BELL LABORATORIES RECORD

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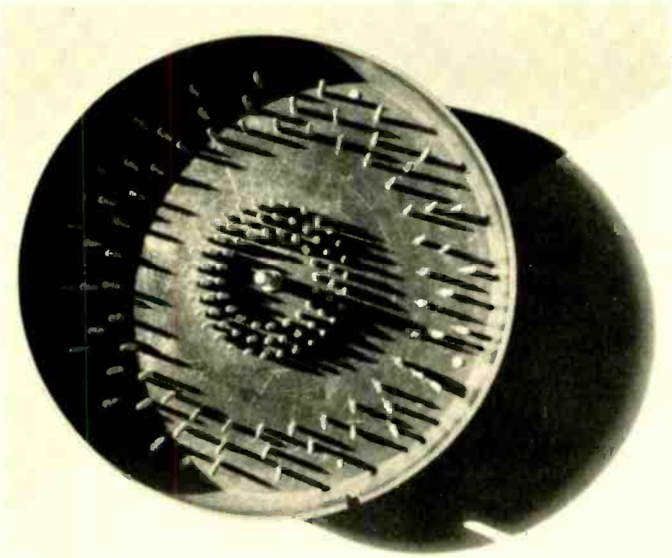

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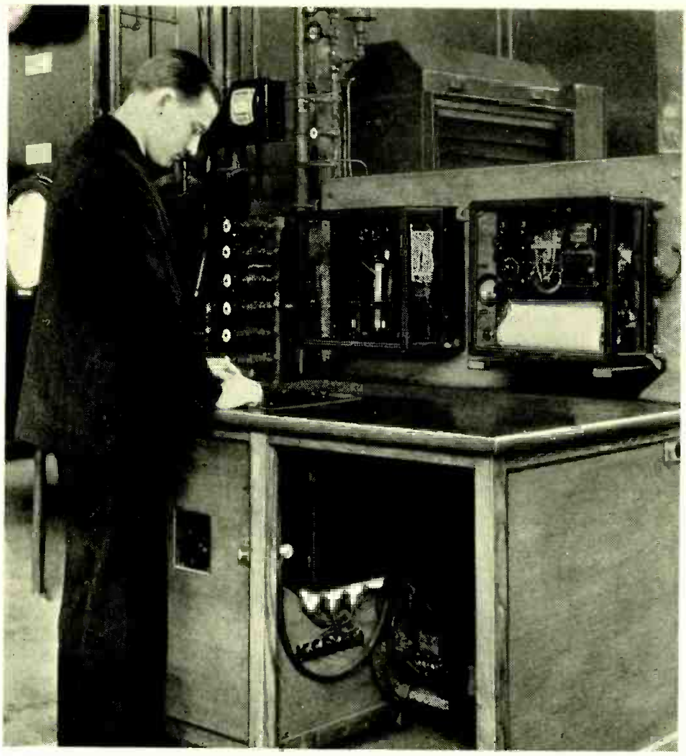


Measuring and Recording Low Humidities

By A. C. WALKER
Telephone Apparatus Development

ONE of the recent improvements in the manufacture and handling of lead-covered telephone cable is the storage of the dried cable cores in ovens whose atmospheres are as free as possible from water vapor. The control of these ovens requires the use of apparatus for continuously measuring and recording the humidities within them.

Since 1813 the familiar wet-and-dry bulb hygrometer has been the instrument generally used to measure atmospheric humidities. Many refinements, however, must be added to the elementary form of the instrument to make its readings reliable, and even then under the best conditions an absolute error of less than two per cent cannot be assured. As the temperature rises, or the humidity declines, still more serious errors are introduced by the difficulty of keeping the wet bulb wet. Within limits it fulfils a definite place and in recent years it has been made self-recording. Other methods of measuring humidity, such as the dew-point apparatus, hair or cotton hygrometer and chemical absorption methods, do not lend themselves readily to precision recording, and all but the chemical method are decidedly limited in accuracy.

The method finally adopted for the cable ovens, therefore, is one which was first applied commercially to the

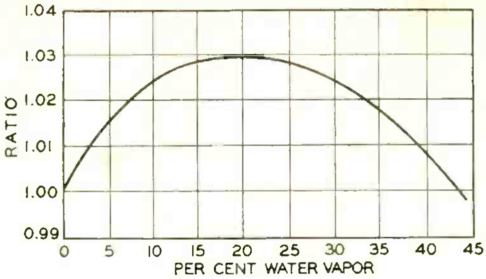


Fig. 1—The ratio of the thermal conductivity of a mixture of water vapor and air to the conductivity of dry air, plotted against the percentage water vapor contained by volume. Over the whole range of mixtures the relationship is complicated, but in the range of normal atmospheric humidities it is approximately linear

weight of water vapor. Furthermore the maximum water content of air at ordinary temperatures is but 3.2 per cent by volume, and thus the entire normal range of humidities corresponds to but a very small range of thermal conductivities (Figure 1). It is, therefore, noteworthy, that apparatus based on this principle could be produced for measuring and recording continuously the water vapor content of air with an accuracy of ±0.0016% by volume, corresponding to less than 0.05% relative hu-

analysis of various other gaseous mixtures. It is based on the fact that the thermal conductivity of a gas is a function of its molecular weight, and therefore the conductivity of a gaseous mixture varies with the differing proportions of its constituents if these constituents have different molecular weights. The addition of hydrogen to nitrogen, for instance, increases the thermal conductivity perceptibly, for the latter is some fourteen times heavier than the former.

The differences in the conductivities of atmospheres of different humidities are considerably less, for the average molecular weight of air is only 1.6 times the molecular

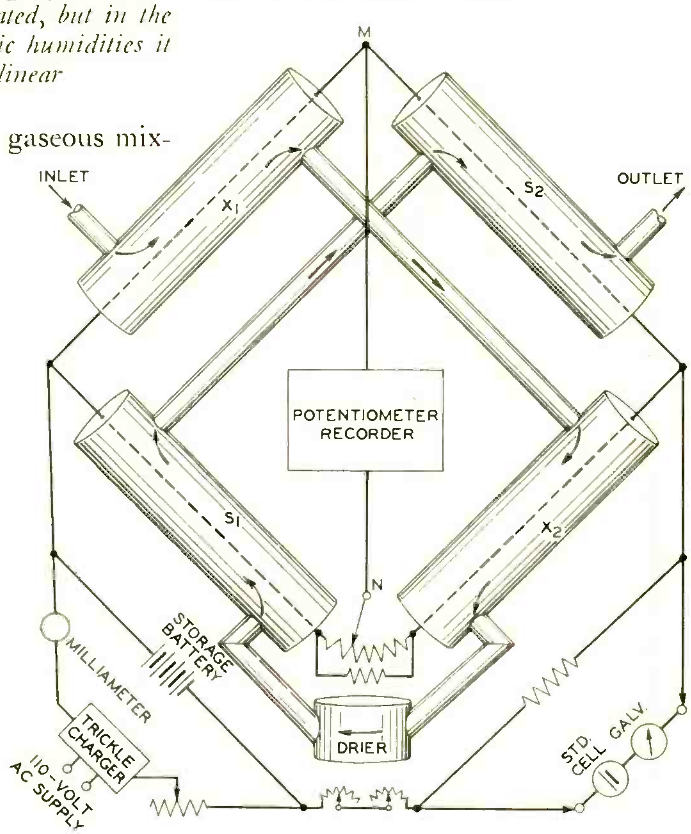


Fig. 2—Air to be analyzed passes through tubes X_1 and X_2 in series, through the drier, and finally through tubes S_1 and S_2 in series. The difference in the thermal conductivities of moist and dry air holds the heated platinum wires in X and S at different temperatures, and thus at different resistances. The resulting unbalance of the wheatstone bridge formed by the wires is measured by a recording potentiometer connected to the bridge points M and N

midity under normal atmospheric conditions.

Essentially the apparatus is a wheatstone bridge whose four arms consist of fine platinum wire mounted axially in tubes (Figure 2). The air to be analyzed passes first through two of the tubes, is then thoroughly dried, and passes through the remaining two tubes.

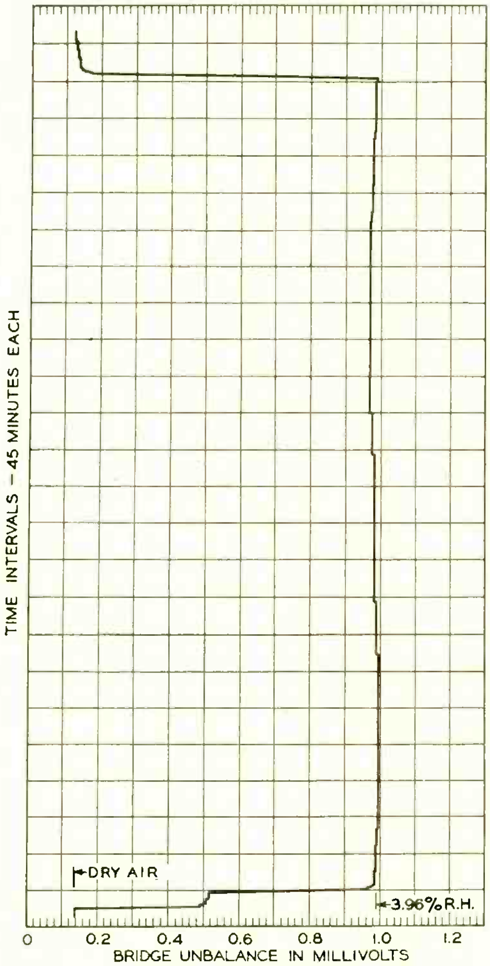


Fig. 3—This overnight record of humidity shows the accuracy of the recorder and the constancy of the calibrating supply. The dry-air readings before and after the run are furthermore almost the same. Each small division on the chart (shown only at top and bottom) corresponds to 0.096 per cent relative humidity at 25 degrees Centigrade

The tubes, formed by drilling holes in a solid block of metal, are four and a half inches long and about four-tenths inch in diameter. The platinum wires, only two thousandths inch in diameter, are gold soldered to heavy platinum lead-in wires.

All four wires are heated by a constant current; and if the composition of the air were the same in the four tubes, the wires would all reach the same temperature. The air containing moisture in one pair of tubes has, however, a higher thermal conductivity than the drier air in the other, and thus conducts heat more rapidly from its pair of wires, keeping them at a lower temperature. Since the resistance of platinum varies with its temperature, the difference of wire temperatures unbalances the wheatstone bridge by an amount which is measured with a sensitive recording potentiometer. The use in the S arms of the dried gas from the X arms cancels the effect which any variations in composition, other than variations in humidity, would have on the readings of the potentiometer.

The required high sensitivity presented difficulties, not only in the design of a suitable thermal conductivity cell and associated recording equipment, but more particularly in securing a satisfactory method of calibration and some means of testing its reliability under conditions comparable to those in service. A previous development of the Laboratories, an apparatus* for providing continuously flowing streams of air of controlled, known moisture content was the principal factor contributing to the success of the humidity recorder.

With these air streams of constant

*Record, *February*, 1933.

composition the conductivity cell could be calibrated and operated with assurance that any observed variations in the recorder were attributable to the circuit itself, and with the problem thus simplified it was soon evident that two factors must be closely controlled, i.e., the heating current and the temperature of the conductivity cell itself.

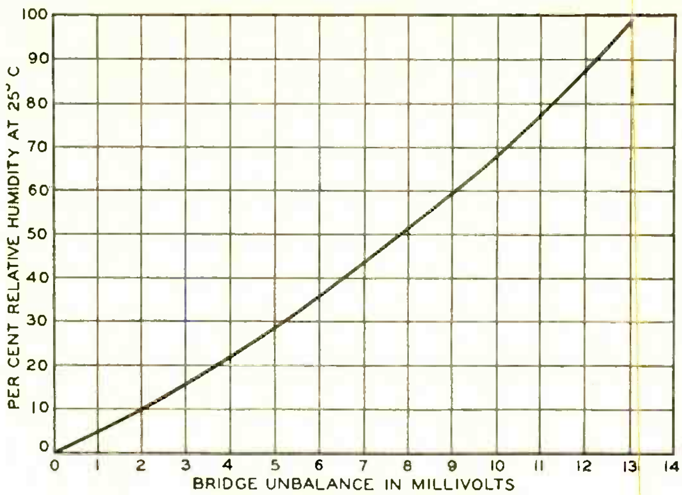


Fig. 4—Calibration curve of humidity recorder. Up to bridge unbalances of about two millivolts, the relationship between bridge unbalance and humidity is linear

The heating current (about 0.6 ampere for this design of cell) must be held constant to a thousandth of an ampere. This was accomplished by trickle-charging the storage battery at a rate equivalent to the heating current, thus maintaining constant supply voltage. Furthermore, the rheostat adjustments necessary from time to time to maintain the proper value of the heating current required an indicator more sensitive than the usual electro-magnetic milliammeter. Accordingly, a galvanometer was employed in a potentiometer network, to indicate the balance between a standard cell and the voltage drop across a fixed resistance in the heating circuit. The conductivity cell was immersed in an oil bath maintained at constant temperature to within one one-hundredth degree C., by means of a reliable, sensitive thermostat control circuit worked out in the Radio Development laboratory by P. H. Betts.

Not only the sensitivity, but also the constancy of humidity supplied by the apparatus for calibrating the recorder, are shown in Figure 3. It is a record of an overnight test of air of 3.96 per cent relative humidity at 25 degrees Centigrade, during which no change was made in the adjustments of either the recorder or the air supply. In this case each small division on the chart paper is equivalent to 0.092 per cent relative humidity. The slight downward drift in the middle of the run is known to be due to a slight change in the line-voltage supplied to the trickle-charger such as would be corrected in normal operation by adjusting the rheostats which control the heating current, or by the introduction of ballast lamps in the trickle-charging circuit.

At humidities as low as this, the relationship between bridge unbalance and humidity is sensibly linear. The calibration curve of Figure 4 shows that at high humidities the linear relation no longer holds, and a given change in bridge unbalance corresponds to a lower change in humidity.

In operation, a zero setting is secured by passing dry air through all four arms of the bridge and bringing the pen of the recorder to a predetermined zero line by adjusting a slidewire. The zero line is chosen above the zero line of the chart so that accidental variations causing the pen to go down will be recorded. At the end of the run, the setting of the slidewire is checked.

The calibration curve in Figure 4 was secured with a circuit having but one tenth the sensitivity of that with which Figure 3 was obtained. Thus it is evident that the apparatus is adaptable to different ranges. In fact, by employing suitable thermostat temperatures to prevent condensation of water vapor, analyses may be made up to saturation at 200 degrees C. However, increasing the range by bridge circuit alterations and using the potentiometer galvanometer as a deflection instrument necessitates corresponding decreases in sensitivity since the width of the recorder chart is fixed.

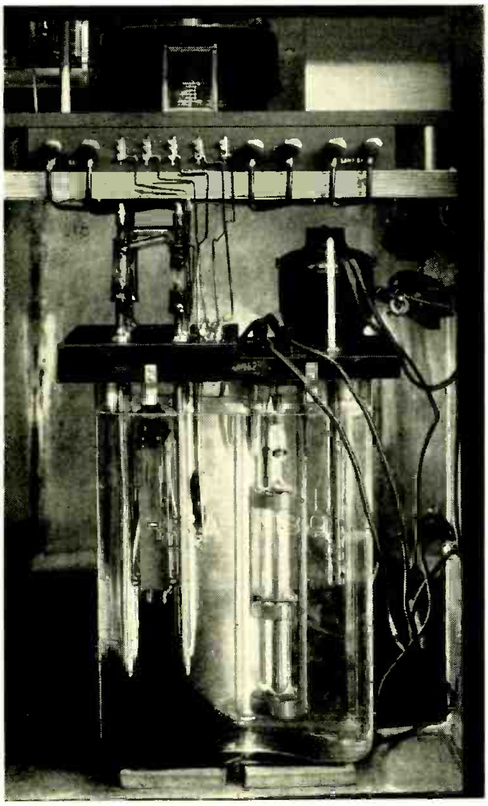


Fig. 5—The humidity-measuring cells, as actually installed in the Point Breeze Works of the Western Electric Company

In the course of our experimental work it was found that the range could be extended with practically no decrease in sensitivity, up to saturated air at relatively high atmospheric temperatures, with no change in the circuit design. This is possible by using the recorder galvanometer as a null-point instrument and calibrating moisture contents against settings of the Kohlrausch slidewire connected as shown in the circuit at the point N (Figure 2). This has greatly added to the usefulness of the equipment and it is unlikely that this application of the equipment could have been readily determined without the use of the apparatus for furnishing air streams of constant humidity.

Installations of the humidity recorder equipment designed and built to our specifications by the Leeds and Northrup Company, are now used by the Western Electric Company (Figure 5 and the head piece) in recording the atmospheric humidities in cable storage ovens, where the water vapor content usually does not exceed 0.03 per cent by volume (less than 1 per cent relative humidity under normal operating conditions). Both the recorder and the constant humidity apparatus for calibrating it have been useful also in the Laboratories in fundamental investigations of the properties of textile insulation under different atmospheric conditions and similar high sensitivity apparatus is being used in several universities for scientific investigations.

A Mercury Jig for Testing Toroidal Cores

By C. H. YOUNG
Telephone Apparatus Development

THE quality of speech transmitted over the long lines of the Bell System depends to a considerable extent on the characteristics of the loading coils* which are inserted in the lines at regular intervals. Great care is taken, therefore, in the design and manufacture of loading coils to prevent the finished coils from producing a variety of possible disturbances† in the circuits. Manufacturing requirements placed on them are severe, and to reduce the number rejected because unsatisfactory, the various materials used are tested before being made into coils. Thus one of the important steps in the manufacture of loading coils is the testing of samples of each lot of core material to determine permeability and losses. By such a test, the expense of applying subsequent manufacturing processes is saved on core material already doomed to rejection. To realize a maximum net saving, it is obvious that the costs of such tests must be kept at a minimum.

Permeability of a core is calculated

*Record, *September*, 1927, *p.* 1.
†Record, *July*, 1930, *p.* 522.

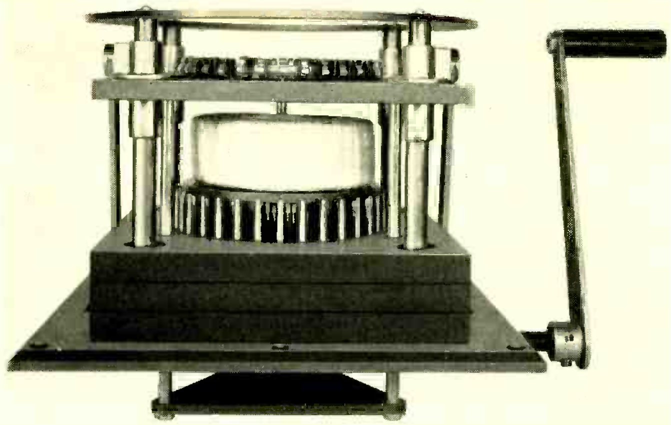


Fig. 1—Testing jig employed for measuring core loss and permeability of iron-dust cores

from a measurement of the inductance of a winding placed on it; and the losses of a core, from the difference between the d-c and the effective or a-c resistance of such a winding. Both tests thus require that some form of test winding, with a sufficient number of turns to yield measurable quantities of inductance and effective resistance, be placed on the core. To apply a winding to each test sample would be relatively expensive, and it has been common practice to avoid this necessity by the use of a jig such as shown in Figure 1. The lower portion of the jig has a number of vertical rods placed in two circles around an annular space reserved for the core of a loading coil, and the upper portion, which may be raised or lowered by means of the crank at the right, has corresponding circles of receptacles into which the rods fit when the top is lowered. The rods in the base and the receptacles in the top are electrically connected to form the equivalent of a continuous winding around the core when the jig is closed.

Any variations in the characteristics of the jig winding during the progress of a test affect the observed values of permeability and loss. It is essential, therefore, both that the rods be so securely placed that no relative motion can take place and thereby affect the inductance, and that changes of resistance in the jig winding are negligibly small compared with the a-c resistance increment measured. Since both inductance and resistance are extremely small, great care had to be taken in the design to secure the necessary constancy of the characteristics. Changes in resistance were the greatest potential source of error. With the thirty-two turns of the early jig there were sixty-four contacts in series, and since the difference in resistance measured was of the order of only a few thousandths of an ohm, it was conceivable that even vibration might change the contact resistance sufficiently to affect the results. By careful design, however, the requirements were satisfactorily met for the existing conditions, and the type of jig shown has been used successfully for a number of years.

When permalloy-dust came to be applied to loading coils its higher permeability permitted the cores to be reduced to about one third the size of the equivalent iron-dust cores, along with a considerable gain in time constant. To adapt a jig of the pressure contact type to these smaller cores, and at the same time obtain an even higher order of resistance constancy, placed prohibitive requirements on its design. However, a new type of jig employing mercury as a contact medium was developed, thereby avoiding the difficulties inherent in the pressure contact type. The design is shown in cross-section in Figure 2. U-shaped ducts in the ebonite base, provided by radial and axial borings, are filled with mercury to form the lower half of the winding. The copper rods projecting from the top of the jig, pointed and amalgamated with mercury at their ends, fit into the openings of these ducts and complete the winding circuit when the top of the jig is placed over the core. A photograph of an experimental model of a ten-turn jig is shown in Figure 3. In the center of the jig is an axial pilot rod which, fitting in a central hole in the base, serves to align the top and bottom of the jig so that the conductors enter the centers of the mercury ducts. A raised portion in the center of the base centers the core within the winding, and a cylindrical fibre sheath, fastened to the top half of the jig, shields the conductors during a test from external thermal influences which might change their resistance.

Although at first there was some apprehension that trouble might arise from oxidation of the mercury and the accumulation of dirt, very little has been experienced. Impurities entering the mercury tend to float to the surface and cling to the conductors when withdrawn. An occasional brushing of the amalgamated points and replenishment of the mercury ducts are all that is necessary to maintain the apparatus in satisfactory operating condition.

The ten-turn jig of Figure 3 will accommodate cores of not less than one

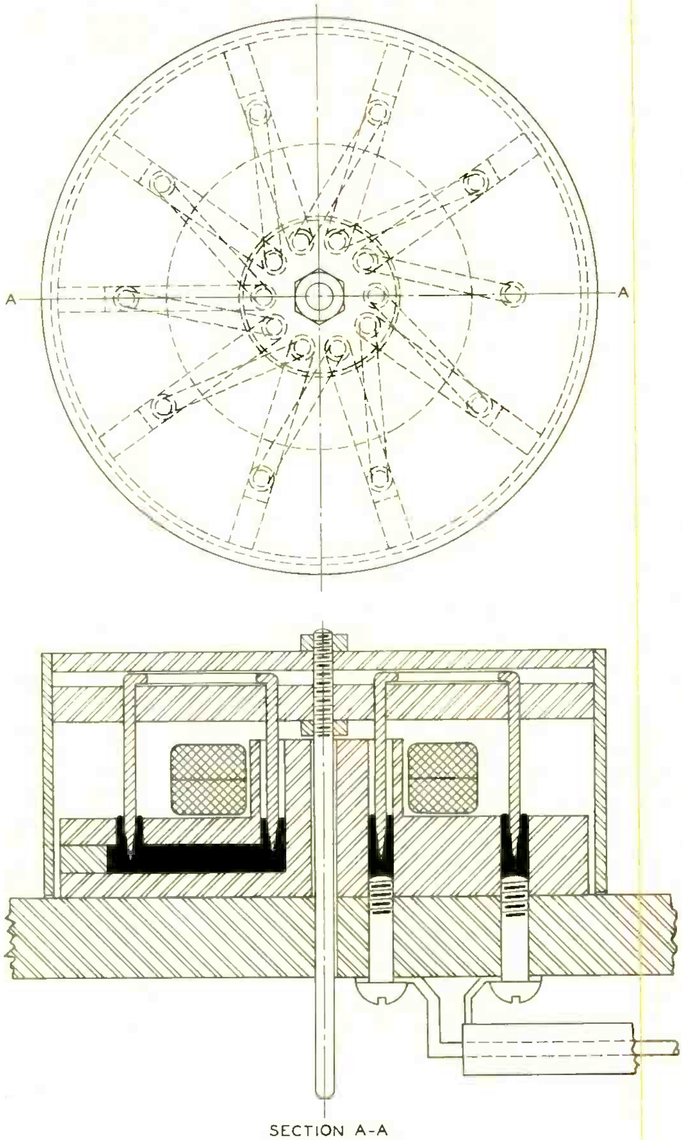


Fig. 2—Typical cross-section of mercury-contact jig

inch inside diameter nor more than two and one-half inches outside diameter. Both the size range and the number of turns, however, may be chosen to suit the cores being tested. A 75-turn jig, shown in Figure 4, accommodates cores with an inside diameter of not less than two inches and an outer diameter of not over three and a half inches. This jig has three layers of turns, and the middle layer is pitched oppositely to the inner and outer layers to minimize the external magnetic field. In this photograph may be seen a small lug projecting from the face of the jig between the two binding posts, which fits into a slot in the shield. In conjunction with the central aligning rod, this secures the proper positioning of the upper and lower sections of the jig.

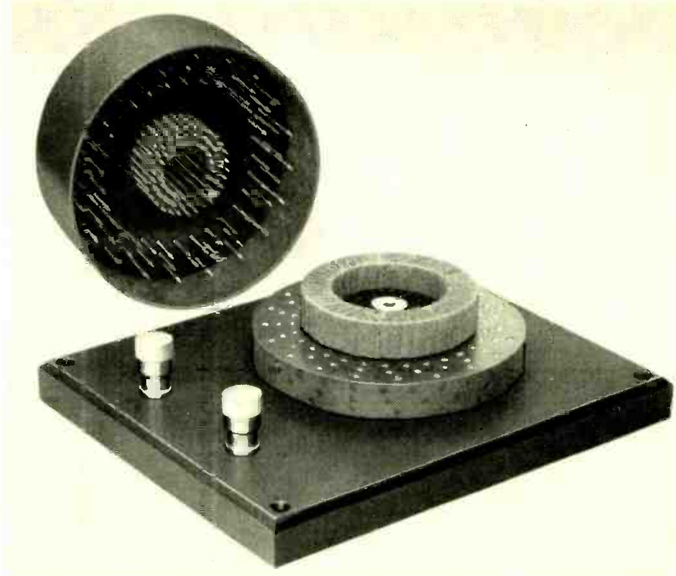


Fig. 4—A 75-turn mercury jig with a three-layer winding

The constancy of resistance maintained by these mercury jigs is very high. The resistance of the 10-turn jig, which has 20 contacts in series, remains constant between successive operations to within ±.0005 ohm, and during the period required for testing a single core it remains constant to ±5 microhms, even when subjected to severe mechanical shocks. A skilled operator using a low impedance testing circuit equipped with a mercury type jig can test cores for

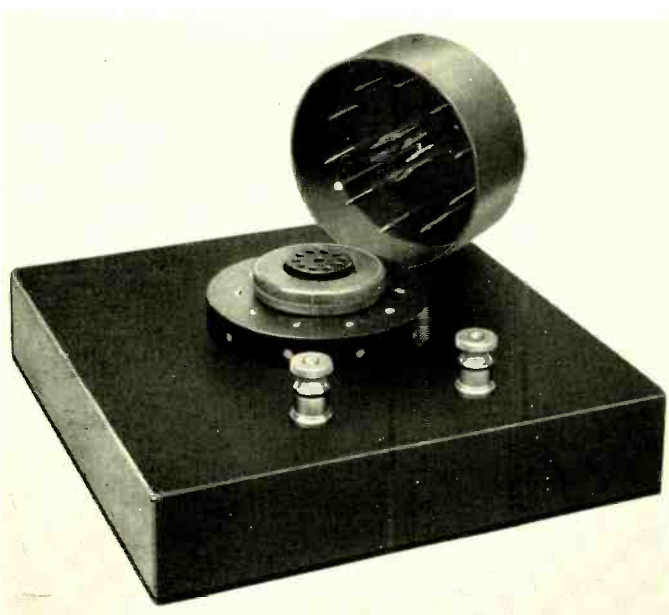


Fig. 3—Experimental model of a ten-turn mercury-contact jig

permeability and losses at the rate of about one a minute, including the recording of data. With the older method, the time for placing a winding on the core, before any testing was started, would be several minutes. The economy effected by the improved method can be readily appreciated.

Telephone Service to Panama

Telephone service between the United States and the Republic of Panama, and between the United States and the Panama Canal Zone, was formally inaugurated on February 24 by conversations between officials of the two governments at Washington and Panama City. The service embraces all Bell and Bell-connecting telephones in the United States, Canada, Cuba, and Mexico and the telephone systems of Panama and the Canal Zone. The link between them is a radio telephone circuit from the American Telephone and Telegraph Company's new short-wave station at Miami, Florida, to the station of the Tropical Radio Telegraph Company near Panama City. This will be the fourth service to open through the Miami station, which is already handling communication with the Bahamas, Colombia and Venezuela. The charge for a 3-minute call between New York and any point in the Republic of Panama or the Canal Zone is $21.

Experimental Paint and Varnish Compounding

By W. J. CLARKE
Chemical Laboratories

THE Bell System makes extensive use of paints, varnishes and lacquers in the finishing of telephone apparatus and in the decoration, preservation and maintenance of its plant and manufacturing equipment. The selection of proper materials for finishing telephone apparatus is often particularly difficult, for the finish must not interfere with the continual functioning of sensitive equipment. Often commercial finishes meeting all the requirements are not available. To care for such cases, and to learn more about how finishes and their components behave, these Laboratories have installed equipment in which finishing materials can be made experimentally, and the properties of their many components can be examined at first hand.

The various types of finishes now in use may be conveniently classified as paints, varnishes and varnish enamels, and lacquers and lacquer enamels. A paint is formed by dispersing pigments in a drying oil such as linseed oil. The familiar exterior house paint is usually applied by a brush, and the paint film dries in a day or so by reacting with the oxygen of the air. The life of a paint film, usually several years, depends on the severity of exposure as well as composition.

A varnish is made by cooking a resin with a drying oil, and thinning the resulting solution so that it can be readily applied. Such a finish sets initially by evaporation of the volatile constituents, but remains tacky to the touch for several hours while the film dries and hardens as it reacts with oxygen. It is the field of varnishes that has seen the biggest recent changes, for the chemist is learning not to depend on natural resins but to make them himself, fitting them closer to his needs. The newer varnishes so made dry more rapidly, to form coatings of superior toughness and durability. In varnish enamels, as in paints, pigments are dispersed in a liquid, here a varnish instead of an oil. When made from synthetic resins, clear varnishes and varnish enamels may advantageously be baked, and heat has materially speeded the finishing of some kinds of telephone apparatus.

A modern lacquer usually contains four classes of ingredients. The nitrocellulose imparts strength to the ultimate film; the resin causes the film to stick; the plasticizer makes the film flexible; and the solvent makes the lacquer thin enough for application. The drying of lacquers, unlike that of oil paints and varnishes, is only an evaporation of solvent, requiring minutes instead of hours or days.

The methods of compounding these various types of finishes are quite different, and may vary considerably for any one type. To make an oil paint, a paste of the pigments in some of the linseed oil is ground through a mill. Generally called grinding, the action of the mill is really more that of wetting all the pigment particles by the oil. In the burrstone mill the paste is forced between two flat circular stones, one of which rotates. In the roller mill, a recent development, the paste is squeezed between parallel steel rollers, the contacting faces of which move in the same direction at different speeds to produce a shearing effect. It may be necessary to grind the paste through the mill two or three times in order to wet all the particles properly. To avoid thickening caused by frictional heating, stones and rollers are water-cooled.

Into the ground paste the proper amount of oil and a small amount of drier are stirred. The drier acts as the "oxygen-carrier," helping the paint film to dry in contact with the air. The most common driers are solutions of organic lead compounds, usually the linoleate, resinate or naphthenate. The corresponding cobalt and manganese derivatives are also sometimes used.

The pigments, hundreds of which are in use, are finely powdered insoluble substances, generally inorganic. Their primary purpose is to give color and opacity, but they contribute materially to other characteristics such as resistance to fading and tendency to chalk when exposed to the weather. Among the more common pigments are basic carbonate of lead ("white lead"), zinc oxide, Chinese blue, chromic oxide, lead chromate, carbon black, and the natural yellow and red iron oxides. Sometimes a transparent inert pigment such as powdered silica or asbestine is ground into the paint, to serve as a cheap filler or as a suspending agent for some other heavier pigment which would quickly settle out if it were not supported in the fluid.

Varnishes are compounded in the laboratory in kettles made of resistant monel metal, placed over a high heat gas burner in a special hood which removes the fumes. The raw materials for varnish are natural and synthetic resins; drying oils, such as china wood oil or linseed oil; lead, manganese, and cobalt driers; and volatile thinners such as turpentine or light petroleum spirits.

The natural resins, now fast being superseded, include rosin, kauri, Manila and Congo copal. Ester gum, rosin that has been treated with glycerine at a high temperature, stands midway between the natural and synthetic. The early synthetic

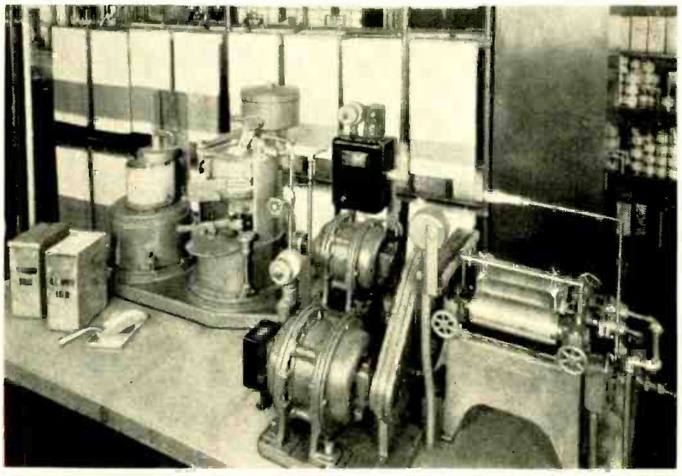


Fig. 1—In compounding paints and varnish enamels the powdered pigments are mixed with oil or varnish in the mixer (left) to form a paste, which is then ground in either the burrstone mill (center) or the roller mill (right)

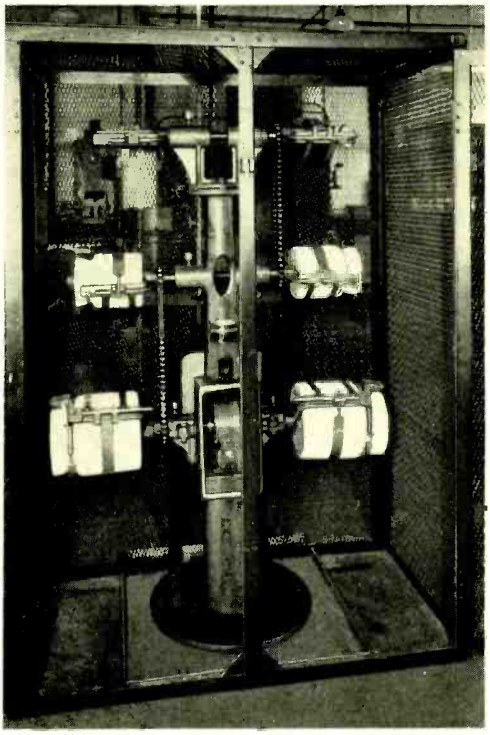


Fig. 2—In compounding lacquer enamels, the pigments are ground with the lacquer by agitation with pebbles in closed porcelain containers, to avoid loss of the highly volatile constituents by evaporation

moulding resins, formed by condensing phenol and formaldehyde, were dark colored and insoluble in the common varnish constituents, but they have since been modified to form the modern oil-soluble "Bakelites" and "Amberols." "Glyptal" resins, made by the interaction of glycerine and phthalic acid, give excellent light-colored bake-type finishes. Less known are "Cumar," produced by polymerizing with sulphuric acid an oil obtained from a coal tar distillate, and the "Aroclors," formed by chlorinating diphenyl, which are being tried in certain kinds of varnish.

The chief problem in varnish making is to determine the most suitable conditions for blending the raw materials, and considerable experience is needed to judge when these conditions have been found. The preparation of a short oil* "Amberol" varnish, such as might be used in finishing telephone booths or switchboards, typifies the procedure. Into the melted resin the required amount of china wood or linseed oil is stirred while the temperature is raised to about 570° F. The resin and oil progressively polymerize and the viscosity or "body" of the mixture increases so that the fluid begins to string when a drop is placed on a cool glass plate. Too much polymerization will result in a hard, brittle varnish, and under-cooking often gives a soft, spongy film. When the mixture strings properly, the fire is cut and a little cold oil is added, to check the reaction by chilling the batch below the critical reaction temperature. When it cools to about 430° F. the thinners are stirred in slowly, and then the drier solutions. If the latter are worked in at a higher temperature the finish is somewhat darker in color.

The varnish is then filtered or centrifuged, to remove dirt and foreign matter and give when dry a smooth glossy coating that can be rubbed with pumice in oil to the preferred dull furniture finish. Longer oil varnishes, for outdoor exposure, are often made by a blending process, or by cooking a small portion of the batch and later using this to check the reaction in the remainder. Certain resins, notably the "Bakelites," need not be heated above 425° F. to effect the proper polymerization. Variations in the handling of varnish batches are almost always necessary because the

*The number of gallons of drying oil to every one hundred pounds of resin is known as the "length" of a varnish, a short oil varnish being about 10 gallons in length and a long oil varnish about 70 gallons.

raw materials are chemically impure and variable.

In compounding enamels, a paste of pigment and a light-colored varnish is ground through a stone or roller mill. Many wall paints and undercoats are so made, using a minimum of varnish as a binder, and bringing the paste to brushing or spraying consistency by adding a large amount of thinner. When such a paint dries, the minute pigment particles protrude from the surface and give a "flat" appearance. Many synthetic resin varnishes are distinctly acidic, and if reactive basic pigments such as zinc oxide are used, a progressive "livering" action will change the enamel to a useless jelly. Titanium oxide white, and titanium dioxide precipitated around an inert filler, are common base materials for light-colored enamels because of their excellent hiding power and non-reactivity, and the white base can be tinted with small amounts of colors ground in linseed oil to standard shades such as grey or cream.

Compounding clear lacquers is relatively simple. The raw materials can be dissolved by agitation unaided by heat. Sometimes the resin, nitrocellulose and plasticizer are dissolved together, but more often separate solutions of each are mixed in the desired proportions. It is important to have mutual and complete solution of the constituents, not only while the lacquer is in the container but also while the film is drying. Hence the volatile portion of a lacquer is a mixture of high, medium and low boiling organic esters with light petroleum and coal tar solvents, blended to insure complete solubility of all the components as the lacquer dries. No single substance has been found satisfactory. Too rapid evaporation chills the film, and moisture condenses upon it from the air causing it to "blush." Toluol, an excellent solvent for many resins, does not dissolve nitrocellulose, and too rapid evaporation of the organic ester as the film dries will precipitate the nitrocellulose before the toluol has evaporated and ruin the film. The formulator can remedy this by adding a high-boiling solvent to hold the nitrocellulose in solution as the film dries.

Ethyl and benzyl cellulose and cellulose acetate are also used in lacquer coatings, but their high viscosity, and poor compatibility with the available resins and softening agents, limit their use. Among their desirable characteristics are the lower inflammability of cellulose acetate, and the lower moisture absorption of benzyl cellulose.

The tendency in lacquer formulation is to use much resin and little nitrocellulose, since the resins are more resistant to the actinic rays of the sun, an important cause of lacquer

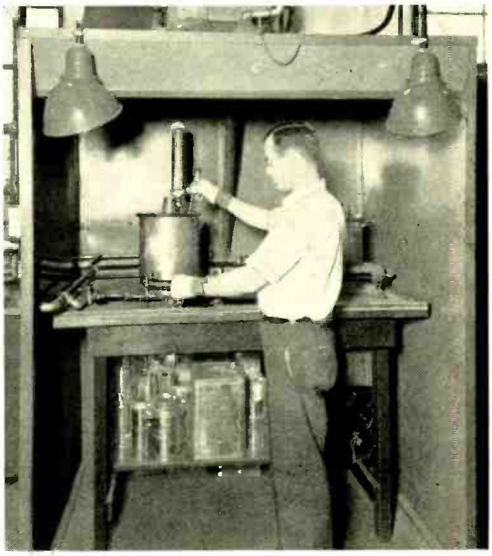


Fig. 3—In compounding varnishes, resin and oil are cooked together in kettles of monel metal

decomposition. The plasticizer is usually a slowly evaporating solvent such as dibutyl phthalate, which remains in the film for many months, keeping it pliable. Gradually it evaporates and the film becomes brittle and cracks open. New plasticizers which will stay in the film longer are constantly being sought and developed.

Lacquer enamels must be ground in a closed system to prevent loss of the solvents by evaporation. The pigments, lacquer and a quantity of hard, round pebbles are placed in a sealed porcelain jar which is slowly rotated for several hours. In this pebble mill all pigment lumps are broken up and the particles are thoroughly dispersed. Sometimes the pigment is ground with the plasticizer in the roller mill, and the nitrocellulose and resin solutions are later added in a mixing tank.

In general, formulation is empirical, since it is difficult to predict the exact effect of adding or substituting a new raw material. A series of samples must be compounded, and complete physical and accelerated aging tests must be made on each, to determine the best composition. Frequently a material will have peculiarities which overbalance its advantages. A new plasticizer, with excellent softening properties, may discolor so badly that it can be used only in very dark products. A resin, highly resistant to acid or alkali, may be so brittle that the slightest knock would chip the finish in which it was used, exposing the under-surface to corrosion.

It is the aim in all formulation to obtain the best possible products from the ever-increasing list of raw materials. The Bell System desires to keep its equipment in service for many years, and the Laboratories must be constantly on the alert for materials that will give more attractive and permanent finishes.

Two New Oscillators for the Radio Frequency Range

By C. T. GRANT
Telephone Apparatus Development

IN recent years rapid strides have been made in the use of ever increasing frequencies for the transmission of speech, both over wire lines and through space. Frequencies as high as 35 kilocycles are used for carrier telephone circuits operating over telephone lines, and frequencies up to 150 kilocycles for power line carrier systems. For radio broadcasting purposes, frequencies from 500 to 1,500 kilocycles are employed, and above this range come various short-wave channels such as those for ship-to-shore and point-to-point communication. Thus, speech can now be transmitted at frequencies as high as about 2,000,000 kilocycles.

To carry on experiments and tests in the lower part of this range it became necessary to develop means for generating currents at different frequencies. Accordingly, the design was undertaken of a high frequency oscillator which would cover at least a substantial part of the above range. Fifty and three-thousand kilocycles were set as satisfactory lower and upper limits.

The circuit as developed, shown in Figure 1, employs a push-pull oscillating stage directly coupled to a balanced two-stage amplifier. An air-core transformer couples the tuned plate circuit of the oscillator to the grids, which are in turn directly connected to the grids of the first amplifier stage. The purpose of the first

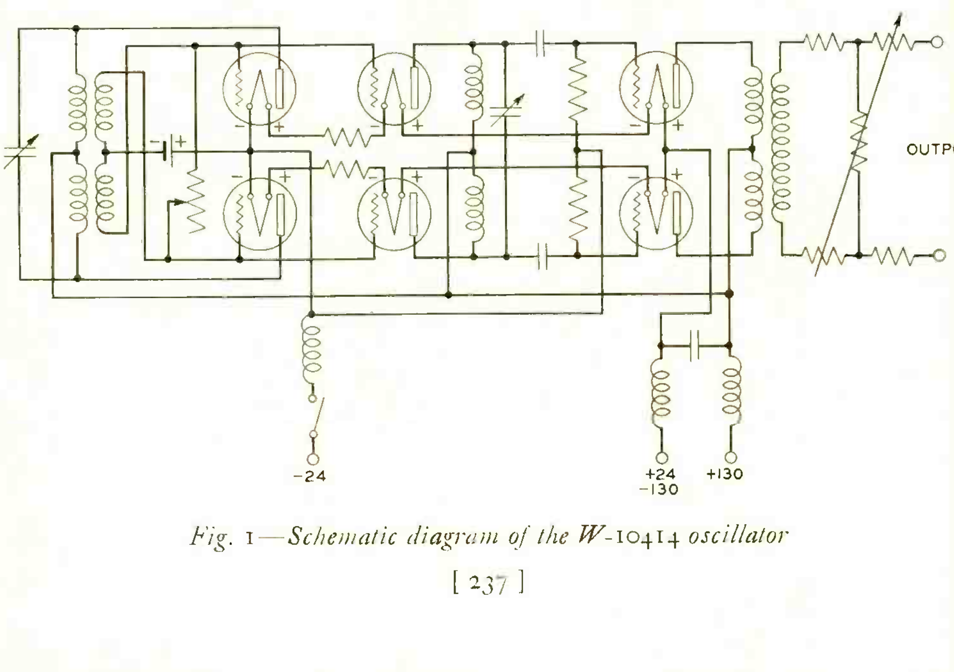


Fig. 1—Schematic diagram of the W-10414 oscillator

amplifier stage, which is coupled to the second by retardation coils and condensers, is solely to act as a buffer between the output stage and the oscillator, so that any change in load will not reflect back and change the frequency of the oscillator. A balanced circuit throughout was selected as the

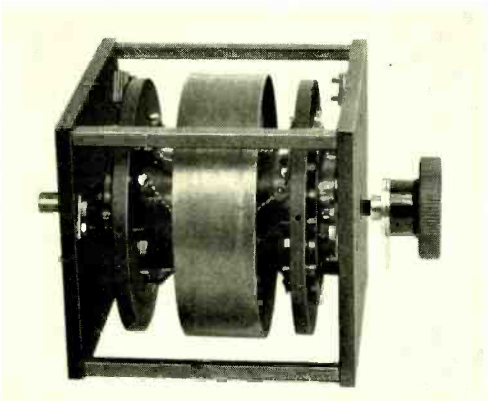


Fig. 2—Decade condenser for the new high frequency oscillators

most ready means for controlling the impedances between high potential points.

Plate supply to the first amplifier stage is connected to the mid-point of an input transformer which is used as a retardation coil and tuned to offer a high impedance at the operating frequency. The second amplifier stage has its plate supply connected to the mid-point of the output transformer which steps down the impedance of the vacuum tubes to one hundred ohms. The output is then controlled by a balanced H type resistance network, which may be varied over a 40 db range in steps of 2 db.

This new radio frequency oscillator, known as the W-10414, has a frequency range from forty to four-thousand kilocycles, and will deliver an output current of approximately sixty milliamperes into a resistance load of one hundred ohms. Its harmonic content is held to less than three per cent by use of the balanced circuit. The output frequency is calibrated to an accuracy of two-tenths of one per cent and this accuracy will be maintained with normal variations in filament current and plate supply voltages, and with changes of tubes.

One special feature of primary importance encountered in the design of this oscillator was the development of suitable decade condenser switches. Since the inductance of the oscillating circuit, which includes the wiring to the condensers, must not change as the capacitance is varied, a special decade switch had to be designed. As shown in Figure 2, this is of the "ferris wheel" type and is designed so that when one condenser is removed from the circuit another is put in its place. In laying out the assembly of the oscillator, these decade switches, of which several are employed, are placed around the oscillating coil so that the wiring from each switch is of approxi-

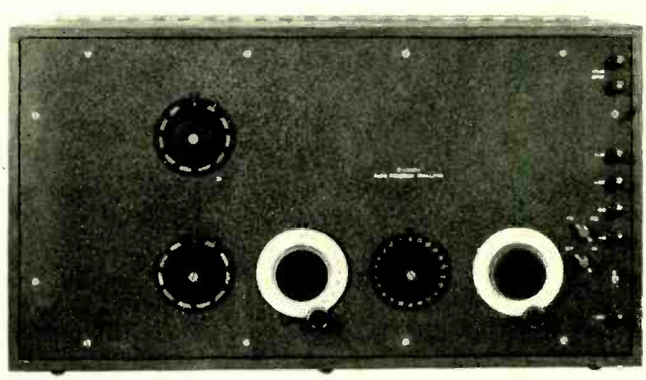


Fig. 3—Front panel of the W-10465 oscillator

mately the same length.

With the completion of the design of this oscillator, development work was immediately started on a similar oscillator but with a frequency range from 3,000 to 30,000 kilocycles. This second oscillator, known as the W-10465, differs from the lower frequency one chiefly in certain precautions taken to decrease high-frequency losses. Heater type tubes, which had just become available, were used in this oscillator because they had plug type sockets which offer less capacitance from high potential points to ground. To balance the capacitances to ground, all wiring on each side of the balanced circuit was made of equal length and as short as possible.

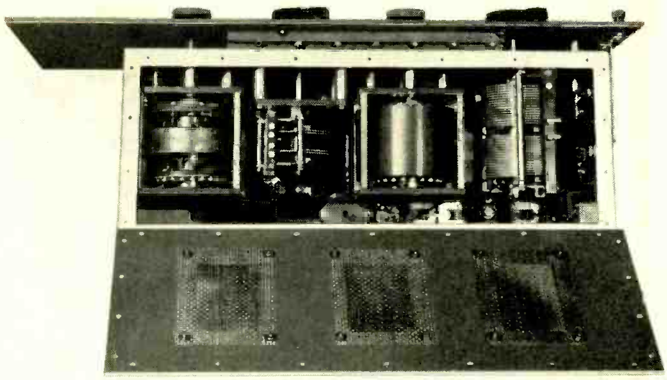


Fig. 4—From left to right are the decade tuning condensers, inter-point air condensers, resistance across first amplifier stage, and output tuning condenser

To cover the wide frequency range, three "plug in" type oscillating transformers are used. These transformers are wound with gold-plated wires on isolantite cylinders to minimize the high-frequency dielectric and resistance losses. The same type of decade condenser is employed, but it is composed of smaller units. A balanced variable air condenser is used to span the range between the steps of the decade condenser. The output transformer steps down the impedance of the plate circuit to one hundred ohms, as with the oscillator for the lower frequency range, since this value of output impedance has been found most satisfactory for radio frequencies. The output transformer is tuned with a variable air condenser, which tends to reduce any harmonics that may be present in the output circuit. This tuning condenser may also be used as a volume control by detuning, and no adjustable resistance network has been used in the output circuit of this oscillator. A transformer is inserted in the mid-arm of the output stage which permits the output frequency of the oscillator to be modulated with a voice or carrier frequency, thus allowing the oscillator to be used for bridge and transmission measurements with a short-wave receiver as a detector.

The appearance of the front panel of the oscillator is shown in Figure 3, and the arrangement of the apparatus as viewed from the two sides, in the two following illustrations. A double electrostatic shield is employed, the inner shield being a $\frac{1}{8}$-inch aluminum box and the outer a $\frac{1}{32}$-inch copper lining for the fumed oak box which houses the oscillator. The purpose of the double shielding is to enable this oscillator to be used in close proximity to other sensitive measuring equipment without danger of coupling between the two circuits. To provide adequate ventilation for the larger tubes used with the W-10465 oscillator, rectangular holes are cut in the inner shield, which are covered with metal screening to maintain the effectiveness of the shielding. Retardation coils and by-pass condensers are inserted in both the filament and plate-circuit supply leads to keep out radio frequencies.

This oscillator delivers an output current of approximately fifty milliamperes into a load resistance of one hundred ohms, and, like the W-10414, has a harmonic content of less than three per cent and a calibration which is maintained to better than two-tenths of one per cent with normal variations in filament and plate voltages and with changes in tubes.

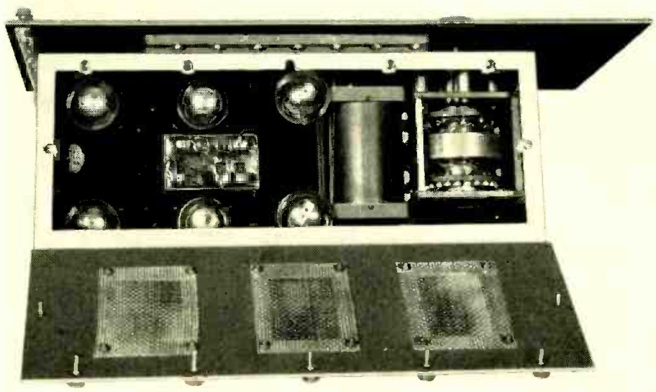
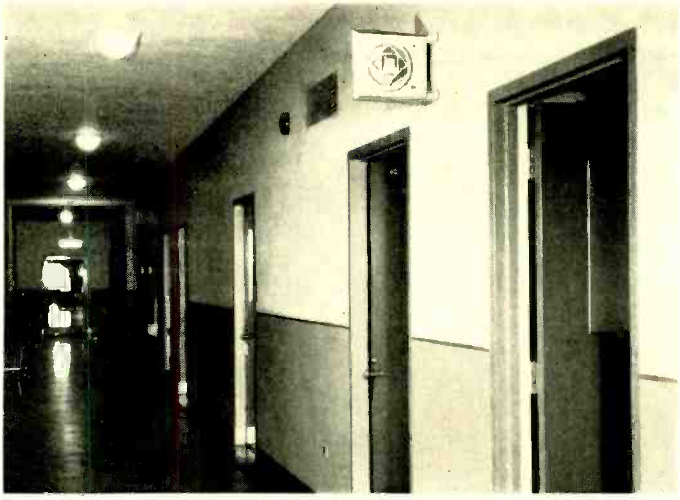


Fig. 5—Viewed from the top may be seen (left to right) the output transformers, the six vacuum tubes, the oscillating transformer, and the decade tuning condensers



Loud Speakers Summon Physicians in the New York Hospital

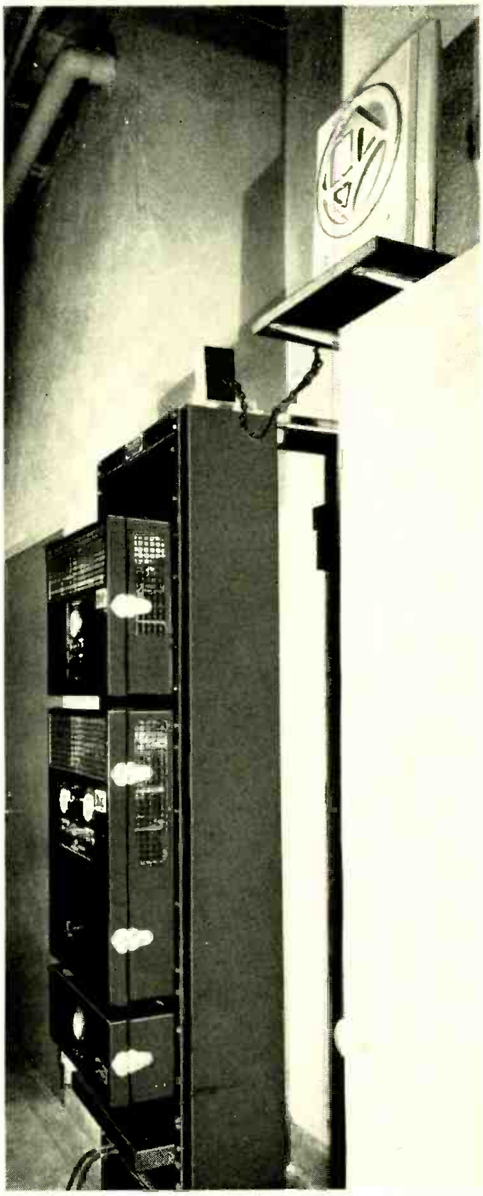
CALLING physicians promptly to the telephone has always been of great importance to the larger hospitals; in fact, one of the earliest applications of loud speaking telephones was to this "Doctors' Paging" service. Although an "In and Out" indicator at the entrances will tell whether the physician is in the hospital or not, there still is the problem of locating him in one of the several score places where his duties may take him. Loud speaking telephones on the desks of various attendants and at other points where no attendant is stationed can immediately broadcast the news that Doctor So-and-So is wanted, and should he not hear the summons someone is sure to tell him within a few minutes.

In the New York Hospital, the newest and finest of that city's institutions, calling of doctors and others is accomplished through a Western Electric paging system. A dynamic transmitter is mounted on a swinging bracket at one position of the information switchboard. After amplification, the speech currents are distributed over any or all of five circuits which serve a total of 85 loud speakers distributed throughout the hospital. Some are placed on desks in various locations, so that the attendant can notify the doctor if he is in one of the adjacent rooms; others are mounted on walls and project sound in both directions along corridors. By selecting appropriate circuits, the call will be repeated only in localities in which the physician is likely to be found.

When a telephone call for a physician is received at the main switchboard, it is referred to an information operator, who determines from an electrical "In and Out" board in front of her that the person wanted is in the hospital. She then switches in the appropriate loud speaker circuits, and announces, "Dr. So-and-So, Dr. So-and-So." The doctor has instructions to dial from the nearest telephone a number which connects him with the information desk. He gives his name, and the operator then connects him with the calling party, or gives him the message.

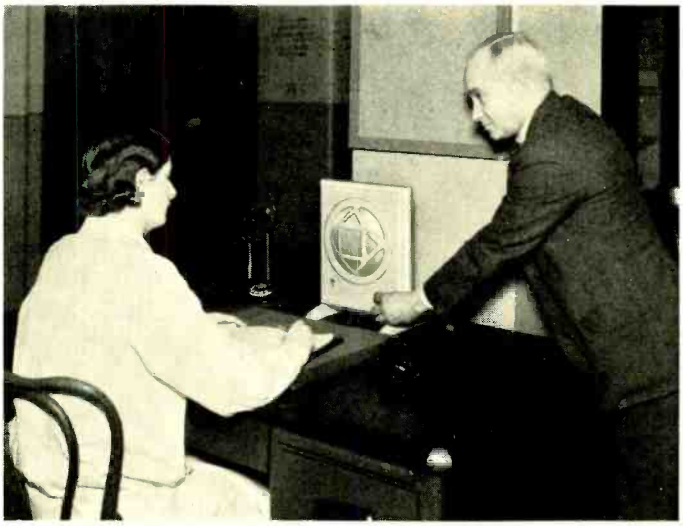
A control cabinet in front of the operator houses not only the selecting keys, but switches which turn the amplifiers on and off, and lamps to indicate that the system is ready for use. In an apparatus room in the basement is located the amplifying equipment. It consists of a 63A amplifier feeding a 59A amplifier, with a 57A amplifier in parallel with the final stage of the latter. All the power supplied to the system is alternating current, and no batteries are used. Volume controls on the amplifiers permit an adjustment for the system as a whole, and by individual controls on the loud speakers the loudness is adjusted to give satisfactory coverage from each station without annoying those within earshot. To prevent tampering, these controls, as well as the "on-off" switches in the loud speakers, can be operated only by

Paging position at the information center of the New York Hospital. The loud speaker control cabinet is at the left. Keys on the shelf connect the operator to the telephone system



Amplifier rack of the paging system of the New York Hospital inserting a key. The speakers are of the small cone magnetic type. Due to the fidelity of reproduction, calls are entirely intelligible at a loudness level which is never annoying. Provision has been made for liberal increases in circuits and loud speakers as the growth of the institution requires more extended facilities.

This paging system was specially designed by the Laboratories for the Western Electric Company under the supervision of L. B. Cooke, J. E. Crowley, and C. A. Clarke of the Special Products Development Department.



By turning a key, A. R. MacDonald, electrical superintendent of the New York Hospital, adjusts the loudness of the paging calls so as to be just comfortably audible to the attendant

A New Service for Residences

By W. M. BEAUMONT
Local Circuit Development

NO longer is the telephone a luxury, something to be used only at rare intervals or from curiosity, but—like electric light and the automobile—it is an essential part of our daily existence. And the more it is used, the more are found other ways in which it may simplify and make easier our ordinary affairs. Few establishments, whether office, factory or private residence, can be adequately served by a single telephone. One does not want to be continually running back and forth or up and down stairs to answer or to place a call. Small business houses and the larger residences require a number of telephones, and to take full advantage of the service they offer, intercommunicating features are highly desirable.

For installations requiring fairly extensive intercommunicating facilities, a number of private branch exchanges are available.* Where the intercommunicating needs do not require more than a single channel, however, and where privacy on this channel is not essential, facilities are now available in the form of the 15A and 23A key equipments. These two key equipments are alike except that the 23A provides for two central office lines, and the 15A for only one.

Hand telephone sets with five buttons in the base, as shown in the accompanying photograph, are employed at all stations that are to have access to the central office lines. From left to right these buttons are marked, 1, 2, H, L, and B, and are used to establish a connection with either of the central office lines, to hold an outside call while it is being transferred,

*One of these, the No. 750 P.B.X., was described in the RECORD for *February*, 1930, *p.* 278.

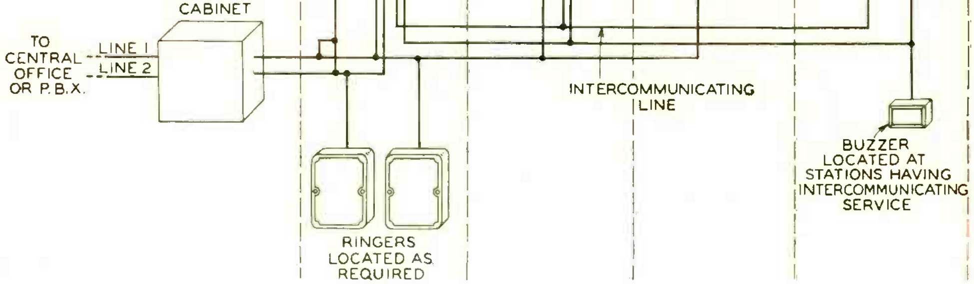
to connect to the intercommunicating circuit, and to signal other stations.

Incoming calls are signalled by bells—those on the two lines being arranged to give different tones to indicate which line is calling. To answer an incoming call one lifts the handset and presses button 1 or 2, depending on which line is being used, and then talks. Should the call be for someone who can answer more conveniently at some other station, the H button is pressed to hold the call, then the L button is pressed to connect to the intercommunicating line, and button B is pressed to signal the station wanted. Code signalling is usually employed for this purpose. When the person at the distant station answers on the intercommunicating line, the person at the calling station tells him there is a call waiting on line one or two, as the case may be. The second station then goes in on the line by depressing the push button associated with that line and the first station hangs up, thus making his station available for other calls.

Considerable flexibility is provided in the facilities made available at various stations, a typical arrangement for residences being shown in Figure 1. A station may be given access to either or both of the outside lines, or it may have intercommunicating service without access to the outside lines. The latter type of station does not employ the push-button handset, but is provided with a separate button to enable other stations on the intercommunicating line to be signalled.

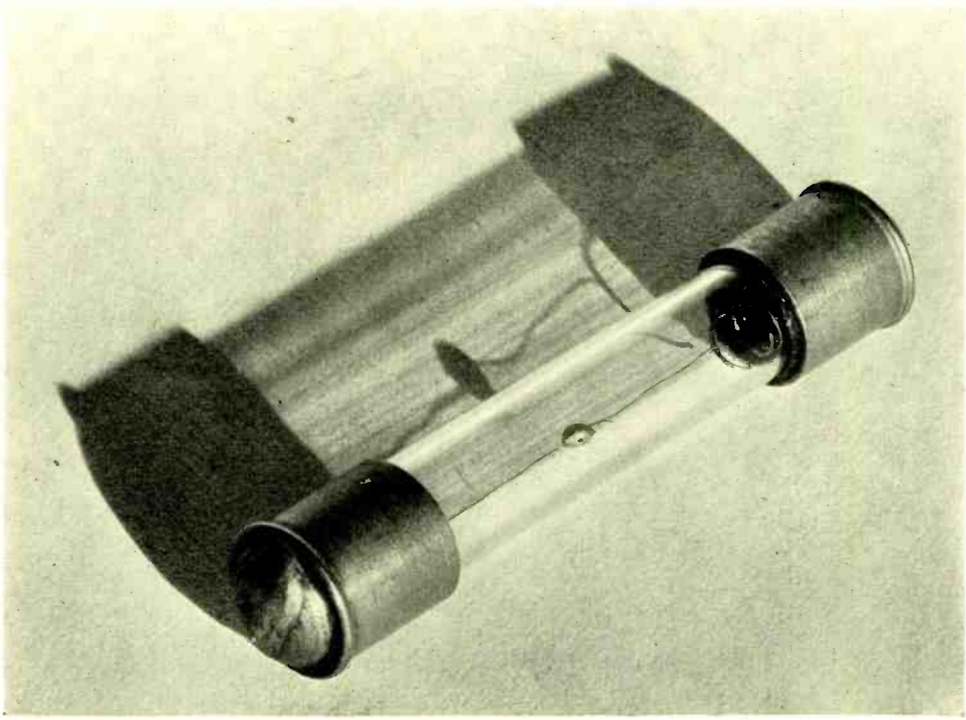
A small lamp, shown in the illustration, may be employed, if desired, to indicate a busy outside line. If, for example, a person should press button 1 to make a call and line 1 was busy, the lamp would light, and he would then place his call on line 2. A single lamp is employed for indicating a busy condition on both lines, associating itself automatically with the trunk corresponding to the button pushed.

When a station is using an outside line all the other stations are normally cut off from it, but if desired, arrangements may be made so that any other station or stations are not cut



A typical arrangement for the 23A key equipment off. This permits a flexible privacy system which may be arranged to accommodate the requirements of the subscriber.

These new equipments thus provide very convenient and satisfactory telephone service features for small businesses and for residences which require a number of telephones but which do not need the 750 P.B.X.



In the No. 62 Fuse, a globule of low-melting alloy joins two heating wires which are placed under tension by a small helical spring

The Underwriters' Laboratories

By M. WHITEHEAD
Telephone Apparatus Development

SOON after the introduction of electricity for commercial uses, insurance organizations began to realize that a reduction in fire losses from electrical causes depended upon the use of electrical apparatus designed and built to minimize the fire hazard. Several committees were accordingly formed to carry on the inspection of electrical apparatus, but it soon became evident that efforts would have to be centralized to avoid unnecessary duplication and even conflicting practices. After several consolidations of committees, the Underwriters' Laboratories was established to provide an organization for the examination and testing of appliances, systems, and materials submitted to them by manufacturers. The activities of the Underwriters' Laboratories are not limited to electrical items but include the investigation of any other devices, systems, and material which have a bearing on life, fire, and collision hazards, and theft and accident prevention. Since certain apparatus manufactured by the Western Electric Company, particularly sound reproducing and radio equipment, is sub-

Guide No. 361 A4. August 18, 1931—Laboratories' File E5832.

Western Electric Co., Inc., Mfr.,
463 West St., New York, N. Y.

Radio Appliances.

Radio receiver for rack mounting, 21 watts, 103-127 volts, 50-60 cycles, Type 10-A.
Rectifier, primarily for use with 10-A receiver, 70 watts, 107.5-122.5 volts, 50-60 cycles, Type 5-A.
Portable amplifiers designed for connection to branch circuits. Consisting of one or more stages of audio-frequency amplification, 45 watts or less, 110 volts, 50-60 cycles, Types 25-B, 25-C, 32-A, 34-A, 34-B, with low potential output terminals-45A; 120 watts, 120 volts, d.c., Type 31-A.
Marking: Manufacturer's name.

STANDARD—Fire and Accident.

REEXAMINATION SERVICE.

See description of Reexamination Service on guide card.

This card replaces E5832, dated Sept. 24, 1929.
This card is issued by Underwriters' Laboratories.

A typical card listing of Western Electric equipment

mitted to the Underwriters' Laboratories, it is necessary that Bell Telephone Laboratories—as designers of the apparatus—be in close contact with the Underwriters' Laboratories and fully conversant with their requirements, organization, and procedure.

Besides the Underwriters' Laboratories there are several other organizations concerned in one way or another with the maintenance of standards relating to fire hazard or safety of electrical apparatus. There is first of all the National Board of Fire Underwriters, an organization composed of stock fire insurance companies, which was largely instrumental in organizing the Underwriters' Laboratories, and which partially supports it. Then there is the National Fire Protection Association, a professional society concerned with fire prevention, which acts as a legislative body in establishing standards by which fire hazards, chiefly those arising from the methods of installation, are judged. They are the creators of the National Electrical Code which, approved by the American Standards Association, is a national standard for the guidance of all electrical and fire inspection groups. This code, published by the National Board of Fire Underwriters, is one of the guides used by the Underwriters' Laboratories in their work.

Guided by the National Electrical Code, the various inspection organizations — both state and municipal as well as those of the insurance organizations —can satisfactorily judge whether electrical installations are properly made, but naturally they are not in a position in all cases to decide whether the materials used are of the proper quality or whether the complete pieces of apparatus are properly constructed. It is information of this nature that the Underwriters' Laboratories undertakes to provide. Manufacturers of electrical apparatus, from rubber-covered wire and insulating tape to complete pieces of apparatus, such as radio transmitters, submit samples of their product to the Underwriters' Laboratories for inspection.

To guide their work, the Underwriters' Laboratories use, of course, the National Electrical Code but in addition they use requirements for various types of apparatus set up by Industry Conferences. These conferences are called by the Underwriters' Laboratories, and consist of representatives of the Underwriters' Laboratories and of the manufacturers who have goods listed in the particular class of apparatus concerned. At these conferences standards for all types of apparatus such as rubber-covered wire, steel conduit, radio appliances, etc., are set up and sent to all manufacturers of listed devices for comment before they are issued in final form. As a further guide in their inspection work, the Underwriters' Laboratories also use the National Electrical Safety Code issued by the Department of Commerce, which chiefly confines itself to securing safety to the user of the apparatus.

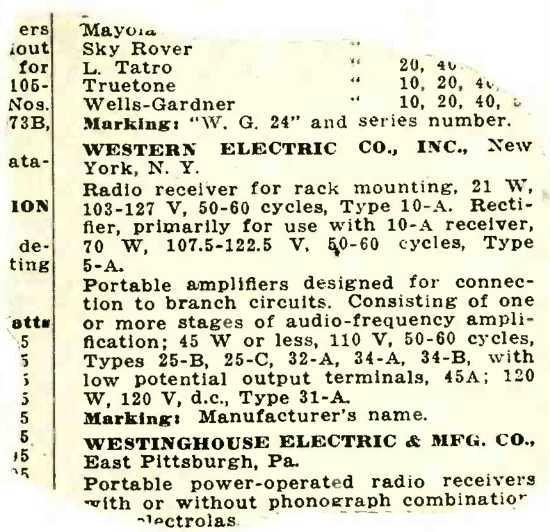
After the technical staff of the Underwriters' Laboratories have found that a device submitted to them by a manufacturer is in compliance with established requirements, they make a technical report to one of their Councils for approval. There is one council for each major division of the Underwriters' Laboratories work, such as the Electrical, the Automotive, and the Burglary Protection councils, and each consists of representatives of insurance organizations and of the various interested municipal, state, and federal bureaus. Only after acceptance by the council to which the report has been referred, is formal approval given to the device.

Such formal approval of acceptance of devices is published through summaries of the reports on printed cards, files of which are maintained at most insurance offices and with other interested organizations. In addition to the cards, a catalog is issued listing the approved appliances, from which manufacturers, architects and others interested can obtain information. An accompanying illustration shows a listing, both on a card and from the catalogue, of some Western Electric Equipment.

Following the initial examination and test, a follow-up inspection service for subsequent factory output is undertaken to insure that the quality of the original sample is being maintained. Three forms of inspection service are utilized, termed reexamination, label, and special services.

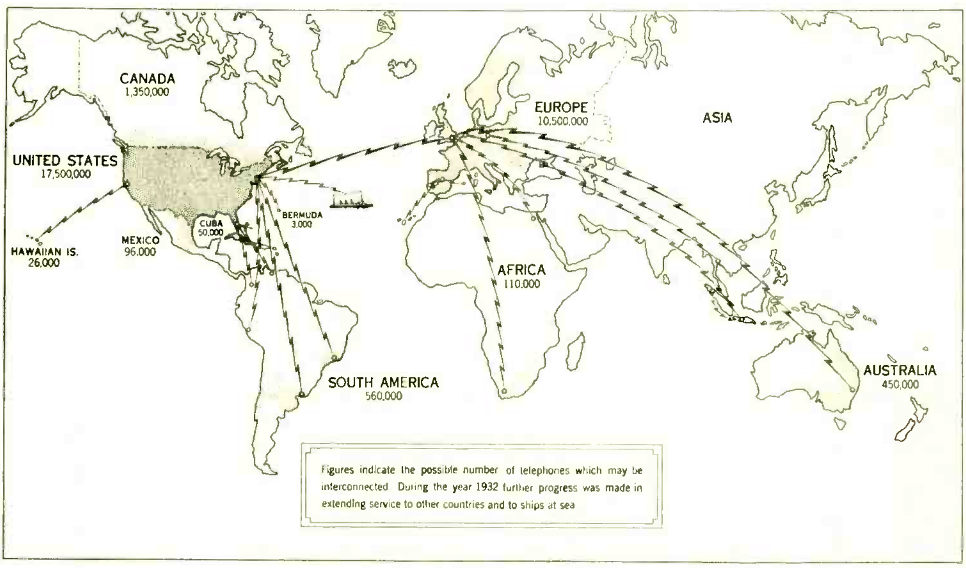
The reexamination service involves an inspection, one or more times yearly, of a sample obtained by the Underwriters' Laboratories either from the manufacturer or from the open market. Any features found not standard are corrected in subsequent products or the listing is discontinued. Until very recently, no marking on the device itself has been allowed, under this form of service, to indicate its submittal to the Underwriters. The listing and the manufacturer's catalogue has been the only way of obtaining this information. Since the Underwriters' approval has become such a distinct advantage from the sales standpoint, a marker applied in the form of a paper sticker or otherwise has now been provided which may be applied to the apparatus.

The other two forms of inspection, label and special service, are similar



Approved apparatus is also listed in a catalog for the use of those interested to each other in involving inspections at the factory of a large quantity of the output. Under label service, a label is applied to each piece of apparatus complying with the requirements. The photograph at the head of this article shows such a label applied to a Western Electric reproducer set. The special service differs from label service in being used where the application of a label is not practicable. These two forms of service are used where close inspection is necessary. The reexamination service indicates that the manufacturer is capable of manufacturing devices complying with the standards, while the label and special services indicate that the apparatus is actually in conformance with the standards.

In furnishing the manufacturer, the user, and all those concerned with fire prevention the best opinion which they can obtain as to the merits of a device with respect to fire and accident hazards, the Underwriters' Laboratories thus performs a needed service to industry.



By the end of last year, overseas extensions of the Bell System's telephone service had interconnected ninety-two per cent of the world's 33,400,000 telephones

Contributors to This Issue

After two years at the University of Colorado, A. C. WALKER went to Massachusetts Institute of Technology, where he received the B. S. degree in Chemical Engineering in 1918. After a year in the chemical warfare service, and two in chemical research for a paper mill and a firearms plant, he went to Yale University for graduate study in physical chemistry, and received the Ph.D. degree in 1923. Coming to these Laboratories in that year, he has since been concerned with research on paper and textiles, first with the Chemical Laboratories, and since 1929 with the telephone apparatus development group. He has had a large part in developing and applying methods of purifying textile insulation, and methods for the inspection control of commercially purified textiles for telephone apparatus.

W. J. CLARKE received the B. Chem. degree from Cornell University in 1924, and for the following five years was connected with Devoe and Raynolds as a plant and research chemist dealing with problems in the manufacture of paints and varnishes. In 1930 he joined our Chemical Laboratories, where he has been working with the paint and varnish group in its studies of organic finishes for telephone equipment, and particularly on the compounding of improved finishing materials. A year ago he received the M.A. degree for part-time study at Columbia University.

C. H. YOUNG received the degree of B.S. in Electrical Engineering from the University of Michigan in 1927. He at once joined the Technical Staff of the Laboratories, where with the electrical measurements group, of the Apparatus Development Department, he has engaged in the development of precise impedance measuring equipment and resistance standards with low time constants.

W. M. BEAUMONT entered the Bell System as substation installer with the Bell Telephone Company of Pennsylvania early in 1911. After spending a short time in the Installation Department he was transferred to the Maintenance Department and remained in that department up until 1919, when he joined the Technical Staff of Bell Telephone Laboratories, at that time the engineering department of

A. C. Walker

W. J. Clarke

C. H. Young

W. M. Beaumont

M. Whitehead

C. T. Grant

the Western Electric Company. Here with the Circuit Laboratory he has participated in the development of manual central offices and private branch exchanges. At the present time he is engaged in the development of manual and dial P.B.X's. He is a graduate of the night school of the Drexel Institute of Philadelphia.

M. Whitehead received an E. E. degree from Rensselaer Polytechnic Institute in 1926 and a year later joined the Technical Staff of the Laboratories. With the Apparatus Development Department he was first engaged in writing specifications. Later, he transferred to the repair requirements group where he has been chiefly concerned with our relations with the Underwriters' Laboratories and their associated organizations.

C. T. Grant received a B.S. degree in electrical engineering from the University of Illinois in 1916 and spent the following year with the General Electric Company at Schenectady. In 1917 he joined the Chemical Warfare Service of the United States Army, and while in charge of the engineering work of the experimental laboratory at Puteaux, France, received a commission as Lieutenant. For a year following the armistice he was with the Nikoosa Edwards Pulp and Paper Company in Wisconsin. In 1920 he joined the Technical Staff of the Laboratories. Here he has been engaged in the design and development of fault locating apparatus for open wire and cable circuits, transmission measuring sets, amplifiers, detectors, oscillators, and general transmission testing apparatus for the telephone plant.