BELL LABORATORIES **RECORD**

VOL. XXVII • NO. 4 • APRIL 1949

The 555 PBX

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Switching Equipment Engineering

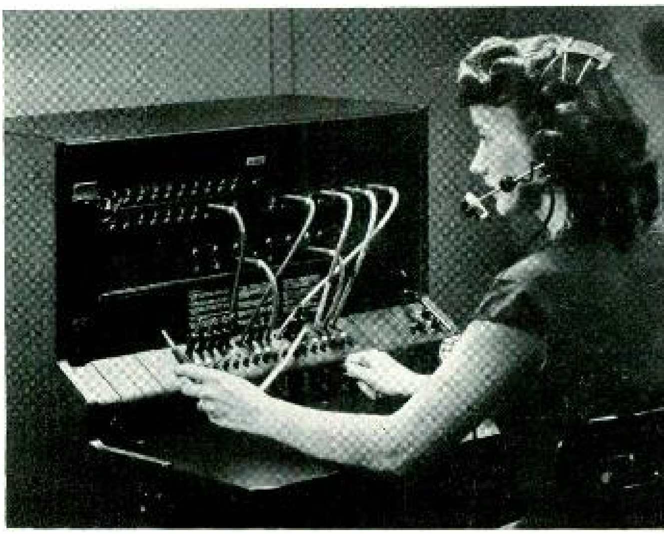
The 555 PBX is a non-multiple manual PBX switchboard designed to replace the present standard 551* and the earlier 550 boards in capacities up to 120 lines. The latter two types have long been familiar landmarks in offices generally and in department stores, small manufacturing plants, and hotels all over the country, and during the war even substituted as emergency central offices and toll switchboards.

Until interrupted by the war, development work had proceeded on the 555 board to a point where trial installations were made in the territories of several Associated Companies. The response by both the subscribers and the companies was very favorable, and resulted in the decision to complete development as soon as conditions would permit. Since the end of the war, steps have been taken to put the new switchboard in production at the Kearny plant of the Western Electric Company and units are now available for use in the Bell System.

The 555 PBX has a capacity of 120 lines, fifteen cords, and thirteen trunks. By use of a longer double-pulley cord available as an option, two of these boards may be placed side by side, and thus provide double this capacity. With over-all dimensions of about four feet high by two and one-half wide, it is somewhat wider than the 551, but its design is more modern in appearance, and many outstanding improvements are incorporated.

A front view of this new board is shown in Figure 1. It will be noticed that the cord circuit equipment—plugs, lamps, and ringing and talking keys—are in a sloping and short vertical section, and that a large unencumbered horizontal shelf, which on

Fig. 1—Front view of one of the new 555 PBX's



*Record, *July*, 1928, *page* 363.

previous boards was the key shelf, is available for writing or other work the attendant may be carrying on when not operating the switchboard. In the first row of the vertical jack section are the trunk jacks and lamps, and above these are the jacks and lamps for extensions. There is space for six extension jack strips, and these may be of either ten or twenty jacks per strip. With the wider spaced jacks, the entire space will be filled by sixty extensions, while by using the closer spaced jacks, there is room for 120 extensions. The dial shown at the right is used in dial system areas, and a handset —for which a mounting is evident at the left—may be used by the attendant if desired instead of the new 52A operator's telephone set shown.

One of the interesting features of this new board is the provision of the cord and trunk circuits in removable plug-in units. This makes it possible to avoid tying up excess equipment to take care of future expansion, since additional units may be added as necessary. One of the cord units is shown in Figure 2. Such a unit may be easily removed or added in a few moments merely by releasing two fasteners at the rear and disconnecting or connecting a plug. Central-office trunks and various types of tie trunks are similarly arranged as shown in Figure 3. The attendant's telephone circuit is also arranged in a plug-in unit. Besides taking care of the addition or removal of units, this plug-in feature will greatly assist maintenance. In case of serious difficulties on a particular unit, a spare tested unit can immediately be inserted, thus cutting down any service interruption to a minimum. However, the construction of the units is such as to make most of the apparatus accessible from the rear of the board, making it possible to inspect all relay contacts and most key contacts without removing the unit.

Such unit construction also lends itself to the most efficient and economical assembly-line manufacture, and the latest designs of apparatus and materials are used. All units employ die-cast and molded plastic parts not only to facilitate manufacture but also to permit maintaining the precise limits necessary for easy placement and removal in the switchboard.

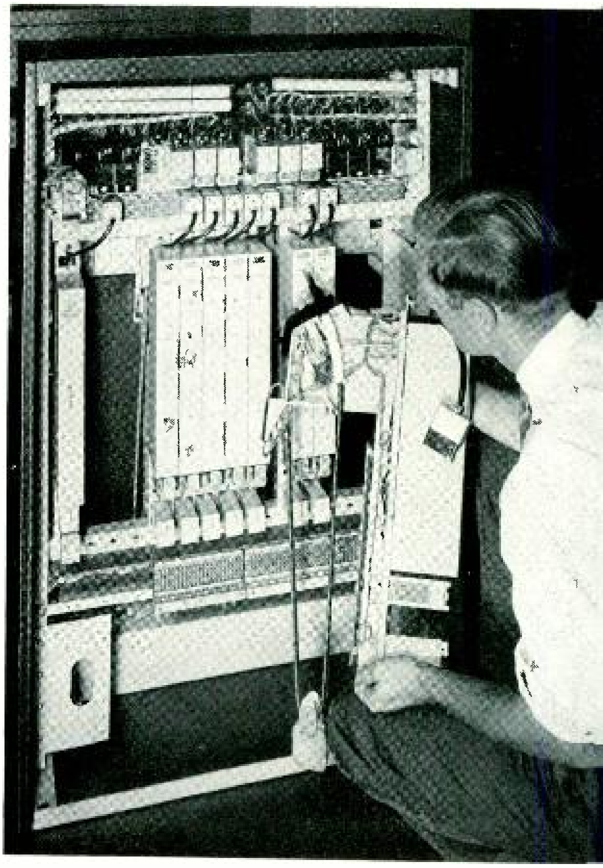


Fig. 2—Rear view of the 555 showing one of the cord units being removed

Another feature of the new board is the supporting of all equipment from an inner welded steel frame evident in Figure 4. Wood panels of either light oak or mahogany are secured to the frame by slide fasteners and screws, and may be put in place or removed in a few minutes. The wood casing members and the writing shelf are shipped in a separate package, and thus possible damage during shipment or installation is minimized. Surfaces subject to wear are afforded special protection. The jack panel and writing shelf have a facing of phenol fiber, and the edges of the end panels, which are of plywood, are faced with an extruded plastic strip that is glued in place.

In their operating features, the circuits of the 555 PBX provide essentially the same functions as the conventional switchboard. Lamps are lighted as signals from the central office or extensions, and cords are used to complete the connection between the central office and the extensions, or between two extensions. However, the key operations used to accomplish these functions are entirely different from those of the usual lever type. For answering and talking, the lever of the cord key is turned to the right in a rotary manner in a vertical plane, and ringing is accomplished by push buttons located in the sloping section. The talking key is pushed inward to establish a through-dial or night connection and in this position is locked in place, minimizing the chance of accidental restoration of the key when the PBX is unattended.

Except in the smaller sizes, PBX boards have heretofore often required a local battery to maintain the operating voltage within satisfactory limits. By taking advantage of the most improved equipment and using a new switchboard lamp with a very wide operating range, the 555 has been designed to operate satisfactorily with voltages between 16 and 50, and thus under ordinary conditions will not require a local battery. Power and ringing current will both be supplied over cable pairs from the central office. A hand generator of a new and more powerful type is provided to supply ringing current in emergencies. Another improvement of the new board is the incorporation of extended trunk and station ranges, making possible the use of less long line equipment than was formerly required.

Any of three types of supervision may be provided by the cord circuits. On extension-to-extension calls, supervision is obtained independently from each extension. On central-office calls, "through" supervision is normally provided: the central-office operator gets the disconnect signals directly from the station. By a simple strapping change, however, conversion to "non-through" supervision is readily obtained. With this arrangement, the PBX attendant gets the disconnect signals, but this is not transmitted over the trunk to the central office until the PBX attendant disconnects the cord. By adding one optional relay, automatic discrimination on central-office calls can be achieved, thus providing "through" supervision on all outgoing telephone calls and "non-through" supervision on incoming calls.

A germanium varistor* of small size is provided as protection across the windings of each of the relays on the sleeves of the cords to reduce the potential which would otherwise be impressed on the cord sleeve when the plug is taken from the jack. The current drawn by the varistor is of the order of only 0.1 milliampere, which is much lower than would otherwise be required by the usual non-inductive relay winding employed for this purpose, and contributes to the lowered current requirements of the switchboard. An equally efficient condenser-resistance combination would oc-

*Record, *December*, 1948, *page* 485.

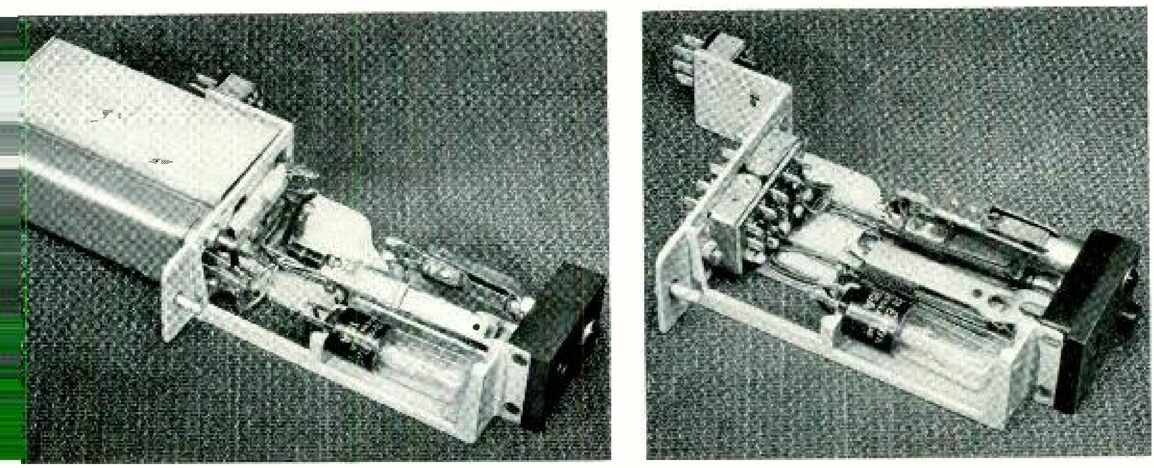


Fig. 3—Central-office trunk unit, left, and a ring-down tie trunk, right

cupy considerably greater space. However, the principal factor contributing to the low-current requirements is the use of UA-type relays instead of E-type relays.

Other new features included in the 555 are a master splitting key for handling "announcement" calls, and automatic grouping at times of light load when two positions are used. By operating the master splitting key after the called station has been rung on an incoming central-office call, the attendant can communicate privately with the called station. Position grouping at times of light load is accomplished automatically when the attendant's plug is removed from the telephone jacks, rather than by the usual grouping key operation. A UA-type relay rather than the conventional AC relay is employed as the ring-up relay, operating on ringing current rectified by a varistor. Two thermistors are provided in the circuit to prevent false operation of the ring-up relay on transient surges on the trunks, and to furnish the high impedance of the ringing bridge across the trunk required for the transmission of high-speed dial pulses from the PBX dial. This ring-up relay being across the trunk at all times eliminates the need for a similar relay in each cord circuit, since the re-ring signals are indicated on the trunk lamps instead of the cord lamps.

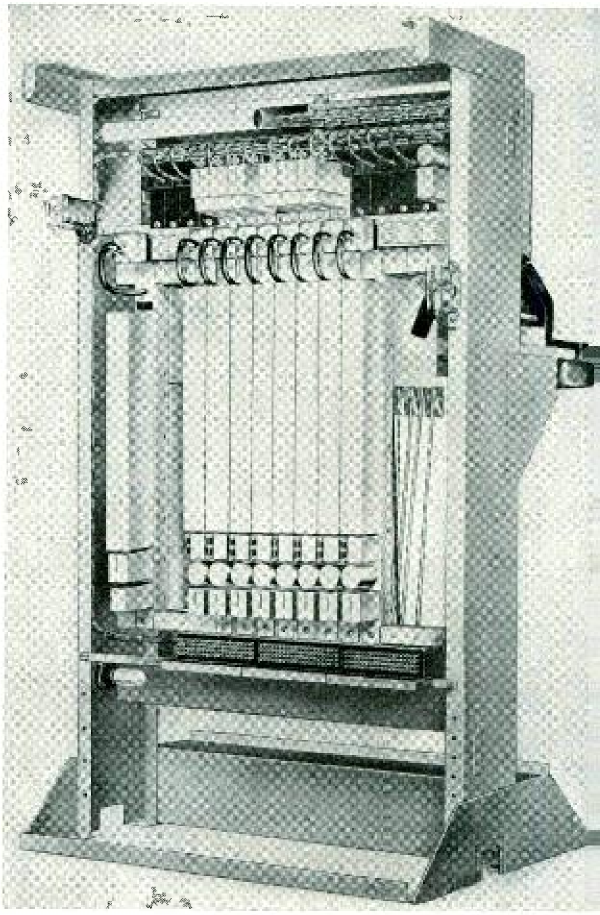
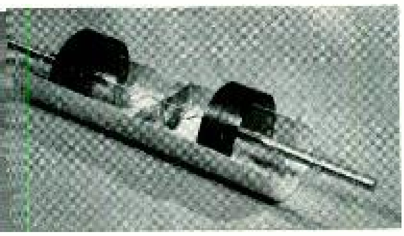


Fig. 4—The 555 *board from the rear*

Like most new systems developed by the Laboratories, the 555 is a product of cooperative effort by many engineers. Among the author's associates who made significant contributions are R. L. Lunsford, V. I. Cruser, J. G. Ferguson, F. W. Treptow, O. C. Olsen, L. J. Bowne (retired), W. Bennett, R. W. Harper, A. Tradup, and P. V. Welch.

THE AUTHOR: G. F. Sohnle joined the Laboratories in 1921 as a technical assistant in the Systems Development Department. After completing the training course, he transferred to the equipment development group as a trial installation engineer, and later as an analyzation and PBX equipment development engineer. He continued his studies in the evening at the Polytechnic Institute of Brooklyn, receiving the E.E. degree in 1933. During the war years he engaged in the engineering of long transmission lines for the Armed Forces, and in the development of airborne radar. Following the war, he resumed PBX development work, and at present is engaged in developing equipment for automatic message accounting.



The Coaxial Transistor

Shortly after the discovery of the Transistor, J. N. Shive of these Laboratories observed that amplification could be obtained with a germanium wedge when the emitter and collector points were placed on opposite sides of the wedge.* In this construction, the germanium wedge is narrowed down to a sharp edge and the point contacts are placed on opposite sides at a point where the wedge is only a few thousandths of an inch thick.

Investigation of the wedge device seemed to indicate that the current passing between emitter and collector was actually passing through the semi-conductor and not around the wedge surface. Thus the effect was apparently not a surface phenomenon but rather a current amplification process occurring within the semi-conductor itself. If this were true, transistor action should also be possible by reproducing the wedge geometry in circularly symmetrical form, thereby providing complete shielding between emitter and collector points.

A disc of germanium ⅛ inch in diameter and 20 mils thick was cut from a thin slab of germanium by means of a hole saw. Two dish-shaped depressions were ground and lapped into the faces of the disc by means of a spherical tool. This wafer was placed in a mount and held by spring pressure.

The germanium disc, normally grounded electrically, is seen to provide an electrostatic shield between the emitter and collector points, and all three parts—emitter point, collector point, and germanium disc—are coaxial.

With the highly polished surfaces desirable for operation at higher current, it had been found with the Type A Transistor that points which were not perpendicular to the surface often had a sufficient tangential component of force to cause them to slip as they were pressed against the surface. In the coaxial construction, the two contact points are on opposite sides and thus can be exactly perpendicular to their contacting surfaces.

Characteristics are comparable with those of the Type A Transistor, which has both points on the same side of the disc.

Advantages which might be attributed to the coaxial construction are: improved stability of the points, especially on highly polished surfaces; electrostatic shielding between input and output circuits; and the avoidance of construction problems involving the placing of two spring contacts within a few thousandths of an inch of one another. Close tolerances are not completely avoided by this design, however, since the two points should be accurately in line on opposite sides of the germanium for most satisfactory operation.

W. E. Kock and R. L. Wallace, Jr., with a large model of the coaxial Transistor which they described in a paper at the A.I.E.E. Winter Convention

*"The Double Surface Transistor," J. N. Shive, *Physical Review, page* 689, *February* 15, 1949.

Gas engine cooling

F. F. SIEBERT
Power Development

For the unattended repeater stations commonly used with long carrier or radio relay systems, power is often obtained from commercial power lines. It is necessary, however, to supply alternators driven by gasoline engines that will automatically take over the load should the commercial supply fail. The engines are cooled by blowing air through a radiator through which the engine-cooling water flows. Because of the wide range of outside temperatures, however, it is necessary to control the amount of air passed through the radiators to secure the best performance of the engine. The methods employed for controlling the airflow through the radiator differs somewhat with the size of the engine. For sets between 30- and 60-kw capacity, the KS-5704 duct system has recently been developed.

This unit is shown in Figure 1. It mounts between the engine radiator and the outside wall of the building—the flexible coupling section evident at the left of the photograph being attached to the radiator. A set of automatically controlled shutters in the outside end of the duct control the amount of air discharged from the building, while a similar set of shutters in the top of the duct allows some of the air to enter the engine room to warm it in cold weather.

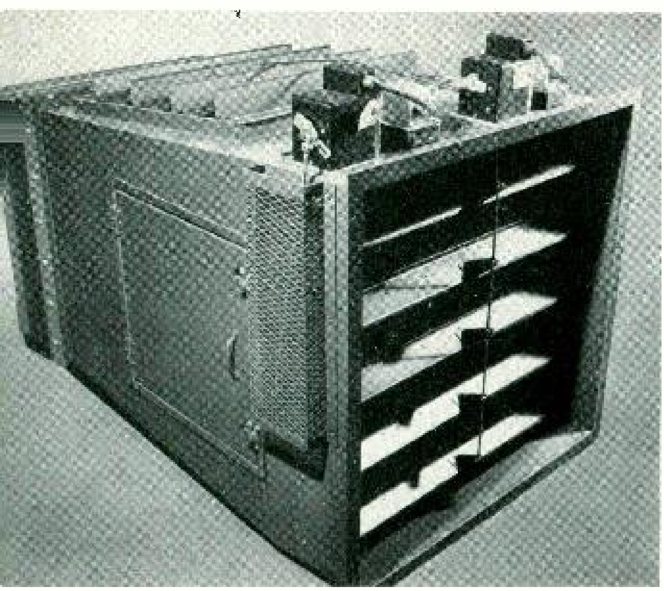


Fig. 1—The KS-5704 duct system showing the two sets of shutters and their controls

The complete cooling system employs in all, three sets of thermostatically controlled shutters; the two on the duct mentioned above, and a third in the outside wall of the building to serve as an intake. These latter shutters are automatically opened when the engine starts and automatically closed when it stops, and thus insure a source of outside air at all times the engine is operating.

The shutters in the top of the KS-5704 unit are controlled by a thermostat in the engine room, and open when the temperature drops below 75 degrees F and close when it rises above 75 degrees. This prevents the room temperature from dropping too low in cold weather or from rising too high in hot. Both these shutters in the top of the KS-5704 duct and the intake shutters in the wall of the building are normally either open or shut—no intermediate positions are provided for. The shutters in the end of the duct, however, may assume intermediate positions, since the amount of their opening has a more direct control on the temperature of the cooling water of the engine.

For controlling these latter shutters, a temperature-sensitive vapor-filled bulb in the water line between the engine and the radiator is connected through a copper tube to a metal bellows associated with the controller as shown in Figure 2. This bellows, in turn, adjusts a potentiometer in the cir-

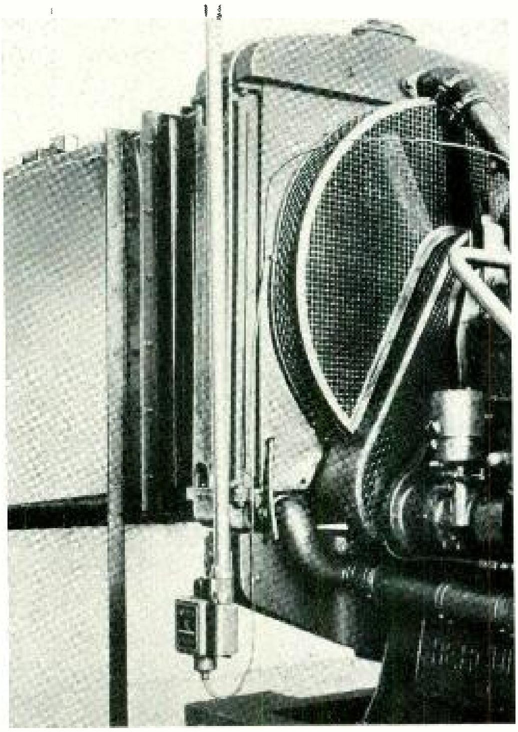


Fig. 2—A KS-5704 duct system connected to an engine radiator

cuit controlling the motor that opens or closes the shutters. It tends to open the shutters as the temperature of the cooling water rises, and to close them as it drops. The effect of this potentiometer, however, is opposed by another that is controlled by the damper motor itself. A rise in the temperature of the cooling water, acting through the first potentiometer, will tend to drive the damper motor to open the shutters, but as the motor opens them, it also moves the second potentiometer which opposes the effect of the first. This form of balanced, or servo control, results in a definite amount of damper opening that depends on the water temperature. The control apparatus is manufactured by the Minneapolis-Honeywell Company, who collaborated with us in designing the over-all control system.

Twenty or thirty of these units are installed in stations along the L (coaxial) carrier system crossing the southwestern part of this country. It is expected, however, that they will find further use in radio relay or other carrier systems where the conditions are suitable.

THE AUTHOR: F. F. Siebert, after receiving the S.B. degree from Harvard University in 1915, joined the Stone and Webster Management Association and worked on Power Plant installation and Central Station operation until 1917. He then accepted a commission as Engineering Officer in the U. S. Navy, and remained in the Navy until 1919 when he became 1st Assistant Engineer in the Merchant Marine. In 1920 he joined the Engineering Department of the Western Electric Company, now Bell Telephone Laboratories. Here he has since been engaged in the development of power apparatus, such as motor generators, rectifiers, ventilating systems, internal combustion engines, batteries, and transformers.

A test set for mercury contact relays

R. J. HOPF
Switching Development

The mercury contact relay*—a wartime achievement of the Bell System—is now being manufactured in a series of coded 275 and 276 types for the new No. 5 crossbar system and for the automatic message accounting center. These relays are applied mainly where high-speed action with contacts free from chatter and of high current capacity are required. One of their principal advantages is that since their operating characteristics are fixed at the factory, no adjustment or maintenance is required in the field. It is necessary, however, that means be provided to detect defective relays so that they can be replaced.

As indicated in Figure 1, the mercury contact relay consists of a glass-sealed mercury contact switch and a winding, all assembled in a metal vacuum-tube shell and mounted on a vacuum-tube octal base, to the prongs of which the various elements are connected. All contact surfaces are continuously covered with a thin film of mercury, maintained by capillary action from a pool in the lower part of the relay housing. The switch elements within their glass-sealed envelope are in an atmosphere of hydrogen at a pressure of 250 pounds per square inch to minimize sparking. The supports for the armature and make contacts are constructed of magnetic material, and when the winding is energized, the armature moves over to close the front contacts. Upon removal of current, the back tension of the armature spring restores the armature contacts to the back contacts.

*Record, *September*, 1947, *page* 342.

A permanent magnet, not shown in the cross-section view, is furnished only on the 276 type, and is the feature that distinguishes this relay from the 275 type. The magnet provides means for factory adjust-

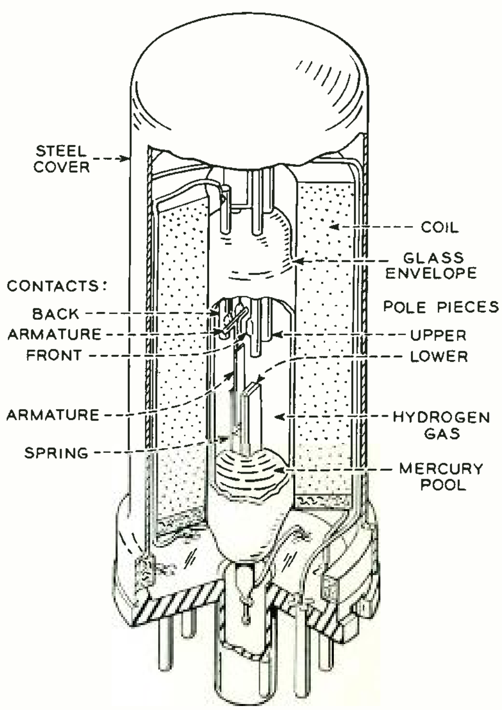


Fig. 1—Cross-section of the mercury contact relay

ment of the relay characteristics by biasing the armature. This increases the operate sensitivity in a direction to reduce the operate current through the winding, and makes the 276 type more sensitive and more marginal than the 275 type. In one coded form, the 276D, the relay is biased to a point of being a fully polar relay, that is, to the point where a current through the winding, approximately equal and opposite to the operate current, is required to release the relay.

Both types of relays are made in several coded forms, the particular form being indicated by a letter after the type number. These coded types differ in the number of windings and their arrangements, and in the connections of the windings and contacts to the eight prongs of the base. Data applying to the various codes are given in Figure 2. The left-hand column of this table gives the code; the next column indicates by a FIG. NO. the connections to the base prongs, shown by the diagrams at the bottom. The four arrangements standardized to date are shown below the table. Other arrangements may be added from time to time as conditions warrant. In the remaining columns of the table are given the winding data, and the test current for operate, non-operate, hold, and release.

To facilitate testing these relays after they have been installed in the plant, the portable test set shown in Figure 3 was developed. It includes sockets for the relay under test—four lamps—one for each of the make and break contacts—to indicate the action of the relay when test current is applied to the winding, and a selector switch that is set according to the FIG. NO. that applies to the relay under test. The set also includes a "cross-test" key to permit detecting short circuits between the two make contacts, 1-2, or the two break contacts, 4-5, shown in Figure 2. A TEST-A key is also supplied to apply the test to either the

275 AND 276 TYPE RELAYS (MERCURY CONTACT)

275 TYPE RELAYS

CODE	FIG. NO.	WINDING	NOMINAL		TEST CURRENT IN MILLIAMPERES			
			RESISTANCE	TURNS	OPERATE	NON-OPERATE	HOLD	RELEASE
A	1	PRI.	2500	18,800	10.1	6.7	7.8	4.5
B	1	PRI.	4000	23,400	8.1	5.3	6.3	3.6
C	3	PRI. SEC.	700 3300	5925 16,950	32 11.2	21 7.4	25 8.7	14.2 4.9
D	1	PRI.	700	9500	20	13.2	15.5	8.9
E	1	PRI.	2	600	315	210	245	140

276 TYPE RELAYS

CODE	FIG. NO.	WINDING	NOMINAL		TEST CURRENT IN MILLIAMPERES				
			RESISTANCE	TURNS	SOAK	OPERATE	NON-OPERATE	HOLD	RELEASE
A	1	PRI.	90	4325	50	16	12.8	9.2	1.3
B	1	PRI.	4000	23,400	9	3	2.3	1.7	0.2
C	1	PRI.	4000	23,400	SPECIAL-NOT FOR GENERAL USE				
D	1	PRI.	4000	23,400	9	+1.5	+0.42	-0.42	-1.5
E	1	PRI.	4000	23,400					
F	1	PRI.	1000	12,357	17	5.6	4.5	3.3	0.4
G	4	PRI. SEC.	700 3300	5925 16,950	35 12	14.2 5	7.7 2.7	5.1 1.8	2.8 1
H	1	PRI.	90	4325	50	32	21.5	18.5	15
J	1	PRI.	4000	23,400	9	4.7	2.9	2.3	1.7

BASE CONNECTIONS — BOTTOM VIEWS

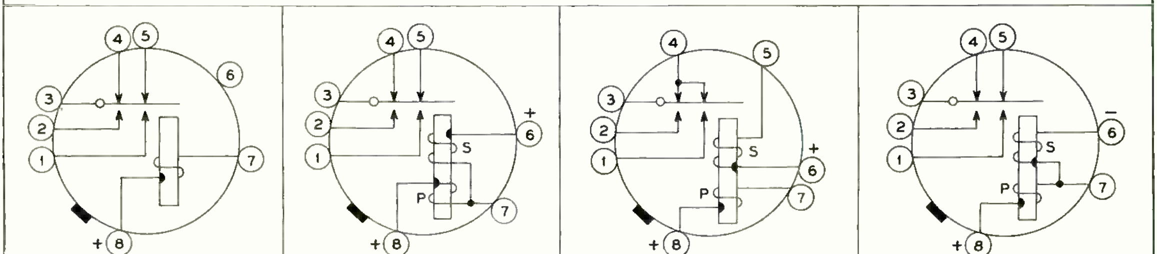


FIG. 1 FIG. 2 FIG. 3 FIG. 4

Fig. 2—Test data for existing coded relays of the 275 and 276 type

primary or secondary winding of the relay.

A No. 35-type test set is employed with the relay test set to provide test currents of the proper values as indicated by the table of Figure 2. This set, shown at the left of Figure 4, has been used in the plant for a number of years, and is widely available. It includes a meter to indicate the test current, and resistances and potentiometers associated with four key-controlled circuits. These four circuits are set up individually to give the proper values of operate, non-operate, hold, and release currents, and then by pressing the proper key, the desired test currents are applied to the relay winding in any desired sequence. Locking-type keys are employed to permit the application of tests in sequence. When

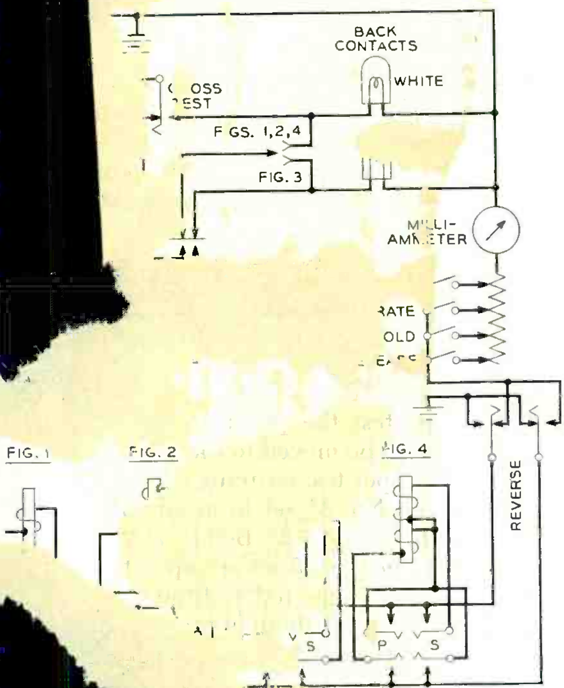
Fig. 3—The J94725A *test set for type* 275 *and* 276 *relays. In the foreground are a* 276*-type relay at the left and a* 275 *type at the right*

making a release test, for example, the release key will be locked down, and the operate key pressed. On release of the operate key, the current in the winding will at once drop to the release value. A reverse key is also included in the No. 35 test set. Power is secured from the 48-volt central-office battery. One double-ended black cord connects this battery supply to the relay test set, and another cord, slate in color, carries the power from the relay test set to the No. 35 set. A third cord, with a red and green braid, is used to carry the test current from the No. 35 set to the relay test set.

Two sockets—one marked A and the other B—are included in the top panel of the relay test set. If the relay to be tested is one [illegible] the standard codes, it is inserted in the [illegible] socket, and the selector switch is rota[illegible] the position corresponding to the FIG. [illegible] applicable to the relay under test. Th[illegible] circuit then established is shown in Fi[illegible] 5. At the bottom of this diagram are i[illegible]cated the connections of the relay [illegible] test and of the TEST-A key, wh[illegible] to select the particular winding to be [illegible] for the four FIG. NOS Only one of the[illegible] be associated with the test circu[illegible] at a[illegible] —the particular combination dependi[illegible] the position of the selector. The o[illegible] changes made by the selector other [illegible] those between the windings and th[illegible] T[illegible] key is in the [illegible] position. This addit[illegible] change is in [illegible] just above and to [illegible] right of the break contacts of the r[illegible] the diagram.

To illustrate the [illegible] of the test [illegible] may be assum[illegible] tested and has bee[illegible] As shown on Figu[illegible] connection an[illegible] ha[illegible] w[illegible] selector will thus be moved to th[illegible] position, and to [illegible] primary [illegible] the TEST-A key wil[illegible] the primary position. The pro[illegible] ll then be set up on the N[illegible] ance with the data on Figure [illegible] of the test keys on the No. 3[illegible] ed, the two break lamps, [illegible] white, will be lighted i[illegible] tween the armature and [illegible] of the relay. When the non[illegible] is pressed, this conditio[illegible] the When the operate key is [illegible] the break lamps should go [illegible] make lamps should ligh[illegible] sumed that the hold and [illegible] been locked closed befo[illegible] is released. Under this [illegible] current will be applied [illegible] the ate key is released. [illegible] therefore, no change [illegible] the lighted lamps. When [illegible] key is released, the release curren[illegible] applied, and the two make lamps shou[illegible] go out and the two break lamps should light. If these tests are successfully met, a similar set of tests could be carried out for the secondary winding by moving the TEST-A key to the secondary position.

.. test for crosses between either the ıke or break contacts may be made at ıme by operating the cross-test key. If elay is unoperated at the time, and the eak lamps are thus lighted, opera- of the cross-test key should leave the break lamps lighted and light the white lamp. If the red make lamp lights, a e en the make contacts is indi- H l the relay been operated when oss est key was operated, the two



cuit as established by the y test set

have been lighted prior cross-test key, and after key, the make lamps ted and the white break . A lighted red break la te a cross in the break conta

Since th ry contact relays are new, the extent c ir application has not yet been fully de nined, and new uses requiring different contact and winding arrangements are continually arising. As a result, the test set may be required to test

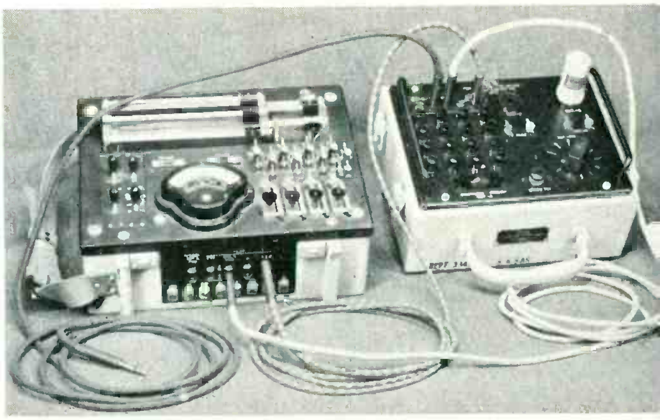


Fig. 4—A No. 35 test set at the left connected to the relay test set by the cords that are provided with the latter set

relays that do not conform to the four diagrams at the bottom of Figure 2. To make this possible, the set includes a second socket marked B and a field of sixteen binding posts at the left of the top panel. The eight terminals of the B socket are connected to eight of these binding posts, while the other eight posts are connected to the circuit. Any relay not conforming to one of the four arrangements shown, therefore, is inserted in the B socket, and short wires are run from the eight binding posts connected to the socket to the posts connected to the points of the circuit to which the particular relay terminal should be connected. Once these connections have been made, a test may be carried out for a non-

Fig. 6—A test set-up for a non-standard relay

THE AUTHOR: R. J. HOPF joined the Engineering Department of the Western Electric Company in 1916, where he was associated with the testing and design of printing telegraph equipment until 1921. During this period he attended Cooper Union, and received a B.S. in E.E. degree in 1921. He later took one year of post-graduate work at Columbia, and received an E.E. degree from Cooper Union in 1936. In 1921 he transferred to the Switching Development Department where he was engaged in testing circuits for step-by-step office and toll dialing systems. During the war he was an instructor at the Bell Laboratories School for War Training and in 1945 joined the toll design group. For the last two years he has been associated with the testing of the No. 5 crossbar system.

standard relay in the same way as for a standard relay. The set-up for such a test, with a non-standard relay in the B socket and the proper set of jumper wires run between binding posts, is shown in Figure 6.

Whenever new base connections a[illegible] proved for standardization, it is plan[illegible] provide additional wired-in selectc[illegible] tions to avoid the need of using the B sc[illegible] for these relays.

New control system safeguards service along coaxial route

With the twist of a dial, a Long Lines maintenance man in Dallas can start the engine for emergency power at an unattended repeater station a hundred miles away.

This kind of remote control, together with an accurate picture of conditions at distant unattended stations, is made possible by a complex new alarm and control system recently installed on the 650-mile coaxial cable route between Dallas and El Paso.

The new device, developed by the Laboratories, is designed to take care of as many as ten main repeater stations. The Dallas-El Paso line was chosen as the first installation because the new system is expected to be especially valuable in safeguarding service along coaxial routes where attended offices are widely separated. Between these two cities there are three unattended and two partially attended main repeater stations.

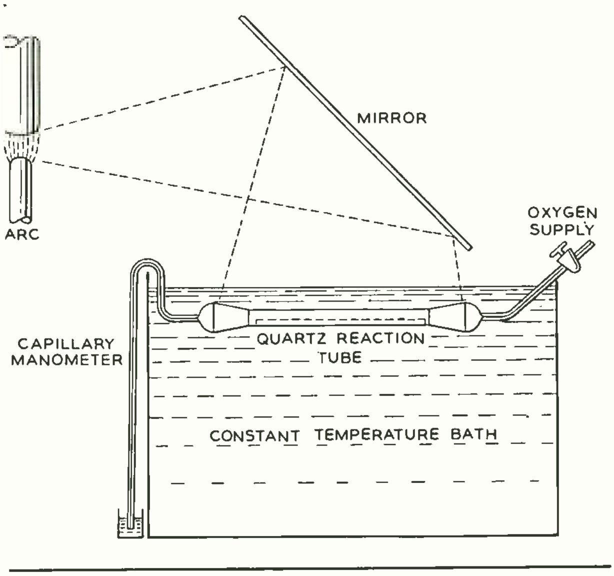
As an alarm, the new system can indicate about 160 different conditions in each subordinate office—conditions such as fire, unlawful entrance or a low supply of gasoline for the emergency power engine. As a control device, the system enables 100 specific operations to be performed at each unattended office. Examples: switching fro[illegible] one coaxial line to another, starting [illegible] emergency gas engine and locating [illegible] exact spot of transmission trouble [illegible] the route.

When trouble occurs at an un[illegible] main or auxiliary station, an alarm [illegible] mitted to the control station. [illegible] maintenance man dials a code back [illegible] unattended office to find out the di[illegible]ulty. In answer, the equipment at the distant point lights up signal lamps indicating just what is wrong. The maintenance man then sends out another code and the equipment starts to take care of the trouble. This system will be described in more detail in a forthcoming issue of the RECORD.

Oxidation of organic materials

Replacements of such materials as paint, wire insulation, cable covering and similar items of outdoor equipment entail large replacement costs in the Bell System. Continuing study is made to obtain materials with greater longevity to effect savings in these costs and one group in the Chemical Laboratories is constantly concerned with general investigations into the degradation of various organic materials. Below, J. Crabtree is shown with apparatus used in measurements of the accelerating effect of light on the rate of oxidation of a variety of organic materials in air.

As seen from the diagram, a carbon arc supplies light which is reflected from a first-surface aluminized mirror upon materials supported in several quartz tubes. The tubes containing measured amounts of oxygen are immersed in a constant temperature bath. The rate of absorption of oxygen is determined by the rise of liquid in the capillary manometers to be noted in the left foreground of the photograph.



Measuring crystal inductance at high frequencies

G. F. CRITCHLOW
Transmission Measurement

In crystal filters,* used extensively for broadband carrier systems and elsewhere in the Bell System, some of the more important properties are determined by the inductance of the component crystals. The departure of the inductance from its nominal value may cause the performance of the crystal to undergo appreciable change, and in the manufacture of such crystals it is necessary to measure the crystals for inductance, so that those with values falling outside accepted limits may be discarded.

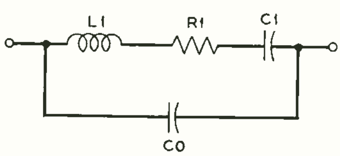


Fig. 1—Equivalent electric circuit of a quartz crystal

The equivalent electric circuit of a crystal is shown in Figure 1. The inductance L1, referred to above, with its associated series resistance and capacitance, R1 and C1, is mechanical rather than electrical in character, and is shunted by the electric capacitance C0. Since this is a network with only two terminals, the inductance is inaccessible for measurement and can be measured only by indirect methods.

At frequencies below about one megacycle, the value of the inductance L1 has been determined by placing a coil inductance in shunt with the crystal, and then measuring several resonance frequencies. To determine L1 by this method, however, it is necessary to know the geometric inductance of the shunt coil, that is, the inductance due only to the magnetic flux linking the turns. The actual measured inductance of such a coil includes also the effects of various inter-turn capacitances, but at frequencies up to about one mega-

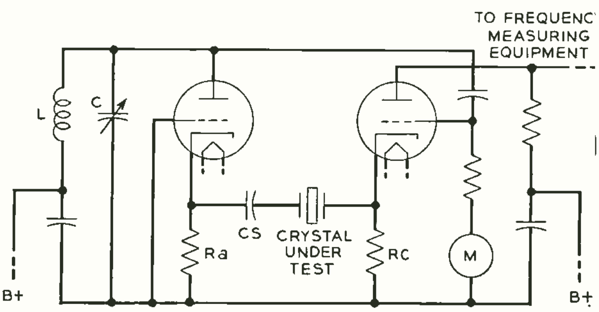


Fig. 2—Circuit for measuring inductance

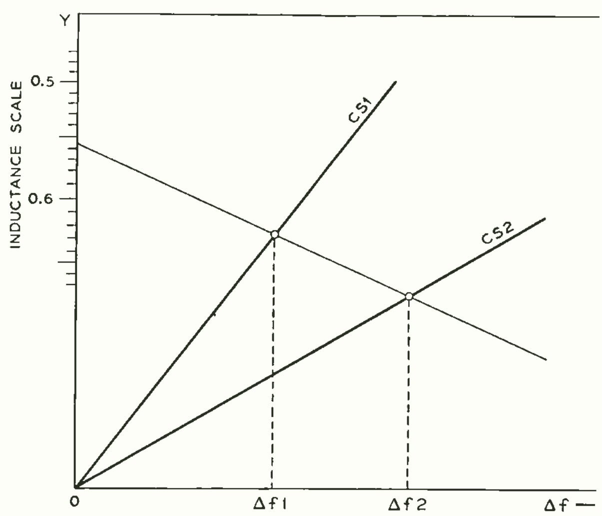


Fig. 3—Method of determining inductance

*Record, *June*, 1935, *page* 305; *October*, 1938, *page* 62.

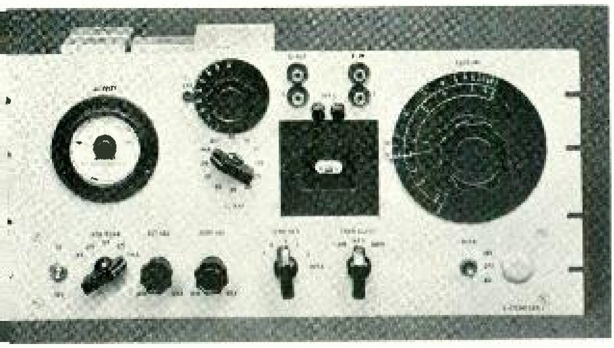


Fig. 4—Test apparatus designed for measuring crystal inductance

cycle, it is possible to determine these latter effects by a combination of measurement and calculation, and thus to eliminate them from the over-all inductance. At frequencies above one megacycle, however, this becomes impracticable. Since in recent years greater and greater use is being made of these higher frequencies, it has been necessary to devise a new method for measuring crystal inductance.

In this new method, L1 is determined also by measuring several resonance frequencies, but instead of using a coil in shunt with the crystal with all the difficulties it entails, a known capacitance is placed in series with the crystal. The circuit employed is shown in Figure 2. Here the crystal whose inductance is to be measured, in series with an added test capacitance CS, is inserted in the feedback path of a crystal-controlled oscillator. The tank circuit LC, at the left, is tuned to approximately the crystal frequency as indicated by maximum current through the meter M. If the capacitance CS were not in the circuit, the circuit would oscillate at the series resonance frequency fo, determined by the crystal parameters L1 and C1. When a capacitance CS1 is placed in series with the crystal, the resonance frequency will shift to some value f1, while with some other capacitance, CS2, it will shift to some other frequency f2. Apparatus is connected to the output of the circuit to measure the frequency, and by determining two such frequency shifts, f1-fo and f2-fo, which may be called Δ f1 and Δ f2, the value of L1 may be calculated.

Although the calculations of L1 from these two frequency shifts are somewhat involved, they are not necessary in using the measuring circuit, since preprinted charts have been provided, from which the value of L1 may be readily determined by drawing a straight line through two points. The essential features of one of these charts are shown in Figure 3. The abscissa scale is frequency shift, and a series of straight lines radiating from the origin represent the various values of CS that may be used. After two frequency shifts for two values of CS have been measured, points are marked on the two corresponding radiating lines above the two values of the frequency shift found. A straight line is then drawn through these two points, and at its intersection with the Y axis, the value of L1 is read directly from the printed scale.

For convenience of use in the manufacturing plants, this measuring circuit has been arranged on a panel as shown in Fig-

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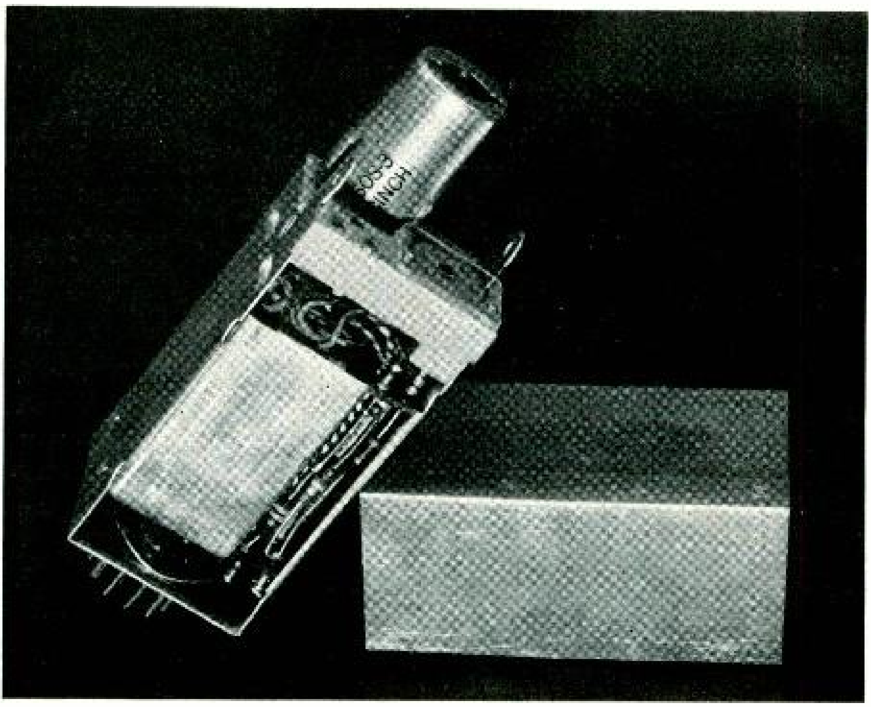
THE AUTHOR: G. F. CRITCHLOW graduated from Cornell University with a B.E.E. degree in 1942, and received a B.M.E. degree in 1943. He then joined the Technical Staff of the Laboratories, working in the transmission and impedance measuring apparatus group of the Transmission Apparatus Development Department. During the war he worked on the development of magnetically controlled weapons. Since that time, he has been engaged in the design of precise impedance measuring equipment and the development of test methods used by the Western Electric Company.

ure 4. The tank frequency is set by the double-range dial at the extreme right, while suitable controls for adjusting the terminating resistances, RA and RC, and the meter sensitivity are arranged along the bottom of the panel. The crystal unit under test is inserted in the socket located in the black square near the center of the panel. To the right of the meter are two dials that determine the value of capacitance inserted for CS. The lower dial inserts fixed discrete values of capacitance, while the upper dial gives continuous control over the capacitance inserted. Occasionally, a crystal will have abnormalities that, if not recognized, will result in a wrong inductance determination. These will be revealed by continuously varying the series capacitance in the vicinity of resonance frequency. This is done as the first step in making an inductance determination.

Sets similar to that shown in Figure 4 have been used in applying this new method of measuring crystal inductance.



A V3 repeater unit of the type now being used in the Bell System plant. Photograph shown as Figure 3 on page 46 of the February 1949 RECORD was of an early laboratory model of this unit

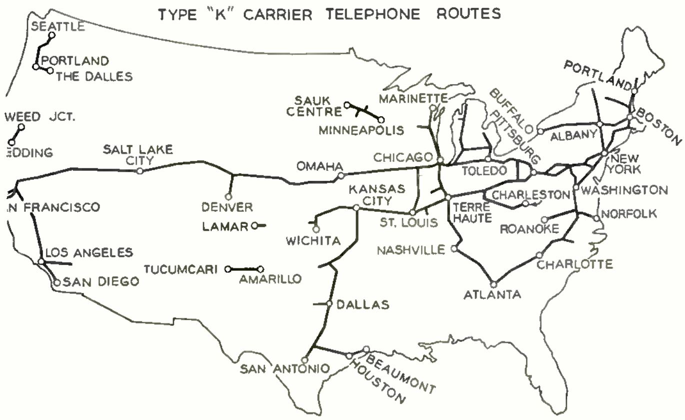


Fig. 1—*K carrier routes as of February* 15, 1949

The K2 carrier system

F. A. BROOKS
Transmission Development

During the past twelve years, K carrier telephone systems* have been installed about as fast as they could be obtained until at the present time a large part of the available pairs in long-haul cables have been equipped. The extent of the cable carrier network as of February 15, 1949, is shown in Figure 1. When the first K installation was made, on cables between Toledo, Ohio, and South Bend, Indiana, in 1937, the designation K carrier system was applied without any number following the K. Development work on thermistors, which was well under way when the first K system was installed, soon indicated, however, that an improved method of regulation could be provided. A system using thermistors for regulation and certain other improvements of more limited scope was therefore designed and put in production. To distinguish these two K systems, the original was designated K1 and the new, K2. All systems installed in recent years have been of the K2 type, and the present network shown in Figure 1 includes both types. So readily interconnected are the two systems that a circuit may be K1 part of the way and K2 the rest of the way.

All broadband carrier systems use essentially the same terminals to modulate twelve voice bands, each 3,200 cycles wide on carriers 4 kc apart, to place them in the band from 60-108 kc. This band, called a "channel group," is then modulated as a whole to place it in a suitable frequency range for transmission. For the K system, the channel group is modulated to be between 12 and 60 kc.

Pairs in toll cables carrying K systems are non-loaded nineteen-gage conductors. Such pairs have a high speed of transmission, and their use thus avoids the extensive use of echo suppressors on long circuits. Each pair carries one twelve-channel group in one direction. A second pair, in a different cable, or in a separate shielded compartment in the same cable, carries the same channel group in the opposite direction. The group in one direction is amplified as a unit in repeaters spaced about seventeen miles apart. Repeater spacing, however, is determined by many factors, and may be as small as eleven or as great as twenty miles. Because of the high frequencies employed, the loss per unit length

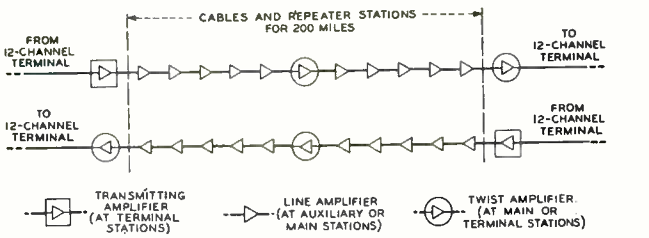


Fig. 2—Relative positions of the various repeaters on a K carrier circuit in aerial cable

*A bibliography of articles on the K carrier system published in the Record is given on page 142.

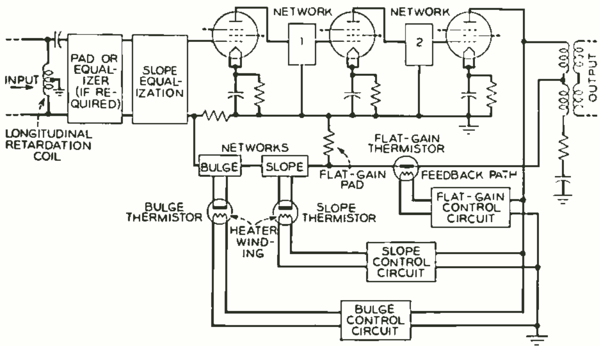


Fig. 3—Twist amplifier used in the K2 carrier system

of cable is high. Over a seventeen-mile repeater section, it is about 40 db at 12 kc and 65 db at 60 kc at a mean cable temperature of fifty-five degrees F. The repeaters equalize for differences in loss with frequency so as to provide an output level that is essentially the same for all frequencies.

The losses change with temperature, however, and change at different rates at different frequencies. With aerial cable, temperatures may vary over a range of 110 or more degrees F, and the changes in temperature often occur rapidly. At noon on a hot sunny day an aerial cable may rise to well over 100 degrees, while the rapid cooling at night may reduce it as much as fifty degrees within a few hours. Automatic regulation is therefore required to adjust the gain of the amplifiers at various frequencies to conform to the changes in loss caused by these temperature changes. In underground cable, neither the range nor the rate of change of temperature is so great, and hence the regulation can be omitted at some of the amplifier points.

How this regulation was accomplished in the K1 system has already been described in the Record.* On this system, the line amplifiers with their equalizers, without the application of regulation, make up for the loss over the frequency band at the mean temperature of fifty-five degrees F. Of the change in loss caused by the temperature varying above or below fifty-five degrees, which is only about ten per cent of the total loss in the repeater section, the greater part is compensated by making the same change in gain at all frequencies. This is called flat regulation. The variation not corrected by flat regulation is called twist. It is small in each section and is corrected about every sixth section on aerial cables by a twist amplifier and regulator. The amount of flat and twist correction required is determined automatically by measuring the resistance of a pair extending over the section to be regulated and adjusting the gain accordingly. This method of operation was known as pilot-wire regulation, since the amount required is determined by measuring the resistance of one of the pairs of wire in the cable, which was called the pilot wire, although it may also be used for transmission. This flat and twist regulation gives satisfactory results for systems up to about 500 miles in length. It was recognized, however, that for greater distances small deviations in gain would have accumulated that required correction. The deviation regulator† was, therefore, developed for use at about 500-mile intervals on the longer circuits.

This latter regulator which usually replaced all of the pilot-wire twist regulation in new systems took advantage of the recently developed thermistors for controlling the gain. The temperature of the thermistors was controlled by three pilot frequencies at 12, 28 and 56 kc transmitted over

*Record, *January*, 1939, *pages* 148 and 160.
†Record, *June*, 1942, *page* 258.

Bibliography for K1 Carrier System

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the cable from the transmitting terminal. This method was called pilot-channel regulation instead of pilot-wire regulation.

With thermistor control, the regulating circuits are much simpler than with the expensive motor-driven control units and master controllers, which are complex precision instruments. It was decided, therefore, to design a new regulating system for K carrier employing thermistor control throughout. It is the K system with this new type regulation using thermistors and earlier article.* The 56-kc pilot heats a fast-acting thermistor in the feedback circuit to control the flat regulation, while the 12 and 28-kc pilots, heating slow-acting thermistors, control the slope and bulge regulation, which together comprise the twist regulation.

The line amplifiers are of about the same physical size as those used in K1 except the mechanically driven condenser and the line equalizer have been removed from the feedback path. In their place is a thermistor,

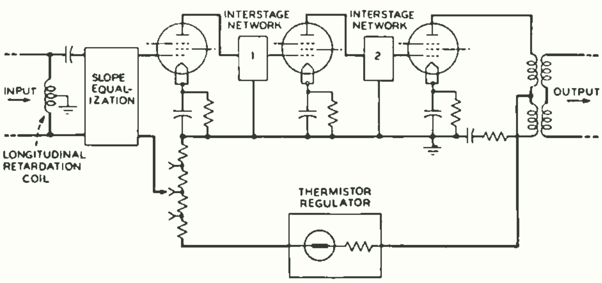


Fig. 4—Line amplifier for the K2 carrier system

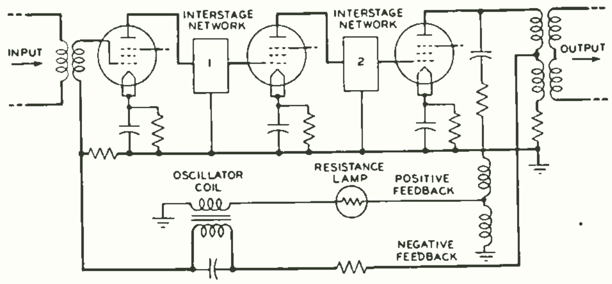


Fig. 5—Transmitting amplifier for the K2 carrier system

pilot channels exclusively that is called the K2 carrier system.

As with the K1 system there is a transmitting amplifier at each terminal, and on aerial cable, a twist amplifier at about every sixth repeater station, and line amplifiers at each of the five stations between twist regulator stations, as indicated in Figure 2. On underground cables, the twist regulator may be placed as infrequently as at every fifteenth line repeater. The twist amplifiers are essentially the same as the deviation regulators developed for long K1 systems and already described.* The twist regulation is controlled by the pilot frequencies of 12, 28 and 56 kc which are derived at the transmitting terminal from the regular carrier supply and transmitted throughout the length of the system. In addition to supplying twist regulation, they also control the flat regulation needed to compensate for the flat loss for the immediately preceding repeater section. The circuit is shown in Figure 3, and the regulating action of the circuit is as described in the and the equalization is obtained by an adjustable network connected in the input circuit, as shown in Figure 4. This thermistor has a negative temperature coefficient—the resistance falling as the temperature rises—and thus the more current fed back, the lower will be the resistance of the thermistor, and the greater will be the fed-back voltage impressed on the input of the amplifier. Feedback is proportional to the integrated power at the output of the amplifier, and the circuit is adjusted so that at the desired output power, the circuit will be stable and hold the output constant for more than the normal range of input. If the output increases for any reason, the feedback current will increase, the thermistor will get hotter, its resistance will decrease, and thus the negative feedback voltage will increase and reduce the output. Should the output for any reason decrease from the desired value, the action of the feedback will tend to increase it. As a result of this action, the line amplifiers therefore tend to hold the mean output at a constant value.

*Loc. Cit., *June*, 1942.

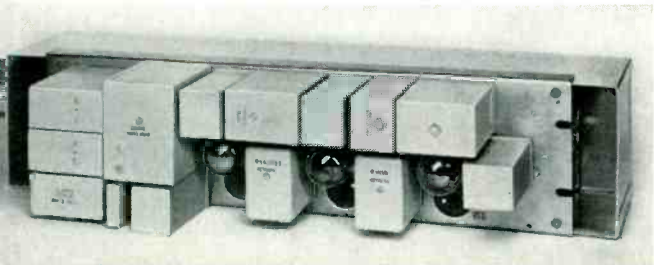
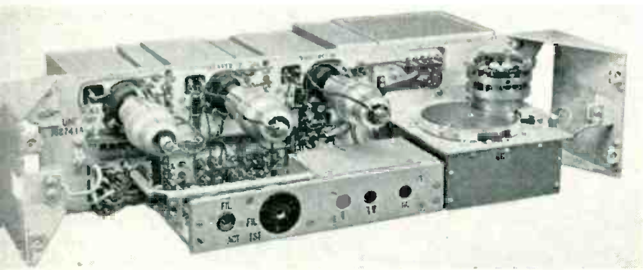


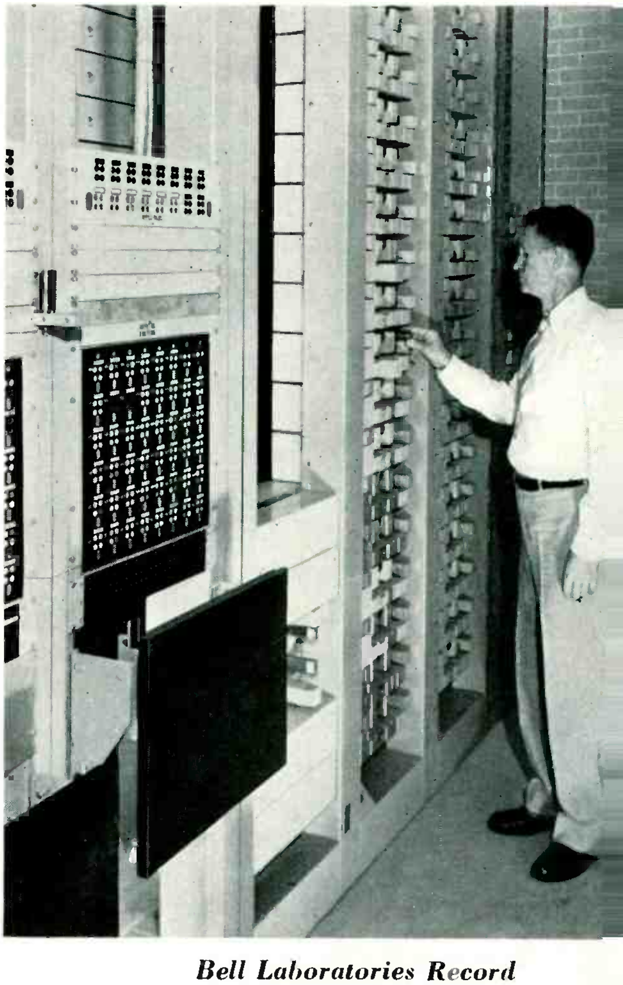
Fig. 6—Line amplifier for the K2 carrier above and for the K1 carrier below



so as to maintain a constant voltage output at all times. With a constant output from the transmitting amplifier, the line amplifiers regulate for temperature changes only.

The forward acting portion of the three types of amplifiers uses the same tubes and substantially the same parts. Each amplifier has two impedance-coupled voltage amplifier tubes impedance coupled to the output stage. Parallel tube sockets are provided to permit replacement of tubes one at a time while the amplifiers are in service. Although similar in many respects, the feedback portions differ significantly because the function of each is different. In each case, the maximum amplification is about 115 db and the feedback varies from

Fig. 7—Auxiliary repeater station Atlanta K2N on the K2 carrier system running north from Atlanta to Terre Haute



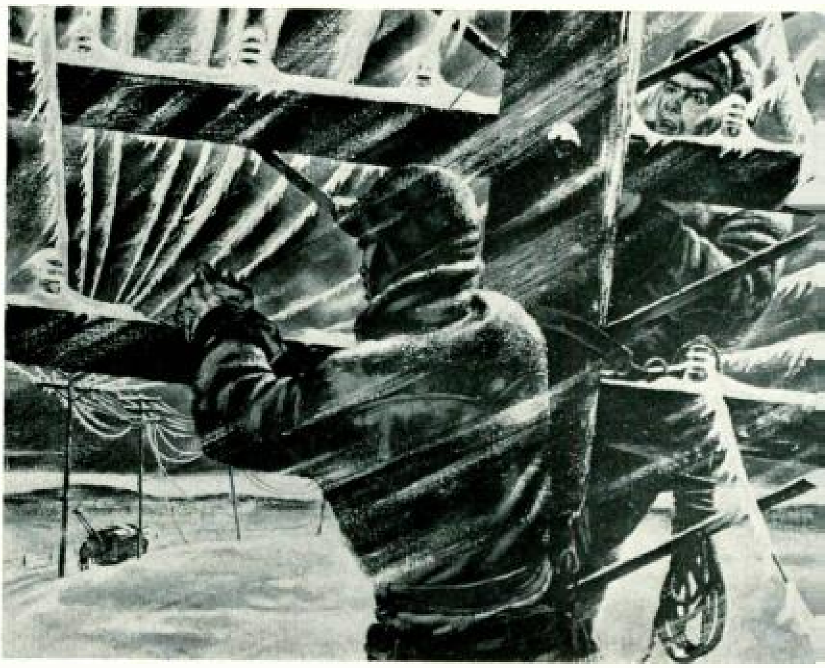
The output of a line amplifier will tend to change, however, either because of a loss change due to temperature in the preceding cable section or because the total volume of the signals transmitted changes, as with the number and volume of the talkers. Thus to maintain constant power in the line amplifier output, the input power must be constant except for the change in loss due to temperature of the cable. Otherwise, the regulator would increase the signal level when the number and volume of talkers was low instead of regulating for the change in cable loss only.

To insure proper action of the line amplifiers, the transmitting amplifier is designed also to maintain a constant integrated output regardless of the volume and number of channels in use. The circuit employed is shown in Figure 5. By using a combination of positive and negative feedback with a 60-kc tuned circuit in both paths, the amplifier will oscillate at 60 kc and put 60 kc power onto the line. The amount of this 60 kc, however, is only sufficient to hold the amplifier output at the desired power. When the signal power is relatively high, there may be little or no 60 kc put out on the line, but as the signal load decreases, the 60-kc component increases proportionally forty to sixty db to give a net gain of fifty-five to seventy-five db, which may occasionally be further reduced by other adjustments.

Little change in size and appearance of the K2 amplifiers has been made by these changes in regulation, as may be seen from the accompanying photographs. The absence of the mechanical regulators, however, is noticeable in a K2 repeater station, and considerably simplifies the maintenance of the office. At the present time, about two-thirds of 9,000,000 channel-miles of K carrier are of the K2 type.

THE AUTHOR: F. A. Brooks received the B.S. degree in E.E. in 1923 from the University of Nebraska, and at once entered the Inspection Methods Department of the Western Electric Company at Hawthorne. His work was in designing shop-testing methods and testing equipment for final testing of voice and carrier frequency repeaters and of various carrier terminals. In 1925 he transferred to these Laboratories. In the Toll Systems Department, he had responsibility for open-wire line circuits and carrier repeater development. Later he was placed in charge of a group working on cable carrier repeaters and regulator circuits. During the war he and his group developed under-water sound-ranging circuits and the application of pulse-modulation technique to Army communications. At present he heads a group engaged in circuit development for wire carrier repeaters, short-haul open-wire systems, and program transmission.

Telephone Teams Slug It Out With Ice Storms and Blizzards



An Oklahoma newspaper reporter, shivering in near-zero cold, called it "The Great Ice Age of January, '49."

In the Dakotas and neighboring states, January was the month of the "Blizzard of '49."

By whatever name, January storms added up to a major Bell System disaster, measured in terms of both service interruptions and damage to telephone plant. The havoc covered the vast middle regions of the country from the Canadian border to the Gulf of Mexico, knocking out an estimated 75,000 telephones and eight to ten thousand long distance circuits, and isolating over 500 exchanges from the toll network.

The five-state Southwestern Bell Telephone Company, with a total estimated damage of $10,000,000, was the hardest hit. Heavy damage, though less in degree, was sustained by the Northwestern Bell Telephone Company, the Illinois Bell Telephone Company, the Michigan Bell Telephone Company, the Wisconsin Telephone Company, the Southern Bell Telephone and Telegraph Company and the Long Lines Department of the A T & T.

In Northwestern Bell territory, an early January blizzard was followed by two ice-sleet-and-wind storms later in the month. And for telephone people, the significant thing was that when residents of the region needed telephone service, it usually was there. Most calls got through. Thousands of snowbound residents of Western Nebraska, North and South Dakota and Southern Minnesota took to the voice highways to pour into waiting and anxious ears their appeals for help or news of their safety. Telephone men and women bucked huge snowdrifts and biting winds to get to work. They slept in cramped quarters in telephone offices or nearby hotels and worked long hours, earning the thanks of their communities. In many localities, the telephone was the only "way out" for many days.

In the Southwest, there was likewise a series of storms. Sleet, wind, flood—and most of all, ice—ravaged telephone plant from Hannibal on the Mississippi to Pecos near the Mexican border. Sleet and rain built up on sagging telephone lines until the massed weight of ice snapped wires, poles and crossarms by the thousands. Nature's combined effort knocked out 4,800 toll circuits, silenced 53,000 telephones and isolated some 200 communities. Plant wreckage included 24,000 downed telephone poles, 36,000 broken crossarms and more than 200,000 breaks in toll wire alone.

To speed restoration of service in the Southwest, telephone men came with their trucks and tools from all parts of the Southwestern Company territory and from neighboring Bell System companies—Illinois, Southern and Mountain States. The Long Lines Department also sent crews and trucks into the storm area from eighteen states—some from as far away as Michigan, Ohio, Pennsylvania, West Virginia and North Carolina. These men worked from dawn to dark, seven days a week. They slept in short naps, ate on the run. Sometimes they could scarcely stay upright on the ice crust and their trucks stalled on slippery highways. But one way or another, they got where they were needed and did the job.

The nation-wide facilities of the Western Electric Company were mobilized speedily. Supplies poured in by truck, train and plane from 43 cities in 21 states as Western Electric dug deeply and quickly into its nation-wide resources. In wire alone, Western shipped to the Southwestern Company in January more than nine times as much as was needed to restore plant damage after the East Coast hurricane of 1944. At no time was the restoration job held up for lack of supplies.

Copper sleeves, used to join the ends of broken telephone wires, were among the many items urgently needed in quantity to repair storm damage in the Southwest this winter. At one point, to keep pace with the demand, Western Electric had the raw material shipped air express from Rome, New York, to Chicago. It arrived at 7 p.m. on a Saturday and was taken to Western's Clearing Plant for processing, then to the 47th Street Shops for acid dipping, then back to Clearing for finishing. Despite the necessity for handling the materials at two locations, finished sleeves were ready for shipment by noon Sunday.

Working night and day on an emergency basis, Western Electric's Clearing Plant in Chicago shipped more pole line hardware and outside plant apparatus to the Southwest during the January storm period than would be required in six months of normal shipments.

Among the casualties of the January sleet storms was the toll cable between Fulton and Kingdom City, Mo., on the main pole route between Dallas and Oklahoma City. Normally, it would take six or eight weeks to manufacture a replacement for this cable. By giving the job the highest priority, Western Electric's Point Breeze Works made the cable—all eight miles of it—in exactly one week! Then, a couple of weeks later, they turned out four miles of toll cable for emergency replacement near Dennison, Texas, in four days.

Telephone people in the storm-battered towns took it on the chin along with everyone else. Broken power lines left homes without light or heat. Street cars, buses, taxicabs and trains stalled on ice-locked roads or in drifting snow. Falling trees filled yards with wreckage and stove in roofs of houses. Schools closed, mail deliveries stopped and in some communities the storms shut off water supplies.

In Durant, Okla., for example, residents were reduced to melting icicles for drinking water. Telephone men near Durant worked as long as 36 hours at a stretch, and the telephone office there continued to operate with emergency generators, bringing reassurance to desperate townsfolk.

Telephone linemen often saw pole lines they already had restored twice topple a third time as ice struck again. There were places where the telephone men had to carry tools and materials two miles on foot through mud that had stopped the best trucks.

"Hazards and discomforts the men took in stride," said a division construction superintendent pridefully. "But never a grumble from a soul."

A convoy of Illinois Bell men arrived at their Missouri destination at 9:30 a.m. They had been driving all night and none of the men had had breakfast. But they immediately pitched in, regardless of lack of sleep and empty stomachs, and went to work.

Illinois Bell plant men joshed at what the Southwestern gangs called cold weather. "You guys don't think this is cold!" said one Illinois lineman to a crewman from Arkansas. "We had it 22 below in Decatur a week ago."

Crews from farther north were well equipped for the cold. A Texas lineman looked twice as an out-of-state truck pulled in. "Holy smoke!" he exclaimed, "Yankees in leather pants!"

The teamwork wasn't limited to the Bell Companies. Coöperation by power companies and the railroads helped, too. Along one stretch in Oklahoma, the wire breaks could not be reached by telephone trucks. Since the wires followed the M.K.T. tracks, the railroad's officials dispatched railroad motor cars—"putt-putt buggies"—to the area where telephone men loaded poles, wire and equipment on the cars and rail workers whisked the material to where it was needed along twenty-nine miles of pole line.

In Texas alone, during the late January storm, 17 towns were relinked to the outside world by emergency radio. Unusual locations were sometimes utilized. One area's transmission supervisor put a radio set in a chicken house near a toll line break. The emergency circuit, nicknamed "Operation Henhouse," linked Jefferson City with Eldon, Mo.

Most service knocked out by the January disasters was quickly restored. But many of the repairs were temporary. Permanent repairs, especially on toll lines, will require months.

Bell System Announces 1949 Television Network Program

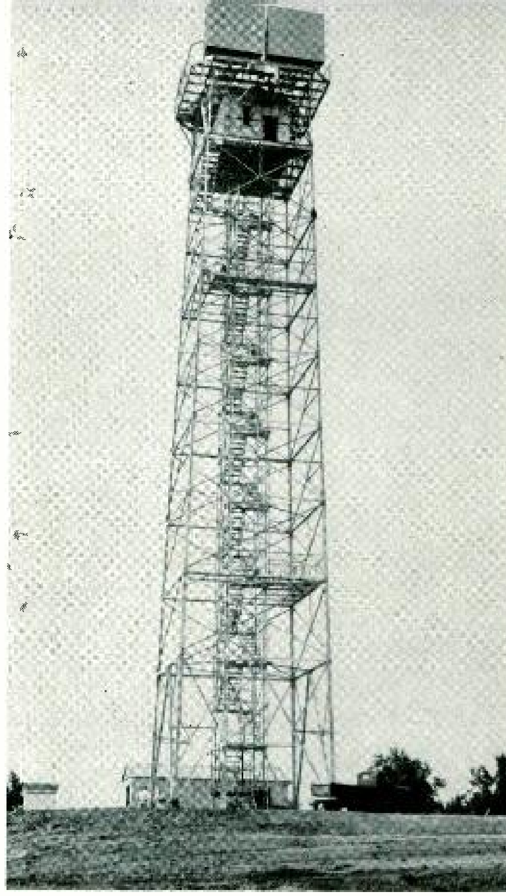
In 1949 the Bell System will double the number of miles of television network channels now available and will bring its network service to thirteen additional cities. By the end of this year there will be some 8,200 miles of television channels in operation, spread over a Bell System inter-city network which will then extend 2,850 miles and link 27 cities.

By summer, under present plans, the fourteen cities already on the Bell System's television network will be joined by Providence and Wilmington. By fall, it is expected that the following cities will be linked: Lancaster, Erie, Rochester, Dayton, Columbus, and Cincinnati. Toward the end of the year, it is planned to equip the existing coaxial route between New York City and Albany for television transmission and to extend it, by radio relay, to Syracuse, which would permit Bell System service to Schenectady, Utica and Rome as well.

Finally, all through 1949 work will go forward on the important radio relay project which is to provide long distance telephone and television service between New York and Chicago and several intermediate points next year, and for which Long Lines filed plans with the Federal Communications Commission last year.

Both radio relay and coaxial cable facilities will be utilized by the Bell System for its 1949 television project, which will include about 450 route miles of radio relay and some 300 route miles of coaxial cable facilities. The cities listed above will be linked to the network in the following manner:

1. The coaxial cable being constructed between Toledo and Dayton will be equipped for television transmission, but from Dayton, radio relay will be used to make the connections beyond to Columbus and Cincinnati.
2. Both Lancaster and Erie will be added to the present coaxial circuits in Pennsylvania and the link from Buffalo to Rochester will make use of radio relay.
3. Radio relay will also be relied upon for the Philadelphia-Wilmington and the Boston-Providence additions to the network.
4. Coaxial cable will form the link between New York City to Albany, and the additions beyond to Syracuse will be via radio relay.



Radio relay tower at La Salle, Mich. This is an intermediate station on the television link between Detroit and Toledo

The 1949 construction program also makes provision for additional channels along certain existing main routes on the inter-city network. An accelerated program to increase the number of circuits between Philadelphia and Chicago by about May 1, for example, has already been announced by A T & T. However, it is also planned to add three additional television channels between New York and Philadelphia and one extra channel to those already in operation between Philadelphia and Washington.

As its share in the Bell System television network program, The Pacific Telephone and Telegraph Company has recently announced a project intended to provide both long distance telephone and television channels between Los Angeles and San Francisco. Initially, one radio relay circuit will travel northward over a series of eight or nine towers to be constructed on mountain ridges overlooking the San Joaquin Valley from the west side. Service is expected in about a year.

New York-Chicago Radio Relay

The radio relay system between New York and Chicago now under way will at first provide two television channels, one in each direction, according to the latest information on the project. Later it is planned to secure additional channels by installing extra equipment in the stations along the route. In addition to terminals in key cities, there are 31 intermediate towers.

Improved equipment, built around the vacuum tube developed in the Laboratories by J. A. Morton and associates and known as the close-spaced triode,* will mark this system, making it an advance over the facilities between New York and Boston introduced in November, 1947. In addition to benefiting from the experience already gained in operating other Bell System radio relay systems, the new system will be simpler to maintain, more reliable and ultimately provide more channels than any other microwave system in service.

As with other radio relay systems, this one will use microwaves, which travel in straight lines and do not follow the curvature of the earth. The relay towers, therefore, must be located so they can direct the microwaves along an unobstructed, line-of-sight path from one tower to the next. Studies of topographic maps were checked by Long Lines engineers, using portable towers† and radio transmission measuring sets developed by the Laboratories.

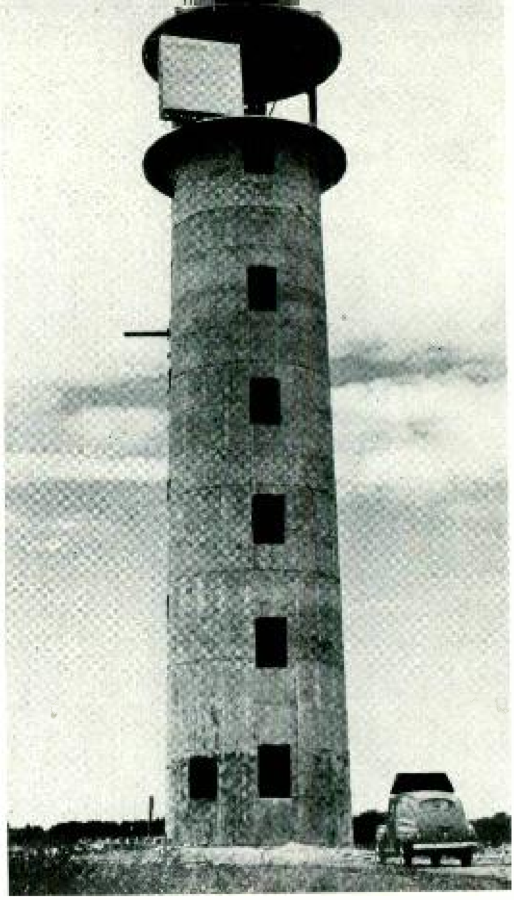
The New York terminal of this system will be erected atop the 450-foot Long Lines Headquarters, while the Chicago terminal will be located on the roof of the new toll building of the Illinois Bell Telephone Company. Already three relay towers have been erected between New York and Philadelphia: at Martinsville, N. J., and Buckingham and Wyndmoor, Pa., while two others are under way at Thomas Hill and Hallam between Philadelphia and Pittsburgh; west of this point field tests have been completed. By late fall, all the other towers will have gone up along the route, which ultimately will permit radio relay transmission from Boston to Milwaukee.

Depending on where they are built, the intermediate towers will range in height from 60 to 200 feet. Between Philadelphia and Pittsburgh, they will be placed on hilltops and will be built from 60 to 80 feet high. Along the flat land in Ohio and Indiana, however, the towers will be constructed about 150 to 200 feet tall. (The towers in the other radio relay projects in Ohio will be about this high, too.)

Except for their varying height, each of the intermediate towers is about the same in design—a square, concrete structure with space for emergency power equipment and storage batteries on the first floor, and radio equipment on the second. The special microwave antennas which beam and receive the communications signals are on the roof.

*This tube will be described in a forthcoming issue of the Record.

†Record, *January*, 1948, *page* 6.



This radio relay tower, on the Bell System television networks between Chicago and Milwaukee, is at Lake Zurich, Ill.

Many groups in the Laboratories are doing their part in the engineering of this project, according to their special knowledge. The project as a whole is being coördinated by G. N. Thayer, transmission development engineer.

F. R. Kappel Heads Long Lines

Frederick R. Kappel has been elected Vice-President of A T & T in charge of Long Lines. He succeeds Vice-President Bartlett T. Miller, who takes charge of Bell System relations with the Federal Government Departments, and relations with other communications companies, including connecting telephone companies.

Mr. Kappel has been Assistant Vice-President of A T & T, coming to that post from the Northwestern Bell Telephone Company, where he had been Vice-President in Charge of Operations since 1942. After graduation from the University of Minnesota, he entered the telephone business as a groundman with a line construction crew in 1924.

Edwin H. Colpitts
1872-1949

On March 6, E. H. Colpitts died at his home in Orange, at the age of 77. He had retired from the Laboratories as vice-president in 1937.

Born in the Province of New Brunswick, Mr. Colpitts was graduated from Mount Allison University in 1893 with honors in science. In 1896 he received a bachelor of arts degree, and in 1897 a master of arts degree, from Harvard, where from 1897 to 1899 he was an assistant in physics.

In 1899 Mr. Colpitts joined the Engineering Department of the American Bell Telephone Company in Boston. He transferred in 1907 to the Western Electric Company in New York as head of the Physical Laboratory, becoming assistant chief engineer in 1917. In 1924 he joined A T & T as assistant vice-president in the Department of Development and Research, and when that department was consolidated with the Laboratories in 1934, Mr. Colpitts became vice-president of the Laboratories.

He served on the Chief Signal Officer's staff in World War I, and in World War II was an active member and Head Technical Aide of Division 6 of the National Defense Research Committee. He gave full time to the N.D.R.C. anti-submarine warfare program, and was awarded the Medal for Merit for his "exceptionally meritorious conduct in the performance of outstanding service."

Mr. Colpitts entered telephone research as an assistant to G. A. Campbell on the problem of the loaded telephone line. He was directly responsible for the experiments undertaken to verify Campbell's theoretical work, and thus provided the first conclusive demonstration of the practicability of loading. He also participated in early application of loading and in much of the development of coils, testing methods and operating standards. One of his important early achievements was an improved battery supply repeating coil for the common battery system. This coil, in which wire is wound on a doughnut-shaped ring of magnetic wire, was the first toroidal repeating coil for exchange plant, and remained standard for 20 years. Another achievement to Mr. Colpitts' credit was the design of retardation coils for use in composite telegraph circuits. Basic features of both his repeating and retardation coils have continued to be used.

Crosstalk between adjacent circuits also received Mr. Colpitts' attention. He introduced the first effective method of determining experimentally the capacity unbalance between wires on an actual pole line, and so laid a foundation for the design of transposition systems, and for the balancing of toll cables.

Beginning in 1911, Mr. Colpitts became the head of the Research Department and was directly in charge of the adaptation of the newly discovered thermionic tubes to long distance telephony, both by wire and by radio. He thus played an essential part in the achievement of transcontinental telephony in 1915 and in the radio transmission of speech across the Atlantic Ocean later in the same year. Some of his patents cover the vacuum tube as oscillator, modulator and amplifier. The best known of these is the so-called Colpitts oscillator, one of two fundamental vacuum-tube oscillator circuits. It is used so generally that it now goes by the name of its inventor.

In 1941 he was elected director of the Engineering Foundation, and continued in that office until his death. In 1948 he was awarded the Elliott Cresson Medal by the Franklin Institute. He was a Fellow of the American Institute of Electrical Engineers, the Institute of Radio Engineers, the American Physical Society, the Acoustical Society of America, the American Association for the Advancement of Science, and a member of the American Chemical Society. In 1926 he received the honorary degree of LL.D. from Mount Allison. His technical contributions are recorded in twenty-four United States patents, and in numerous papers in professional journals.

Employees' Benefit Committee Annual Report

There was an average of 6,043 employees in the Company during 1948. In addition to the accident benefits to which all employees are eligible, 5,526, or 91.4 per cent, were eligible to sickness disability and sickness death benefits.

As compared with the previous year, there were 14 per cent fewer accidents per 100 employees during 1948 and 25 per cent fewer working days lost per 100 employee-days of work. Sickness cases under the Plan increased 5 per cent, while benefit sickness absence decreased 1 per cent.

Twenty-two active employees, 20 retired employees and 2 employees on leaves of absence died during 1948. Payments to their qualified beneficiaries were authorized as provided in the "Plan for Employees' Pensions, Disability Benefits and Death Benefits."

With the approval of the Benefit Committee, pensions were granted to 34 employees during 1948. Of these employees, 19 were retired under the Retirement Age Rule, 12 at their own request and 3 because of disability. As of December 31, 1948, there were 295 retired members of the Laboratories on pension.

There were 130 leaves of absence in effect at the beginning of 1948 and during the year, 127 were granted and 173 were terminated, leaving a total of 84 outstanding as of December 31, 1948.

R. L. Jones served as Chairman of the Employees' Benefit Committee until his death on January 14, 1949. Following Mr. Jones' death, D. A. Quarles was elected Chairman, W. H. Martin was appointed as a member of the Committee and J. W. McRae as an alternate member. At present, the Plan is administered by the following Committee: R. Bown, A. B. Clark, F. D. Leamer, W. H. Martin and D. A. Quarles, Chairman, and, as alternate members, J. W. McRae, W. Fondiller, J. W. Farrell and M. R. McKenney. J. S. Edwards is Secretary and K. M. Weeks is Assistant Secretary.

J. S. Edwards, *Secretary,*
Employees' Benefit Committee

Statement of Payments Under the "Plan for Employees' Pensions, Disability Benefits and Death Benefits" and Status of Pension Trust Fund

Benefit Payments for the Year 1948

Pension Trust Fund	
Disbursements by Trustee for Service Pensions During 1948	$ 534,590.15
Payments by the Company	
Disability Pensions	15,416.32
Payments After Death of Retired Employees	50,778.80
Accident Benefits and Related Expenses	17,653.81
Sickness Disability Benefits	299,401.25
Sickness and Accident Death Benefits	84,013.09
Total Benefit Payments	$1,001,853.42

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

Balance in Fund—December 31, 1947		$23,078,371.10
Additions to Fund During 1948:		
Payments Into Fund by Company	$2,952,214.00	
Interest Revenue, Including Gain or Loss on Investments Disposed of	662,134.94	
Total Additions	$3,614,348.94	
Disbursements for Pensions During 1948	534,590.15	
Net Increase in Fund		3,079,758.79
Balance in Fund—December 31, 1948		$26,158,129.89

M. J. Kelly, right, visits the Lachine plant of the Northern Electric Company with M. P. Murphy, Vice-President and General Manager, and W. H. Eastlake, Manager, Wire and Cable Division, of that company

A T & T Proposes New Issue of Convertible Debentures

The stockholders of the A T & T at their annual meeting on April 20 will vote on a new issue of convertible debentures, which would be offered pro rata to stockholders. The amount is to be determined later, but is not to exceed $100 of convertible debentures for each six shares of stock held. On the basis of the number of shares outstanding at February 15, 1949, the amount of the issue would be approximately $391,000,000 if the maximum offering of $100 of debentures for each six shares of stock outstanding is made.

Proceeds from the sale of the debentures and from conversions thereof into stock would be used to provide funds for extensions, additions and improvements of the plant of A T & T and its subsidiary and associated companies, and for general corporate purposes.

The new debentures would be dated June 20, 1949. It is contemplated that they would bear interest at a rate of not more than 3½ per cent, would mature not later than June 20, 1964, and would be convertible into A T & T stock at a conversion price or prices not exceeding $150 per share. It is expected that final decision as to amount and terms of the issue will be announced at the annual meeting on April 20.

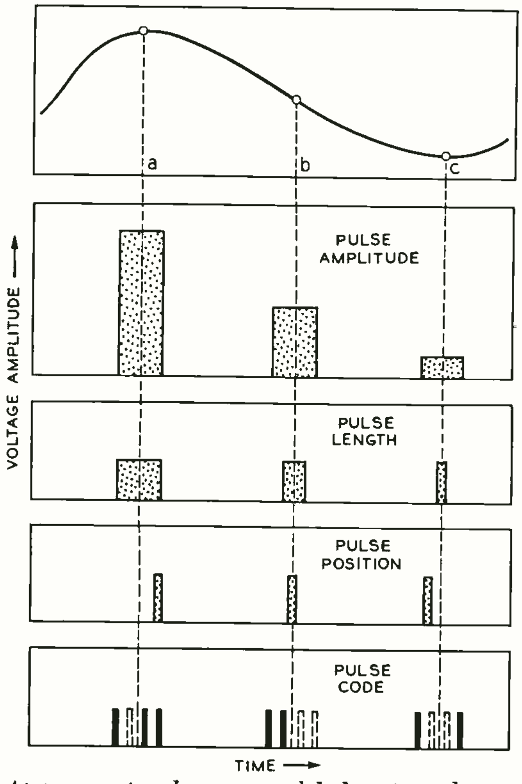
If stockholder approval is granted, the Company expects that assignable warrants to subscribe to the convertible debentures at their face amount will be sent to stockholders on or about May 15, 1949, following registration of the issue with the S. E. C.

Introduction to Pulse Modulation

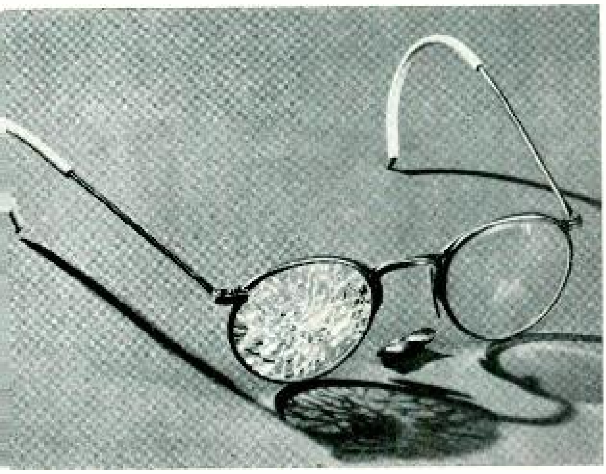
In the West Street Auditorium on February 24, and in Arnold Auditorium on March 7, interested members of the Laboratories heard L. A. Meacham describe pulse modulation.

He pointed out that this field is still in an exploratory stage, where the many complex factors affecting the advantages and disadvantages are being evaluated.

For illustrative purposes, four typical kinds of pulse modulation were described. A pulse-amplitude-modulation system (PAM) was used in explaining the "sampling" of sound waves and the assembly of numerous telephone channels in "time division multiplex." A pulse-position-modulation system (PPM) served to illustrate one way of exchanging band width for tolerance to noise and interference in the transmission path. A quantized pulse-position-modulation system (QPPM) introduced the concepts of "quantization" "quantizing noise," "instantaneous companding," "regeneration," and "frequency occupancy." Finally, the addition of "coding" and "decoding" to the stack of building blocks made possible a pulse-code-modulation (PCM) system.



At top, a signal wave; and below it, pulse methods of sending it as described by Mr. Meacham



Safety Spectacles Save Sight

Although the Laboratories has never had a serious industrial eye accident, it was in line with good practice to provide safety glasses to all who might need them at their work. Accordingly, more than 1,500 people have been fitted with safety glasses. The program has proved its value, with the preventing of an eye injury for a mechanic at West Street. He was doing a milling job, when the tool broke, the end flying off and striking the right lens full in the center. The protection of safety glass averted injury to his eye, which would have been otherwise lost.

F. B. Jewett at Fordham

Dr. Frank B. Jewett, addressing the Graduate Seminar of the Department of Chemistry at Fordham University on *The Crisis in Fundamental Research in America* on January 26, pointed out the impact of the two world wars on scientific thought and development, noting that the technological advances made during these wars were based on primary and fundamental data discovered many years previously.

The phenomenal scientific development which seemed so miraculous in World War II was drawn from the great store of knowledge which is not being replenished at the rate in which it is being used, Dr. Jewett stated.

Thermistors for Soil Studies

A new use for thermistors is disclosed by two scientists* of the U. S. Department of Agriculture, who have made extensive measurements of freezing point of soils and solutions. The application depends upon the fact that the resistance of a thermistor varies quite markedly with temperature, and that this resistance-temperature relation is relatively constant and reproducible. Consequently, a thermistor connected to a resistance bridge permits precise measurements of temperature to be made easily. A thermistor with a small thermal time constant permits rapid determinations of temperature. For this work, a Western Electric 14B thermistor was chosen, consisting of a small bead of semi-conducting material contained in the end of a glass rod two inches long and a tenth of an inch in diameter. The two leads of the thermistor are connected to a simple Wheatstone bridge. A rapid routine method for determining the freezing point of field samples of soil results.

*L. A. Richards and R. B. Campbell, in *Soil Science,* June, 1948.

Changes in Organization

C. F. Wiebusch has been appointed Assistant Cable Engineer in association with J. W. Kennard in Outside Plant Development.

W. L. Tuffnell succeeds Mr. Wiebusch as Station Apparatus Development Engineer reporting to A. F. Bennett. L. J. Cobb succeeds to Mr. Tuffnell's responsibilities in the development of transmission instruments.

Murray Hill Moves

All members of Transmission Networks Engineering, except D. T. Bell and some of his group, have moved to Murray Hill and will be located in 2C and 2D, third floor.

E. I. Green is now located in Room 2D-438.

L. A. Wooten is now in 1A-362 and Elenore Neasham in 1A-358.

G. C. Schley of the Outside Shop work group is now in Room 1E-308.

News Notes

M. J. Kelly addressed the Western Electric Merchandising Conference in Chicago, which he attended on February 2 and 3. Dr. Kelly on February 17 visited the United States Naval Engineering Experiment Station at Annapolis. During a visit to Canada, he spoke on *Creative Technology—Its Organization and Methods* before a joint meeting of the Institute of Radio Engineers and the American Institute of Electrical Engineers in Montreal. Then he visited The Bell Telephone Company of Canada and the Northern Electrical Company, where he addressed the senior officers of each company. He also lectured on *Post-War Industrial Research* at a meeting in Toronto of the Royal Canadian Institute.

R. M. Burns gave a talk on *Corrosion Problems* before the Cleveland Section of the Electrochemical Society.

A. C. Satter Retires

A. C. Satter joined the Manufacturing Department of the Western Electric Company at West Street in 1910, where he assembled relay selector sets. When the manufacturing group moved to Hawthorne, Mr. Satter transferred to the Installation Department at Brooklyn. Shortly thereafter he left the Company and became a supervisor in the Inspection Department of the Johns Manville Corporation. In September, 1917, he returned to the Western Electric Company and, in the Tube Shop, was given the responsibility of maintaining all vacuum pumps, including those in other departments throughout the building, which totaled about two hundred sets.

Following the war, he transferred to the building service group of the Plant Department where, in addition to maintaining vacuum pumps, he assisted in the construction of power panels, life test racks and other equipment. From 1932 to 1934 he was in the Development Shop on bench assembly and general mechanical work but still retained vacuum pump maintenance. He then transferred to the Research Department with the development group engaged in the processing of vertical-cut records. When this work was given to Commercial Products at the end of 1937, Mr. Satter went with it, and when it was discontinued in 1939, he took charge of a small machine shop in the Graybar Varick building. There he was not only an instrument maker, but a practical advisor to the engineers on how to work out their ideas. Late in 1946 he transferred to the Development Shop at West Street as a tool and instrument maker until his retirement.

At his home in East Flatbush, Mr. and Mrs. Satter are the center of a numerous family. They have four sons and two daughters. All are married. With his nine grandchildren, his gardening and his home shop work, Mr. Satter thinks he will have plenty to do. He has enjoyed every day of his telephone career, and is glad that one of his sons—a storekeeper at Murray Hill—is keeping the Satter name on the books of the Bell System.

News Notes

D. A. Quarles attended a Joint Industry-Armed Forces Conference, held in Washington on February 16.

R. K. Honaman spoke before the supervisory employees of the Southern Bell Company on March 1 in Atlanta.

K. K. Darrow, in Bryn Mawr, Pennsylvania, on February 21 and 22 and Montreal on February 25 and 26, lectured to students of Bryn Mawr and of McGill University on *Twenty-Five Years of American Physics.*

D. A. McLean visited Hawthorne and Archer Avenue in connection with the production of metallized paper for capacitors.

W. E. Campbell, after attending a meeting of the Lubricants Division of the A.S.T.M. in Washington, February 15-17, visited the Analytical Department of the Hercules Powder Company in Wilmington, Delaware, where he discussed methods of viscosity measurement.

April Service Anniversaries of Members of the Laboratories

35 *years*

W. P. Albert
A. J. Wier

30 *years*

Michael Bandura
Robert Burns
K. K. Darrow
R. V. L. Hartley
A. L. Hogan
R. B. Miller
L. J. Stacy
P. V. Welch
G. J. Wolff

25 *years*

R. F. Dibble
A. C. Dickieson
Miriam Harold
R. M. Hawekotte
G. Q. Lumsden
F. F. Merriam
R. H. Ricker
Laura Servoss
W. T. Wintringham
Eugenia Wyckoff

20 *years*

S. M. Babcock
Viola Bauer
Emil Belek
G. J. Brown
A. W. Daschke
P. K. Dean
C. C. Fenwick
Daniel Gimenez
H. E. Haring
H. L. Herbert
E. A. Hollis
E. H. Kampermann
Nicholas Knapp, Jr.
A. J. Kuczma
F. Kuepper
Edna Lazarus
F. J. Majorossy
K. M. Martin
M. H. McCormick
E. J. Moravec
Colburn Olsen
R. T. L. Patterson
J. A. Sarich
W. S. R. Smith
George Spilger
E. W. Waters
F. R. Wheeler
Mary White
I. E. Wood
M. N. Yarborough
E. J. Zimany

15 *years*

F. J. Braga
D. J. Brangaccio
R. F. Glore
J. A. Haunss
K. F. Hedel
H. J. Keefer
S. P. Leahy
E. C. Mener
W. J. O'Neill
K. H. Schunke
J. H. Stelljes
J. W. Tengstrom

E. E. SCHUMACHER attended the annual February meeting of the A.I.M.E. in San Francisco. In the course of this trip, he also gave talks on metallurgical topics before groups of telephone executives and engineers in Denver, Salt Lake City, San Francisco and Los Angeles.

B. S. BIGGS and F. S. MALM discussed insulating materials for telephone cables at the Simplex Wire and Cable Company, Cambridge.

H. W. HERMANCE inspected contacts on EA-6 relays at Kankakee, Illinois, Minneapolis and St. Paul. He also conferred with engineers of Illinois Bell Telephone Company in Chicago on maintenance problems.

A. B. CRAWFORD, L. R. LOWRY and S. E. REED were at Gila Bend, Arizona, where vertical incidence radar tests were made at the Navy Electronics Laboratory propagation site in cooperation with a Navy electronics group from San Diego.

R. D. HEIDENREICH spoke before a meeting in Waterbury of the Connecticut Section of the American Institute of Mining and Metallurgical Engineers.

F. J. BIONDI attended conferences on electron-tube materials at the Allentown plant. J. P. AHRENS visited the same location to discuss mica insulation problems.

E. K. JAYCOX and P. P. DEBYE attended the Ninth Conference on Applied Spectroscopy, sponsored jointly by the University of Pittsburgh and the Spectroscopy Society of Pittsburgh, held at the Mellon Institute in Pittsburgh. While in Pittsburgh, Mr. Jaycox attended a meeting of the Advisory Committee of A.S.T.M. Committee E-2 and visited the Research Laboratory of the Carnegie Illinois Steel Company. Mr. Debye attended the meeting of the Society of Applied Spectroscopy in Pittsburgh.

$1,600,000 A YEAR FOR THRIFT

ary Ann Bowe and Margaret Higgins perform two of the operations required for tabulating figures for thrift plans

Members of the Laboratories tuck away $1,600,000 a year through salary deductions alone, according to statistics recently made available for the A T & T annual report. In all, 7,890 deductions from salary through the various thrift plans are made by the Accounting Department, exclusive of A T & T stock deductions. Breakdown of the figures follows:

Thrift Plans	*Number of Deductions*	*Amount of Deductions*
Life Insurance, Commercial	1,084	$ 323,000
Life Insurance, Government	228	30,000
Savings Accounts	997	595,000
U. S. Savings Bonds	1,127	497,000
Hospital and Surgical Service	4,454	155,000
	7,890	$1,600,000

B. A. Diggory and E. A. Thurber visited the Dumont Televison Laboratories concerning the preparation of large fluorescent screens.

A. C. Walker gave a talk, *Growing Piezoelectric Crystals,* before the Chemistry Teachers' Club of New York at C. C. N. Y.

C. M. Hill's trip to the Plastics Laboratory of General Electric Company in Pittsfield, Massachusetts, was in regard to the performance of molded silicone connectors.

W. J. King conferred at the General Electric Company, Pittsfield, on silicone rubber for high-voltage connectors.

E. B. Wood, N. Insley, Marion Cook, L. L. Lockrow and P. A. Byrnes were in Allentown in connection with equalizer production.

R. D. Heidenreich gave talks entitled *Electron Microscopy of Thin Metal Sections* and *Slip in Metal Single Crystals* before the following groups: the New England Section, Institute of Metals Divisions A.I.M.E. in Waterbury, Connecticut; a metallurgical symposium at the U. S. Steel Company in Kearny, New Jersey; the Cleveland Section of the American Physical Society at Case School of Applied Science in Cleveland, Ohio; and a seminar group at Iowa State College, Ames, Iowa.

W. O. Baker attended a conference in Washington on polymers for arctic use, arranged by a National Research Council Subcommittee.

H. H. Staebner and D. T. Eighmey were at Point Breeze in connection with problems on the development of cords for the new lightweight handset.

Symphony Orchestras Hold Joint Rehearsal

Fourteen members of the long-established Symphony Orchestra of Bell Laboratories Club at West Street journeyed to Murray Hill after work recently with their conductor, L. E. Melhuish, to enjoy an evening of music in the Arnold Auditorium with the recently formed Murray Hill Symphony Orchestra. Thirty-two members of that group were present with their director, Paul B. Oncley, conducting. The rehearsal was enthusiastically received and plans are being made to arrange such an event in the not too distant future.

J. P. Messana went to Allentown and to Winston-Salem on problems of hermetically sealed terminals.

P. B. Drake, F. C. Kuch and F. M. Thomas, during a visit to the Teletype Corporation in Chicago, discussed manufacturing and testing problems of AMA perforators and readers.

C. G. McCormick and C. Schneider, in Philadelphia, inspected apparatus in automatic message accounting equipment.

F. W. Clayden visited a central office in Scranton, Pennsylvania, in connection with the solderless multiple for step-by-step apparatus.

Whippany–West Street Bowlers

Ready for the playoff in New York are the Whippany and West Street Bowling teams of Bell Laboratories Club. West Street won after playing the Whippany team again at Whippany and the Murray Hill team first in Summit and then in New York. Bowlers shown above are, rear, left to right: J. A. Rages, J. F. Welsh, W. E. Reichle, F. J. Reilly, J. F. Hurley, J. Kovac, C. A. Bengtsen, H. K. Meyer, E. T. Stammer, F. W. Steele, F. Lohmeyer and C. E. Hollister; and front, left to right: H. Grutzner, L. S. Cooper, P. C. Seeger, A. Pellegrinelli, L. W. Drenkard, C. H. Heller, A. G. Kobylarz, A. Uhl, P. B. Fairlamb and W. R. Steeneck

Right–Team members are keenly interested in the score. Standing: A. H. Wagner, L. S. Cooper, F. W. Starzer, W. Sermeus and V. W. Langborgh. Seated: C. J. Yunger, H. Grutzner, L. W. Drenkard and W. Grutzner

Below–In action, J. W. Johnson, J. J. Darold, H. R. Vail and T. Parker

Below, right–E. W. O'Hara and C. H. Heller

RECENT DEATHS

KEITH L. MAURER, February 23

Upon receiving the B.S. degree from Amherst in 1917, Mr. Maurer joined the Navy, where he served on a submarine chaser during World War I. He then entered Yale and, in 1921, received the Ph.B. degree. For the next four years he engaged in electrolysis work with an outside concern, of which he was vice-president. In 1925 he joined the D & R's inductive coördination group and, with the exception of World War II years, had since been concerned with methods for protecting telephone transmission systems for inductive interference by power systems and electrified railways. He was responsible for important advances in methods of field testing and the engineering of measures to prevent the development of interference in new situations and to control its effects. He served for many years as a principal consultant to Bell System Operating Companies in their dealings with the inductive interference problem, work which brought him the respect and esteem of a wide circle of engineers in the power and railway industries as well as Bell System engineers. During World War II, he engaged in the development of radar indicators and upon counter-measures in the field of radio navigation. Since then, he had been concerned principally with noise frequency induction and more recently with the study of prevention of electrolytic corrosion on telephone cables.

Mr. Maurer's outside interests were many. He was a member of the A.I.E.E., the I.R.E., the National Association of Corrosion Engineers and the Yale Engineering Society. In wartime he was very active in Civilian Defense in Nassau County, and since then had been a member of a temporary committee interested in atomic bomb defense. His main interest in community affairs was in the Congregational Church of Rockville Center, particularly in its building program. He contributed unsparingly to the design and construction of its new edifice, and was chairman of the committee that recently remodeled the parish house.

G. W. COWLEY
1903-1949

K. L. MAURER
1895-1949

ESTHER ALWELL
1902-1949

R. V. TERRY
1892-1949

GREER W. COWLEY, February 18

A native of Nebraska, Mr. Cowley was graduated from the State University in 1930 with the B.Sc. degree in electrical engineering. He had been employed by the Lincoln Telephone and Telegraph Company in 1923 as a cable splicer and after a year in outside plant maintenance was engaged in step-by-step equipment maintenance until 1930, when he joined the Laboratories. His early contributions to the development of C, and later K, carrier terminals was followed by the channel bank development for broadband carrier systems. Before our entrance into the war, he participated in the development of a submarine carrier telephone system for the Russian Government and in 1941 he engaged in the new terminal equipment for the Key West-Havana submarine cable, and was responsible for the installation of the equipment at Havana. During the war, Mr. Cowley engaged in work on early warning radar for the Signal Corps, Marine Corps and Navy. After the war, he joined the submarine cable group, where he had to do with the design of special transmission measuring equipment.

ESTHER ALWELL, March 1

Before joining the Laboratories, Mrs. Alwell had been a member of the New York Telephone Company, where she was a traffic service clerk from 1919 to 1940. Then for a period of four years she remained at home until 1944, when she became a member of the General Service Department in the reproduction group engaged in making various types of reproduced photographic tracings.

Roy V. Terry, retired, March 9

Mr. Terry joined the Technical Staff of the Laboratories in 1922, after extensive engineering experience with the Underwood Computing Machine Company, Thomas A. Edison, Inc., and other manufacturing concerns. His first work here was with the manual apparatus development group. When the Specialty Products Development Department undertook the development of sound picture and picture transmission systems, Mr. Terry was one of the first engineers to be assigned to the mechanical design division. In that capacity he was responsible for the design of the disc and film recording machines which were used respectively in the early Vitaphone and sound film systems. He also designed precision devices for transmitting and receiving pictures over telephone wires and a mechanism for transmitting television pictures over coaxial cables.

In 1935, Mr. Terry was transferred to the Switching Apparatus Development Department where he designed the precision clock used in the Central Time Bureau for time of day service (Meridian 7-1212), special electric clocks for service observing and central office use, improvements in the calculagraph time recording machine and improvements in the pneumatic ticket distributing system. During the war years, he designed target tracking devices for radar and electrical gun directors and later supervised the construction and test of these devices at the plants of the outside manufacturers who were building these units under contracts with the Western Electric Company. Following the war, Mr. Terry worked on improvements to various military projects, particularly on the "Bat." Mr. Terry has been granted twelve patents. He was retired because of poor health in 1947 and since then had been living in Florida. He is survived by his wife, two sons and a daughter.

Lieut. Ernest G. Graf, April 5, 1944

The body of Lieut. Graf of the Army Air Corps was buried with military honors on March 3 in Laurel Grove Cemetery in his home town, Totowa, New Jersey. He had joined the Laboratories in August, 1936, and was a draftsman in the Systems Development Department in 1941, when he was granted leave to enter service. After early military training with the cavalry, he was assigned to the Air Corps and won his wings as Second Lieutenant in early 1943. Later that year, while training as navigator with a bomber crew in Utah, he was made First Lieutenant and shortly thereafter shipped to Italy. He was killed on his fifth bombing mission.

News Notes

T. H. Guettich conferred at Hawthorne on a new design of multi-contact relay; and H. M. Knapp and C. F. Spahn, in connection with wire spring relays.

E. L. Fisher and H. J. Smith conferred with Western Electric engineers at St. Paul in connection with manufacture and design questions pertaining to central office and station fuses.

H. H. Bailey visited the Wright Field Armament Laboratory in Dayton for a conference on radar equipment.

E. R. Morton was elected president of the New York Cipher Society.

H. A. Hilsinger visited the Doelcam Corporation, West Newton, Mass., on production problems.

W. H. C. Higgins and R. R. Hough conferred at Frankford Arsenal, Philadelphia, on Army Ordnance projects. Mr. Higgins and G. G. Smith were at the Douglas Aircraft Plant, Santa Monica, California, in connection with government contracts.

J. D. Sarros and R. A. Devereaux witnessed tests of Navy contract material at the National Research Laboratory.

W. H. MacWilliams, Jr. has been appointed to the Committee on Computing Devices of the American Institute of Electrical Engineers.

H. T. Budenbom presented a paper before a Noise Symposium held at the University of California in Los Angeles.

G. H. Downes and H. W. Hermance visited Minneapolis regarding contact problems and Chicago in connection with panel bank problems. Mr. Downes also conferred in Detroit on air conditioning.

R. A. Miller and R. F. Massoneau with S. J. McDermott of A T & T visited the Automatic Electric Company in Chicago.

W. W. Fritschi visited Madison, Milwaukee, and Omaha in connection with signaling problems on the N1 carrier, single frequency and 1,000-cycle signaling systems.

"The Telephone Hour"

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

April 11	*Nelson Eddy*
April 18	*Lily Pons*
April 25	*Zino Francescotti*
May 2	*Tagliavini and Tassinari*

A. L. Johnsrud, instructor, standing rear, watches with Nurse Anne Connell of Whippany as other members of the Advanced First Aid Course practice on L. E. Lott, Jr. They are, left to right, J. H. Hershey, B. H. Nordstrom, C. A. Warren, and H. J. Battaglia, who received diplomas on March 8 at graduation ceremonies. For Mr. Nordstrom, who is Boy Scout Area Director, and Mr. Hershey and Mr. Battaglia, who are Scout Masters, this training as Active First Aiders will have a great deal of value in their activities

One of the few mother-daughter teams at the Laboratories is Connie and Dorothy Carlson of Murray Hill. Mrs. Carlson, chief operator at that location, is dictating a report on the enlarged PBX to Connie, who came up through the ranks of mail clerk to typist, and now stenotypist in Transcription

R. H. Gumley, C. G. McCormick and C. Schneider observed relay and contact wear in the accounting center office at Philadelphia.

J. A. Weller with J. A. Lee of A T & T assisted The Ohio Bell Telephone Company in the first installation and cutover of E1 telephone repeaters at Fostoria.

R. V. Crawford and H. S. Winbigler visited Philadelphia in connection with the installation of equipment to provide train passenger telephone service on two cars of the Pennsylvania Railroad's *Broadway Limited.*

J. Mallett and N. Monk conferred in Philadelphia with representatives of the A T & T and The Bell Telephone Company of Pennsylvania relative to the proposed installation of mobile radio switching locomotives for the Pennsylvania Railroad.

W. Strack made performance tests at the Illinois Bell Telephone Company in Chicago of a multichannel mobile telephone system.

C. C. Taylor attended meetings of the Radio Technical Commission for Marine Services in Washington.

The No. 5 crossbar system took F. M. Pearsall and H. W. Flandreau to Vineland, N. J.; W. I. McCullagh to Philadelphia; F. E. Blount and C. R. Gray to Media; A. O. Adam, J. W. Dehn, K. M. Fetzer, R. E. Hershey and J. Irish to Hawthorne; and Mr. Fetzer to Troy, N. Y., and Towson, Md.

V. A. Douglas assisted The Ohio Bell Telephone Company at Toledo in field tests of a development model frequency meter for use in mobile radio-telephone systems.

H. W. Evans, L. A. Dorff, F. J. Henneberg, D. Mitchell and representatives of the O. & E. were in Richmond, Virginia, in connection with the trial of reed signaling.

J. W. Schrage visited RCA at Camden in connection with the operation of television relay equipment.

G. H. Baker and D. K. Martin are continuing tests started last August of measurements on microwave propagation carried on in the Salt Flats of Utah.

W. T. Jervey, C. R. Brearty and W. L. French visited New Bedford, Canton and Boston, Massachusetts, on quality requirements of rubber and friction tapes.

J. B. Dixon was at Point Breeze to discuss problems in connection with the production of drop wire conductor.

H. D. Breiner and J. B. Hays observed toll cable testing procedures in Washington.

During the two-day open house in the Restaurant at Murray Hill, over a thousand members of the Laboratories availed themselves of the opportunity to see demonstrated the new facilities in the kitchen areas. At the extreme right is T. J. Crowe of Plant Operation describing special features to one of the groups on tour of the Restaurant

THE LABORATORIES were represented in interference proceedings at the Patent Office in Washington by R. J. GUENTHER, E. C. LAUGHLIN and G. T. MORRIS before the Primary Examiner.

W. W. FRITSCHI and R. E. RESSLER conferred at the Madison and Milwaukee toll offices on the field trial of the N1 carrier system.

F. W. TREPTOW made field studies of PBX and key telephone systems in central offices in Richmond and Atlanta.

W. W. BROWN made a study of No. 4 toll and crossbar tandem equipment at Boston.

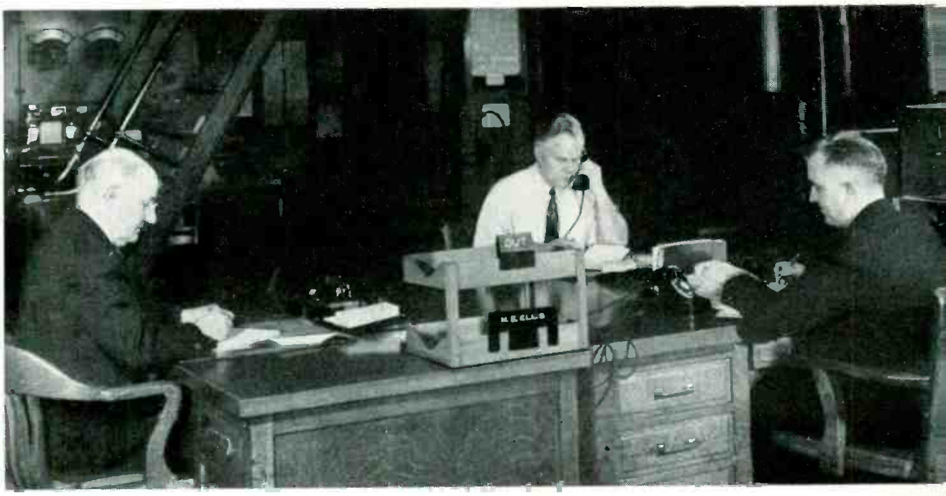
R. J. NOSSAMAN and C. C. LAWSON visited the Tonawanda plant and the Copperweld Steel Company at Glassport, Pennsylvania.

C. C. LAWSON and J. B. DIXON discussed aluminum-coated steel wires at the laboratories of the Aluminum Company of America in New Kensington.

AT POINT BREEZE, E. E. ARNOLD discussed No. 111A key telephone equipment; and W. S. BISHOP and C. V. LUNDBERG, rubber-covered wire developments.

S. C. MILLER, O. B. COOK and G. E. HADLEY discussed the manufacture of a new design of station protector at the Western Electric Company, St. Paul.

W. H. BRATTAIN presented a paper co-authored by J. BARDEEN entitled *The Transistor—Its Properties and Characteristics* before a meeting in Atlanta of the Institute of Radio Engineers.



Focal point of all power distribution and services in the Laboratories at West Street is the Power Plant, where M. E. Ellis, B. P. Herbort and B. A. Nelsen are shown in the desk area. In the rear at the control board when the photograph was taken is C. W. Muccio

European Electronic Developments

The Deal-Holmdel Colloquium on February 4 heard a talk by S. Millman on microwave tube work in the electron dynamics group and by J. R. Pierce on electronic developments in Europe. Mr. Pierce said in part:

"Visiting European industrial and government laboratories convinces one that, technically, at least, what is going on is not recovery but rapid advancement. It is impossible to give in a few words any adequate idea of the details of the work being done, but some idea of its scope can perhaps be conveyed.

"Until recently, for instance, the commercialization of the electron microscope lay in American and, formerly, in German hands. Now, Philips in Holland are well along on the development of a very flexible new instrument with important new features, including a method of accurate focusing at high magnifications. T.S.F. (Compagnie Generale De Telegraphie Sans Fil) in France have a commercial electrostatic microscope, and various British companies are doing similar work.

"The microwave tube work in France is particularly interesting. Forward-looking work on traveling-wave tubes and related devices is being done by Dr. Goudet and his colleagues at a small government laboratory designated CNET, Division of Tubes and Hyperfrequencies. Dr. Warnecke and his co-workers at T.S.F., who in the past have made centimeter-range klystrons for the kilowatt range of power, are planning even more powerful tubes. In addition to this and valuable work on traveling-wave tubes, they have recently produced a traveling-wave magnetron amplifier, which promises to approach the high efficiency which characterizes magnetron oscillators.

"Fine microwave work continues to be done at a large number of places in England, and a particular feature is the low noise figures achieved in traveling-wave tubes.

"One field which is being widely exploited, both at Philips in Holland and at several places in England, including the English General Electric Company and the relatively new Standard Telecommunications Laboratories, is that of development of special tubes, both of the electron-beam and gas-filled types, for performing special operations in pulsed communication, counting and switching circuits.

"It was particularly pleasant to visit foreign laboratories as a representative of these Laboratories. The Bell Laboratories and the whole Bell System are held in the highest regard abroad, and representatives are treated with great openness, friendliness and courtesy."

Pioneer Life Members

During the luncheon and meeting of the Pioneer Life Member Club, Frank B. Jewett Chapter, on February 16, seventy-five members heard M. J. Kelly speak on his European trip and on recent developments at the Laboratories. The luncheon was held in the Auditorium to accommodate the record turnout of retired Laboratories' members and was arranged through the efforts of A. B. Kvaal.

Noon Hour Duet

A half hour of violin and piano music was presented in the Arnold Auditorium on February 15 by L. A. Meacham of the Laboratories' Technical Staff and Miss Martha Mahlenbrock, organist and choir director of the Old Bergen Church in Jersey City, and teacher at the Guilmant Organ School in New York. Mr. Meacham studied at the Cornish School of Music in Seattle and is a member of the Summit String Quartet and of Murray Hill's Chorus and Symphony Orchestra.

Visitors at Whippany

The Honorable Gordon Gray, Assistant Secretary of the Army, and Captain A. G. Shepherd, United States Navy, visited Whippany on February 18. They were accompanied by Vice-President F. R. Lack, C. C. Randolph and J. W. Mehring of Western Electric.

On February 24, Captain H. E. Bernstein, United States Navy, Lt. Col. Frame, United States Army, and Messrs. Reeves and Haltermann, ANEESA, visited Whippany to discuss with and describe for us the activities of the Army, Navy, Electronic and Electrical Standards Agency.

Do You Sing?

If you do, you're invited to join the Glee Club recently formed at West Street under the direction of R. P. Yeaton, which meets alternate Mondays and Wednesdays from 5:30 to 7:00 in the Auditorium. The Club needs more singers, both men and women, who are able to attend rehearsals regularly. Mabel Sleght of Personnel is chairman of the Glee Club and will be glad to furnish further details if you call her on extension 144 or drop in to see her in Room 145 at West Street.

R. M. Evans Guest Speaker at Murray Hill

R. M. Evans, author of the book *An Introduction to Color* and head of the color control department of Eastman Kodak Company, spoke in the Arnold Auditorium on *Seeing Light and Color* during his recent visit to Murray Hill. During his talk, Mr. Evans discussed the physical, physiological and psychological factors involved in vision, with emphasis on color as a mental effect. The appearance of objects under various hues was shown by impressive colored slides.

News Notes

C. C. Lawson has been appointed telephone group representative on A.S.A. Sectional Committee C8 on Wires and Cables.

J. R. Townsend has been elected vice-chairman of the Standards Council of ASA for 1949. Mr. Townsend has represented the A.S.T.M. on the Standards Council for some time. He is also a member of the Mechanical Standards Committee and Chairman of the Board of Review.

F. G. Foster was elected recording secretary of the New York Microscopical Society at the annual election of officers.

Russell C. Newhouse of Radio Development has been elected to a three-year term on the Board of Education of Millburn.

S. C. Hight recently spent several weeks in England visiting a number of research and development laboratories.

P. H. Smith presented a paper entitled *A High Gain Cloverleaf Antenna* at the National Electronics Conference in Chicago.

At Allentown, A. E. Dietz discussed vibration tests on power-line carrier fuses; J. T. L. Brown, O. M. Hovgaard, C. F. Swasey and G. G. Muller, mercury relays; N. Insley and J. P. Messana, inspection standards for glass-sealed terminals; and P. A. Byrnes, N. Insley and L. L. Lockrow, equalizer production.

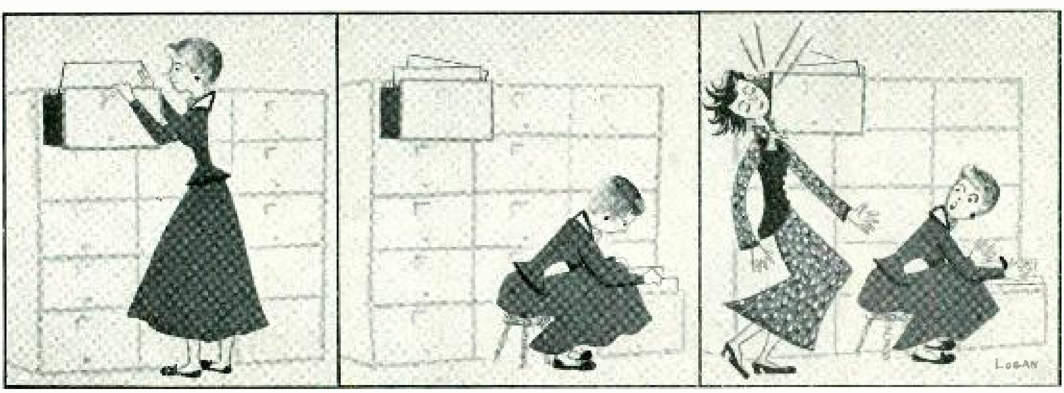
In Burlington, C. R. Taft was concerned with shop problems in the manufacture of submarine electronic equipment and H. A. Reise with the testing of a new type radio broadcasting transmitter for 10-kw operation.

C. S. Fuller has been appointed Chairman of the Standing Committee on Publications of the American Chemical Society.

Phyllis Taylor directed *The Valiant,* one of three one-act plays, given on Mid-Winter Play Night, by the Chatham Players on February 25 at the Chatham High School. This play is being entered in the competition of the New Jersey Little Theater League.

While vacationing in Florida, C. N. Hickman addressed the Committee of One Hundred, a civic organization of industrial leaders who visit Miami in the winter. His subject was *Rocket Explosives,* a field to which he made outstanding contributions during World War II. In appreciation of his talk, the committee presented Dr. Hickman with an engraved silver platter.

Recent speakers of the International Relations Group meetings at Murray Hill were



R. O. FORD, of Purchasing, who spoke on *The Military Occupation of Germany;* Professor James H. Pitman, Chairman of the Department of English at Newark College of Engineering, who spoke on *International Language;* Otto A. Becker, an executive of American Overseas Airlines, who spoke on *The Berlin Air Lift;* and Archibald S. Alexander, 1948 candidate for U. S. Senator from New Jersey, who spoke on *World Law as a Path to World Peace.*

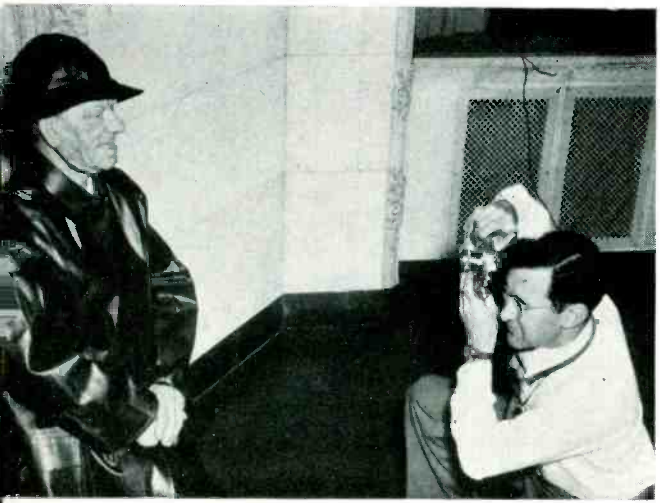
E. DIETZE and C. F. WIEBUSCH are authors of an article entitled *Proposed Standard Terminology for Acoustics Now Out for Year's Trial.*

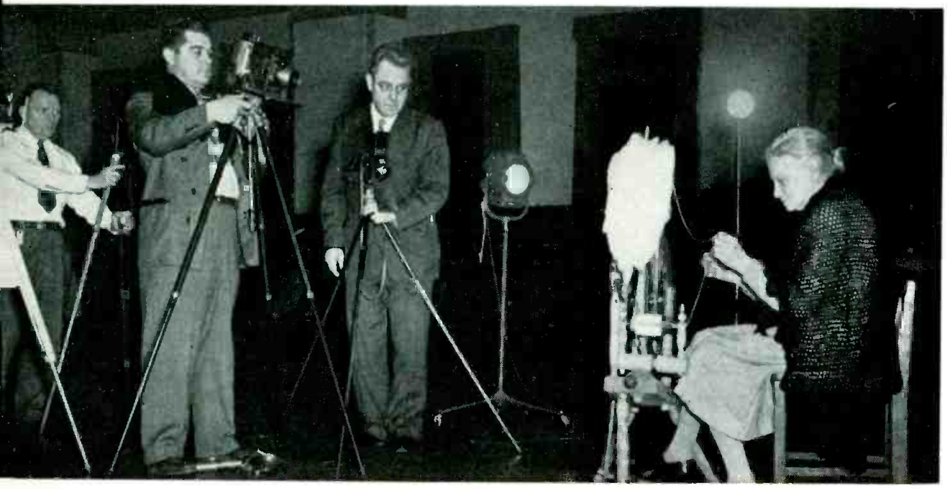
T. G. BLANCHARD and D. E. CAVENAUGH visited Winston-Salem for conferences on manufacturing problems in connection with power transformers of Government projects.

W. S. R. SMITH was one of three members of the Associated Business Stamp Clubs interviewed on Radio Station WNBC on January 22 by Walter Law, director of the NBC Stamp Program, and by Harry L. Lundquist, publisher of the magazine *Stamps.* Mr. Smith discussed activities of the Bell Laboratories Stamp Club, of which he is program chairman.

E. G. HILYARD, A. BURKETT, R. W. BURNS with J. V. Moses of A T & T visited Philadelphia in connection with problems of outside plant testing; and G. A. HURST, A. J. ENGELBERG and G. H. DOWNES to discuss various questions relating to the operation of automatic message accounting.

J. R. PIERCE is author of an article entitled *Paralleled-Resonator Filters,* in the February, 1949, *Proceedings of the I.R.E.* G. N. THAYER, A. A. ROETKIN, R. W. FRIIS and A. L. DURKEE have written on *A Broadband Microwave Relay System Between New York and Boston* in the *Waves and Electrons* section of the same issue.





With cameras focused on living models in the auditorium, photographers of the Bell Laboratories Club prepare to compete for salon shots. At left, J. Baumfalk, R. Wighton and P. Neill make last minute adjustments before taking an old woman spinning near a fireplace, while K. Warthman, above, left, gets an angle on the old sea captain. The latter, Walter Shelton, a model, above, in a character study by Mr. Wighton