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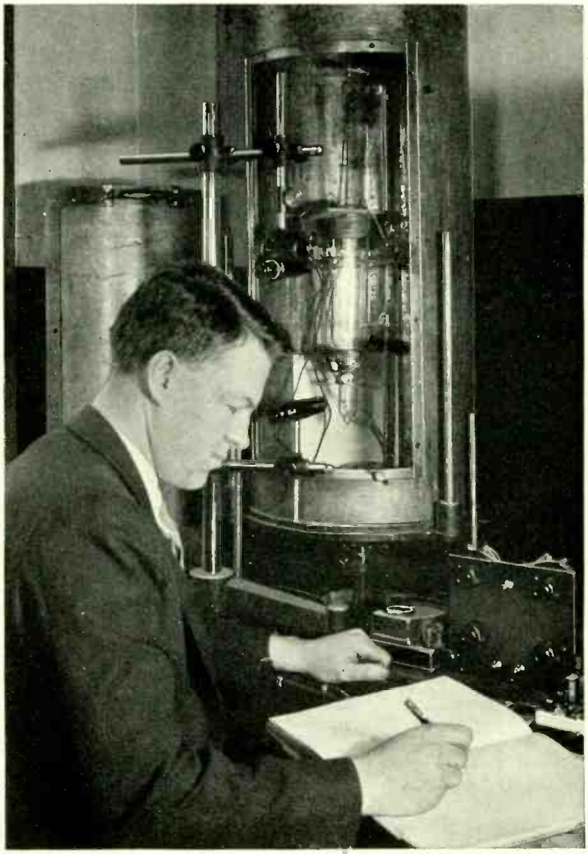

A corner of the Microphone Laboratory showing the calibration of apparatus for measuring contact resistance

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The Role of Barium in Vacuum Tubes

By J. A. BECKER
Physical Research

TWO hundred and fifty thousand vacuum tubes, approximately, are employed in the circuits of the Bell Telephone System. Each vacuum tube has a filament from which electrons are liberated when it is heated by current from a battery. The cost of the power used to heat the filament is part of the operating cost of a tube. Another factor in the expense of maintenance is that of replacement when a filament burns out. Among the filament characteristics, therefore, which are desired in the design of a vacuum tube, are long life and small power for heating.

Of two types of filament, which have the same life, that one will be preferred which gives the greater current, that is, greater emission of electrons, for each watt of power used to heat it. The most desirable filament yet discovered for telephonic purposes is that used today in the repeater tubes of the Bell System plant. It consists of a platinum alloy whose surface is coated with a mixture of barium oxide and strontium oxide. A very minute amount of barium in each filament plays a most important part in its operation and permits the use of a smaller heating power than other filaments, for example those of tungsten, would require.

The possibilities of the oxide-coated filament were appreciated by Dr. H. D. Arnold in the early days of tube development and he made the fortunate decision to develop it rather than those made of tungsten or tantalum. "By the time the transcontinental telephone line was opened in 1914 the development work had advanced to a stage where it was possible to equip the repeaters on that line with tubes containing oxide-coated filaments which were sufficiently stable for commercial operation and on which the annual charges were only about half of what they would have been if tubes containing tungsten had been employed."* During the following years many improvements have been made in the art of manufacture of oxide-coated filaments by members of our Research Department under the direction of W. Wilson, J. E. Harris and M. J. Kelly.

Why the coated filament should liberate electrons more economically and how to increase these economies with added improvements in life and reliability have been important problems basic to tube development. To learn the way in which electrons effect their escape from a filament, and the factors that tend to help them, the method of research was to deal first with simple cases where the factors could be separated and controlled. The experimental procedure involved the preparation of filaments with a single layer of barium atoms, and sometimes only a partial layer, adhering to the metal core.

The remarkable effect that barium

* *c.f. "Reducing the Cost of Electrons," W. Wilson*, RECORD, *Vol. III, No. 3, p. 61.*

has upon the activity of a platinum filament is shown in Figure 1. The current of electrons which can be obtained from the filament, when its surface is covered to various thicknesses with barium, is there plotted against the percentage of the surface covered.

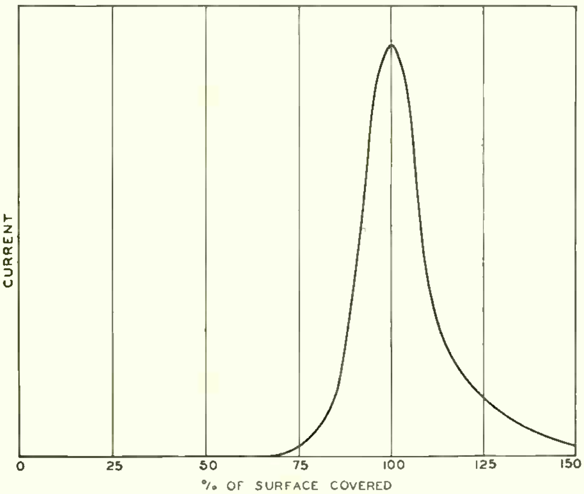


Fig. 1—Curve showing how the emission from a platinum filament increases as a layer of barium atoms covers more and more of the surface

This figure shows that for filaments which are maintained at the same temperature, that is, require the same power expenditure for heating, there is a very much greater emission—in fact, more than a hundred million times as much as for a clean platinum surface without barium—when the filament surface is just completely covered with a single layer of barium atoms. When the surface is only half-covered the electron emission is too small to show on the scale used in plotting the figure. Emission increased rapidly as more and more of the surface is covered until about eighty per cent is covered, when an enormous increase is noted. When filaments were studied with more than enough barium to cover their surfaces, it was found that the current decreases and approaches the value which it would have for bulk barium.

The remarkable fact is that the electron current which is possible at any heating temperature from a single layer of barium atoms on a platinum wire is enormously greater than the current which could be obtained from a filament of either substance alone.

In the filament of the standard repeater tube, the platinum core is covered by a thick layer of oxide coating. In the course of the treatment of the tube some of this oxide is electrolysed and barium is stored up in the core and in the oxide. While the tube is being used some of this barium is adsorbed on the surface of the oxide as an invisible monatomic film. This adsorbed barium film is responsible for the high efficiency of the oxide coated filament.

Subsequent experiments have shown that barium on top of the oxide coating behaves qualitatively like barium on platinum. Its characteristics are even more desirable. Apparently the forces brought into play between the barium and the oxide coating are essentially the same as those between a platinum core and a single layer of barium atoms deposited upon it.

These are the facts but to understand the role played by barium atoms it is necessary to understand first how emission takes place from a clean filament surface. The electrons in the metal must have a certain speed in order to break away from the forces holding them to the metal and escape into the vacuum. Because of the heat energy of the metal, at any temperature a certain very small fraction of the electrons have enough speed to escape, and some do so. As the temperature goes up, the thermal agitation of the electrons increases and the fraction that escape increases rapidly. Therefore, the amount of electron current emitted goes up with increasing temperature.

To make more electrons come out without raising the temperature, it is necessary to arrange matters to make it easier for them to get out. As the electrons tend to escape from the surface, they must overcome forces pulling them back. These forces might be likened to those acting on a ball which is started rolling up-hill. The heavy line in Figure 2 illustrates such an electrical hill for metallic tungsten. It shows the work an electron must do to go from the surface to various distances from the surface. For practical purposes if an electron ever gets out to a distance of 100×10^{-8} cm, or one millionth of a centimeter, it permanently escapes from the filament and reaches the plate. To do this it must have had at least 4.5 equivalent volts of energy when it left the surface.

The electrons of the filament are continually taking a try at this hill, but only a very small fraction of them start with sufficient velocity to reach the top and escape. Of course, if the height of this hill can be reduced, many more electrons can, at any given filament temperature, pass over it. One way of accomplishing this is to apply an external electric field which pulls the electrons out. This field can be produced by raising the plate of the tube to a positive potential. In Figure 2, the dotted straight line which slopes downward represents an applied field of a million volts per centimeter. By combining this field with the original field, we obtain a new electrical hill whose height has been reduced. An electron may now escape if it leaves the surface with 4.2 equivalent volts and reaches a distance of 20×10^{-8} centimeter.

Why the barium atoms on the surface increase the efficiency of the filament is the question. When the barium sticks to the surface, some of the atoms become ionized, that is, they give up one of their electrons to the surface and become positively

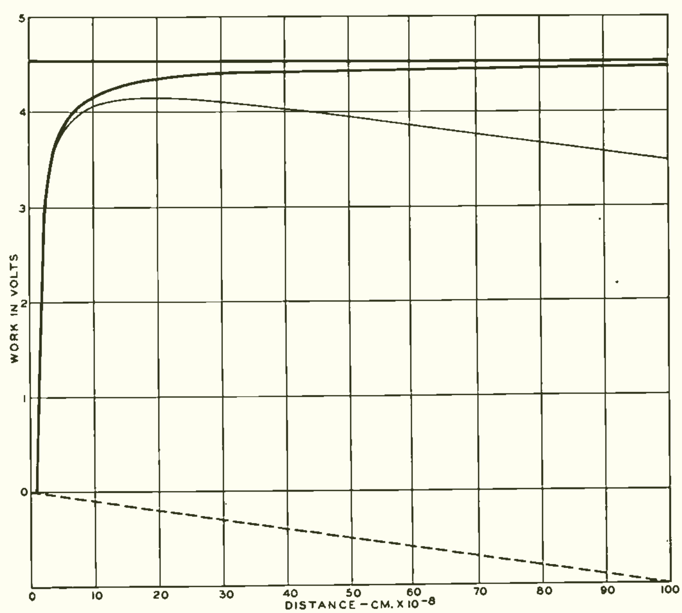


Fig. 2—The heavy line gives the energy an electron must have, to pass a given distance from the filament. The light line shows the effect on this energy of an applied field indicated by the dotted line

charged.* These barium ions act much the same as would a very fine-meshed positively-charged grid placed exceedingly close to the filament. Such a grid produces fields which, close to the surface, help the electrons escape. Due to the fact that this ion grid is very close to the surface, the fields produced by it are tremendously great—several million volts per centimeter—and consequently the effect is proportionately great. The greater the number of ions on the surface the greater is the field and consequently the greater the electron emission.

This is true only so long as the surface is covered with less than one layer of barium atoms. Beyond this point, additional barium atoms cover up the spaces through which the electrons come from the surface, and decrease the number of ions on the surface. Consequently the electron emission is reduced more and more until it reaches a value characteristic of a solid barium surface. This theory as to the action probably explains the peculiar shape of Figure 1.

This same picture of barium ions stuck to the surface receives strong support from another set of experiments. As has been described a positive potential, applied to the plate of a tube, increases the emission from its filament. From the careful analysis of such current-voltage curves, one can deduce the exact value of the forces which act on an electron while it escapes from the surface. Experiment discloses the interesting fact that beyond a distance of about ten atom diameters from clean surfaces, the only forces which tend to pull the electron back are those induced by its own electrical image.* Near a clean metal filament there are thus no electrical fields excepting those produced by the escaping electron. If, now, this clean surface is covered with a partial layer of barium ions, other fields are superposed on the image fields. These fields are presumably produced by the adsorbed barium and may be called adsorption fields. Very close to the surface these adsorption fields are tremendous and in a direction to pull electrons out of the surface. Further from the surface these fields decrease and actually reverse their direction; for a while they then increase in magnitude, come to a maximum and gradually decrease. These field characteristics, revealed by experiment, are just those which would be expected from a non-uniform positively charged ion grid very close to the surface.

Such adsorption fields have a marked effect on the current-voltage or saturation curves. It was long ago noticed that while clean tungsten yielded curves which saturated very well, the corresponding curves obtained with coated filament saturated very poorly in comparison. The cause of this marked failure to saturate is due to the adsorbed barium atoms.

To be of much value, the barium atoms must stick tenaciously to the surface even at high temperatures. It, therefore, becomes of interest to inquire what holds them to the surface. Here again our picture helps us out. Since some of the barium atoms are barium ions on the surface, they are positively charged and hence are held to the surface by the negative charge they induce on it. Furthermore, since

* *"The Life History of an Adsorbed Atom,"* RECORD, *Vol. V, No. 1, p. 12.*

* *"On Electrical Fields Near Metallic Surfaces," J. A. Becker and D. W. Mueller, Reprint B-300.*

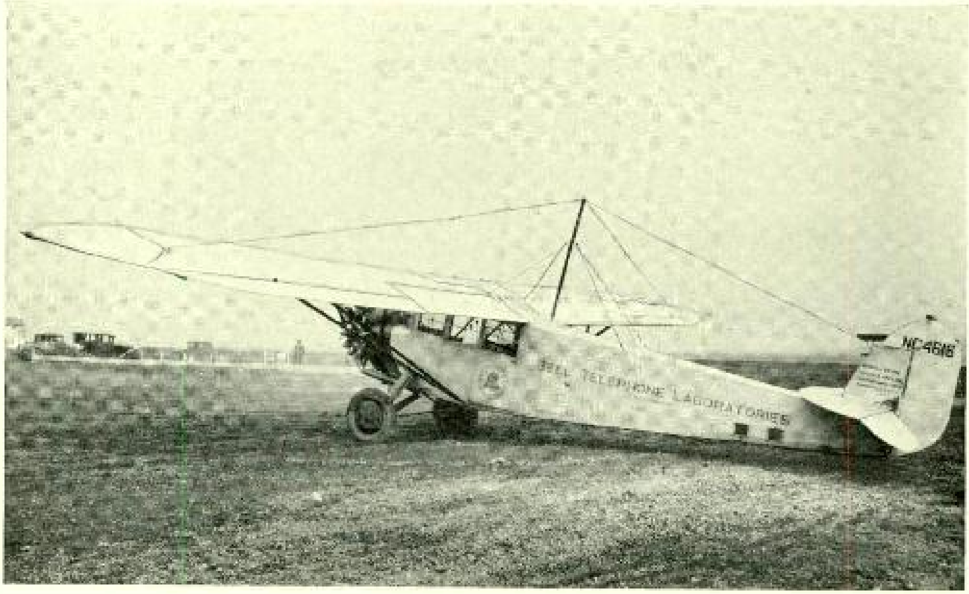
the field produced by the ions helps electrons from the surface, it hinders positive particles from leaving the surface. Consequently each ion helps hold its neighbor to the surface even at temperatures at which solid barium would vaporize rapidly.

Still another prediction from our picture receives experimental verification. Since the electrical forces are chiefly toward and away from the surface rather than parallel to or along the surface, we should expect that each adsorbed ion would not be attached firmly to one particular spot on the surface but should be able to move about on the surface. This prediction was verified experimentally by putting barium atoms on one side of a flat ribbon.* After this ribbon had been heated at a moderate temperature, barium atoms were detected on the other side. This surface creepage continued until only half the original deposit remained on one side.

We thus see how the simple picture of the ionic barium grid accounts for many of the observed characteristics of coated filament in telephone repeater tubes. Although barium is not classed among the precious metals, yet when present at the right time and in the right place, it may be of remarkable value.

In the ordinary telephone repeater tube the single layer of barium weighs about one-sixth of a microgram. For all the thousands of tubes in use in the Bell System the total amount of barium effective in the emission of electrons is not more than a twentieth of a gram. Each barium coated filament, however, requires only about 2.2 watts for heating as compared to about 35 for a clean tungsten filament. Multiplying the 250,000 tubes in use by the cost of current from storage batteries gives an idea of the tremendous importance to the Bell System of a small amount of barium when utilized in accordance with the results of fundamental research.

*"Phenomena in Oxide Coated Filaments," *Physical Review*, Nov. 15, 1929, p. 1323.



Radio-Telephone Equipment for Airplanes

By D. K. MARTIN
Radio Development

TELEPHONE communication equipment, developed by the Laboratories for airplanes, performs three functions. It permits two-way plane-to-ground and plane-to-plane communication, it enables airplane pilots to receive radio-beacon signals and weather-information broadcasts, and it allows intercommunication between as many as four points within the plant itself. Two radio receivers are required since the weather reports and navigation aids are transmitted at frequencies just below the broadcast bands, while radio telephone channels for two-way communication are assigned above the broadcast band. Further restrictions have been placed on the type and arrangement of apparatus both by Federal regulation and by the inherent requirements of airplane service. Such for instance is the requirement that two-way communication be on the same frequency in both directions, and the practical aircraft necessity that all apparatus be of minimum weight, and that its operation require a minimum of attention.

A complete radio-telephone equipment for an airplane is shown in Figure 1. The major apparatus pieces are the transmitter and the two receivers each of which, since they are remote-controlled and accessibility need be considered only for occasional repair or adjustment, may be mounted in an inaccessible place in the ship. Alike in external appearance, the two receivers differ in circuit and equipment in that one is designed to receive at frequencies in the band from 1500 to 6000 kc., and the other in the band from 250 to 500 kc. Their operation

Fig. 1—E. F. Brooke with complete radio-telephone equipment for airplanes

and construction is described in an accompanying article by S. E. Anderson, and that of the transmitter in a third by R. S. Bair. Besides these major items there are the antenna tuning unit, dynamotors for supplying plate and grid potentials, and several pieces of control equipment. The total weight is about 130 pounds.

Control of the equipment is centered chiefly in a small three-point switch with a position for "off", "receive", and "transmit-receive". With this switch in the receive position all head sets are connected to both radio receivers, and weather reports, navigation aids, or calls from a ground station can be received. Either radio receiver may be cut off by moving its volume control all the way to the left. The head-sets and microphones, of which there may be as many as four, are all in parallel so that inter-communication between different stations in the ship may be carried on at any time.

Because of the noise from the engines and propellers, a special silencer type of microphone has been developed for airplane use. With this device such noises are very effectively excluded and are not transmitted over the circuit to the ground station. To further improve the talking conditions, part of the microphone output is carried back to the telephone receivers, thus furnishing side tone so that the speaker can hear his own voice. Also, under these conditions the head set is disconnected from the radio receivers so that disturbing sounds may not come from the outside. The new silencer-type microphone is rectangular in shape and for talking is held close against the face with one hand.

For single-seat mail planes a somewhat lighter microphone, fastened to the aviator's helmet, as shown in Figure 4, is necessary since the aviator's hands may both be engaged with the controls. This microphone, although

Fig. 2—F. C. Ward conducting a test on an engine-driven generator

Fig. 3—The Ford tri-motored plane with fixed V and strut antennas. Standing beside it are the Laboratories pilots, Capt. A. R. Brooks and P. D. Lucas, and the ground crew: left to right, R. Zilch, C. T. Garner, and Walter Funda

not of the silencer type, has been found very satisfactory. Used with these microphones are the small phonette receivers designed for the Western Electric audiphones, which may be seen in the first illustration.

Fig. 4—For single seat mail planes a lighter type of microphone is used, fastened to the aviator's helmet

Power supply for airplane telephone equipment is naturally of vital importance but there is some difference of opinion as to the form it should best take. Standard airplanes employ a 12-volt battery for miscellaneous services and so this voltage has been accepted as a basic potential for radio purposes. Unless the use of the equipment is to be rather limited, however, additional charging apparatus must be provided, and in addition higher potentials are needed for plates and grids. For these higher voltages there are three possible sources. Wind-driven generators may be employed which have the advantage of constant speed, or engine-driven generators which possess an inherently higher drive efficiency, or dynamotors may be

Fig. 5—A tuning adjustment being made on the Fairchild plane by F. B. Woodworth

utilized which are driven by the ship's batteries. The great advantage of the latter method is that power is available when the engine is stopped and even when the plane is on the ground.

There are, of course, other advantages and disadvantages to the various methods. Weights and efficiencies vary and must be given consideration. The dynamotor method allows the high-voltage supplies to be interrupted at low voltage by opening the 12-volt supply. When a dynamotor is employed, however, greater charging capacity is usually necessary which requires a larger generator. When air- or engine-driven units are used they may be made double voltage to supply both high voltage for plates and low voltage for filaments and battery charging. The testing of various possible types of generators has been no inconsiderable task and special apparatus has been set up for the purpose as shown in Figure 2.

At the present time airplane operators are allowed a choice of power supply. Generators of the three types are available and which type is selected makes little difference in the arrangement of the radio equipment.

In regard to antennas also, there is some difference in opinion, and some choice allowed. In general, the trailing wire antenna has been found most effective, but it is in some disfavor with airplane operators because of the difficulties in handling it in an emergency, and the hazard involved should the weight at the end of the wire become detached. Some form of fixed antenna is usually preferred, and the Laboratories' planes have been equipped with several experimental types as shown in Figure 3 and the headpiece.

On the Fairchild is a strut antenna with capacity loading formed by wires

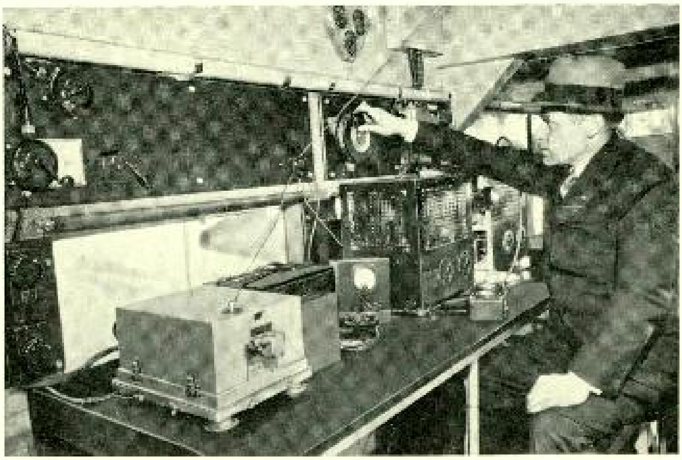


Fig. 6—In the Ford plane is a laboratory bench for experimental apparatus. F. S. Bernhard is shown making an antenna test

running to the wing tips and to the tail. This is used for both transmitting and receiving and gives fairly satisfactory results in the band from 3000 to 6000 kc. In the lower range from 1500 to 3000 kc. the loss due to the excessive loading required and the small effective height of such an antenna will probably bar its extensive use in practice. Boeing Air Transport, Inc., proposes to use a somewhat similar loaded strut antenna on mail planes for its Western Electric radiotelephone equipment.

The Laboratories' Ford plane has been equipped for experimental purposes with two trailing wire antennas, an unloaded strut antenna, and a horizontal V antenna—composed of wires running from the tail to struts on each wing tip—which may be used either in a V doublet or in a T connection. The unloaded strut has proven very satisfactory for receiving and is usually operated untuned because of the necessity of using it with two receivers operating at widely different frequencies. The horizontal V is more satisfactory for transmitting and will be used by Western Air Express for its radio telephone. Views of the interiors of the Laboratories' planes showing the experimental apparatus are given in Figures 5 and 6.

As has already been mentioned, the circuit arrangement will vary slightly depending on the type of power supply and antenna, but the method of

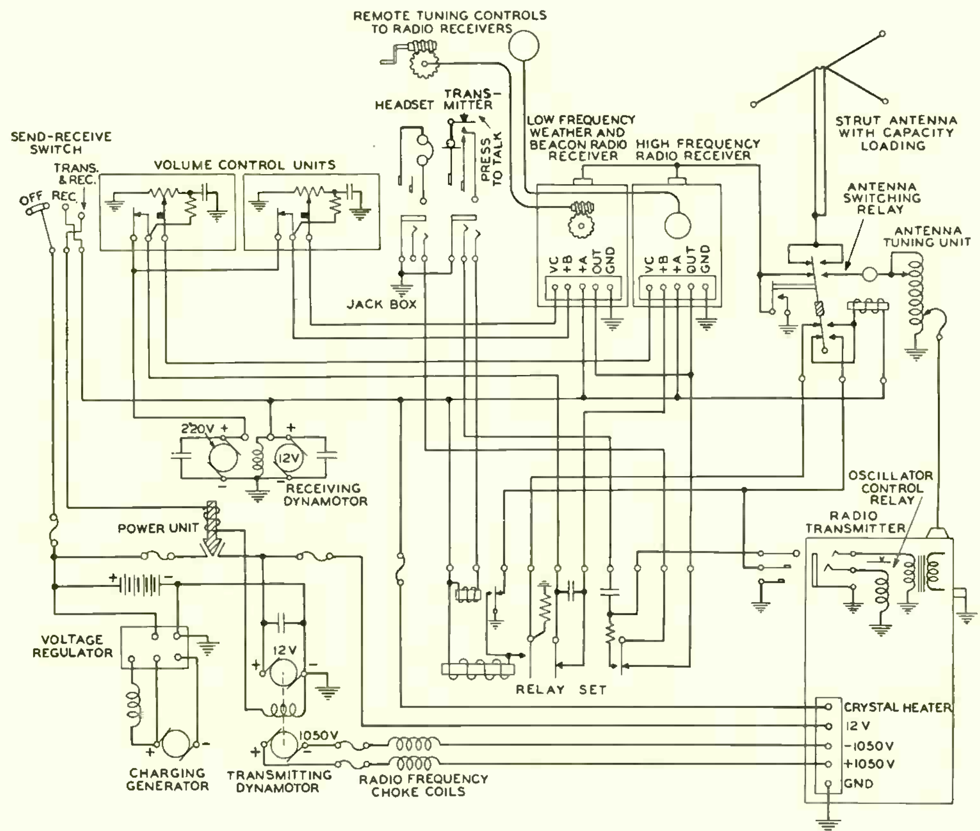


Fig. 7—Typical arrangement of equipment and circuits for airplane use

operation will be evident from Figure 7 showing the circuit for Boeing Air Transport, Inc.

Moving the three position control switch from "off" to "receive" puts the interphone circuit and the radio receivers into service. The single contact made in this position connects battery to both the receivers for their filaments, and to a dynamotor that supplies 220 volts for plates and grids.

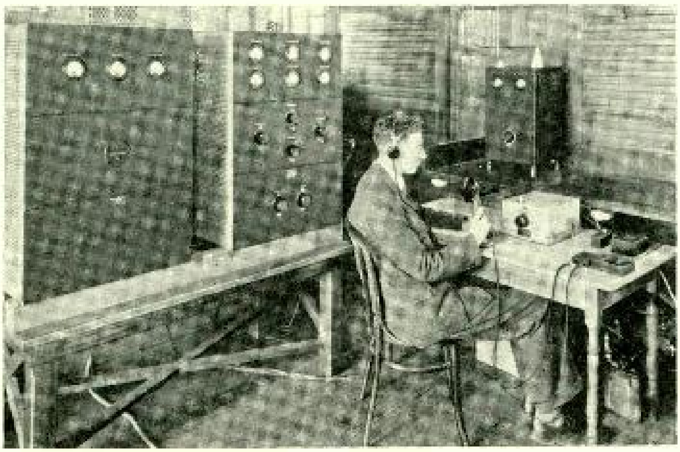


Fig. 8—W. K. Caughey listening at a ground station

In this position signals from both receivers may be heard or interphone conversations may be carried on.

To talk on the interphone circuit a button on the microphone is depressed which makes two contacts in succession. The first supplies power to the microphone from the ship's twelve-volt battery and operates a relay set which disconnects the head-sets from the radio receivers and connects them to the interphone circuit. The second contact connects the microphones to both the interphone set and the radio transmitter but inasmuch as this is not connected to its power supply with the three-way switch in the "receive" position no speech currents are radiated.

To talk over the radio circuit the three-way switch is moved to the "transmit-receive" position. This maintains the battery connections already made and in addition connects the battery to the filaments of the radio transmitter and starts another dynamotor which supplies plate and grid potential for it. When the talk button is pressed with the contact switch in this position, voice currents from the microphone modulate the carrier current and speech is radiated. Releasing the microphone button restores the circuits to their receiving condition.

Ground station equipment, shown in Figure 8, differs from that in the airplane chiefly in the use of a larger capacity transmitter, described in Mr. Bair's article, and in employing only one receiver. The circuit and method of operation are modified only slightly to meet this different equipment.

Many overall tests have been made of the radio-telephone service afforded by this equipment with the plane flying from Hadley Field as a base. On such trips a log is kept of the quality of transmission and other data such as distance from base, altitude, and weather conditions. Good transmission is obtained over distances up to 100 miles. Voluntary reports have been received from people who have heard the signals from distances as great as 500 miles.

New Radio Transmitters for Airway Applications

By R. S. BAIR
Radio Development

AFTER exhaustive studies of the conditions and requirements of aviation service, two radio transmitters have been developed to serve as part of the complete airway radio equipment. One of them, known as the 8-A, is for the aircraft, and combines simplicity and reliability of operation with a degree of compactness and lightness best gauged by a glance at Figure 2. The other, for the ground station and known as the 9-A, is released from the stringent requirements of size and weight and is of greater power. The relative sizes of the two transmitters may be seen by comparing the right-hand cabinet of Figure 1 with the plane transmitter of Figure 2.

Fig. 1—The ground-station transmitter with W. N. Mellor at the transmitter panel on the right, and J. G. Nordahl at the power control

Both are designed to operate at frequencies from 1500 to 6000 kc, in which band the Federal Radio Commission is issuing licenses for airplane-to-ground communication channels. Although the range of the transmitters for satisfactory communication is given as 100 miles, they will reach much farther under favorable conditions. In addition to their projected use, these transmitters are already in

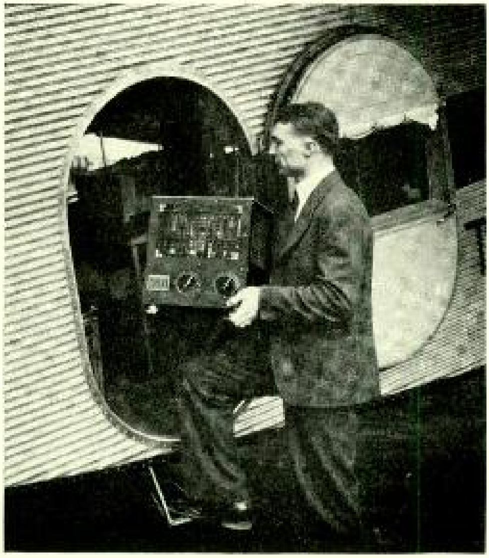


Fig. 2—R. C. Carlton carrying an 8-A radio transmitter into the Laboratories' Ford plane

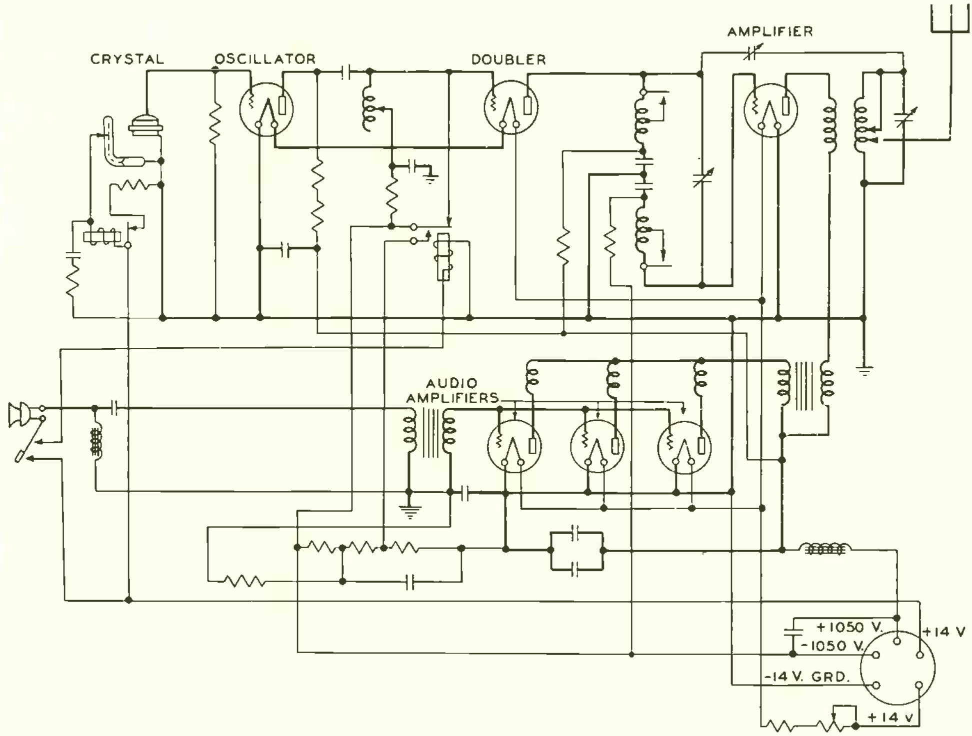


Fig. 3—Diagram of 8-A transmitter

demand for employment on tugs and fire boats as well as for police department work.

The 8-A transmitter, for which R. C. Carlton and H. Vaderson are principally responsible, is shown schematically in Figure 3. It consists essentially of a crystal-controlled oscillator, a frequency doubler, a modulating power-amplifier, a speech power-amplifier, and the necessary power and control circuits. Some of the principal elements may be seen in their actual location in Figure 5.

By accurate temperature control the frequency of the oscillator is held constant to better than twenty-five thousandths of 1%, even at the extreme external temperatures encountered in flying. Clamped firmly between two specially shaped metal electrodes, the crystal is maintained at a temperature of 55°C by an electric heater and a thermostat embedded in the lower electrode. These parts are heat insulated and supported by an isolantite housing arranged with connection prongs to plug into a socket similar to those used for small vacuum tubes. For the range of frequency from 1500 to 4000 kc square crystals similar to those used with broadcasting transmitters are employed. For the higher-frequency band smaller circular crystals are used. The two types of holders required to accommodate these crystals were designed by O. M. Hovgaard. Extremely small compared to those used for broadcast transmitters, their appearance may be seen from Figure 4.

The crystal frequency is only half of the radiated frequency. The output of the oscillator tube feeds into a frequency doubler—like the oscillator a 205-D tube—which operates with a fixed bias and large grid leak to augment the generation of harmonics. A parallel-tuned circuit fed by the plate selects the second harmonic to act as input for the modulating amplifier.

The plate circuit of the modulating power-amplifier, which employs a 211-D tube, is tuned by a condenser across the secondary of a close-coupled radio-frequency transformer which has taps for connection to the antenna. To span the entire frequency range, two of these transformers are required and are readily interchanged by means of four clamping screws which also make the four necessary connections. Plate modulation is accomplished by supplying a thousand-volt direct-current potential through the secondary of the output transformer of the audio power-amplifier. The radio-frequency transformer insulates the plate voltage from the antenna and the tuning condenser. The amplifier is neutralized by the Rice method from voltage developed by half of the input coil.

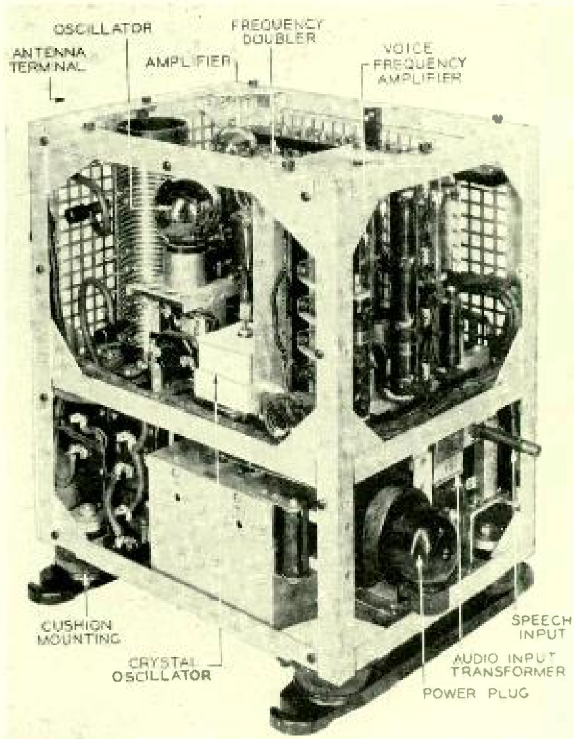


Fig. 5—Removing the two sides and cover of the 8-A Transmitter shows the compact disposition of its component parts

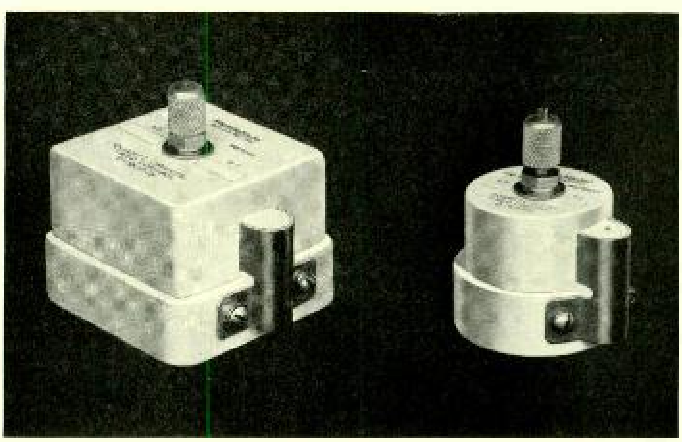


Fig. 4—Crystal containers are small and have prongs for plugging into a socket of the vacuum tube type

Audio-frequency amplification is by three 211-D tubes connected in parallel, which supply sufficient power for complete modulation. Special transformers are used for input and output circuits, the former with permalloy cores. Developed by the group under E. L. Schwartz, they are light and very small, as shown in Figure 6 where one of them appears beside the

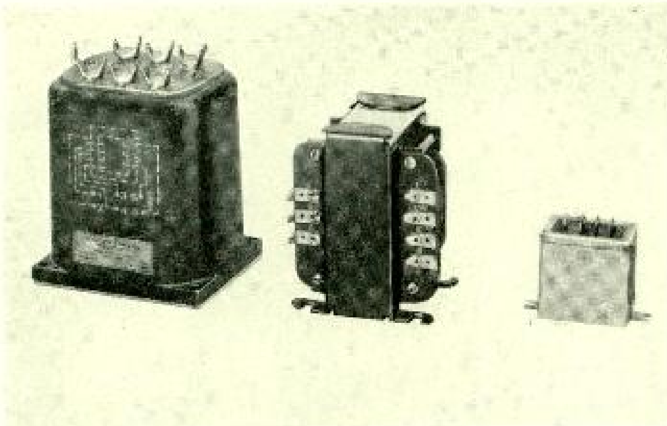


Fig. 6—The audio-frequency transformer weighs but four ounces in remarkable contrast with the four-pound transformer used for broadcasting

corresponding broadcast transformer.

To obtain a quiet source of power for the filaments, approximately fifteen amperes at twelve volts is taken from the ship's battery which is ordinarily floated across a charging generator. For the thousand-volt plate supply, at which about four-tenths of an ampere is needed, a separate generator may be used, or—as is sometimes desirable—a dynamotor driven from the ship's low-voltage battery. Connection of these power supplies to the transmitter is made through a single plug shown in the illustrations.

The ground transmitter, shown schematically in Figure 8, is essentially the same as the 8-A but includes a power amplifier in addition to increase the power of the modulated carrier. Its carrier output, also capable of complete modulation, is 400 watts—eight times as great as that of the 8-A. The power amplifier uses a 251-A vacuum tube, shown in Figure 9, which is a recent development of the vacuum tube research group. A rotating coil, inductively coupled to the output of the modulating amplifier, supplies its grid input and neutralizing voltages. The output circuit is tuned by the constant - impedance type of circuit with a variable inductance and capacitance coupling to the transmission line.

An antenna tuning unit, shown in Figure 10, is enclosed in a copper box for protection and shielding, and is arranged for wall mounting. It consists of a variometer with a tapped stator and fixed series condenser for resonating the antenna to any desired frequency. The transmission line is clipped on the proper turn of the variometer to match the

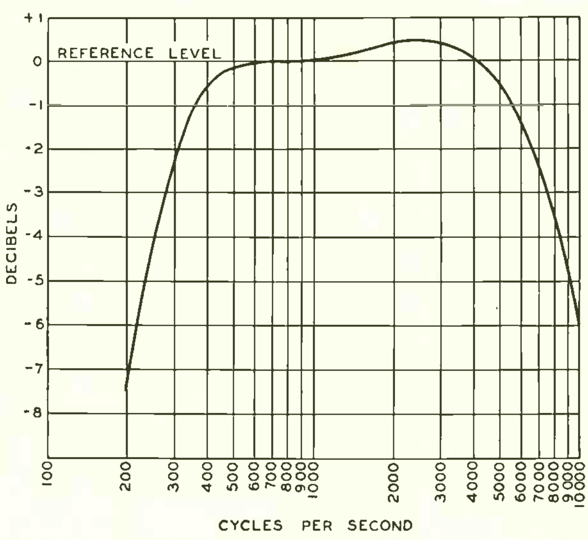


Fig. 7—Overall audio-frequency characteristic of the 8-A transmitter

impedance of the line. This arrangement is sufficiently flexible to work with antennas of widely different resistance and impedance characteristics and is simple to adjust.

Power for the ground station is supplied by a rectifier, shown beside the transmitter in Figures 1 and 9, which was developed by J. G. Nordahl and H. Vaderson. It is known as the 2-A and supplies all power for filaments, grids, and plates. The set is push-button operated, and safety switches are provided on all cabinet doors which disconnect the power supply when the doors are opened. A total of about three kilowatts of sixty-cycle, three-phase, 220-volt power is required for the operation of the transmitting equipment at the ground station.

Fig. 9—Rear view of the ground transmitter and power cabinets. A 251-A tube is being inserted by J. B. Bishop

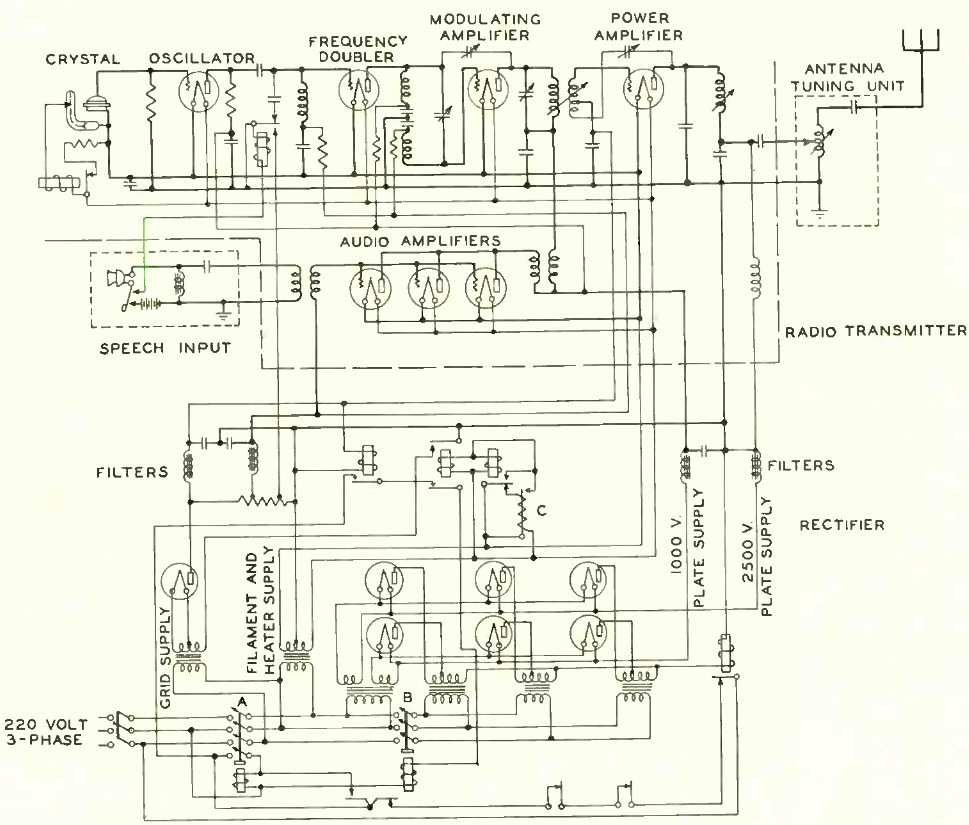


Fig. 8—Diagram of 9-A transmitter

All filaments, and the heater for the crystal oscillator, are supplied from a transformer with a grounded center tap.

Plate power, at two voltages, is obtained from two three-phase mercury-vapor rectifiers — one supplying plate voltage for the power amplifier, and the other supplying a lower voltage for all other tubes. One set of three

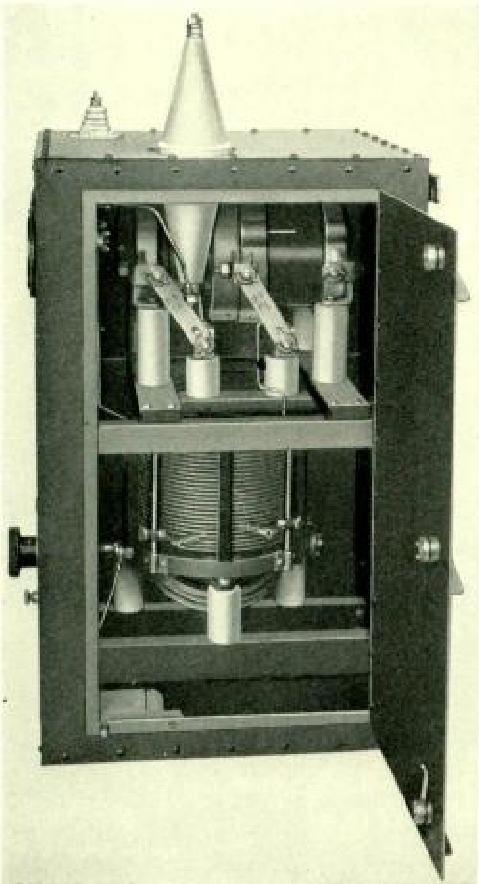


Fig. 10 — The antenna coupling unit, copper enclosed, mounts on the wall in any convenient location

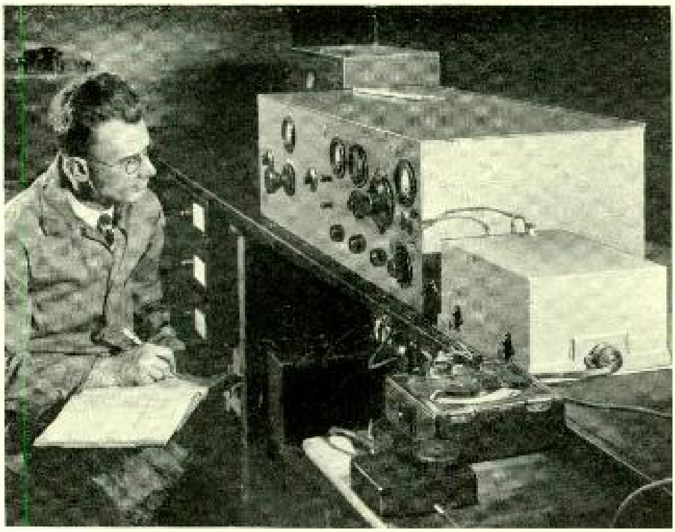
transformers serves both rectifiers but the secondaries are tapped for the lower-voltage rectified. The rectifier filament circuits are specially insulated, and operated at the plate voltage above ground in both rectifiers, which allows the center of the star-connected transformers to be grounded through an overload relay for protection. Single section filters are provided in each plate supply to reduce the low-frequency ripples to less than 1% of the DC voltages.

One tube is used in a single-phase half-wave rectifier for grid-bias voltages. This rectifier works directly into a load resistance, and the two voltages desired are obtained from taps on that resistance. Single section filters are used here also for each voltage.

The set is put in service by pressing the start button as J. G. Nordahl is shown doing in Figure 1. This operates switch A of Figure 8, which holds itself in through a series circuit including the various door switches and the overload relay. The closing of this switch energizes all filament circuits in both transmitter and rectifier. The filament voltage, after an interval of about 10 seconds, operates a thermal relay, C in the illustration, which in turn actuates a relay to put plate voltage on the grid-bias rectifier. As the grid-bias voltage builds up another relay, B, is operated which puts plate voltage on the two high-voltage rectifiers and the set is in operation.

The overall audio-frequency characteristic of the 8-A transmitter is shown in Figure 7. The characteristic for the 9-A is substantially the same as that for the 8-A.

A very considerable number of both of these transmitters are already in successful operation on the airways of the United States and are proving very satisfactory.



Aircraft Radio Receivers

By S. E. ANDERSON
Radio Development

IN the design of radio receivers for airplanes, besides such special requirements as are necessitated by the unusual conditions encountered, the good old-fashioned requirement of reliability assumes increased significance. After coming to depend upon the many advantages afforded by the successful reception of weather reports and beacon signals, for example, a pilot is likely to find himself in serious trouble if the radio equipment should fail at a critical moment. Unfavorable weather conditions at his destination, of which he could be advised by radio, might make a change in his plans desirable, or, if he had risen above the clouds to avoid bad weather—depending on the radio beacon to guide him—its sudden failure might result in his becoming completely lost and being forced down in unfavorable terrain through exhaustion of his fuel supply.

The Western Electric 9-A and 9-B radio receivers have been developed to meet certain specific needs of the aircraft industry for reliable radiotelephone communication. In their mechanical design, for which B. O. Browne was largely responsible, they are as nearly alike as possible, thus effecting a considerable economy in the cost of manufacture through the use of identical parts for the more important structural units. The receivers are clamped to a special mounting which provides some degree of cushioning against the shocks and vibration encountered in an airplane. Although every effort has been made to reduce the weight, no sacrifice of strength or rigidity that would impair the performance or reliability has been permitted. This has resulted in a well balanced mechanical design which has proved very satisfactory and will provide a firm foundation for further

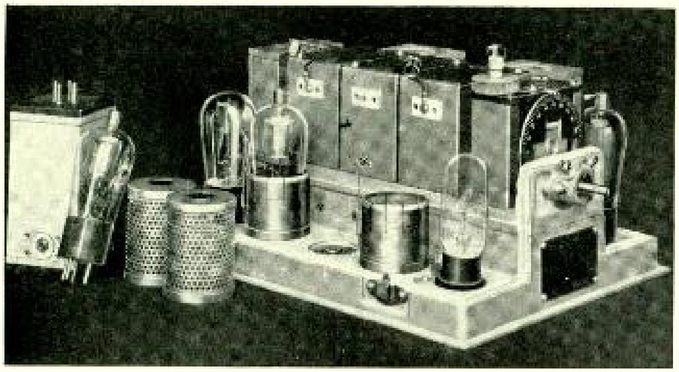


Fig. 1—Major elements of the radio receiver are arranged in three rows with tuning condensers down the center and plug-in coils and tubes on the two sides

refinement and for the development of other similar equipment.

The base casting of these receivers not only serves as a light, rigid support for all of the apparatus but, by the proper use of the partitions which act as strengthening webs, provides some of the shielding required between the various parts of the circuit which is so necessary in a high-gain receiver. This shielding is particularly essential since the dimensions have been reduced as far as possible because of the limited space available for aircraft radio equipment. Despite the compactness of the design, however, a reasonable degree of accessibility has been maintained, and it is possible to make practically all of the soldered connections after the assembly has been completed, which is very desirable from a manufacturing standpoint. This is greatly facilitated by the use, wherever possible, of condensers with pigtail connections instead of soldering terminals, which permits mounting the condensers in inaccessible positions while the terminals to which the leads are connected are readily available.

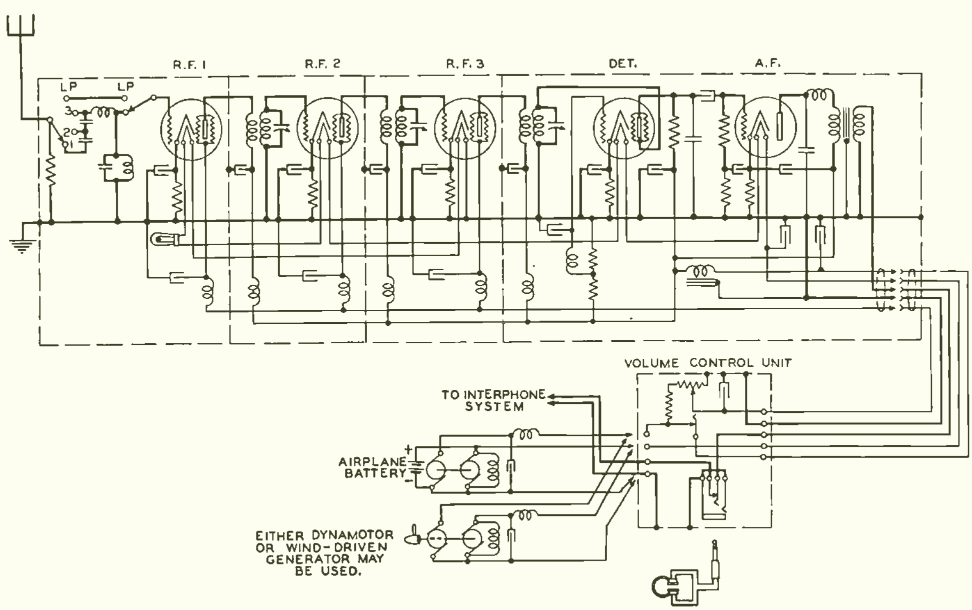


Fig. 2—Schematic diagram of 9-A radio receiver

A view of the receiver with the cover and some of the tubes and plug-in coils removed is shown in an accompanying illustration. The cover is held in place by four light catches similar to those used on suitcases, and only the loosening of these catches and the disconnection of the antenna lead are required for tube replacements or for changing the coils. A strip of soft felt around the entire receiver, together with a sponge-rubber washer around the antenna binding post at the top of the set, renders it substantially dust proof when in service.

A three-gang tuning condenser is mounted in the center of the set and the shaft terminates at one end in a dial visible through a window in the cover. A worm-gear drive with a flexible shaft and a remote control unit permits tuning the receiver from any distance up to forty feet. The drive may be turned to any position to facilitate the installation. A gear ratio of 264 to 1 between the flexible shaft and the condensers reduces lost motion to a negligible amount. For ground-station operation the flexible drive may be replaced by a knob for local control, which is designed to cover up the clamping arrangement for the drive, and the ratio of six to one between it and the condenser shaft gives a very satisfactory tuning adjustment.

On one side of each condenser shield is mounted a lead for the grid of a vacuum tube, and on the other side, a pin which engages a jack on the shield of a plug-in coil. These pins also serve to hold the coils in place. Each coil is completely shielded and the other connections to it are made through the socket into which it plugs. Two of the tubes are shielded by perforated cylinders which hold the tubes in their sockets, and in turn are themselves held in place by special spring clips.

Fig. 3—H. B. Fischer testing a 9-A radio receiver in the shielded room

The tubes that need no shielding are secured by springs which engage a pin on the tube base, while the ballast lamp is held in place by a toothed spring engaging the ridge near the lower end of the base. Any possibility of a tube or coil working out of its socket due to vibration is thus eliminated. The alternate arrangement of the tubes and coils on the two sides of the tuning condensers results in the shortest possible grid and plate leads.

At the rear end of the set is a multiple point receptacle for making all necessary electrical connections except

Fig. 4—W. E. Reichle talking to P. D. Lucas and adjusting the volume control of the 9-A receiver in the Laboratories' Fairchild plane

that to the antenna. The plug that fits this receptacle is supplied with a special collar which shields it and locks it firmly in place. Shielded cables connect the receiver to other units of the radio installation.

A schematic circuit of the 9-A radio receiver, for the development of which H. B. Fischer and W. E. Reichle have been directly responsible, is shown in an accompanying illustration. This receiver is designed primarily for the reception of the weather reports and radio beacon signals transmitted by the United States Department of Commerce. It covers the frequency band from 250 to 500 kilocycles and has a sensitivity limited only by the tube and circuit noises. A signal input of 5 microvolts with average telephone modulation is more than sufficient to give an output of six milliwatts. For headphone reception, as used in airplanes, this gives a signal sufficient to override noise from the engine and propeller. Reserve power is available to supply several sets of headphones if desired.

The receiver employs three stages of tuned radio-frequency amplification using 245-A vacuum tubes, a space charge grid detector using the same tube, and one stage of resistance-coupled audio-frequency amplification using a 244-A vacuum tube. The three inter-stage circuits are tuned with a single control as already mentioned and provide a high degree of selectivity.

The antenna circuit consists of a single-section band-pass filter. This eliminates interference from outside the desired band, especially that from powerful broadcast stations which is likely to be severe under some conditions. It also permits the use of the receiver on the same antenna simultaneously with a 9-B radio receiver, used for two-way radio-telephone communication, without seriously reducing the efficiency of the latter. A special connecting link, together with a movable grid connection to the first tube,

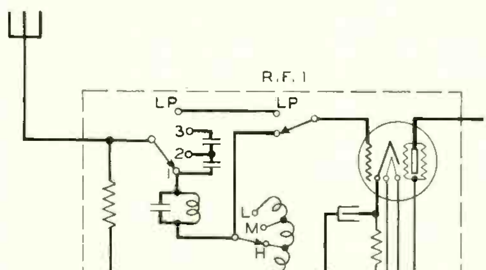


Fig. 5—Schematic diagram of antenna tuning unit of 9-B receiver

permits the complete elimination of this special filter when it is desired to use either a loop antenna or an external antenna-tuning unit.

Remote volume or sensitivity control is obtained by a tapered potentiometer with a filter condenser, which controls the voltage on the screen grids of the radio-frequency amplifier tubes. The change in sensitivity is approximately uniform over the entire range. Where only a radio receiver is installed, a control unit is employed which includes a jack for the headphones and a substantial switch for turning the complete equipment on or off. For complete two-way installations the switch is omitted from the control unit.

When a storage battery is available on the airplane, especially when it is equipped with a charging generator, it usually furnishes power for the receiver. The filament circuit is connected directly to the battery while plate voltage is supplied by a dynamotor which is driven by it and weighs, complete with its filter, only about eight pounds. This is less than half the weight of the lightest practicable plate battery, which would also have the disadvantage of requiring frequent replacement.

When no storage battery is available, or when a charging generator is not used so that the extra current drain of the receiver cannot be tolerated, power can be obtained from a small wind-driven generator. The propeller of this generator is of the single-blade, self-regulating type. The apparent unbalance of the single blade is fully compensated for in the regulating mechanism, which, by changing the angle of the blade, keeps the speed within very close limits for all normal flying speeds above 70 miles per hour. The generator complete with propeller weighs but seven pounds.

All of the power-supply circuits are carefully filtered and shielded from each other to avoid undesirable regenerative effects, and the shielding of the radio-frequency amplifier circuits is likewise made as complete as possible. The output circuit embodies a shielded transformer of the proper ratio to fit the interphone circuits used with the two-way system.

Fig. 6—E. S. Dobson removing a 9-A and 9-B receiver from the Laboratories' Ford plane

All of the vacuum tubes are of the heater or unipotential cathode type which permits the use of noisy sources of filament supply, such as a generator, without elaborate filters. Filtering is required only to eliminate the radio-frequency interference due to sparking at the commutators. The heaters are all connected in series and a ballast lamp permits a variation in the supply of voltage from 11.5 to 14 volts without a serious change in the filament current from its normal value of 1.6 amperes. An adequate plate-supply filter is also incorporated in the receiver. The plate voltage required is from 200 to 220 volts, and the total current drain, including that for the shields and their associated potentiometer is from 20 to 25 milliamperes.

The circuit of the 9-B radio receiver, designed for use with two-way radio-telephone systems, is substantially identical to that of the 9-A except for the antenna circuit. Its frequency range is from 1500 to 6000 kilocycles. The many special problems arising out of the necessity for obtaining extreme sensitivity and selectivity at these high frequencies, and in a very limited space, with a single tuning control have been solved by R. H. Herrick and E. S. Dobson. Although the sensitivity is not so great, because of the higher frequencies, as that of the 9-A radio receiver, a signal input of 10 microvolts is sufficient to give the standard zero-level output of six milliwatts.

The antenna circuit for the 9-B receiver differs from that of the 9-A in employing an adjustable tap on one of the filter inductances which is changed in accordance with the particular frequency range being used. The 9-B receiver, due to the greater liability of regeneration at these higher frequencies, also requires more elaborate filtering in the detector plate circuit. The only other major differences between the two receivers are in the size of the tuning condensers and the power-supply chokes.

A demonstration set-up of a complete radio receiving outfit, including the receiver proper, its remote control units, and two alternative sources of power supply, is shown in the accompanying illustration. The weight of the complete outfit amounts to approximately forty pounds.

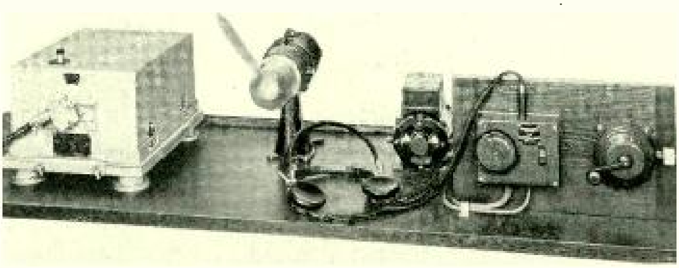
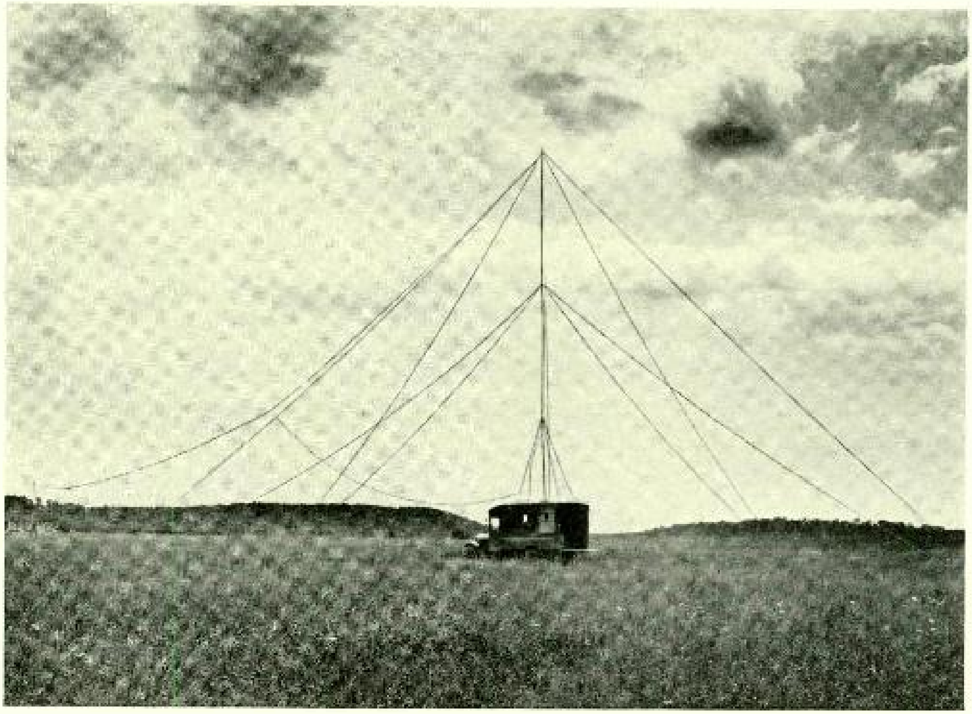


Fig. 7—Complete low-frequency weather and beacon receiving outfit showing alternative power supplies



Test Truck for Aircraft Radio

By W. K. CAUGHEY
Radio Development

RADIO - TRANSMITTING stations mounted on trucks have been frequently used by Bell Telephone Laboratories in making transmission studies and field strength surveys at both broadcast and transatlantic frequencies. A need has recently arisen for a similar portable station to operate at the frequencies employed for communication with aircraft. For this purpose the two-ton truck shown in Figure 3 has been equipped with complete 400-watt ground-station apparatus for operation from commercial three-phase power supplies. A 50-watt airplane equipment operating from a 12-volt storage battery has also been installed for use at places where commercial three-phase power is not available.

The interior of the truck is shown in Figure 2. At the left are the aircraft-type radio receivers, and, to the right of them, the aircraft transmitter with its antenna tuning unit above. Near the center of the truck are the ground station units; the 9-A radio transmitter at the left with the antenna coupling unit directly above, and the 2-A rectifier at the right. The latter, because of its greater weight, is placed as near the center of the truck as possible. In the cabinet under the aircraft equipment are spare tubes and miscellaneous equipment. The smaller cabinet near the tail board contains an amplifier for use with the public address system.

On the same side of the truck, between the spare-tube cabinet and the ground-station transmitter, are the aircraft dynamotors. One supplies 200 volts for the receivers and the other, 1,050 volts for the transmitter. Above them, mounted on the end of the cabinet and not visible in the photograph, is the necessary relay and control apparatus.

A charging generator geared to the truck's motor supplies 12 volts for charging the 400 ampere-hour storage battery mounted on the right-hand side of the truck as shown in Figure 1. Beside the battery is a reel of 200 ft. of three-conductor cable used for connecting to the nearest 220-volt 60-cycle supply for operation of the ground-station transmitter.

A tungar rectifier is available for charging the battery when 220-volt power is available. It is mounted against the front end of the truck at the left and is just visible in Figure 2.

Fig. 1—J. M. Henry in communication with an airplane

Fig. 2—Within the body is complete radio equipment of the type used in both aircraft and ground terminals

The battery has sufficient capacity to operate the aircraft equipment continuously for six hours. A power panel with main 220-volt switch for the alternating current supply, and the necessary relays and meters, is mounted over the battery. The field rheostat for the charging generator is also mounted on this panel.

The control units, consisting of the send-receive switch, tuning controls for the receivers, volume controls, and a clock, are mounted on an aluminum panel just above the operating table on the right-hand side of the truck. To avoid duplication of equipment the same control apparatus is used for both the 50-watt and the 400-watt equipments.

Bamboo is used for the antenna masts to secure maximum lightness. The mast on the truck, shown in the headpiece, is composed of six 7½-foot sections which rest on a block on top of the body, and is guyed with hemp rope. The four lowest guys are fastened to the top of the truck and the other eight to stakes driven in the ground at convenient distances. The ground mast is similarly constructed and guyed but consists of only two 7½-foot sections.

The antenna may be either of the inverted "L" type or a fixed half-wave type with a single-wire transmission line connected to the 500-ohm point. Since each half-wave antenna is good for only one frequency, several antenna wires, cut to the correct lengths, are included in the equipment. Use has also been made of this portable station for the excitation of a number of special types of antennas, the efficiency of which for aircraft was under investigation.

This truck has also served as a ground station for communication with the Laboratories' planes in connection with demonstrations of our aircraft radio-telephone system at distant points where it is not possible to communicate with the Whippany ground station. On such occasions a loud speaker is mounted on the top of the truck (Figure 3) so that communication with aircraft may be heard by a group of people on the ground.

Fig. 3—Truck-mounted portable radio station for aircraft survey work

Glow Discharge Lamps for Television System

By H. W. WEINHART
Special Research

SINCE the historic television demonstration by Bell Telephone Laboratories on April 7, 1927, and the showing of television in color early in 1929 when objects were reproduced with their true color values, many advances in the efficiency of the equipment have been made. Some of these were incorporated in the two-way television apparatus shown this spring. Notable among them are the changes made in the glow discharge lamps used at the receiving end. The lamps used with the present equipment permit much greater power input than those of the earlier demonstrations and their structure has been changed quite radically.

It is essential that glow discharge lamps for television uses contain some of the noble gases, such as argon and neon, which produce a light of high intrinsic brightness that may be modulated with sufficient rapidity to follow the incoming signals. For monochromatic television neon is usually employed. For television in color, which requires the three basic colors, red, green, and blue, the neon tubes may also be used but only for part of the reproduction. Behind a suitable filter, they supply the red component. For the blue and green, however, argon is employed because of its richness in both blue and green lines of the spectrum. Suitable color filters are also used with them. For monochromatic television no color filters are required; the image is reproduced in the pinkish glow of the neon lamp.

All such tubes are constructed with two electrodes, and the glow forms on the cathode. Its quality depends not only on the material of the electrode but on its structure and its treatment during manufacture. The material of the anode requires less care in preparation. For it the chief consideration is position relative to the cathode.

Lamps used for the early television demonstration (Figure 1) had flat plates for electrodes. These are separated by only about 3/32 of an inch and this small separation maintains effective insulation and forces the glow discharge to develop only on the outer surface of the cathode. Radiation is depended upon entirely for cooling, which limits the operating current to about fifty milliamperes. The brightness of the glow is a function of the anode current and is thus limited by the cooling arrangement.

To obtain a greater brightness, water cooling was resorted to and one of the early water-cooled tubes is shown in Figure 2. The cooling of the cathodes of such tubes is not a limiting factor, and currents as high as 500 milliamperes may be used, giving a very bright glow on the cathode surface. A nickel-plated hollow copper cylinder is employed for the cathode and the glow occurs on one end. The other end is sealed to the glass container and has two tubes entering it for water circulation. Surrounding the cathode is a glass shield which restricts the area of glow to the end, and also serves as insulation between anode and cathode.

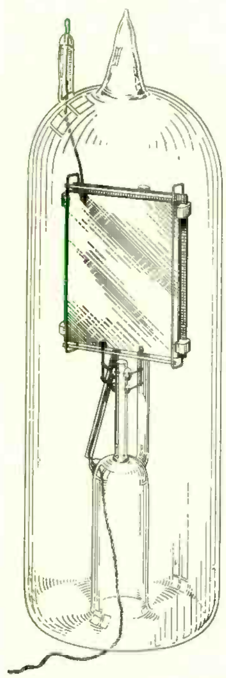


Fig. 1—The earliest television tube had flat plate electrodes

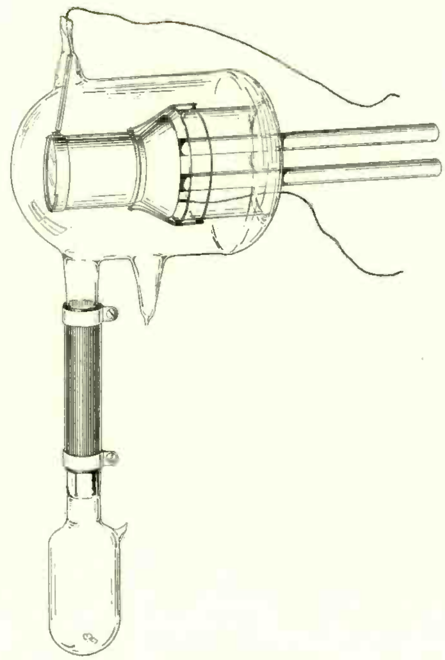


Fig 2—An early water-cooled tube used for monochromatic television

One of the lamps used with the early demonstrations of television in color is shown in Figure 3. A single piece of tubular nickel-plated copper, closed at one end and flattened along one side, forms the cathode. Its open end is sealed to a glass tube through which water is passed for cooling.

The glow forms over a rectangular area of the flattened surface; on the rest of the surface glow formation is prevented by a protective coating of lavite and insulating cement. The anode is a metal strip bent into a rectangle open at one end, and the tube is mounted so that the cathode is viewed nearly end on through the open end of the anode. A rubber stopper, not evident in the illustration, is inserted in the glass cylinder that supports the cathode, and glass tubes passing through the stopper allow the cooling water to enter and leave.

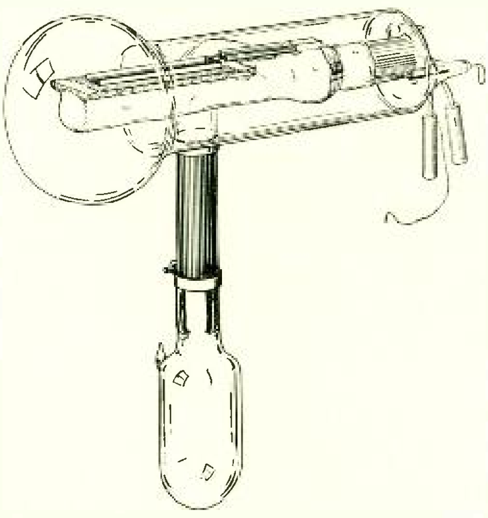


Fig. 3—A neon tube used for the early work with color television

This early lamp possessed many objectionable structural features which have been eliminated in the tube for television in color, shown in Figure 4. The cooling water for this tube is not in direct contact with the cathode but is confined to a glass tube to which the cathode is tightly clamped. A mica shield replaces the lavite and cement insulation and by providing a long insulating path prevents the glow from forming anywhere but on the flat rectangular area. The anode is similar to that of the earlier tube but supported in a slightly different manner.

The bulb shown attached to both of these tubes is used for supplying small quantities of hydrogen which has been found essential for the efficient operation of all television lamps. After the lamp has been in operation over a period of time, the glow discharge develops a sluggishness which causes fuzziness or poor definition of the image produced. If a small amount of hydrogen is allowed to mix with the gas in the tube at this time, the sluggishness immediately disappears and good definition is again obtained. Such hydrogen admission is required periodically during the life of the tube.

The construction of the admission system is shown in Figure 5. Two porous plugs, one sealed in an extension of the lamp and one in the end of the hydrogen supply bulb, are normally sealed with mercury but when pressed tog ther permit the passage of hydrogen into the tube. Lavite is used for

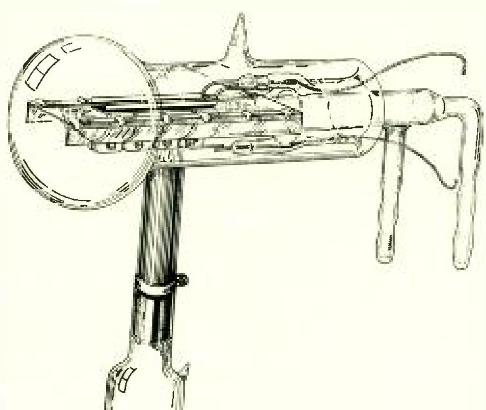


Fig. 4—The more recent tubes for color television attain greater structural perfection

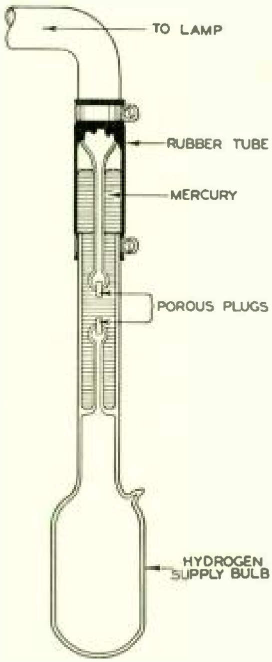


Fig. 5—A hydrogen valve attached to the television lamp permits hydrogen to be admitted as required from time to time

the plugs and is heat treated until it is porous enough to pass hydrogen but not mercury. After the supply bulb is formed, the glass tube around the porous plug, with a short piece of rubber tubing attached to its upper end, is filled with mercury to prevent air leaking into the bulb, which is then evacuated, filled with hydrogen, and sealed. After this the upper end of the rubber tube is attached to the lamp, as shown in the illustration, so that the two plugs are about a quarter of an inch apart. When hydrogen is required the supply bulb is raised until the two porous plugs are in contact, when hydrogen may pass into the lamp.

For the more recent work on monochromatic television the type of lamp shown in Figure 2 has been displaced by the one shown in Figure 6. As with the latest lamp for color television, the cathode is clamped in good contact with a glass tube through which the cooling water circulates. The glow discharge is confined to a flat square surface by mica shielding, and the anode is a metal strip fencing off this active area.

The uniformity of the glow of neon tubes and the sputtering from the active surface depends very much on the use of proper technique in preparing the cathode surface. Sputtering is the dislodging of material from the surface by impact of ions from the glowing gas. The matter released leaves the surface with high velocity and deposits on the inside of the bulb directly in front of the glow. This soon renders the lamp useless by reducing

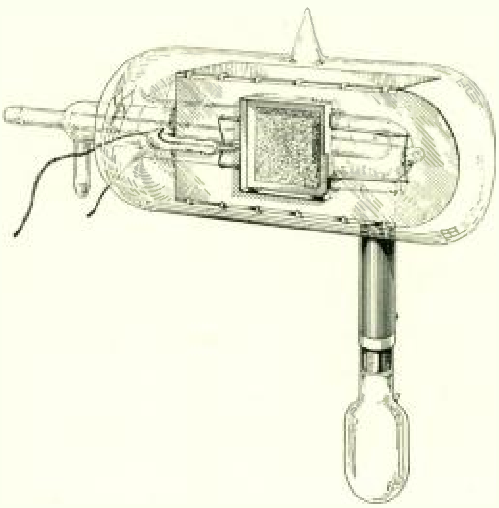


Fig. 6—Neon lamp used in the most recent television demonstrations

the intensity of the light as viewed through the bulb. It has been found that beryllium sputters far less than other materials and so is used for the final plating of the surface.

In preparation the cathode is first baked at 800° centigrade in a vacuum for an hour, which anneals the copper without oxidation. The flat surface is then sand-blasted and nickel-plated but not polished. The rough surface allows the final plating to adhere tightly. Beryllium is not easily worked. It can neither be electroplated nor readily deposited by cathode sputtering so it is necessary to deposit it by the method of vaporization and condensation. This is done in a high vacuum to prevent oxidation and to leave the surface as free from gas as possible.

A special tube shown in Figure 7 is used for the purpose. The cathode is mounted face downward over a tungsten filament to which have been welded a large number of pieces of beryllium. The filament is then raised to a high temperature when the beryllium forms melted globules which slowly vaporize. Some of this vapor condenses on the nickel-plated cathode where it forms a thin and uniform coating. In transferring the cathode to the neon tube, care is exercised to keep the surface free from dust, moisture, or finger marks.

After assembly, the tubes are sealed to a vacuum pumping system and evacuated to a low pressure. During this period the entire bulb is baked at a high temperature and then allowed to cool. Neon or argon is then admitted through a porous plug system similar to that used for admitting hydrogen, and a glow discharge is started. During this operation the current used is always at least 100 milliamperes more than the anticipated operating current so as to provide sufficient local heating to degas parts of the tube and to release any remaining gases from the cathode.

After treatment in this manner, the impure gas is pumped out, water is

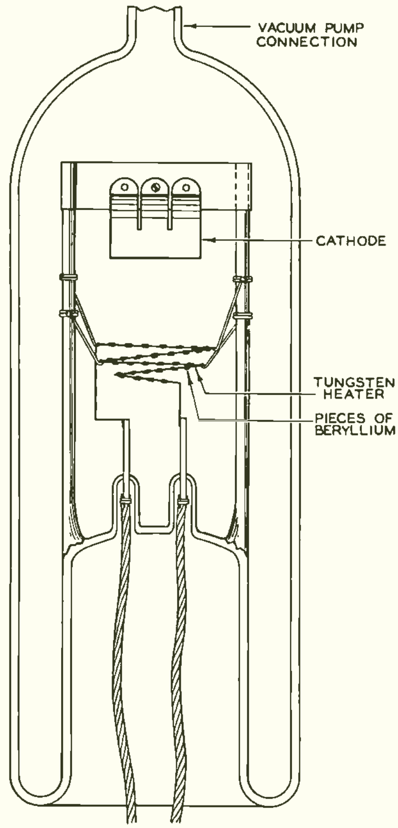


Fig. 7—Beryllium vapor is condensed on the nickel-plated cathode in a high vacuum

circulated in the cooling system, and fresh gas is admitted to the pressure that produces the most efficient glow on the cathode surface. The tube is then sealed off from the vacuum system and is ready for use.

A Standard Test Set for Vacuum Tubes

By M. H. A. LINDSAY
Radio Development

IN making final tests on apparatus employing vacuum tubes, it is necessary for the Western Electric Company to use selected tubes whose characteristics are known and constant in order that the results will indicate the performance of the associated apparatus itself. Several thousands of such tubes, specially manufactured at the Laboratories' Tube Shop at Hudson Street, are maintained at the Western Electric plants for testing oscillators, amplifiers, telephone repeaters, speed control equipment for sound pictures and similar apparatus. Characteristics of the tubes must be maintained constant within certain narrow limits and for this purpose a new and comprehensive procedure has been worked out.

The complete scheme is three-fold. It provides a method, developed by the Research Department, of supplying tubes which have constant characteristics obtained by a protracted aging process, a method of frequently checking these tubes at the manufacturing plants by test sets, and — of immediate importance — a method of calibrating the test sets used at the manufacturing plants against a recently developed standard test set at the Laboratories.

Plate current and gain are the characteristics measured. The plate current is merely the direct current that flows from the "B" battery through the plate and filament of the tube. The gain is expressed in decibels and measured under certain standard conditions of impedances and voltages.

In the test sets used by the manufacturing plants, the gain is measured by a null method indicated by the diagram of Figure 1. By means of a potentiometer, a portion of the output voltage of the tube is balanced against a known portion of the input, and the phase difference is compensated for by an inductometer. The measurement is made by listening to a thousand-cycle tone in a receiver while the potentiometer and phase corrector are alternately adjusted. The disappearance of the tone indicates when the setting is correct. The set shown in Figure 2 is designed for measuring 215A, 230D, 231D, and 239A tubes but it is typical of the other sets used.

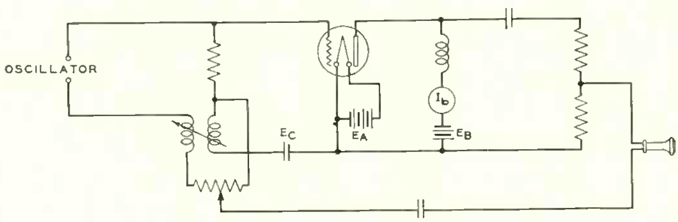


Fig. 1—Calibration is made by balancing known portions of the output and input against each other

The standard test set at the Laboratories is more accurate than those used at the manufacturing plants and employs a method of

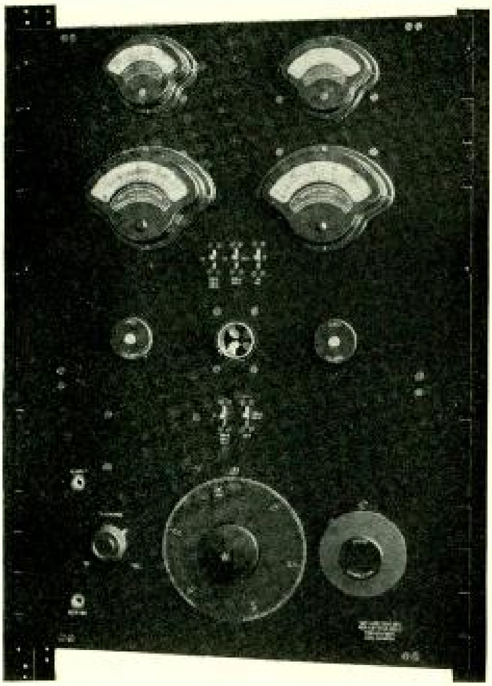


Fig. 2—Test set used for calibrating tubes at the manufacturing plants

direct substitution and comparison. The total gain of a tube and an associated transformer may be divided into two parts: one, the major part, is constant for any type of tube, and depends only on the constants of the circuit; the other and much smaller part varies with the individual tubes. It is this variable part that is measured with the new test set. A simplified schematic indicating the method is shown in Figure 3.

A current through the 600-ohm impedance supplies the required voltage to the amplifier which in turn provides a deflection of the indicator. Following this first step, the vacuum tube to be tested is inserted between the artificial line and the detector by throwing a key. The same input current is supplied and the artificial line is adjusted to cause a loss just equal to the gain produced by the tube under test. This point is indicated by a reading on the indicator equal to that obtained on the first step.

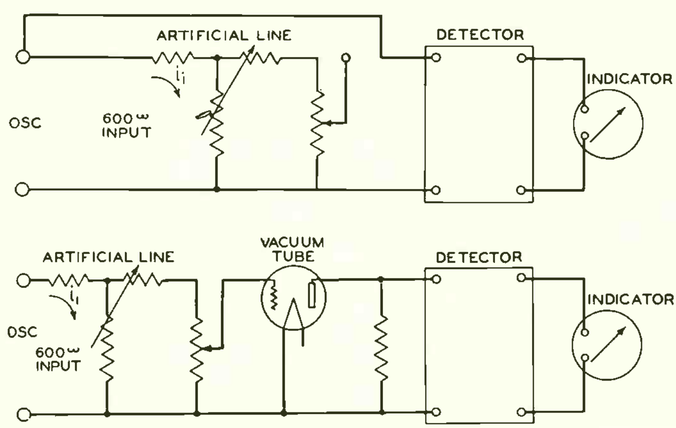


Fig. 3—Calibration at the Laboratories is by a substitution method. The first step is shown above and the second, below

The complete test set is shown in Figure 4. Toward the right, on the lower horizontal shelf, is a key to change from the first position, marked standard, to the second, or tube position. The artificial line is adjusted by the two dials at the left of the upper vertical section; the left-hand dial causes changes in 1 db steps from 0 to 10 db, and the right-hand dial varies the loss continuously over a range of 1.7 db in divisions of .01 db but readable to .0025 db.

To make possible the use of the set for a large number of different types of tubes, with a minimum of effort and an assurance of correct connections and meter scales, a sub-panel

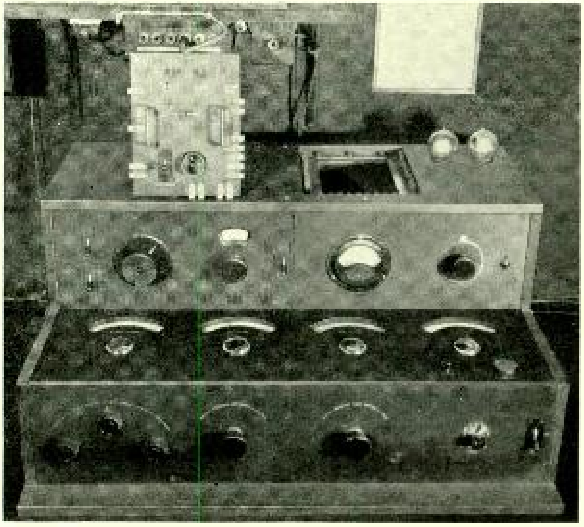


Fig. 4—Standard test-set used at the Laboratories

the meter. After the balance has been approximately obtained the shunt is removed and the battery connected. Under these conditions the meter indicates only the difference between the currents flowing in the battery and amplifier, and high accuracy is obtained.

The control key is operated by the knob at the extreme right of the set where it may be controlled by the same hand that operates the comparison key. This leaves the left hand free to adjust the artificial line and obtain the balance. The operation is thus very simple. With the comparison key thrown to the standard position, the circuit is adjusted to give a mid-scale deflection. Then the comparison key is thrown to the "tube" position with the shunt across the indicator. After the artificial line has been adjusted for approximate balance the shunt is removed and the battery connected, which allows the final adjustment to be made. The reading of the artificial line plus the constant portion already mentioned gives the total gain.

Plate current is measured by the meter on the extreme right which is provided with several suitable scales.

Test sets located in the Western Electric Plants and at the Laboratories' Tube Shop are calibrated

is used for mounting the tube under test. One is shown resting on top of the set in the photograph. There is one such panel for each type of tube. These panels, besides the tube socket, contain a certain number of terminal clips, mounted along three sides, for selecting the proper circuits and meter scales. The panel fits into a rectangular opening in the top of the test set and the clips make connection to the proper terminals. There are 34 of these in the set, and the clips on the sub-panels — usually 15 in number — are spaced to make the selection.

It was decided to make the set capable of detecting a change in gain of .005 db. To detect this small difference, a differential method of measurement is employed which is indicated in Figure 5. The detector was designed so that its rectified output voltage under normal balanced conditions would just about equal that of a single dry cell. During the preliminary balancing the battery is disconnected by a control key and a low-resistance shunt is connected across

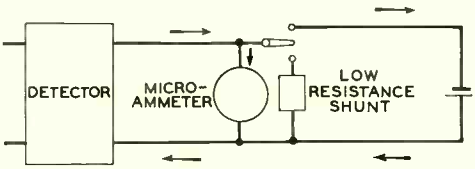


Fig. 5—A low-resistance shunt is used to obtain an approximate adjustment, but is replaced by a single dry cell for the final setting

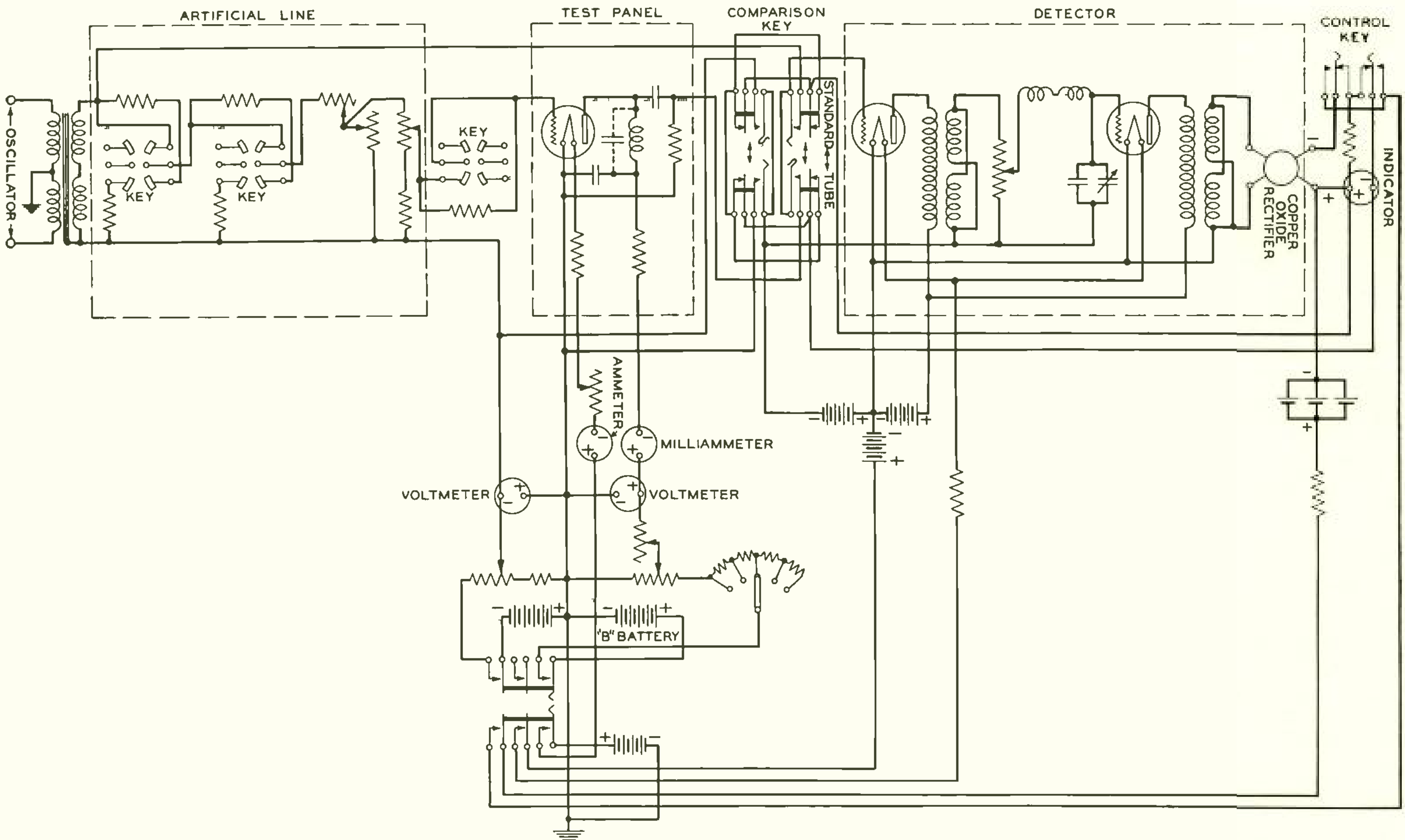


Fig. 6—Schematic diagram of the complete standard test set

against the Laboratories standard by a statistical method. Twenty-five tubes from the stock maintained for testing purposes are tested for gain and plate current by the set to be calibrated. These tubes are then sent to the Laboratories and their gain and plate current are measured on the Laboratories standard. Following this they are returned to the manufacturing plant and again measured. The two measurements of a tube at the manufacturing plant must be alike within a certain specified difference or that tube is discarded. By statistical computation from these various readings on the test set and standard, the correction to be applied to the test set is determined and at the same time a measure of the reliability of the calibration is obtained.

The use of the new primary-standard at the Laboratories insures that the test sets at the manufacturing plants do not vary more than a very small and negligible amount either from other test sets or from an absolute standard. Tubes for testing purposes are calibrated both before they leave the Tube Shop and after they are received at the Western Electric plants, and if there were differences in the characteristics of the test sets at the two places, a certain number of the tubes passed by the Tube Shop would be incorrectly discarded at the Western Electric plant as not suitable standards. The new method, by maintaining all test sets at a certain absolute value, has realized considerable savings to the Company, not only on account of the saving of tubes which would have been rejected and the time required to select replacements, but in the fact that the characteristics of the tubes actually lie within the specified limits and hence, when used in testing the vacuum-tube apparatus, produce results that better indicate the the characteristics of that apparatus.

Arrangements have been made by the Laboratories and the Equitable Life Assurance Society to supplement the Plan so that any employee of the Laboratories may purchase life insurance policies on the life of his wife, or children if over 10 years of age, or both, and have the premium payments made by regular deductions from his salary.

Mr. Lloyd H. Bunting, our Life Insurance Counselor, will be glad to discuss this with anyone who is interested and will arrange for the insurance when desired. Mr. Bunting may be found every afternoon in Room 144 at West Street.

New Insulation Now in Production

OUR continual investigations toward bettering the insulation of wire used in the Bell System have recently led to a new improvement which is now being introduced into the plant. This consists of impregnating with cellulose acetate lacquer the outer serving of the textile which insulates the copper conductors in switchboard cable and distributing frame wire. The new covering is a clear lacquer formed by dissolving cellulose acetate in a volatile solvent. It is applied to the wire in a continuous process by machines in which the completed coating is formed from several successive thin coatings dried between applications. Cellulose acetate is the product of a rather complicated process in which cotton is acetylated by acetic anhydride and glacial acetic acid.

A few years ago it was concluded from our investigations that a careful washing of the textile, which would remove ionizable conducting salts, would increase the insulation resistance of the textile and would make that resistance less variable with changes in humidity.* The new improvement is supplementary to that effected by washing, adding insulating properties of its own which further increase the insulation resistance and decrease the sensitivity to changes in the environing humidity. So large is the overall improvement in insulation resistance thus affected that it is possible to reduce the total amount of insulation used, by the omission in some cases of enamel and in others of a serving of textile. The lacquer treatment is of such a nature that the wire need not be impregnated with wax, thus reducing the flammability of cable forms.

Steps are under way to incorporate the new insulation as widely as possible in the telephone plant, and already all toll quaded switchboard cable and all No. 20 gauge distributing frame wire is being manufactured with the new covering. In the former application especially important economies are expected to result from the improvement in transmission and reduced cost of manufacture and installation. In the latter the smaller diameter of the wire reduces the pile-up in a frame, and its smooth surface facilitates installation and removal.

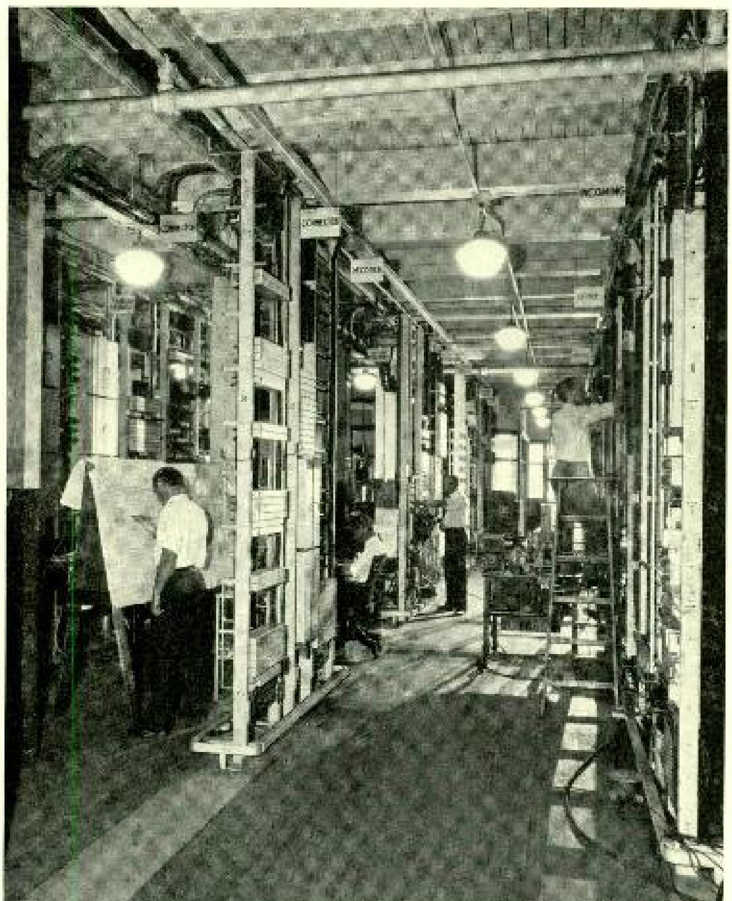
This use of cellulose acetate was originally suggested by J. H. White of our Chemical Laboratory. Engineering development of the process of applying the material was made in the Transmission Apparatus Laboratory by H. H. Glenn, E. B. Wood and D. R. Brobst under the leadership of E. B. Wheeler.

* Bell Laboratories Record, *April*, 1929.

NEWS AND PICTURES

of the

MONTH



Panel dial systems laboratory

General News Notes

A PHONOGRAPH record reproducing the amplified sounds of a brain tumor has been made in the Laboratories by D. G. Blattner assisted by engineers of his group. This unusual undertaking was done at the request of Dr. C. G. Dyke of the Neurological Institute of New York who was interested in obtaining a permanent sound record of a specific type of tumor rarely encountered by the medical profession. The patient had been operated upon and that portion of the skull removed directly over the tumor.

Early in the summer Dr. Dyke called with the patient for a recording. The 1-A electrical stethoscope with the standard stethoscope transmitter was used and no difficulty was encountered in picking up the sounds. It was found that the sounds of a tumor differ quite materially from the characteristic heart murmur sounds in that they have strong power components for frequencies above 1000 cycles. As a consequence none of the stethoscope filters could be used without altering the tone quality of the murmur. The murmur was sufficiently loud to be picked up and recorded on a standard phonograph recorder operated directly from the stethoscope. As reproduced from the record, the tumor pulsations sound not unlike the characteristic beats of a heart with leaky valves.

Regular Out-of-Hour Courses Resume Classes October 20

The Out-of-Hour Courses, which are now in their eleventh year, will resume classes for the first term of 1930-1931 on October 20. Announcements in booklet form describing the compass of each course have been distributed and applications must be in not later than October 6. As in past years the courses will be conducted by members of the Laboratories.

New courses to be given this year will include one on Vector Analysis to be given by F. B. Llewellyn and one on Partial Differential Equations conducted by S. A. Schelkunoff. Magnetics from a new viewpoint will be placed on the out-of-hour program in a course given jointly by E. Peterson and R. M. Bozorth and specifically entitled Magnetic Modulation. The success of the course Topics in Modern Physics given during the past two years has encouraged the development of a more advanced course under the title of Advanced Problems in Thermionics, which will discuss chiefly photoelectricity and adsorption. J. A. Becker who developed the more elementary course will have charge and will prepare the text to be used.

The remaining courses are those that have proved the backbone of the out-of-hours work in previous years. The course on Telephone Practice which provides a general picture of telephone systems will be conducted by C. A. Collins. An opportunity to study from the engineer's viewpoint basic problems in manufacture and shop manufacturing practices will be provided in the course Manufacturing

Do you remember when—Park Avenue just above Grand Central Terminal was known as Victory Way during the Victory Loan drive? One of the earliest public address installations was designed and set up by Laboratories engineers for this celebration

Methods to be given by C. G. McCormick.

Manual Telephone Systems will be taught in two sections, Section 1 in charge of H. D. Cahill and Section 2, H. A. Sheppard. Of the dial systems, the Panel course will be conducted by A. J. Busch, and Step-by-Step by R. E. King. The Toll System course will be given by K. M. Fetzer and H. S. Black. C. H. Greenall will again give his course Materials of Design for those interested in the study of materials entering into the manufacture of telephone apparatus.

For the coming term J. L. Hogg will be assisted by H. W. Bode and W. R. Bennett in his course Transmission Principles of Communication Circuits which deals with principles involved and methods employed in the design and development of transmission circuits. The course on the application of these principles to the use of filters, transformers, loading coils, equalizers, balancing networks, phase correctors and other passive networks, which is known as Transmission Networks, Theory and Practice, will be conducted by F. B. Monell and A. G. Ganz. Mechanical and acoustical wave propagation which enters so prominently in the investigations of telephone engineers will be outlined in E. L. Norton's course Elementary Theory of Electro-Mechanical and

Acoustical Systems. Vacuum Tube Dynamics will be given in two sections this term, in charge of M. W. Baldwin and J. G. Kreer. G. G. Muller will again have charge of the course on Elementary Differential Equations which has attracted large registrations in previous terms. The course, Power Plants for Telephone Systems, which treats with the basic problems of obtaining power, insuring absence of noise, and regulating voltage, will be given this year by J. M. Duguid.

An added course among the women's group, English Grammar, which is expected to draw a large registration, will be conducted by Miss M. E. Ball. The courses of past years, in speed dictation and typing, will be given by Miss E. Bode and Miss A. Stewart. The elementary course in drafting, as well as the courses in mechanical and circuit drafting are included as heretofore in the out-of-hour program. W. J. Gordon will be in charge of the first, and the latter two courses will be given respectively by J. Maurushat and W. E. Grutzner who were in charge last year.

Blimp Describes Cup Races Over Two-way Equipment

Flying above the International Yacht Races off Newport between the American cup defender *Enterprise* and Sir Thomas Lipton's yacht *Shamrock V,* the Goodyear blimp *Defender* reported the progress of the race through standard two-way radiotelephone equipment installed by Laboratories engineers. The apparatus which consists of an 8-A Radio Transmitter and 9-B Radio Receiver, with battery and dynamotor power supply, was installed at the Navy hangar at Lakehurst.

The equipment is portable, requiring twenty minutes to install and ten minutes to take out. A trailing wire antenna was used. Those in charge of the work consisted of D. B. McKey, F. C. Ward, P. Brake and W. A. Funda. During the latter part of August Mr. McKey with Captain A. R. Brooks journeyed to Akron to inspect the blimp previous to the installation of the two-way equipment.

Temporary Domicile in Jersey for Chemical Groups

Announcement has been made of the lease of a three-story building in Summit, New Jersey, by the Laboratories. The building will be occupied by thirty members of the Chemical Research Department engaged in wood-preservation, paint and varnish, and electrochemical research. The transfer is part of a larger plan which includes the erection of a suburban laboratory on the site recently purchased at Murray Hill. The building at Summit has been leased to accommodate research work which must be moved before the buildings at Murray Hill are ready for occupancy.

"Times" Resorts to Telephone to Cover Argentine Revolt

An aspect of the newspaper reporting of the recent Argentine revolution which should prove of interest to Laboratories members is detailed in a recent news item in the New York *Times*. Last-minute, uncensored accounts of the situation in Buenos Aires were obtained by the *Times* over radio telephone when a rigid censorship was imposed on cable dispatches.

The first intimation of hostilities in the Argentine capital came to the *Times* on Saturday, September 6, when in calling their correspondent over the transoceanic service to South America they learned that the revolutionary forces had seized the Government House and the Irigoyen government had fled. A vivid, startling account of the attack of the soldiers, cadets, and populace was given breathlessly by the *Times* correspondent who had just rushed from the vicinity of the Government House. He reported that the casualities numbered about a score as against a thousand that later cable reports carried. On a later check-up by the *Times*, the smaller number given by the correspondent in the radio-telephone conversation was found to be the accurate account.

The *Times* continued to rely on the radio-telephone for its information on the Argentine situation during the remainder of the critical week. On Sunday night news of the spread throughout the republic of the revolt and of the measures General Uriburu was taking to restore order was obtained. On Monday night reports came of gun firing in the streets of Buenos Aires following the inauguration of General Uriburu as Provisional President in the Plaza de Mayo that afternoon. The wireless service had been closed for the day and the *Times* by cable arranged with the telephone officials in Buenos Aires to send technicians to Hurlingham, sixteen miles outside of the capital, to reestablish the connection. At 2:30 A.M. the newspaper obtained from its correspondent another thrilling story of the second battle of the revolution which just occurred in the streets.

The high point of the covering of the revolution by means of the five-months' old radio-telephone service to South America probably came on Wednesday afternoon, September 10. An interview with Provisional President Uriburu was arranged. In a half-hour's talk the Provisional President sitting at his desk at the Government House described the situation in the Argentine Republic and detailed what the new government hoped to accomplish to a reporter at the telephone in Times Annex. His words, spoken in excellent English, were carried with startling clarity across the 5,300 miles of sea and land. The interview which was reported in the newspaper on Thursday morning was regarded as an outstanding achievement in journalistic annals.

Departmental News

DURING the period from August 6, to September 3, 1930, the following members of the Patent Department visited Washington in connection with the prosecution of patents: C. A. Sprague, G. F. Heuerman, and W. B. Wells.

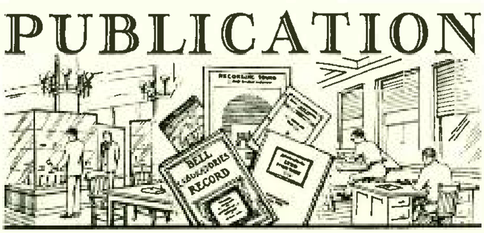
Personnel

M. B. Long attended the convention of the Institute of Radio Engineers at Toronto.

Outside Plant Development

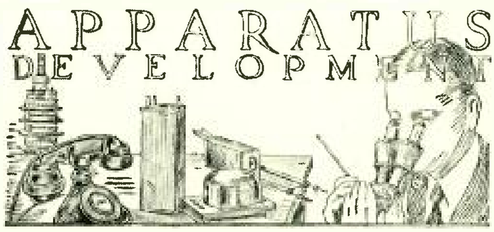
E. St. John visited the Long Lines plant near Morristown, New Jersey, and the plant of the Southern New England Telephone Company, at Torrington, Connecticut, on a trial installation of new grade clamps.

C. H. Klein was in Lebanon, Pennsylvania, in connection with the development of insulator pins. While there he visited the plant of the Bethlehem Steel Company.



At the annual convention of the Telephone Association of Canada at St. Andrews, New Brunswick, L. S. O'Roark spoke on *The Transmission of Personality*.

J. B. Lyon, a resident of California and former Western Electric employee now retired after thirty-odd years of service, was a recent visitor to the Laboratories. He was escorted through the various departments by S. P. Grace and G. F. Fowler and renewed his acquaintance with many of his co-workers of former years. Mr. Lyon retired from active service in 1917 and on his tour of the building marvelled at the changes and the great growth of the Laboratories work wrought since his retirement.



William Fondiller, who has been on an extended trip through Europe observing telephone practices and attending technical conferences, has returned to the Laboratories. O. F. Forsberg, who sailed in the party with Mr. Fondiller, has also returned.

Special Products

H. C. Curl and H. L. Walter attended a conference in Washington with members of the Western Electric Company, Graybar Electric Company and the Navy Department. Various matters concerning battle telephone systems and general announcing systems were discussed at the meeting.

R. Nordenswan spent several days at Hawthorne in connection with new developments in loud-speaking telephones.

Work concerned with the 703-A

Drive used in the theatre reproducer required L. A. Elmer's presence also at Hawthorne.

H. S. Price is in Hollywood on an inspection trip of the sound picture studios.

Questions relative to sound picture developments were discussed by T. E. Shea, W. Herriott, and N. R. Stryker with Bausch & Lomb and Eastman Kodak representatives at Rochester.

T. H. Crabtree was at Hawthorne to confer upon problems in connection with the portable recording amplifier.

Transmission Apparatus

At Hawthorne A. J. Christopher conferred with engineers on a new design of induction coil for subscriber's sets.

Materials

J. R. Townsend discussed various materials problems with Western Electric engineers at Hawthorne.

A trip to the Western Electric engineering offices in Jersey City was made by W. A. Evans and I. L. Hopkins to discuss hard-rubber material used for the No. 49 jack mountings.

F. M. Nolan visited the Halowax Corporation at Bloomfield, New Jersey, in connection with various waxes and sealing compounds used in the manufacture of condensers.

R. Burns and H. E. Van Siclen were at the Queensborough Works of the Western Electric Company and discussed the wood finishes on telephone booths.

Manual Apparatus

J. F. Baldwin and P. Neill visited Kearny for a consideration of manufacturing problems in connection with a new design of switchboard jack.

Accompanied by E. W. Niles of the American Telephone and Telegraph Company, F. A. Hoyt visited Monticello, New York, to investigate trial installation of coin collectors.

F. R. McMurry visited the Teletype Company in Chicago on matters associated with development of printing telegraph apparatus.

William Scharringhausen completed thirty years of service on Sep-

William Scharringhausen

tember 27. He began his service as a draftsman when the present building was a manufacturing unit of the Western Electric Company.

Recalling his early days in the Bell System, Mr. Scharringhausen points to his first job as an indication of the tremendous strides the telephone industry has made in thirty years. In 1900 a small group of draftsmen was engaged on a special task of making drawings of apparatus parts. Before this time, workmen in the shops in making new piece parts, took their dimensions from a previously manufactured part and then duplicated the model. He became a member of this group and for three and a half years was engaged on the task. These drawings were the first drafting record of piece parts manufactured in this building, supplanting the records contained on what were known as "sample boards". A specimen of each part used was fastened on these sample boards and cataloged in a letter-number series. Telephone parts constituted a comparatively small proportion of these pieces, as the Western Electric Company at that time manufactured most of the apparatus parts for the Western Union Telegraph Company.

In 1907, while still associated with drafting work, he handled the checking of the drawings of apparatus for the first semi-mechanical system to be placed in operation. This system, consisting of 400 lines, was given a trial installation in this building and its functioning closely studied by telephone engineers to determine its merits. He was transferred to Hawthorne in 1913 with the last of the manufacturing work carried on in this building.

Upon his transfer to the engineering department of the Western Electric, he returned to New York in 1918. He has since been engaged on engineering work on deskstand and handset mountings.

Dial Apparatus

P. T. Higgins visited Hawthorne in connection with manufacturing problems on step-by-step apparatus. He also attended meetings of the quality survey committee on this apparatus.

At Hawthorne also, G. H. Somerville discussed the design of relay covers and H. F. Dobbin was occupied with new dial developments.

In his twenty-five years of continuous service, J. N. Reynolds has seen many changes in the telephone art—notably the introduction of dial switching, to which he has made substantial contributions. Entering the System on September 13, 1905, with two periods of service before and after his graduation by Purdue in 1904, he had two years of designing miscellaneous pieces of apparatus. He then entered on the

J. N. Reynolds

work of development of dial apparatus with which, in both creative and supervisory capacities, he has been associated ever since. Among his early contributions to the art were the friction-roll drive, clutches and sequence switch of the panel system, and the use of brush tripping as a means of selecting one particular brush on a rod. He was in charge of apparatus development for the early semi-automatic and call distributing installations at Newark and at Wilmington and for the later panel system development. A total of eighty-five United States patents stand to his credit.

Radio Development

O. M. Glunt accompanied by Captain A. R. Brooks, and H. E. Young of the Western Electric Company, visited the National Air Races at Chicago to meet representatives of the air transport companies and to confer with them concerning the performance of the aircraft radio telephone equipment recently designed by the Laboratories.

W. J. ADAMS and J. G. NORDAHL accompanied by Mr. Charles E. Fonda of the Philadelphia Instrument Shop visited Wayne County airport at Detroit to examine a model of the visual type of radio beacon developed by the Airway Division of the Department of Commerce. Mr. Adams returned by way of Cleveland, where he inspected the radio beacon transmitter at Sky Harbor airport.

ON SPECIAL transmission tests between the transoceanic radio station at Rocky Point, Long Island, and an inland point S. E. Anderson, F. W. Boesche and G. C. DeCoutouly were at Rochester. The tests are in conjunction with work to determine the practicability of transmission of printed material by radio.

ON AN INSPECTION tour of Western Electric broadcasting installations in the South, A. B. Bailey visited Miami, Jacksonville, Mobile and Atlanta. He supervised the installation of crystal frequency-control equipment at station WRUF operated by the University of Florida.

F. S. BERNHARD has returned from a trip to Cheyenne and Chicago where he inspected the Western Electric aircraft radio equipment in use by the Boeing Air Transport.

W. L. BLACK visited stations WBBM and WLS in Chicago to make recommendations on special speech input equipment. These stations are owned respectively by the Atlas Investment and Agricultural Broadcasting Companies.

THE INSTALLATION of 1 kw broadcasting equipment for station WKBH at La Crosse, Wisconsin, was supervised by B. R. Cole.

S. A. HARNESS made an extended tour throughout the middle west visiting Western Electric equipped broadcasting stations in Toledo, Detroit, Pontiac, Cleveland, Akron, Buffalo and Rochester. While in Cleveland he inspected the Western Electric 1 kw transmitter used by the Police Department and had a good opportunity to observe the effectiveness of the system. During the inspection a telephone report of a gasoline station hold-up was received. Instructions were immediately forwarded by radio to the cruising cars and the bandits were caught before they could leave the scene of the hold-up. He was informed that radio communication between headquarters and the receiver-equipped cars used by the detective force has resulted in a marked reduction of burglaries and hold-ups during the period of about three months that the Police Department has been using the equipment.

J. C. HERBER supervised the installation of a 50 kw Western Electric radio transmitter for station KMOX, The Voice of St. Louis.

A FIELD STRENGTH survey of a tentative site for the location of a 50 kw transmitter for the Columbia Broadcasting System at Wayne, New Jersey, was made by W. P. Fisher, J. F. Morrison, S. A. Magness, and E. Babcock. Mr. Fisher also made a field strength survey for the Onondaga Company, Incorporated, of Syracuse, in connection with the proposed location of a 5 kw transmitter.

WESTERN ELECTRIC equipped stations in the middlewestern and southwestern states were inspected by F. H. McIntosh. He visited Lawrence, Kansas; Kansas City, Missouri; Tulsa, Oklahoma; Wichita, Kansas; Beaumont and Fort Worth, Texas; St. Louis and Chicago.

W. N. Mellor visited the Naval Research Laboratory at Anacosta, Washington, D. C., to inspect and adjust their Western Electric 9-A Radio Transmitter.

The inspection and adjustment of radio-telephone equipments of Police Departments in Detroit and Louisville occasioned visits by H. E. J. Smith to these cities. He also modified the 500 watt transmitter of Doubleday Hill Electric Company in Pittsburgh to provide crystal control of the carrier frequency.

F. R. Stansel and H. D. Wilson have been in Bangor, Maine, installing a test radio transmitter for the A. T. & T. Company.

J. E. Tarr has been in Chicago on preliminary work on special speech input equipment for station WBBM of the Atlas Investment Company at their new studios.

On a west coast tour, O. W. Towner visited stations KHJ and KTM in Los Angeles, Station KFRC in San Francisco and station KFSD in San Diego. On his way to the coast he visited station KMOX in St. Louis and station WISN in Milwaukee.

A. R. Brooks addressed the Rotary Club of the Plainfields on September 10 on the Laboratories' recent developments in aircraft radio.

F. W. Cunningham testified as an expert witness on the application of station WABC to obtain a permit to construct a 50 kw transmitting station in Wayne Township, New Jersey.

Equipment Development

C. Borgmann has returned to the Laboratories following a visit to European countries. He spent several weeks observing telephone operations and practices during a tour of England, France, Germany, Switzerland, Norway, Sweden, Holland, Belgium, and Denmark.

A. D. Knowlton and H. A. Lewis journeyed to Saddle River and Ramsey, New Jersey, to inspect No. 11 switchboards in the process of installation.

F. C. Moak visited the toll office at Atlanta to test improved grid battery supply equipment for use with carrier telegraph systems.

Development work in connection with unit-alarm equipment for the step-by-step system required N. H. Thorn's presence at Hawthorne.

Also at Hawthorne, C. E. Boman spent several days in

Cock-pit of mail plane of the Western Air Express showing control equipment for Western Electric aircraft radio system connection with equipment design problems and C. H. Achenbach attended a meeting of the Cost Reduction committee.

ON A RECENT visit to England, F. T. Forster investigated the storage battery operating and maintenance practices now in use in the telephone power plants operated by the British Post Office. He gave special attention to practices differing from our own, and returned with considerable data which will be analyzed in connection with studies now being made on these subjects.

J. H. SOLE visited Durham, North Carolina, and H. H. Spencer visited Boston to observe the operation of the new voltage regulators installed in the repeater stations at these cities.

V. T. CALLAHAN participated in tests made on gasoline engine radiators at the engine manufacturer's plant in Buffalo.

H. M. SPICER visited the first installations of the emergency alternators at the new toll offices in Atlanta and Akron which will be used to furnish power to busy signals in case of outside power failure. He also visited Lynn to confer on these alternators with General Electric engineers.

TOLL DEVELOPMENT

THE SHIP-TO-SHORE radio-transmitting station at Ocean Gate and the receiving station at Forked River, were visited by K. M. Fetzer, E. Vroom and A. F. Grenell.

TESTS ON straightforward toll trunks between Atlantic City and Philadelphia were made by E. Von der Linden at Pleasantville and Hammonton, New Jersey, and at Philadelphia.

B. R. BLAIR has returned from Glens Falls, New York, where he completed an engineering study on shop assembled and tested bays of telephone repeater equipment.

AT DETROIT an inspection of a trial installation of group busy tone was made by J. B. Shiel.

CARRIER AND REPEATER DEVELOPMENT

A. L. BONNER was in Morristown, New Jersey, for a few days investigating low-frequency equalization of four-wire phantom circuits of H-44-25 cables. He was also at Kearny assisting in the testing of 44-B telephone repeaters and associated regulating networks which will be used on the proposed 4000-mile, four-wire cable trial.

J. L. HYSKO was in Cleveland to investigate relays used in the voice-frequency carrier telegram system.

R. A. VANDERLIPPE was in Philadelphia studying the equipment for voice-frequency carrier telegraph installed there.

THE INSTALLATION OF single-line telegraph repeaters was inspected by R. B. Hearn on a recent trip to Akron.

LOCAL CENTRAL OFFICE DEVELOPMENT

C. H. BERRY completed twenty years of service on September 19.

TWENTY YEARS of service were also completed by V. H. Heitzmann. His association with the Bell System dates from September 16, 1910.

H. A. SHEPPARD spent several days in Akron in connection with the centralized cordless "B" board which serves this new step-by-step area on a 5 and 6 digit basis.

H. C. CAVERLY, in charge of sender development, completed thirty years of service in the Bell System on September 17. He is a member of the group consisting of G. W. Weaver, A. W. Horne, and others that came to the Laboratories in 1919 when the Local Circuit division under the late H. L. Darrah was augmented by a number of practical telephone men recruited from the Associated Companies.

His association with the telephone industry began with the New England Company, in the Central Division which in 1900 included Massachusetts and New Hampshire. His first work was subscriber's-station installing on which he worked for three years. He was appointed manager of the Southbridge exchange in 1903 and in 1906 assumed similar charge at Marlboro. He went to Worcester in 1909 as P.B.X. and Central Office installer and came from that city to the Laboratories.

His work with the Laboratories has been devoted entirely to sender development. He assumed charge of the group engaged in this work in 1923.

TWENTY-FIVE years of service were completed by G. W. Weaver on September 18. He has been with the Western Electric Company and the Laboratories since 1919 when he was transferred from the Bell Telephone Company of Pennsylvania.

After leaving school Mr. Weaver decided to cast his lot with the telephone industry. He became installer of telephones for the Bell Telephone Company of Pennsylvania in Philadelphia and at the end of six months was made inspector. At the end of two years on this work he became night central-office man. He was engaged in central-office and later test-board operation until 1914 when he became assistant wire chief. Advancement to wire chief followed after six months. Before coming to the Laboratories he was wire chief of the Spruce-Locust exchange, the largest in Philadelphia.

Becoming a member of the Local Circuit group he worked on current-drain analysis until 1921 and then was engaged on panel development until 1928. On this work he was actively associated with panel cordless-switchboard development. He also has had a prominent part in the circuit work in the key-pulsing toll-sender program. Since 1928 he has been on manual development.

RESEARCH

SEVERAL DIVISIONS of the Research group have been transferred to the Graybar-Varick building where they have established themselves in new quarters on the twelfth, thirteenth, and fourteenth floors. One-half of the twelfth floor is occupied by R. A. Heising's department doing work on the fundamentals of radio circuits. R. C. Mathes and M. E. Strieby are directing work on transmission studies on the thirteenth floor and H. A. Larlee and C. A. Finley with their respective groups are carrying out development projects on telephone instruments on the

H. C. Caverly

G. W. Weaver

fourteenth floor of the new building.

Departmental Service groups have been established at the Graybar-Varick in charge of C. B. Dalphin, L. G. Rector, and F. W. Stubner.

An article *Acoustical Characteristics of Movie Screens,* written by H. F. Hopkins appears in the August number of the *Motion Picture Projectionist.*

T. C. Fry attended the meeting of the American Mathematical Society at Brown University during the early part of September.

Chemical Laboratories

R. M. Burns has been at Hawthorne in connection with finishes and other chemical matters.

A Hawthorne visit was also made by B. L. Clarke and H. S. Davidson to discuss methods of analysis for calcium-lead cable sheath.

C. M. Hill made a visit to our Chester laboratories to supervise test pieces for wood-preservation study.

Work on atmospheric-dust and sulphur tests, on which D. C. Smith has been engaged for several months, occasioned his recent trip to Harrisburg, Pennsylvania.

C. L. Hippensteel and C. W. Borgmann are authors of the article *Cadmium vs. Zinc-plating and the Status of Salt-spray Corrosion Testing* published in the August issue of *Metals & Alloys.*

C. O. Wells was at Kearny in connection with work on glazed threads.

Electro-Optical Research

E. F. Kingsbury was at Toronto to attend a meeting of the Television Standardization Committee of the Radio Manufacturers Association. The meeting was held during the I. R. E. Convention week.

A treatise entitled *Method of Enhancing the Sensitiveness of Alkali Metal Photoelectric Cells* and written by A. R. Olpin is published in the July 15 issue of the *Physical Review.*

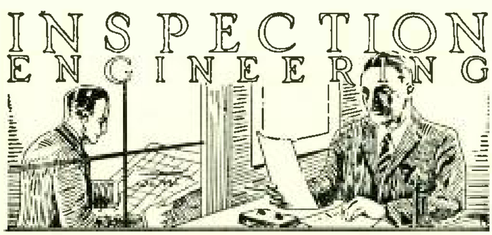
Radio Research

The convention of the I. R. E. at Toronto was attended by W. Wilson, R. A. Heising, F. R. Lack and J. C. Schelleng.

In connection with tests on the ship-to-shore system J. G. Chaffee, W. L. Lawrence, and C. P. Sweeny have been on the United States liner *Leviathan* in recent trips to Europe.

Submarine Cable

W. S. Gorton has returned from a recent European trip in connection with the transatlantic telephone cable. His work took him to Germany, England and Ireland where he made contact with Laboratories representatives on cable work in these countries. On this same work, in connection with the transoceanic telephone cable, A. M. Curtis returned from a recent trip to Newfoundland.



W. A. Shewhart read a paper *Random Sampling* at the convention of the American Mathematical Society at Brown University during the early part of September.

Field engineering activities on the Pacific Coast, formerly handled by H. W. Nylund, have been recently divided. Mr. Nylund will continue as Field Engineer in the Northern

California and Nevada, Oregon, and Washington areas of the Pacific Telephone and Telegraph Company with headquarters at San Francisco. G. Garbacz has been appointed Field Engineer in the Southern California area with headquarters at Los Angeles.

DURING the latter part of August, E. G. D. Paterson and W. H. Stracener visited Point Breeze to attend the first quality survey to be held there on lead-covered cable.

P. H. BETTS spent a week in Newark attending a quality survey on radio communication equipment for aircraft.

ALSO ON A quality survey, on carrier-telephone repeater equipment, C. J. Hendrickson made a visit to Hawthorne.

W. E. WHITWORTH, Field Engineer in the Cleveland Territory, made several trips to Akron during the past month for the purpose of studying the new dial-conversion project which is now going on there. Mr. Whitworth also spent a few days in New York discussing engineering matters with other members of the Department.

FIELD ENGINEER R. C. Koernig of the Omaha Territory was in Denver during the early part of the month and later spent a few days at the Laboratories to discuss routine engineering matters.

J. H. SHEPARD visited Savannah to investigate difficulty experienced with gas engines. In the same connection E. J. Bonnesen was called to Wichita. Mr. Bonnesen later visited Kansas City, Oklahoma City and Dallas on routine engineering matters.

ENGINEERING MATTERS required the attention of H. K. Farrar in Buffalo and Pen Yan during the past month. T. L. Oliver was in Boston and New Haven in connection with routine investigations.

STAFF

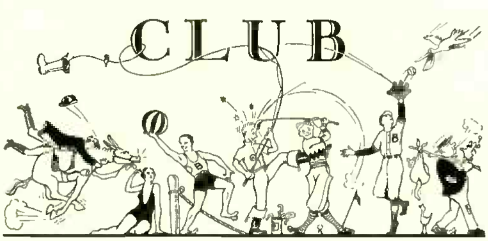
PLANT MANAGER W. B. Sanford completed twenty-five years of continuous service with the Western Electric Company and the Laboratories on September 5. He entered the factory engineering department of Western Electric following the completion

W. B. Sanford

of his course in Mechanical Engineering at Cornell in 1901 and left after working almost two years. After two years' absence he returned in 1905 to the same department. Appointed Factory Engineer, he assumed charge of plant operation and construction in 1909.

In addition to his plant-maintenance duties of which he has since had charge for this building, Mr. Sanford in 1913 was given supervision of the shop departments. In 1915 to originate a new line of work involving the application of technical and manufacturing information to buying, he was transferred to the General Purchasing Department. He was on this work for two years when he was requisitioned by his old department to aid in building operation and manufacturing. During the war period he superintended the operations of a day and night force engaged in the manufacture of vacuum tubes for government use.

Practically all physical alterations in the building during the past fifteen years have been carried on under Mr. Sanford's direction. The construction of sound-proof and humidity rooms and the erection and tearing down of office partitions have all been accomplished by men in the building maintenance department. As Plant Manager he approved the architectural plans and supervised the construction of Section H and the recently-completed Sound Picture Laboratory.



With more bowlers besieging Dwyer's and the Albee Square Recreation alleys, Brooklyn, than ever before, and several high scores that indicated mid-season form—not to mention many a stiff back the next morning—the Club Bowling League officially ushered in its 1930-1931 season on September 26. Two more teams known as the "Dials" and "Cords" have been added to each of the four groups or leagues "A", "B", "C", and "D". With the addition of two more teams this year, each of the four groups consists of ten teams each, comprising in all 200 bowlers.

As stated in announcements posted early in the month the expansion of the league was due to the successful efforts of the committee in securing additional alleys for the season. In addition to the thirty-six alleys at Dwyer's the Committee contracted for ten alleys at the Albee Square Recreation in Brooklyn. The increased facilities also permit a special arrangement whereby thirty extra bowlers, known as "specials", may bowl each League night.

Applications to bowl either as regulars or substitutes totalled 375, the largest of any season thus far. In the regular league schedule 200 are being accommodated and the remaining men will be called on from time to time to fill in as "specials" or on the regular league teams in substitute capacity. A. B. Sperry is chairman of the substitute committee. C. E. Flaig is in charge of assigning substitutes for Group A; N. H. Thorn, Group B; H. W. Heimbach, Jr., Group C; F. Huebsch, Group D; and H. A. Miloche, special bowlers.

The League for 1930-1931 is headed by I. MacDonald of the Patent Department and F. A. Korn of the Systems Development Department is Secretary-Treasurer. J. P. Greene has been appointed Recorder to assume charge of the compilation of averages, an office newly established this year to relieve the Secretary-Treasurer of his steadily-growing duties.

Contributors to This Issue

R. S. BAIR graduated from the Electrical Engineering course of Newark Technical School in 1915 and came to West Street the following year. In 1917 he joined the Research and Inspection Division of the Signal Corps and spent the following two years in France. On returning to the Laboratories he entered the Research Department where he engagd in radio development. In 1922 he went to Rio de Janeiro for a year where he was engaged in two-way radio communication and broadcasting in connection with the Centennial Exposition celebrating the independence of Brazil. At the present time he is supervisor of the group developing aircraft radio transmitters.

J. A. BECKER received his bachelor's degree from Cornell in 1918 and after spending some time with the Bureau of Standards in Washington, the Research Laboratory of the Westinghouse Company in East Pittsburgh, and with Bell Telephone Laboratories, he returned to Cornell as an Instructor and received his Ph.D. in 1922. For the next two years he was a National Research Fellow at California Institute of Technology where he worked with Professor Millikan. For the summer of 1924 he was Acting Assistant Professor at Stanford University, and in the fall returned to the Laboratories. His work here has been on thermionic emission from coated filaments, and from thoriated and caesiated tungsten, and on adsorption, electron conduction in solids, and surface phenomena in general.

D. K. MARTIN had been actively interested and engaged in radio work before getting his B.S. degree from the Polytechnic College of Engineering at Oakland, California, in 1916. Shortly after graduation he went to Alaska for the Alaska Packers Association where he was occupied with

R. S. Bair

J. A. Becker

D. K. Martin

S. E. Anderson

H. W. Weinhart

W. K. Caughey

the installation and operation of their radio facilities. During the World War he was an Ensign in the United States Navy, spending much of his time as radio instructor. In 1919 he joined the American Telephone and Telegraph Company where he continued his radio work in the Department of Development and Research. Transferring to the Laboratories in 1928 he engaged in the development of aircraft radio apparatus, and at present is supervisor of the group handling radio transmission studies and radio beacons.

PRIOR to receiving his B.S. degree in Electrical Engineering from the University of Michigan in 1919, S. E. ANDERSON had had considerable experience as a commercial radio operator. Following graduation, his first work was in the General Motors Research Laboratory where he aided in the solution of some of the electrical problems associated with motor car manufacture. He joined the Laboratories in 1920, where he was associated with the carrier-telephone group in the Systems Department. In 1922 he transferred to the Radio Development group and started the work with which he has since been continuously identified—radio receiver development. He is at present in charge of the development for commercial purposes of much of the radio receiving equipment and measuring apparatus sold by the Western Electric Company.

M. H. A. Lindsay

H. W. WEINHART joined the research organization under H. D. Arnold in 1912 and was engaged in the development of the mercury-arc repeater. With the advent of the vacuum tube he was occupied with the development of vacuum-tube repeaters, and later of power amplifiers for the Arlington-Paris radio channel. About this time the transcontinental line was engaging the attention of development engineers and Mr. Weinhart worked on the repeaters for that project. Since then he has been in supervision of a group occupied with the development of many types of vacuum tube apparatus among which was the cathode-ray oscillograph and, more recently, the various glow tubes for television.

W. K. Caughey received an M.E. degree from Stevens Institute of Technology in 1928 and joined the Apparatus Development Department of the Laboratories that autumn. Most of his time has been spent at Whippany where he worked on the development of radio apparatus for aeronautical stations. He is now located at the Laboratories on West Street.

M. H. A. Lindsay received a B.Sc. degree in physics from Mt. Allison University in 1925 and immediately joined the Technical Staff of the Laboratories. In September of that year he went to M. I. T. as Instructor in the Physics Department but returned to the Laboratories the following September and joined the Electrical Measurement Group. Here he was concerned with bridge measurements and the development of apparatus for testing vacuum tubes. Last summer he transferred to the Special Products Department and is now engaged in radio broadcast development. While at the Laboratories he has continued his studies at Columbia under the part-time post-graduate plan and has recently received a M.A. degree in physics.