. J. Kelly, the Kearny conference was planned by R. G. McCurdy, H. H. Lowry and H. Rossbacher, Works Engineer of Manufacture at Kearny. After an introduction by R. F. Clifford, Works Manager, the program was outlined by Dr. Kelly and H. C. Beal, Vice-President of the Western Electric Company.

Presentations were made by engineers of the Laboratories and of Western Electric covering a number of areas of development and bringing out the relationships between the manufacturing and development problems in these fields. The subjects covered included coaxial line and terminal equipment, television terminals and video amplifiers, networks, equalizers and filters, measurement problems, crystals, component apparatus, the current size-reduction activities, and transmission economics.

It is the purpose of these conferences to bring up for discussion at an early date problems of engineering design and problems of manufacture relating to the developments being made by the Laboratories. As a result of these discussions, the manufacturing and development programs are geared together to achieve maximum effectiveness in translating new ideas from the Laboratories into equipment for the operating telephone companies of the Bell System.

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over Europe, despite severe shortages in materials and components, one finds great activity in the development of new communication equipment operating in the ultra-high-frequency and microwave bands and employing FM and pulse modulation multiplex methods.

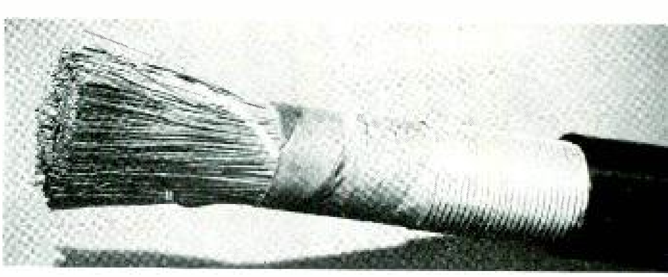
Television is popular in Britain, and video transmitting stations are planned for Birmingham and other important centers. For linkage with the present London installation, trials of both radio relay and broad-band coaxial cable are to be made, somewhat paralleling our own television network plans. British receivers, interestingly enough, differ from ours in being built for one channel only and for carrier-and-double-sideband reception.

The diary of the American traveler in Europe is sure to contain references to the droves of bicycles on the streets of Dutch and Swiss cities; to the immense variety of noisy motorbikes and midget cars that dart about dangerously in Rome and Paris; to food rationing and London fogs. My notes mention these and other experiences, but the really deep impressions were of warm hospitality extended by Europeans everywhere, and of diligent and courageous efforts toward recovery in countries hard hit by the war.

Political tension was evident in Italy and France, with daily threats of a general strike, but except for a short walkout on the *metro* in Paris, there was no outward disturbance. The subsequent outbreaks of violence make one glad to be safely back, but concerned for the new friends left on the Continent to weather the storm.

POLYETHYLENE CABLE SHEATH

In a move to further accelerate the Bell System's nation-wide construction program, the Laboratories has developed a new type of telephone cable sheath using a thin sheet of aluminum covered with a polyethylene compound, a tough, flexible plastic that looks like black rubber. The new cable will supplement the familiar lead-covered cable which is now



at peak production. Following extensive tests of its suitability, the Western Electric Company has begun quantity production of the new type of cable at Kearny and Hawthorne. The cable, called "Alpeth," is to be used within local exchange areas on pole lines and in underground conduit. It will be made in a variety of sizes, ranging from the smaller cables to those containing hundreds of pairs of wires.

The immediate purpose to be served by the new cable will be to step up the delivery of cable to the telephone companies and help meet the continuing heavy demand for telephone service.

The name "Alpeth" is derived from the sheet of aluminum which goes next to the paper-insulated wires, and from the outer covering of polyethylene. Before carbon black is added, the polyethylene has a milky color.

For many years the Laboratories has carried on continuous research on cable improvement. Insofar as can be predicted from laboratory and field tests, polyethylene promises to give satisfactory service as a cable sheath material. No change has been made in the cable core itself.

Meanwhile, with the production of lead-covered cable continuing at a record pace, the new composite sheathing is helping to increase still further the total output of much-needed exchange cable.

EDITOR'S NOTE: A more extensive account of this development will appear in an early issue of the RECORD.

Murray Hill Stamp Club Organized

Philatelists exhibited their prize specimens at an exhibition in the Lounge at Murray Hill on November 20 and 21, signalizing the beginning of the newly organized Stamp Club at that location under the direction of the Bell Laboratories Club. S. C. Tallman was awarded first prizes for his displays in both the United States and foreign classes. C. W. Ferguson and K. H. Schunke took second prizes in those classes, while H. T. Webber took both prizes in the novelty class and also won the award "best in show."

W. A. Shewhart Now Lecturing in India

W. A. Shewhart sailed for Southampton on November 22 on the first leg of a trip by boat and plane to India for a four months' visit and lecture tour. Dr. Shewhart's invitation was sponsored jointly by the Indian Standards Institution; the Indian Science Congress Association, the Indian counterpart of the American Association for the Advancement of Science; and the Indian Statistical Institute, the largest research organization of its kind in the world. As Visiting Professor to the Statistical Institute, he plans to give a series of lectures at Calcutta University and one or more lectures elsewhere in India. He will also participate in round-table quality control conferences in Bombay and Calcutta with statisticians, industrial leaders and technical representatives from all over India.

In his lecture equipment, Dr. Shewhart included pamphlets describing the over-all organization and workings of the Bell System; descriptive material and lantern slides showing views of the newer Laboratories' buildings and equipments; a Fastax camera; and a colored sound film on quality control.

Christmas Programs at the Laboratories

The Murray Hill Chorus presented a varied program of Christmas music in the Arnold Auditorium on Tuesday, December 23, with the audience participating in several of the familiar carols. Daniel F. Kautzman directed the Chorus and Capitola Dickerson was the accompanist. W. H. Martin, chairman of the Murray Hill Committee, gave the annual Christmas greeting.

M. J. Kelly receives the Presidential Certificate of Merit from Secretary of the Navy John L. Sullivan "in recognition of his efforts in the field of electronics which proved to be an invaluable contribution to the war effort of the United States." The presentation ceremonies were held in Washington on November 19

Carols were sung outdoors at Whippany, where members of the Laboratories gathered on the steps of the Administration building at noon on Christmas Eve. At about the same time, the System's Christmas Chorus of sixty-seven voices rendered a selection of carols in the drafting room of the Equipment Development Department on the ninth floor at West Street. The carolling was picked up by a microphone, transmitted into the courtyard, and amplified, so that many more members

Present at a conference to appraise technical and related subjects submitted to the Patent Department for consideration are, standing (left to right), Loretta Spacek, Catherine McQueeny, H. A. Burgess, G. H. Heydt, R. E. Poole, N. S. Ewing and E. L. Nelson. Seated around the conference table are (left to right) E. V. Griggs, J. W. Schmied, H. A. Blake, M. R. McKenney, D. A. Quarles, W. C. Kiesel and J. R. Wilson

of the Laboratories than could be accommodated in the Auditorium had the pleasure of hearing the program. Under the direction of R. P. Yeaton, the chorus sings together only at Christmas and has been in existence five years. Originally comprised of draftsmen, it has grown each year, adding, as it did in 1947, a number of trained new voices from other departments.

New York State Veterans' Bonus

Many inquiries have been received regarding the New York State veterans' bonus in connection with transfers to New Jersey or other out-of-state locations of the Laboratories and subsequent changes in residence. To be eligible, the bonus law states "residence in New York State at the time of entry into service and at least six months immediately prior, and residence in the state at the time application for bonus is made out" is necessary. Thus, a member of the Laboratories who has been a resident of New York State is not eligible for the bonus if he or she changes his or her residence to another state before application for the bonus is made. Some veterans may be required to file special residence questionnaire forms after submitting their applications in order to clarify their domicile status.

New York State veterans who are on leaves of absence from the Laboratories to attend school are eligible for the bonus unless there are indications that he or she has become a permanent resident of some other state.

Recent Organization Changes

H. A. Blake, Assistant Commercial Relations Manager, was transferred to the Patent Department on October 22 as Executive Assistant to M. R. McKenney, General Patent Attorney.

Coincident with this appointment, C. R. McConnell and H. Schmitt, Commercial Projects Supervisors for New York and Murray Hill, respectively, now report to B. B. Webb. The title, Assistant Commercial Relations Manager, has been discontinued.

During the Months of September, October and November the United States Patent Office Issued Patents on Application Filed by the Following Members of the Laboratories

T. Aamodt	R. C. Davis	R. H. Gumley	F. B. Llewellyn	R. K. Potter
W. P. Albert (2)	T. L. Dimond	H. A. Hilsinger, Jr.	G. A. Locke	R. M. Ryder
M. C. Biskeborn	R. A. Ehrhardt	W. H. T. Holden (2)	G. R. Lum	J. H. Scaff
F. B. Blake	C. H. Elmendorf	H. Hovland	W. P. Mason (2)	O. A. Shann
E. M. Boardman	E. P. Felch, Jr.	R. G. Humphrey	A. L. Matte	F. J. Singer
J. H. Bollman (2)	A. G. Fox	E. M. Julich	W. H. Matthies	T. Slonczewski (2)
W. L. Bond	A. L. Fox	A. P. King	H. J. McSkimin	J. E. Tarr
A. E. Bowen (2)	C. J. Frosch	W. Koenig, Jr.	W. J. Means	H. S. Wertz
D. E. Branson	G. W. Gilman	J. A. Krecek	W. A. Mehmel	A. H. White
H. W. Bryant	H. W. Goff	J. G. Kreer, Jr.	E. A. Nesbitt	H. T. Wilhelm
A. J. Busch	W. M. Goodall	A. G. Laird	C. W. Norwood	R. O. Wise
J. A. Carr	H. L. B. Gould	A. G. Lang	W. G. Pfann	

PAGING SANTA CLAUS

A—Florence McGuire, chairman of the New York Doll and Toy committee

B—Graybar's committee, Rose Rovegno, Molly Radtke, chairman; Eve Coll, Mary Burke, Shirley Zitzmann, and Marion Greenberger

C—Whippany's committee. In the rear, Dorothy Clothier, Harriet Filmer, chairman; Joan Helm, Evelyn Selzer, and "Pat" Rooney; center, Bette Mocksfield, left, and Marion Merck, right; front row, Marilyn Miller, Betty Minerowitz, Elizabeth Myers, and Jean Force

D—F. D. Leamer, president, and Mrs. Anne Brokaw, executive secretary, Family Service Association of Summit, accept toys from Dorothy Thom

E—Peggy Grillo and three children of the Nursery School at the Greenwich House

F—Doll and toy display at West Street

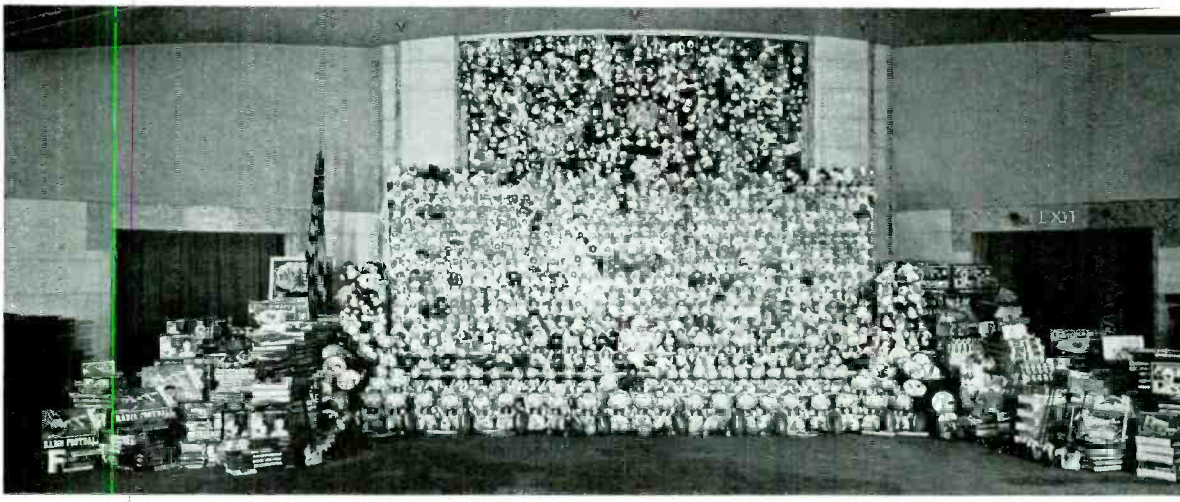
G—Dennis Cronin admiring the little dogs he made from wash cloths for the display

H—Madeline Kiselica exhibiting story book and opera character dolls she dressed

I—Mrs. Claire Stevens, wife of P. A. Stevens at Graybar, dressed twelve dolls

J—At Whippany, Mrs. Filmer (left) with guardians of children in boarding homes

K—Mary Mahairas (left) and Florence McGuire present gifts to servicemen's children at a party given by the Red Cross in Flushing


F


G

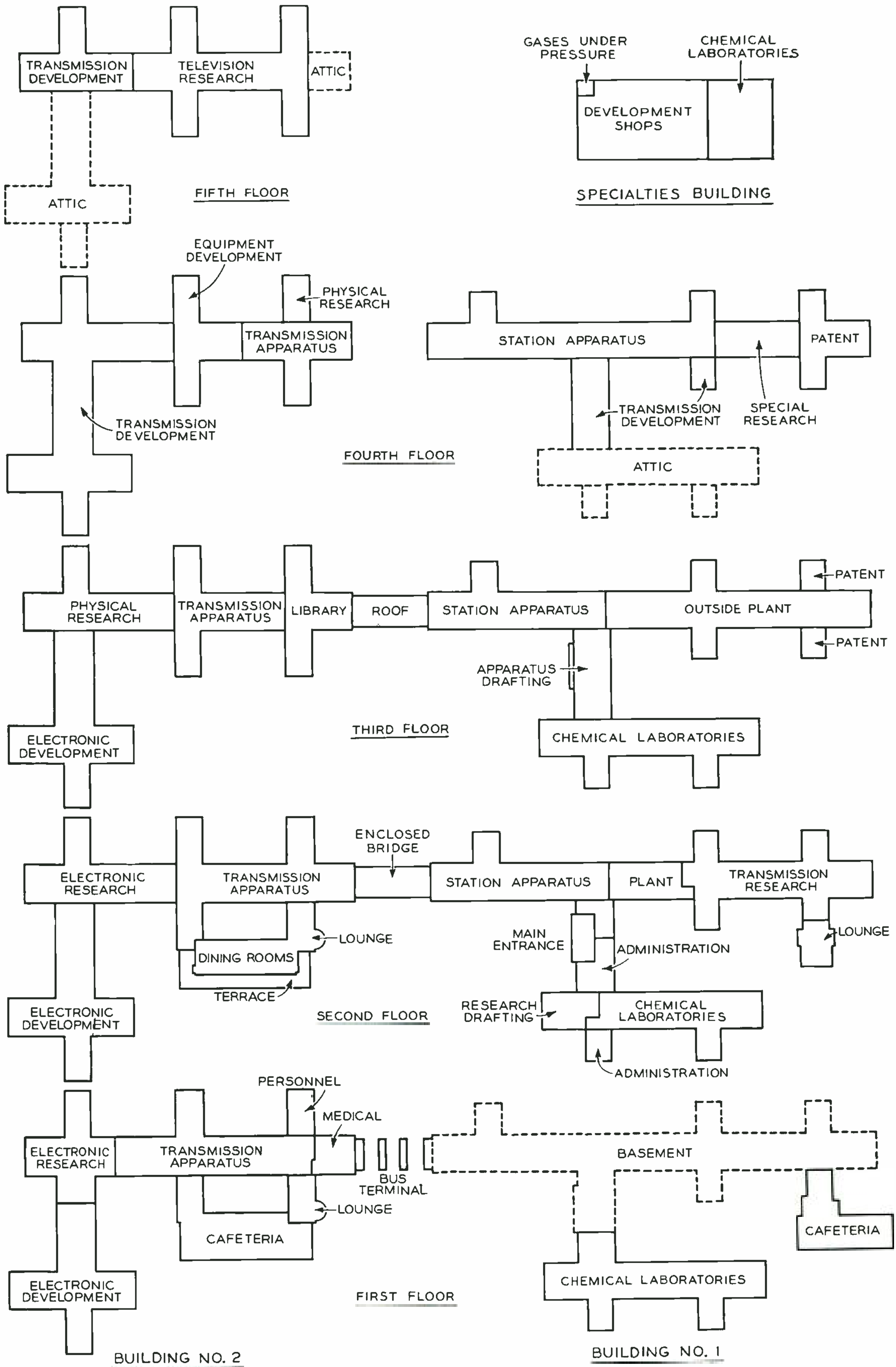

H

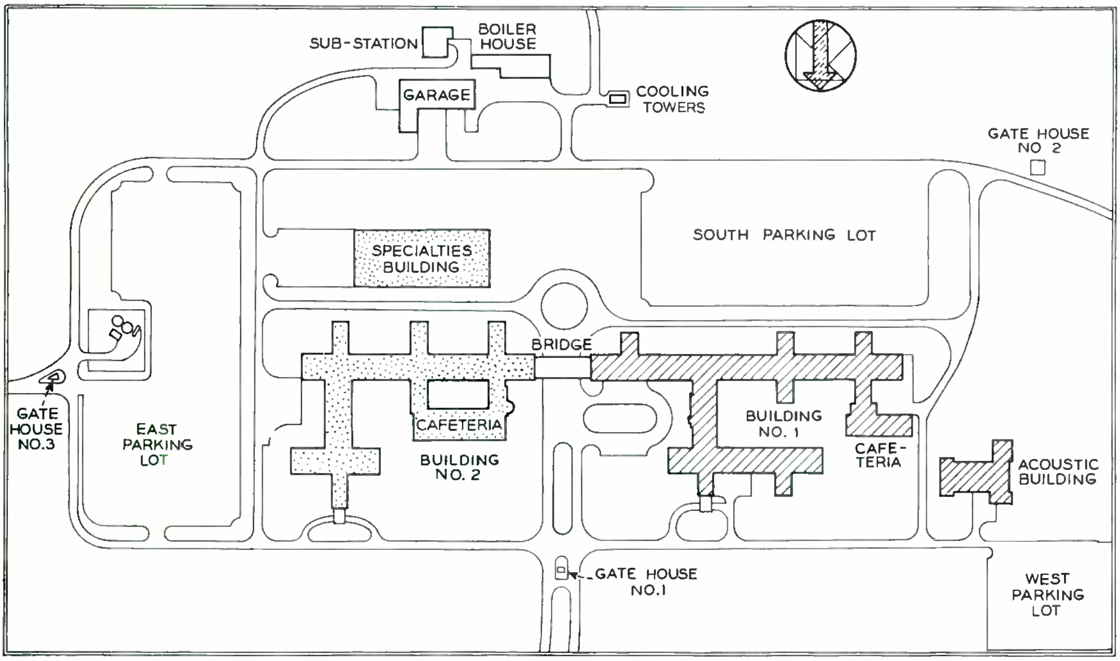

I


J


K

FUTURE FUNCTIONAL LAYOUT AT MURRAY HILL





Progress on Project No. 2 at Murray Hill indicates that the first of its new occupants can begin to move about August 1 of this year. The chart on the opposite page shows where you will find the various departments when the moves are completed some time in 1949. The shaded arrow (circle, upper right) indicates the direction usually referred to as "North"

NEWS NOTES

M. J. Kelly addressed the engineering and supervisory force of the Southwestern Bell Telephone Company at St. Louis. He also attended the biannual meeting at Rolla, Missouri, of the Board of Directors of the Missouri School of Mines Alumni Association on November 7. On the following day, Dr. Kelly delivered the main address at the Homecoming Convocation at the School, his alma mater (B.S., 1914, and Honorary Doctorate in Engineering, 1936), selecting as his subject *Science, Technology and the "Good Society."*

During a two-day Research Conference in Washington of the Navy Industrial Association, Dr. Kelly, who is Chairman of the Research and Development Committee, addressed the Conference on its opening day, November 18, at a dinner session. His subject was *Our Country's Preparedness Research and Development Program—A Coöperative Undertaking of Our Military, University and Industrial Laboratories.*

D. A. Quarles went to Chicago for the Board of Directors meeting of the American Institute of Electrical Engineers. He was also in Washington on November 13 attending the meeting of the Committee on Electronics of the Joint Research Board and on November 19 attending the Navy Research Conference of the Navy Industrial Association.

A. B. Clark was a guest at the Navy Conference in Washington on November 18 and 19.

On November 25, Mr. Clark, H. H. Lowry, F. J. Scudder, T. C. Fry, J. G. Ferguson and F. A. Korn conferred with officials of The Bell Telephone Company of Pennsylvania in Philadelphia, and visited the No. 5 crossbar office in Media.

Harvey Fletcher has written on *The Science of Hearing* in the book *The Scientists Speak.* Two retired members of the Laboratories have also contributed articles to the book, H. E. Ives, *Physics and Art,* and R. R. Williams with R. J. Williams, *The Golden Age of Biochemistry.* Dr. Fletcher attended meetings of the National Academy of Science, November 17 to 19, in Washington. He also visited Rutgers University.

A. R. Kemp, rubber technologist and insulation engineer of the Chemical Laboratories, has been designated one of the country's ten ablest chemists in the field of rubber chemistry by his fellow-members in the American Chemical Society.

Lloyd Espenschied spoke on *The Dawn of Electrical Experimentation* on November 12 at a supper meeting of the Institute of Radio Engineers, New York Section, preceding the technical meeting.

C. H. Townes spoke on *Microwaves* at a joint Harvard-M.I.T. seminar at Cambridge.

C. Kittel selected *Paramagnetic Resonances* for his topic when he spoke to the Physics Colloquium at Rutgers University.

NELSON E. SOWERS HONORED

In 1942, Nelson E. Sowers' health would not permit him to remain longer in the New York area, so he was granted a Disability Pension which allowed him to withdraw from Radio Research and live in the southwest. Three years later he went to work for the Army Ground Forces Board at Fort Bliss, Texas, as a Mathematical Data Analyst. Recently he has received from the War Department a *Decoration of Exceptional Civilian Service*. The citation, signed by the Secretary of War, reads: "His outstanding service in the development of instrumentation and computing equipment and procedures for antiaircraft artillery service testing constituted a contribution of inestimable value to the mission of his command."

Mr. Sowers' friends will be gratified to learn that his health has been restored. However, family reasons require his continued residence in the southwest, so he has now resigned from the Laboratories.

Retired But Active

George B. Thomas, until last summer Personnel Director, is now chief of the Industrial Relations Department of the Los Alamos laboratory of the Atomic Energy Commission.

Joseph P. Maxfield, who retired in September, is now a consulting engineer on the staff of the Altec-Lansing Corporation, acoustic engineers. His headquarters will be on the Pacific Coast.

Catharine C. Maull, who retired in October, 1945, from Personnel, is curator of the museum in the Zwaanendael House in Lewes, Delaware. This building is a replica of the town hall in Hoorn, Holland.

News Notes

J. R. Haynes presented an invited paper before the Houston meeting of the American Physical Society entitled *Behavior of Photoelectrons in Silver Chloride Crystals Exhibited by Colloidal Silver Produced at Electron Traps.*

G. T. Kohman, A. N. Holden, W. L. Bond and S. O. Morgan discussed crystal growing problems at the Squire Laboratory.

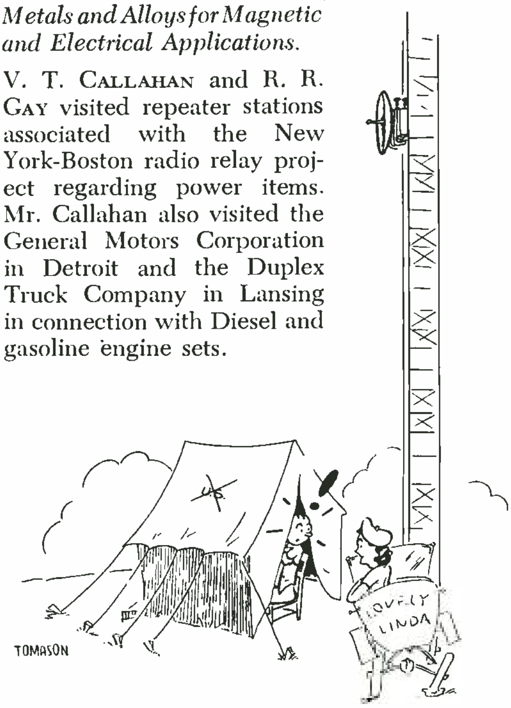
J. R. Flegal, G. T. Kohman, N. Y. Priessman and G. K. Teal visited the Norton Company in Worcester, where they discussed silicon carbide varistors. Mr. Kohman has been appointed to represent the Laboratories on the N.R.C. Committee on Design, Construction and Equipment of Laboratories.

L. H. Germer and F. E. Haworth participated in a colloquium on Electrical Contacts at Massachusetts Institute of Technology.

A. R. Kemp discussed plastic sheathing with cable engineers at Hawthorne during his week's visit to that plant.

J. R. Townsend visited The Mountain States Telephone and Telegraph Company, Denver; the Northwestern Bell Telephone Company, Omaha and Minneapolis; and the Southwestern Bell Telephone Company, St. Louis, where he spoke to telephone personnel on *Materials Developments*. During his trip, Mr. Townsend visited the University of Colorado at Boulder, Colorado. At Washington University, St. Louis, he addressed a joint session of the American Institute of Chemical Engineers and American Society of Mechanical Engineers. In Los Alamos, New Mexico, he addressed the local chapter of the American Society for Metals on *Metals and Alloys for Magnetic and Electrical Applications.*

V. T. Callahan and R. R. Gay visited repeater stations associated with the New York-Boston radio relay project regarding power items. Mr. Callahan also visited the General Motors Corporation in Detroit and the Duplex Truck Company in Lansing in connection with Diesel and gasoline engine sets.



"Could you use a flagpole sitter?"

W. BABINGTON witnessed a series of die casting experiments at the Precision Casting Company in Syracuse. He also went to Hawthorne for die casting discussions.

E. E. SCHUMACHER and I. V. WILLIAMS made an inspection trip to the School of Mineral Industries at Pennsylvania State College.

H. A. BIRDSALL visited the International Business Machines Company at Endicott, N. Y. He also attended the meeting of the A.S.T.M. Committee D-6 on paper and paper products at Albany. With D. A. MCLEAN he attended the open house meeting of the Textile Research Institute at Princeton; and with K. G. COUTLEE, J. J. MARTIN, G. DEEG and R. BURNS, the meeting at Atlantic City of Committee D-9 on electrical insulating materials.

F. G. FOSTER received Honorable Mention in the metallographic exhibit at the recent National Metal Congress and Exposition at Chicago for his entry of a chart with eighteen photomicrographs.

R. BURNS' trip to Massachusetts Institute of Technology at Cambridge concerned new developments in mechanical testing of plastics.

W. O. BAKER delivered an invited lecture at Northwestern University, Chicago, on *The Organic Structure and Physical Nature of High Polymers.* The lecture was one of a series sponsored by the university. Mr. Baker visited Hawthorne en route for casting resin development conferences. He also was in Washington for an advisory panel meeting called by the Office of Naval Research and the Bureau of Ordnance concerning polymer research.

C. C. HIPKINS and J. C. OSTEN attended the convention of the Federation of Paint and Varnish Production Clubs in Atlantic City. Mr. Osten's paper, *A Comparison of Infra-red and Convection Oven Baking,* which was presented at the convention, received the first award.

G. N. THAYER addressed the New York Sections of the A.I.E.E. and of the Institute of Radio Engineers on the *New York-Boston Radio Relay System.*

THE FOLLOWING MEMBERS of the Institute of Radio Engineers have been elected to the grade of Fellow by the Board of Directors of the Institute: M. W. BALDWIN, JR., H. S. BLACK, L. A. MEACHAM and J. R. PIERCE.

A. B. HAINES, in Rochester on November 19, attended a meeting of R.M.A. 10C Committee on power transformers (receiver section). Mr. Haines and L. W. KIRKWOOD were at Wright Field in connection with the development of high operating temperature transformers.

J. R. WEEKS and R. K. EVENSON attended conferences at Hawthorne on the aluminum can condenser problem.

W. R. NEISSER observed the assembly at Archer Avenue of a trial lot of networks for the new combined set.

ARE YOU VACATIONING IN FLORIDA?

During the next few months, some members of the Laboratories may be spending their vacations in Florida. A number of retired members live in Florida and would be glad of a visit, particularly from those who have known them in their more active days.

Clearwater
Ray S. Wilbur — 511 Hilltop Ave.

Daytona Beach
H. Francis Kortheuer — 709 Goodall Ave.

Delray Beach
Harry C. Dieffenbach — P. O. Box 873, 8 Nassau St.

East Lake Weir
Loyd D. Plotner — East Lake Weir

Eau Gallie
Bruce Freile — Box 126

Eustis
Stanley F. Nelson — ———

Fort Pierce
James L. Crouch — P. O. Box 405

Lake Wales
Charles R. Young — 813 Campbell Ave.

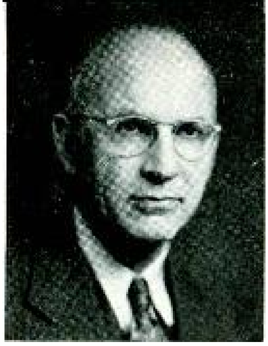
Miami
Lansford B. Stark — 2513 SW 20th St.

Oneco
Gilbert T. Ford — P. O. Box 336

Opa Locka
Walter E. Newton — P. O. Box 1283

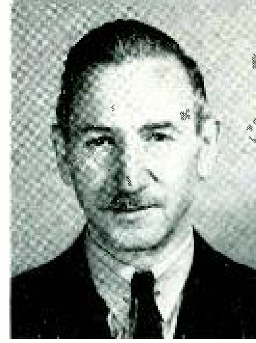
St. Petersburg
Oscar E. Benson — 1014 Bay St., NE
George W. Folkner — Hollander Hotel
Joseph F. Johlfs — 4200 4th Ave., North
Charles W. Keckler — 1151-34 Ave., North
Wm. Scharringhausen — 201 6th St., South

Tarpon Springs
Donald Ross — Star Route



R. J. HEFFNER

S. W. SHILEY



ANTON LODER

E. W. HANCOCK

RETIREMENTS

Members of the Laboratories who retired recently include E. W. HANCOCK on December 28 and S. W. SHILEY on December 31, both with 43 years of service; ANTON LODER on December 31, 32 years; and R. J. HEFFNER on December 22, 29 years.

ROY J. HEFFNER

Roy J. Heffner of the Personnel Department retired on December 22 following twenty-nine years of service. After receiving the B.S. in E.E. degree from the University of California in 1916, Mr. Heffner immediately joined the Western Electric Company in Chicago but was soon transferred to the Engineering Department in New York. He served with the Air Service of the U. S. Army from 1917 to 1919 and when discharged had attained the rank of Major. For the next two years he was first Chairman of Engineering Extension at his alma mater and then Educational Director of the Hawaiian Department, U. S. Army. In July, 1921, he joined The Pacific Telephone and Telegraph Company, where he became supervisor of employment and training for men and women in 1924.

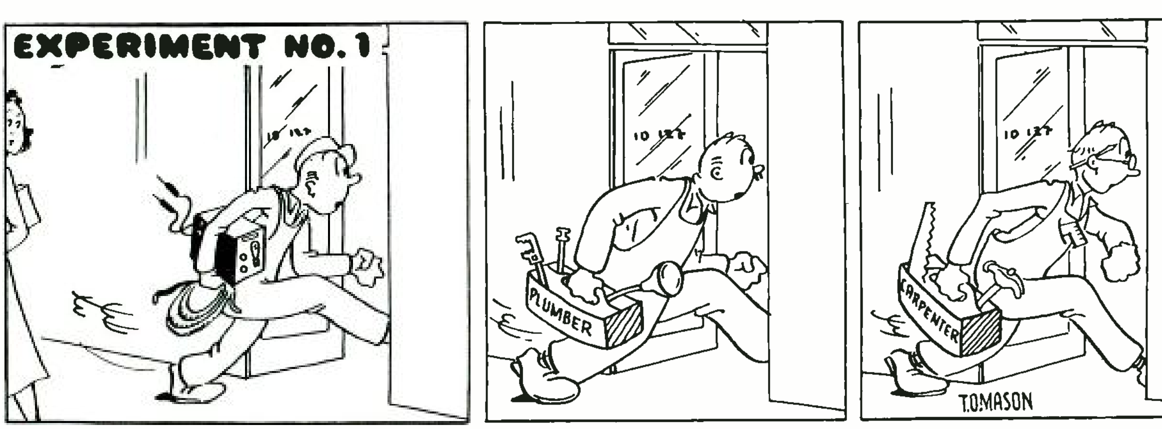
Mr. Heffner transferred to the Laboratories in 1929 and after a year as Assistant Educational Director, was made Educational Director in charge of the employment and training of members of technical staff, student assistants, drafting assistants and shop apprentices. From 1936 to 1939, as Assistant Personnel Director, he was in charge of employment and training. Since 1939, he has directed the personnel analysis and planning group.

SAM W. SHILEY

Sam W. Shiley of Transmission Development retired on December 31 following forty-three years of service. Mr. Shiley joined the Clinton Street Works of the Western Electric Company in 1904 where he held several supervisory positions in the Drafting Department and was in charge of telephone circuit drafting when it was moved to Hawthorne in 1907. The following year he transferred to the Engineering Department to participate in the development and standardization of telephone switchboards, distributing frames, and racks. He was Standardization Engineer when he came to New York in 1915. Here he took part in the development of many manual and toll systems. Mr. Shiley became Laboratory Engineer in the carrier telephone and telegraph laboratories at the Graybar-Varick building in 1930. Previous to his retirement, he was in charge of the Transmission Development Laboratory and was also responsible for handling drawings and specifications of his department.

EDMUND W. HANCOCK

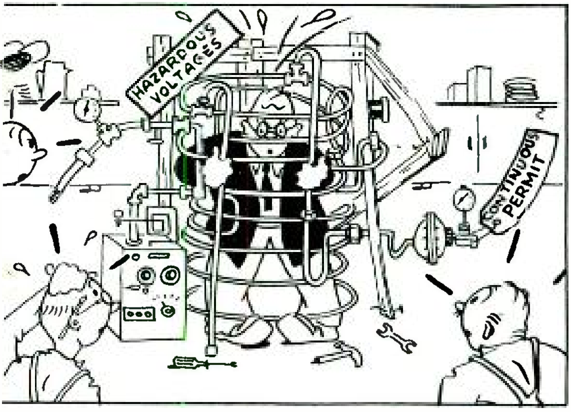
Edmund W. Hancock of the Switching Development Department retired on December 28 following forty-three years of service. His



first work with the Bell System was in connection with installation of manual central offices in the New York area. After several years with the Installation Department he transferred to West Street, and took part in work on the first machine switching system which was tried out as a PBX in the West Street building, and which preceded the panel system. He was next engaged in design and development of the panel semi-mechanical system and supervised part of the testing of this system at the Newark and Wilmington installations. Later he was in responsible charge of a group designing selector circuits for the panel dial system. Beginning in 1926, he conducted field development work in connection with new features of various telephone switching systems and investigations of irregular conditions. In more recent years he has been associated with the development of the No. 1 crossbar system.

Anton Loder

Anton Loder of the Transmission Development Department retired on December 31 following thirty-two years of service. Mr. Loder joined the Development Department in 1914 and worked as an instrument maker on printing telegraph equipment and then on radio apparatus for the Signal Corps. Later, in 1917, he left the Company and went with the M. I. Instrument Company, where he worked on apparatus they were making for the Western Electric Company. He returned to the Development Department in 1919 and for the next fourteen years was engaged as an instrument maker with a variety of telephone apparatus, particularly for transatlantic and ship-to-shore service. From 1933 to 1938 he was with the design and wiring group of the Research Department on special wiring and mechanical work of an experimental nature. He then was transferred to do the same general type of work for the broad-band cable group of Transmission Development. Since April, 1946, Mr. Loder has been with the coaxial systems group of the same department.



News Notes

C. C. Houtz inspected manufacturing facilities and initial production of ceramic condensers for radar applications at Winston-Salem.

L. W. Stammerjohn's visit to the New York Transformer Company at Alpha, N. J., had to do with manufacturing problems on power transformers for amplifier use.

C. N. Hickman spoke on *Rockets* at the Deal-Holmdel Colloquium on December 3 at Deal. He also lectured to the students of the Air War College, Maxwell Field, Ala., on December 8.

R. E. Poole, W. C. Tinus and M. H. Cook attended the meeting in Washington of the Navy Industrial Association.

F. L. Langhammer participated in discussions on components of radar equipment at the N.R.K. Manufacturing and Engineering Company in Chicago.

A. K. Bohren and B. O. Browne witnessed tests on an FM antenna tower at the Blaw-Knox Company, Pittsburgh.

W. W. Brown visited the Western Electric Repair Shop at Philadelphia to discuss operators' chair problems.

R. G. Koontz and W. J. Adams visited Winston-Salem and Burlington to discuss engineering and drafting practices for Bell System Radio Communication equipment.

M. D. Brill and I. E. Fair attended the National Electronics Conference in Chicago, November 3 to 5.

R. A. Sykes attended the Piezoelectric Committee meeting of the Institute of Radio Engineers in New York on November 3.

E. B. Wood and N. Insley visited Hawthorne to consult with Western Electric Company engineers on switchboard lamp problems.

R. H. Ross studied aircraft radio motors at A. W. Haydon Company in Waterbury.

F. S. Malm, H. Peters and V. T. Wallder witnessed the field splicing of "Alpeth" cable at Belleville, N. J. Mr. Wallder and J. B. Howard conferred at Point Breeze on plastic compounding methods.

J. P. Guerard went to Pittsburgh for meetings of the A.S.T.M. Committee B5 on copper and copper alloys.

W. P. SMITH has been reëlected Mayor of Atlantic Highlands, N. J., for another two-year term. In his twelve years of civic life, Mr. Smith has been councilman for ten years, a member of the school board for six, and mayor for two.

M. S. MASON, in his capacity as a member of the New York Engineers Committee on Student Guidance, met students of the Bronx High School of Science on December 3 to discuss preparation for and opportunities in the engineering profession.

D. E. TRUCKSESS and M. A. FROBERG investigated noise conditions in connection with the use of the new 100-ampere selenium rectifier at Buffalo and Erie.

E. M. TOLMAN recently received a Ph.D. degree in Chemistry from Columbia University. Dr. Tolman presented his thesis as a paper before the September meeting of the American Chemical Society in New York City.

A. E. RUPPEL and F. J. SKINNER visited Albany to discuss problems concerning the New York State Police mobile telephone system.

O. J. MORZENTI went to Media and Duluth in connection with equipment development problems concerning No. 5 crossbar system.

R. L. LUNSFORD conferred at the Northern Electric Company, Montreal, on studies of small community dial offices.

J. R. STONE participated in discussions on ringing equipment for No. 5 crossbar system at the Holtzer-Cabot Electric Company in Boston.

A. A. BURGESS and R. P. JUTSON, at Philadelphia, conferred with local telephone engineers on special equipment for the No. 5 crossbar.

H. H. SPENCER tested electronic speed regulators for motor-generator sets used to supply power for the L carrier system at Dallas, Mineral Wells, and Sweetwater, Texas.

Following an illustrated lecture in the West Street Auditorium on Night Photography *by Stanley Rayfield of* Life Magazine, *forty-eight members of the Photography Club took a field trip to Central Park. Putting into practice the techniques outlined by Mr. Rayfield were this group of photographers taken by Chairman W. S. Suydam. Left to right, K. L. Warthman, A. L. Johnsrud, R. Olsen, R. J. Nielson, two unidentified guests, W. J. Rutter and H. J. Braun*

W. C. KIRKMAN is treasurer of Troop Committee No. 114 of the Boy Scouts of America in Rochelle Park, N. J. In the campaign just concluded for funds for the Council, Mr. Kirkman's committee doubled the quota set for their area.

H. O. SIEGMUND spoke on the subject of *Rockets* at a meeting of the American Society of Mechanical Engineers on November 20, and on December 3 before the New York Chapter of Alpha Chi Sigma.

A. C. PETERSON discussed mobile radio equipment problems with Motorola engineers at Chicago.

W. STRACK visited Chicago in connection with the multi-channel mobile telephone system.

P. T. SPROUL discussed television switching problems with engineers of the Illinois Telephone Company in Chicago.

J. L. MERRILL, JR., and J. A. WELLER conducted a trial installation of the E-1 exchange area repeater in Chicago. G. C. REIER observed the installation and performance of these repeaters.

R. E. CRANE attended the Midwest General Meeting of the A.I.E.E. and the National Electronics Conference in Chicago during the period from November 5 to 7. He presented before the A.I.E.E. a paper, *Frequency Division Techniques for a Coaxial Cable Network*, of which he was co-author with J. T. DIXON and G. H. HUBER.

OBITUARIES

Hugh M. Stoller, November 17

Mr. Stoller, who was a member of the Technical Staff in the Switching Apparatus Development Department, was stricken on his way to work and died shortly afterwards at a nearby hospital. A native of Schenectady, he had received his E.E. degree from Union College in 1913 before joining the Bell System. After a year in relay development work, he returned to his alma mater and received his M.S. degree in electrical engineering in 1915. Returning to the Physical Laboratory, he was engaged in miscellaneous research problems until World War I, when he designed and developed power equipment for radio apparatus used on airplanes and submarine chasers.

Mr. Stoller then transferred to what is now the Commercial Products Development Department, where he was responsible for the development of synchronizing and speed control devices for sound recording and reproducing systems for television and for picture transmission. Following that, he engaged in the development of electromagnetic apparatus for switching systems.

During World War II he contributed to the research and development of the electrical gun director, magnetic mines and sonar. The more than seventy patents that he held on voltage and speed regulators and on sound picture equipment attested to the valuable contributions he had made in his various fields of interest. Mr. Stoller was author of numerous articles in technical publications.

Alfred E. Kopetz, December 9.

Mr. Kopetz, who was born in 1872, was transferred from the Manufacturing Department of the Western Electric Company to the Model Shop of the Engineering Department in 1908. Prior to World War I he worked on machine switching equipment and was one of a group of instrument makers assigned to install the semi-mechanical switching system in the Market and Waverly exchanges in Newark. During World War I he became a supervisor of a group of instrument makers.

Mr. Kopetz retired March 1, 1926, and thus became the first employee to be pensioned under the benefit plan which was established when the Laboratories was incorporated in 1925.

H. M. Stoller
1891-1947

Amanda Force
1896-1947

Shortly after retirement, Mr. Kopetz, with his wife and two children, moved to a small farm in Greene County in the Catskills. Now both children are members of the Murray Hill Laboratories; Edward is an instrument and tool maker in the Development Shops, and his daughter, Mrs. Elsie K. Melroy, a clerical supervisor in Central Files.

Amanda L. Force, December 8

Mrs. Force joined the Plant Department of the Laboratories at Murray Hill on October 22, 1942, as a member of the Restaurant staff. For the past two years she had been making salads at the Cafeteria counter, where she was a familiar figure to the patrons.

January Service Anniversaries of Members of the Laboratories

35 years

L. H. Bachmann
G. F. Fowler

30 years

A. O. Adam, Jr.
Phyllis Barton
J. D. Beatty
M. E. Ellis
P. B. Findley
J. C. Gabriel
Rosario Gerardi
T. B. Grant
E. F. Helbing
M. J. Kelly
T. J. Mazzi
William Muldoon, Jr.
I. C. Osten-Sacken
F. J. Redmond
Elizabeth Viggers

25 years

A. J. Aikens
Erland Anderson
E. T. Ball
B. G. Bjornson
W. C. Burger
H. N. Christopher
J. F. De Zavala
William Eichinger
R. F. Elliott
J. R. Erickson
Richard Haard
H. W. Heimbach
I. M. Kerney
E. H. Leonard
V. L. Lundahl
Ethel McAlevey
D. S. Myers
Dorothy Patchell
H. R. Vail
C. A. Webber

20 years

E. F. Billman
J. H. Harding
O. M. Hovgaard
A. F. Klare
M. R. Kleist
Bernice Potwin
Mildred Ralph
H. G. Raupp
C. H. Rumpel
J. D. Tebo
C. G. Wennerberg

15 years

Theresa Marion

10 years

F. C. Cathers
C. S. Jackson
J. A. Miller
Alma Ostar
Muriel Walter

Engagements

*Selma Bruckner—Jess Kaufman
*Carolyn Burton—Robert L. Culp
*Doris Hogben—Albert E. Kudrle
*Harriet Marcus—Seymour Feiring
*Elizabeth Minerowicz—Anthony F. Yavorski

Weddings

*Lillian Benjamin—Earl W. Fraser
*Marcae Bitowf—James G. Carolan
*Frances Fitzpatrick—*Eugene Flannery
Shirley Littman—*Bernard Litwack
*Janet Mysel—Ralph Sinclair
*Kim Mee Ng—Joseph F. Chu
Susan Rolio—*Bernard C. Guinter
Muriel Smith—*S. E. Michaels

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

At Burlington, L. Vieth, F. S. Corso and R. Black were concerned with production of the new broadcast microphone; F. L. Crutchfield, matters relating to the high quality moving coil receiver; T. H. Crabtree, testing problems associated with hearing aids; and L. Vieth, the manufacture of the new broadcast microphone.

H. F. Hopkins attended the meeting on *Loud-Speakers* of the Sound Equipment Section of the Radio Manufacturers Association in Buffalo.

J. R. Power, J. M. Rogie and F. S. Corso visited the Western Electric hearing aid dealers in Boston, Detroit and Washington in connection with the field trials of hearing aid cords.

F. L. Crutchfield was at the Archer Avenue plant regarding problems on the new operators' receiver.

F. F. Farnsworth visited a number of plants in the Pacific northwest area that produce and treat poles, crossarms, and other timber products for Bell System use. He also discussed current outside plant development projects with interested engineers of the Mountain States Company at Denver and The Pacific Telephone and Telegraph Company at Portland, Seattle, San Francisco and Los Angeles.

J. W. Kenard and R. P. Ashbaugh visited Hawthorne and the Illinois Bell Telephone Company for discussions pertaining to the new types of composite sheath that is being used for exchange area cable.

A. H. Hearn was in Washington in connection with a special committee assignment to revise and reissue the present Manual of Standards of the American Wood-Preservers' Association. At Orville, Ohio, he supervised experimental treatments of Douglas fir poles to prevent bleeding. Mr. Hearn, G. Q. Lumsden and R. H. Colley inspected creosoted southern pine poles in the Harrisburg area.

F. E. Ward appeared before the Board of Appeals at the Patent Office in Washington relative to an application for patent.

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

W. Hartmann attended the fall meeting of the Optical Society of America in Cincinnati, October 23 to 25, at which he presented a paper, co-authored by B. E. Prescott, *The Quantitative Spectrochemical Determination of Barium, Strontium, and Calcium.*

A. E. Johnson, M.D., of the West Street Medical staff, has recently completed four articles in a series of ten for the *Encyclopedia Americana*. Dr. Johnson's subjects include *Penicillin Aerosol; Recent Advances in Tuberculosis;* and *Pulmonary Physiology.*

C. B. H. Feldman, H. J. Fisher, M. D. Brill and I. E. Fair attended the National Electronics Conference, November 3 to 5, in Chicago.

J. R. Power participated in conferences at the United States Naval Hospital in Philadelphia on hearing aid problems.

B. E. Stevens conferred at the Magnetic Windings Company in Camden on magnetic materials for power transformers manufactured at Winston-Salem.

C. A. Smith visited Boston in connection with the VE repeater trial.

G. H. Keillen's visit to Winston-Salem concerned a Signal Corps project.

E. T. Ball, at Hawthorne, made framework studies for the No. 5 crossbar system.

J. R. Power and F. S. Corso were in Chicago in connection with initiating a field trial on hearing-aid receiver cords.

"The Telephone Hour"

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

January 12	*Marian Anderson*
January 19	*Fritz Kreisler*
January 26	*Lily Pons*
February 2	*Set Svanholm*