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Photo by T. J. Maitland, A. T. & T.

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A J-carrier terminal pole near the Loxahatchee River, on the Charlotte-West Palm Beach system.

A Telephone Set for Explosive Atmospheres

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Station Apparatus Development

THE telephone is, by its design, a harmless instrument. Its potentials are low, and its current-carrying parts are enclosed and out of the user's reach. Unusual voltages and currents, if any are to be anticipated, are excluded by station protectors. Small sparks at contacts create no hazard in normal atmospheres. Occasionally, however, telephone service is wanted where an explosive atmosphere may be present, as in gas works, oil refineries, or chemical plants. For such locations, a telephone set of the manual type was developed some years ago. The switchhook contacts were enclosed in a small cylinder, the induction coil potted, the terminals protected, and other precautions taken. This set* has proven entirely satisfactory, and later an enclosed dial was developed to make dial service also possible in explosive atmospheres. More recently, however, the demand for telephone service in places where explosive atmospheres exist has increased. It seemed desirable, therefore, to design a compact set that could be used for either manual or dial service. The 320 type telephone set, shown above, is the result of this work.

The principle on which the design is based is to install all of the apparatus except the handset, the finger-wheel of the dial, and the gongs in a strong and tightly closed housing. Although this housing is not gasproof, it is so strongly made that should explosive gases enter it and be ignited, the housing would remain intact, and the high pressures built up inside as a result of the explosion would escape

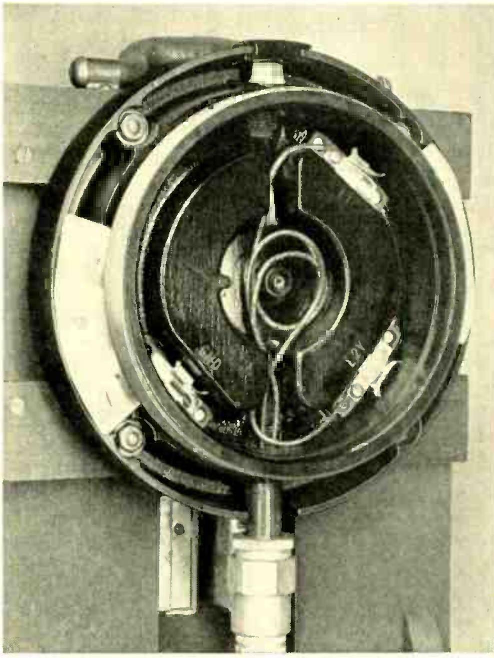


Fig. 1—The base of the new set provides termination for the wires and is designed to support the housing and to mount on a wall, either directly or by use of a backboard

*RECORD, *June*, 1934, *p.* 297.

over so long and restricted a path that the gas would be cooled below the combustion temperature before reaching the outside. A modified handset is also provided, and additional precautions were built into it so that during installation and maintenance explosions would not be created by sparks or arcs originating in the handset.

The set provided is cylindrical in shape and built in three parts: a base, a housing, and a face plate. The handset forms a fourth part of the complete set.

The base, shown in Figure 1, is designed for supporting the housing and for mounting on a wall, either directly or by use of a backboard, or on a pedestal-type support, shown in Figure 2. It also provides three spring terminals for the two line wires and the ground conductor, and a conduit entrance at top and bottom, into either of which the conduit carrying the wires may be screwed. Rigid conduit installed in accordance with the requirements of the National Electrical Code for hazardous locations must be employed, but none of it forms part of the set. The base carries an externally threaded annular projection to which the housing is screwed. It also carries two springs, which when compressed by the housing prevent lateral movement due to thread clearance. A small cavity in the center of the base provides space for storing slack wire, and is covered with a metal plate after the wires have been connected to the spring terminals.

The housing is of the same external diameter as the base and houses all the apparatus in a way to minimize unoccupied space and thereby reduce gas volume. As viewed from the back, it appears as shown in Figure 3. It

Fig. 2—Where more convenient, the set may be mounted on a pedestal

has an internal thread for fastening to the base, and three contact studs which make contact with the spring terminals when the housing is screwed in place. Although the wall of the housing is of ample thickness at all points, the front is of irregular shape since it is designed to provide cavities for the various pieces of apparatus. It is hidden by the cover, however, and so the set presents a smooth appearance from the outside.

Both the dial mechanism and the ringer are within this housing, but the dial fingerwheel and the gongs and clapper of the ringer are mounted on the front of the housing as shown in Figure 4. The dial fingerwheel is carried on an auxiliary shaft passing through a long, close-fitting bearing, and inside the housing is connected to the regular dial shaft through a linkage member that compensates for misalignment of the two shafts. The clapper for the bell is operated through a similar shaft and bearing. While these bearings are not gas tight, their clearance is so small and their length so relatively long that burning gas, escaping under the pressure of an explosion within the housing, will be cooled below the ignition point before it reaches the outside. A pin, used as a link between the handset-supporting hook on the outside of the housing and the associated contacts within the housing, passes through a similar close-fitting bearing.

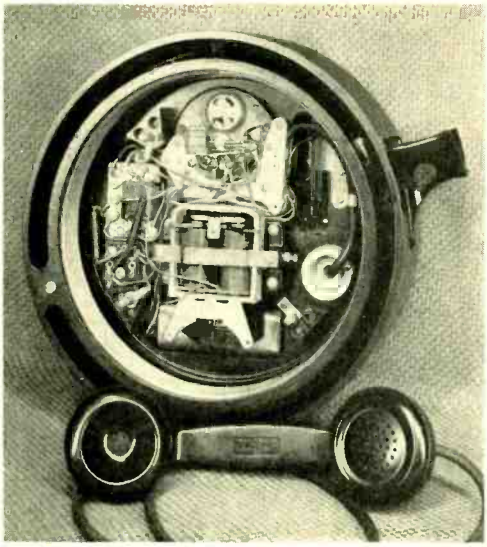


Fig. 3—The housing includes all the apparatus, and screws to the base

The face plate, which is shown in the photograph at the head of this article, serves to conceal the irregularities in the front of the housing and to protect the fingerwheel and gongs. It is fastened to the housing by three screws, and is slotted over the gongs to let the sound out. It also covers the lock, which is mounted on the front of the housing. The bolt of the lock, when in the locked position, retains a long steel pin, which passes through the housing outside the explosion chamber, and into a recess in the base. With the pin in the locked position it is impossible to turn the housing, and thus it cannot be removed without unlocking.

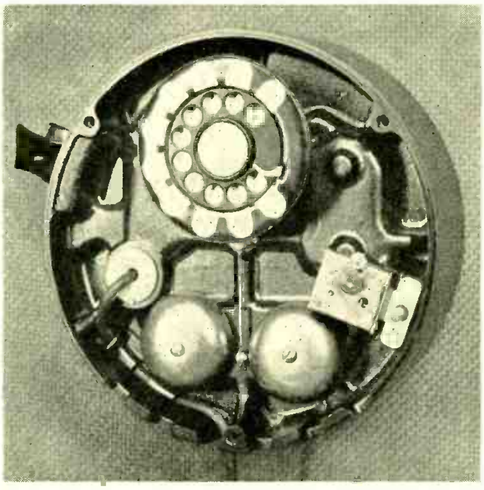


Fig. 4—The gongs and dial fingerwheel are mounted on the front of the housing under or within the face plate

In installing the set, the base is first fastened to the wall, the conduit run to it, and the wires pulled in and fastened to the spring terminals. The housing is then screwed on, which brings the three contact studs on the housing into contact with the spring clips in the base. The length of these studs is made such that they will not engage or disengage the clips except when a sufficient number of threads are engaged to prevent flame passing to the outside.

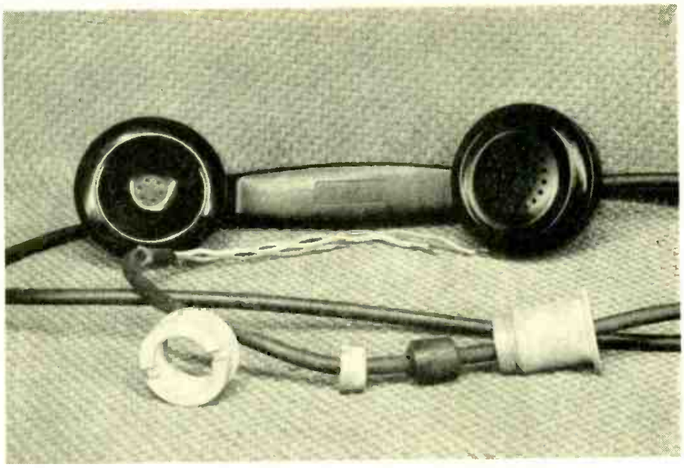
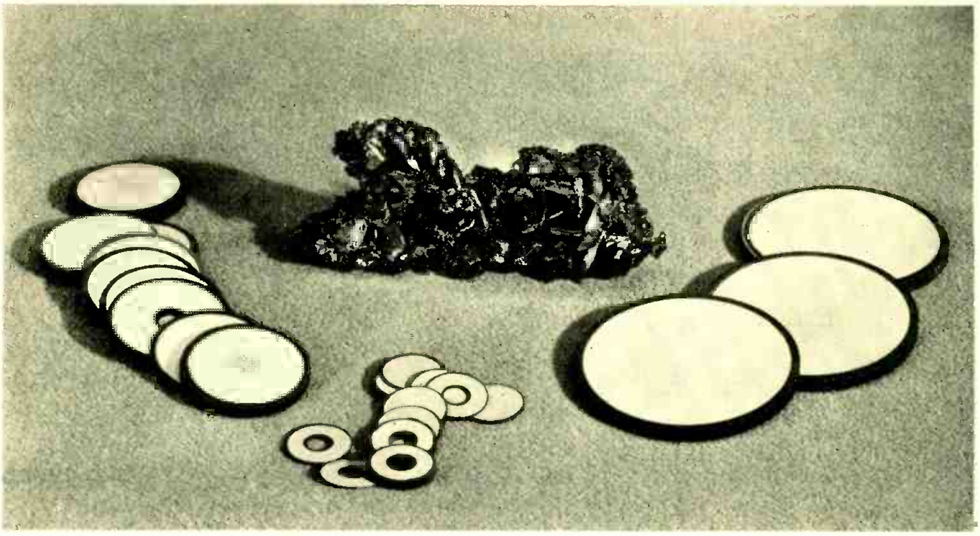


Fig. 5—The handset is connected to the housing by a rubber-insulated cord through a rubber-sealed clamp

The handset, shown in Figure 5, is connected to the housing by a rubber-insulated cord, which passes into the housing through a rubber-sealed clamp removable only with a special tool from inside the housing. The handset is of such construction that if gases seep into it and are ignited, no flame will be propagated to the surrounding atmosphere. To accomplish this a special transmitter unit is employed, and it, together with the receiver unit and cord, is so assembled in the handle that it is not feasible to replace them in the field. When any part of the handset becomes defective, therefore, the handset and cord assembly must be replaced as a unit. Since this requires the removal of the housing, the circuit to the cord is broken before the cord can be disconnected.

Since the set is designed to withstand an internal explosion, the base and housing are made of a high-tensile strength alloy and are strengthened by stiffening ribs. In this way a large factor of safety is secured. Special finishes and treatment of the component apparatus and parts are used to minimize deterioration due to corrosion, since the places where these sets are used frequently have corrosive as well as explosive atmospheres. Resistors are shunted around the condensers in the ringing and receiving circuits to dissipate any charge that otherwise might remain on the condensers. This avoids the possibility of a spark from the release of the charge when the set is opened. Special fuse protection, which is always installed remote from the explosive atmosphere, has also been designed for use with the set as an additional safeguard. This telephone set has been tested and listed by the Underwriters' Laboratories for certain specified atmospheres.



Silicon Carbide Varistors

By R. O. GRISDALE
Research Department

AS MIGHT be inferred from its name, the silicon carbide varistor owes its distinguishing characteristics to the properties of silicon carbide, which is familiar as an abrasive. As it comes from the electric furnace in which it is made, this substance is in the form of large crystalline aggregates such as those shown in the headpiece of this article. When these aggregates are crushed and a mass of the resulting small granules is compressed between metallic electrodes it has a current-voltage characteristic in double logarithmic coördinates such as is shown in Figure 1. Since the characteristic of an ohmic resistance in such coördinates is a straight line inclined at an angle of forty-five degrees to the current and voltage axes, it is apparent that, while at low voltages the unit obeys Ohm's law, the current increases much more rapidly than in direct proportion to the voltage as the voltage is increased. The result of this is that the resistance of the unit decreases with increasing voltage; but, unlike that of the copper oxide varistor, its resistance is independent of the polarity of the applied voltage and hence it does not rectify an alternating potential.

Experiment has shown that the specific resistance of silicon carbide, when measured in such a way as to eliminate errors due to contact resistance, is small and independent of voltage. Consequently the departure of a compressed aggregate of carbide granules from Ohm's law does not originate within the grain but is localized at the points of contact between adjacent particles. The voltage-dependent resistances of the intergranular contacts act in series with the internal or body resistances of the grains themselves and the mass of granules may be idealized as a large number of contacts arranged in series and in parallel as is indicated in Figure 1. Because of the series arrangement of body and contact resistances, the net resistance of a mass of carbide granules does not decrease indefinitely as the applied voltage is increased but it approaches as a limit a resistance equal to the sum of the body resistances of the grains themselves. The schematic circuit diagram for a mass of granules is given in Figure 1 and the shape of the resistance voltage characteristic is given to show how, at high voltages just as at low voltages, the resistance is independent of voltage. The constancy of resistance at high voltages means that Ohm's law is obeyed and this fact is further illustrated by the dotted portion of the current-voltage characteristic in the figure. The nature of this characteristic is such that over a considerable range the current, I, is proportional to the n^{th} power of the voltage where n is about 5; thus an increase by a factor of ten in voltage increases the current about a hundred thousandfold.

Now in such an aggregate of granules several intergranular contacts always act in series and as a consequence the voltage drop across any single contact is never more than a fraction of the total voltage applied to the unit. It is because of this that the silicon carbide varistor is essentially a higher voltage device than the copper oxide varistor; for in the latter there is but one voltage dependent contact and virtually all of the applied potential appears across the interface between the copper and cuprous oxide.

The current-voltage characteristic of a mass of silicon carbide granules is symmetrical about the origin; but this need not necessarily lead to the conclusion that each individual contact between particles has a resistance independent of the direction of current flow. For if a large number of rectifying contacts, such, for example, as single copper oxide varistor discs, were arranged at random it is probable statistically that there would be equal numbers rectifying in either sense and hence that the total resistance would be independent of the polarity of the applied voltage. While consideration of this statistical symmetry is undoubtedly of importance in any study of this nature, it may not be the sole underlying reason for the symmetry of the characteristic for the silicon carbide varistor.

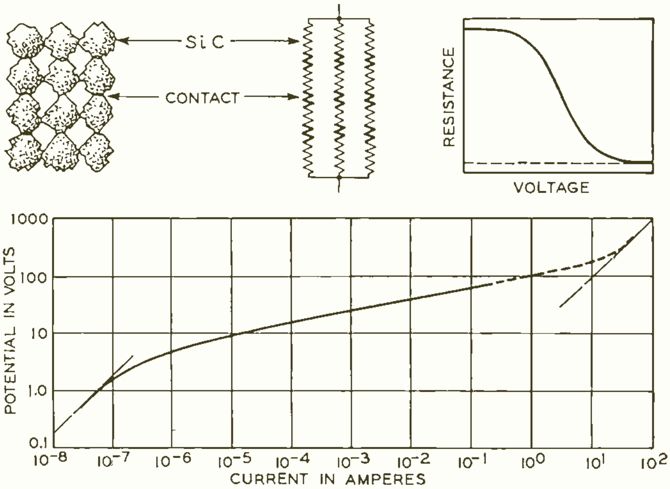


Fig. 1—Electrical characteristics of granular silicon carbide

While a unit composed of small granules of the carbide compressed between metallic electrodes possesses the desired varistant properties, it is

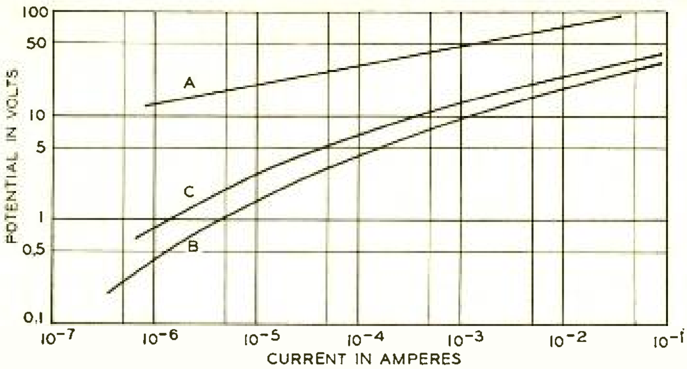


Fig. 2—Characteristic curves for varistors 0.045 *inch thick and* 1.3 *square inches area. Sample* A *passed through the furnace at* 5 *minutes per inch; sample* B *at* 15 *and sample* C *at* 12 *minutes per inch*

unsuited for practical use because its characteristics are subject to mechanical vibration and to variations in pressure. To secure the required stability and small size, other means of holding the grains of carbide in contact are employed; and the silicon carbide varistor now in use consists of such granules firmly embedded in a vitreous ceramic matrix.

The granular carbide is mixed with a plastic clay and a small amount of graphite. After adding water, the mixture forms a plastic mass which is forced through screens until it is finally obtained as a damp granular powder. This damp material is compressed to the desired size either in steel moulds on hydraulic presses or in automatic tableting machines. In either case, however, the pressure employed is about eight tons per square inch and care is exercised to ensure that the pressed parts are not laminated or cracked. After drying in an oven to remove the water added in mixing, the pieces are heat treated in an atmosphere of hydrogen and nitrogen, the furnace employed for the heat treatment being so constructed that the pieces pass at uniform rates through an electrically heated gas-tight tube.* After passage through the furnace, the samples are very hard, strong, stone-like discs and, to attach suitable electrodes, firmly adherent layers of tin, copper or other metal are sprayed onto their two opposing faces. Since the varistors are porous and because moisture condensed in the pores leads to electrochemical polarization, they are vacuum impregnated with some moisture-repellent material.

*Record, *March,* 1935, *p.* 214.

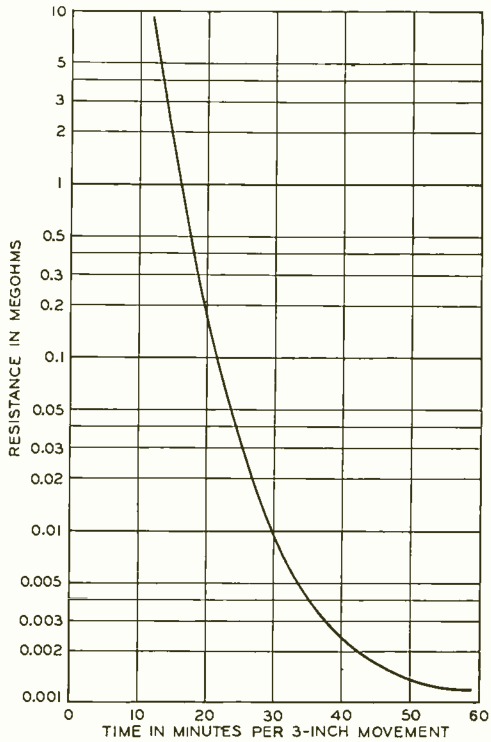


Fig. 3—Resistance of the varistors of Figure 2, *measured at* 20 *volts and plotted against length of heat treatment*

The electrical characteristics of the completed varistors are dependent on their compositions and on the heat treatment to which they have been subjected. Merely by varying the temperature of the furnace and the rate of passage through it the specific resistance of the material—or its resistance at some selected voltage gradient—can be varied a hundred thousandfold. It is this fact which makes necessary the precise control of firing conditions, since it is found that a change of less than 0.2 per cent in the temperature of the furnace is sufficient to produce significant variation in the resistance of the varistors.

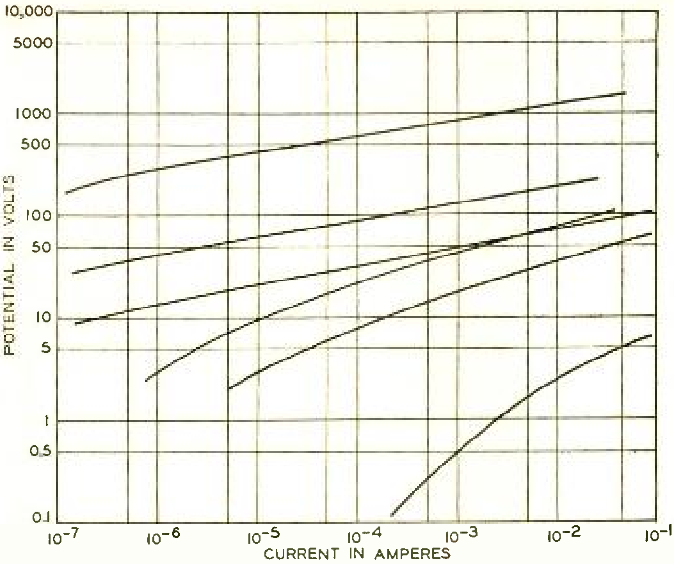


Fig. 5—An indication of the variety of characteristics which can be obtained in silicon carbide varistors

The effect of varying the rate of passage through the furnace on the properties of typical silicon carbide varistors is shown by the current-voltage characteristics of Figure 2. As the rate decreases, or, in other words, as the duration of heat treatment increases, the specific resistance of the varistor decreases and as a consequence the current-voltage characteristic is shifted bodily from left to right in the figure. The successive characteristics were obtained from varistors which had been subjected to progressively lengthened heat treatments and the relation between the rate of passage through the furnace and the resistance at 20 volts is shown in Figure 3. This figure illustrates the fact that the resistance of the varistors does not decrease continuously as the duration of heat treatment is increased but rather that it approaches a minimum limiting value. It is thus impossible, by varying the firing process, to produce varistors of a specific re-

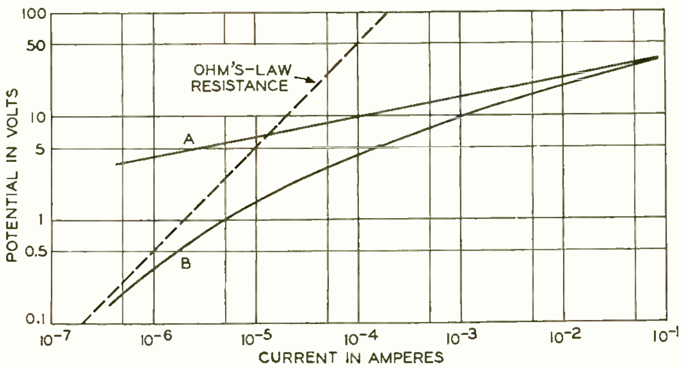


Fig. 4—Curves of Figure 2, when rearranged, show clearly that high resistance varistors depart more from Ohm's law than do ones of low resistance

sistance less than a certain minimum value. Despite this fact, however, varistors of very greatly varied characteristics can be prepared. Perhaps the minimum resistance which can be obtained by varying both size and heat treatment is somewhat less than a thousand ohms at low voltage but there is no practicable upper limit to this resistance.

Unfortunately, there is associated with a decrease in the specific resistance of silicon carbide varistors a decrease in the value of n, or, in other words, in the degree of departure from Ohm's law. To illustrate this

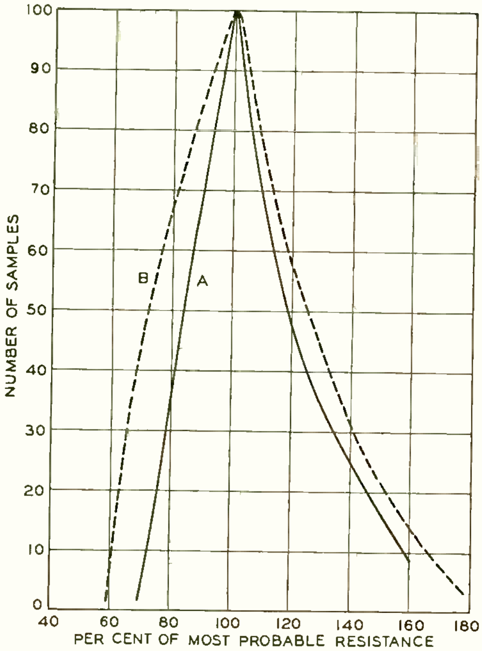


Fig. 6—Characteristic frequency distribution curves: A, *when measured at high voltage;* B, *at low voltage*

fact, the characteristics A and B of Figure 2 have been so displaced in Figure 4 that at high voltages they coincide, and it is seen from this figure that the varistor A departs more from Ohm's law than does the varistor B having the lower specific resistance. The curve B is similar to that which would be obtained if an ohmic resistance having the characteristic given by the dotted line were connected in parallel with the varistor having the characteristic A in the figure. As a matter of fact, the decrease in the degree of departure from Ohm's law with decrease in specific resistance is due to the creation of ohmic leakage paths in shunt with the intergranular contacts during the firing process.

As an indication of the variety of characteristics which can be obtained in silicon carbide varistors, a series of current-voltage curves is given in Figure 5. Although such a wide variety of varistors can be prepared, it still has been possible to reproduce any given characteristic over a period of several years. Characteristic frequency distribution curves taken on a large lot of varistors are shown in Figure 6. In this figure curve A is for the resistance measured at a high voltage, while curve B shows the distribution of resistance values at a low voltage on the same lot of varistors. The two curves serve as an illustration of the fact that the spread in resistance values becomes smaller for higher measuring voltages. Since the low-voltage resistance value is determined largely by the electrical characteristics of the ceramic matrix, this indicates that the shunt resistances created across the intergranular contacts during the heat treating process are of a less reproducible nature than the characteristics of the contacts themselves.

It is largely changes in these shunt resistances with time which account for the aging process in silicon carbide varistors. In general, there is a tendency for the varistor to increase slightly in resistance with time and the rate with which this change occurs as well as its magnitude is augmented by an increased temperature or by frequently repeated voltage surges. When a surge potential of the magnitude encountered in normal service is applied to a varistor, its resistance is permanently increased. However, if the surge is applied repeatedly, the resistance does not continue to increase, but, instead it approaches a constant limiting value. While the magnitude of this permanent increase in resistance is a function of the surge voltage, it is in general less than ten per cent of the original value. For surges whose peaks correspond to voltage gradients of about a hundred kilovolts per inch there is a large and permanent decrease in resistance, particularly at low voltages, and this decrease approaches a limiting value as the surges are repeated. The increase in resistance with normal use corresponds in part to the removal of the ohmic resistances in shunt with the contacts, while the decrease in resistance after high voltage surges is due to the creation of additional leakage paths by the discharge.

Besides these permanent aging effects, silicon carbide varistors exhibit a reversible resistance change with change in temperature. The temperature coefficient of resistance is negative, and at low voltages it is such that the resistance decreases to one-half its original value when the temperature is raised about forty-five degrees Centigrade. At higher voltages the temperature coefficient is much smaller, and this fact is illustrated by the current-voltage characteristics taken on a varistor disc at different temperatures as shown in Figure 7.

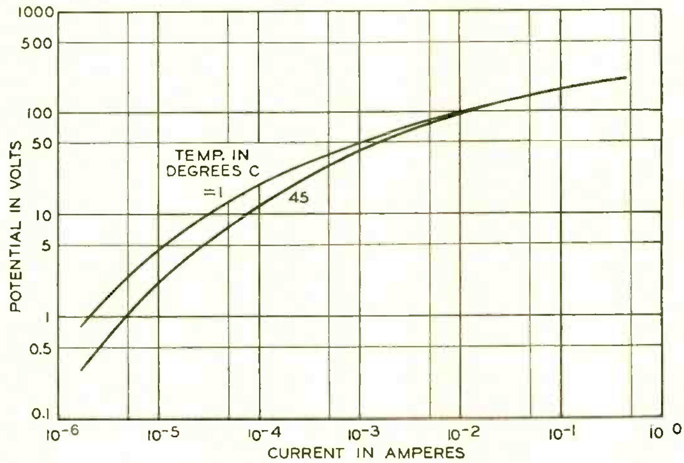


Fig. 7—For the same voltage, current approximately doubles with increase of temperature from 1 *degree Centigrade to* 45 *degrees Centigrade*

Because of its refractory nature, the silicon carbide varistor is a relatively stable device. It may be subjected repeatedly to temperatures up to 350 degrees Centigrade such as might result from a power overload and it will withstand repeated voltage surges of several thousands of volts per inch without breakdown and even without substantial change in its characteristics. Since it is a higher-resistance, higher-voltage element than the copper oxide varistor, it supplements the latter which finds application as a varistor principally in low-voltage, low-resistance apparatus.

The C5 Carrier Terminal

By G. W. COWLEY
Carrier Telephone Development

SHOULD one enter an office having some of the new C5 carrier terminals* as well as some of the older C terminals, the first difference to strike his attention would probably be the smaller space required by the new terminal. While more than three bays are required for the older equipment, including its associated pilot channel, a single bay is sufficient for all of the new equipment including the pilot channel, and in addition leaves some space available for mounting other associated equipment in the upper part of the bay. The actual mounting space required for the new equipment is less than twenty-five per cent of that required for the older equipment. This great difference in size is partially brought out in Figure 1, where a C5 terminal is shown at the left, and an older C terminal—minus the regulator — at the right. The regulator used with the older system is mounted on a separate bay and does not appear in the photograph. The fewer vacuum tubes required by the new system would probably be noticed at a second glance, and many other improvements would be discovered

*Record, *August*, 1940, *p.* 354.

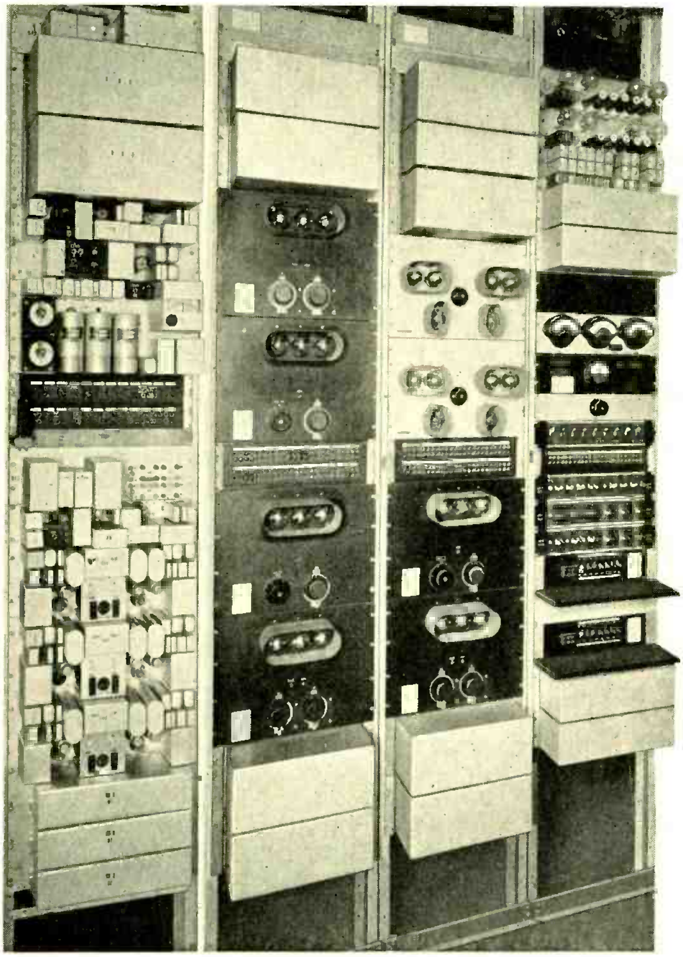


Fig. 1—A C5 terminal, at the left, occupies less than one-third the space required for one of the earlier C-carrier terminals

as the two systems were compared more closely. Both old and new C systems provide three channels in each direction and occupy approximately the same frequency range. The great reduction in size has been effected by the utilization of new apparatus and methods that have been developed since the earlier systems were standardized. The new band filter and modulator-demodulator panels, for example, each occupy but one-quarter of the amount of space previously required. Two of the two-tube negative feedback amplifiers are used to replace the two six-tube amplifiers previously used. The regulator equipment has also been greatly reduced in size.

A block schematic of the C5 terminal is shown in Figure 2, where those elements not strictly a part of the terminal are shown in dotted lines. The terminal itself is terminated as a four-wire circuit to permit it to be directly connected to any other four-wire circuit—either voice-frequency or K or J carrier—but where desired, a four-wire terminating set is provided to transform the four-wire to a two-wire circuit.

From this four-wire terminating set, the outgoing speech passes directly to the modulator, the circuit of which is shown in Figure 3. A repeating coil is provided to isolate the balanced terminating set from the unbalanced modulator circuit, and a low-pass filter to reduce any carrier leak that might have entered the circuit from a preceding carrier link when two type-C systems are connected in tandem. The modulator proper consists of four copper-oxide varistor elements arranged in a bridge circuit balanced with respect to the carrier, so that under ideal conditions the carrier, connected across opposite corners of the bridge, will produce a zero potential difference across the other two opposite corners, and thus will not appear on the line. In this way the carrier is suppressed. One of the resulting side bands will be eliminated by the modulator band filter, and thus only one side band is sent

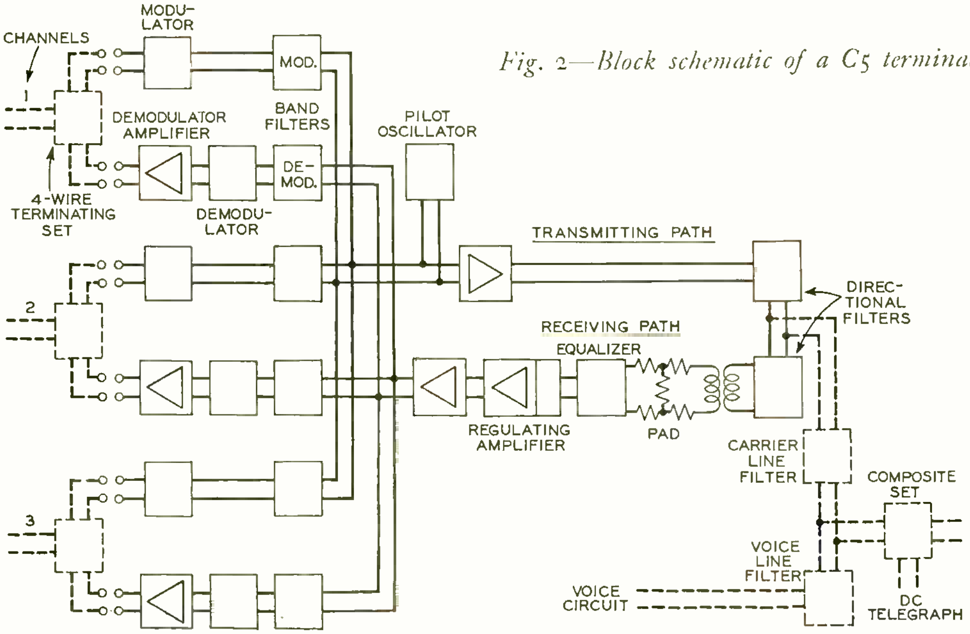


Fig. 2—Block schematic of a C5 terminal

over the line. An output pad, and a network consisting of either a series retard coil or a shunt condenser—the latter shown dotted on the diagram—serves, in conjunction with the output circuit, to provide the proper impedance termination for the modulator. The output pad permits a small range of level adjustment.

The oscillator is coupled to the modulator through a transformer, and the series resistance between the transformer and the modulator, together with the impedance of the transformer, provide the proper a-c impedance termination for the carrier branch of the modulator, while the shunt retard coil and resistance provide the proper d-c termination. The modulator unit may be considered as an electrical switch. When current from the oscillator flows in one direction, the copper-oxide discs are conducting, and hence have a low impedance. The series-parallel combination of the four arms of the bridge thus present a low-impedance shunt to the circuit. The succeeding half-cycle of current from the oscillator flows in the opposite direction, with the result that the varistors take on a high impedance. This action produces in the output, components of the speech currents, the first order sum and difference products of the speech and carrier currents, together with higher order products of modulation. The band filter passes only the first order sum or difference product, as the case may be, thus eliminating the other components.

Since the carrier is suppressed, it must be resupplied in the demodulator at the receiving end. For proper operation, therefore, the frequency of the demodulator must be held close to that of the modulator. It is necessary, then, that the frequency of the oscillators, after adjustment, be little affected by outside conditions such as changes in temperature and battery voltage. Changes in frequency caused by variations in battery voltage have been kept small by the proper selection of the circuit constants. The frequency of the oscillator, however, is principally governed by the tuned circuit consisting of one secondary of the oscillator transformer, and the fixed shunt condenser in parallel with the shunt adjustable condenser. Taps are provided on the secondary winding for coarse frequency adjustment, and with the adjustable condenser provide a continuously adjustable frequency over an adequate range. Changes in frequency caused by temperature variations arise chiefly from changes in the inductance and the two capacitances. By use of a new core material, whose temperature-inductance characteristics can be controlled by proper heat treatment, it has been possible to secure improved stability. The temperature characteristic of the transformer is made equal in magnitude and opposite in sense to that of the condenser, with the result that a change in capacitance due to temperature is offset by a corresponding and opposite change in the inductance of the transformer.

The action of the modulator depends on the direction of current flow through it. Since both oscillator and voice currents flow through it, however, it is the current of largest value that will be controlling. This characteristic permits the modulator to be used to prevent overloading of the transmitting amplifier by an occasional speech peak of too high volume. The taps on the secondary of the oscillator transformer permit the current from the oscillator to be adjusted relative to the voice currents, so that when the speech peaks exceed the desired maximum, they will assume control of the modulator. The momentary shunting action of the modulator under control of these peaks results in a loss that tends to maintain the output below the desired maximum value.

From the output pad of the modulator, the speech and modulation components pass to the modulator band filter, which passes only one side band. This side band is combined with the single side bands of the other two channels, and the three are passed through the common amplifier. Bridged across the input to the amplifier is the pilot oscillator, which supplies current to be used in maintaining a constant net loss over the circuit. The amplified side bands and the pilot then pass through the transmitting directional filter, the carrier-line filter, and the composite set to the open-wire line. The transmitting directional filter together with the receiving directional filter form a high-pass and low-pass filter combination with a separating point at about 16 kc. These filters prevent modulation products produced in the transmitting amplifier between the three side bands from producing interference in the receiving side of the circuit. If the transmitting circuit is operating with three side bands in the range from 6 to 15 kc, for example, modulation products of these side bands might fall in the receiving range from 17 to 28 kc. The receiving directional filter is also effective in preventing the high-level output of the transmitting side of the circuit from overloading the receiving amplifier. The line filter set is required similarly to separate the carrier channels from the voice-frequency channel. The composite set is required to separate the d-c telegraph from the voice and carrier frequencies that are used in the system.

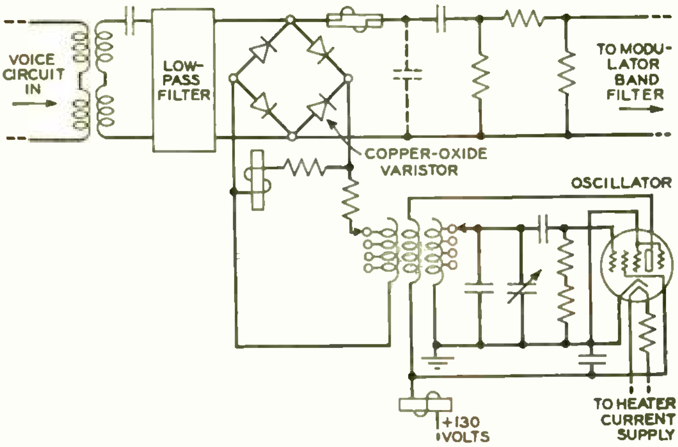


Fig. 3—Simplified schematic of the modulator circuit

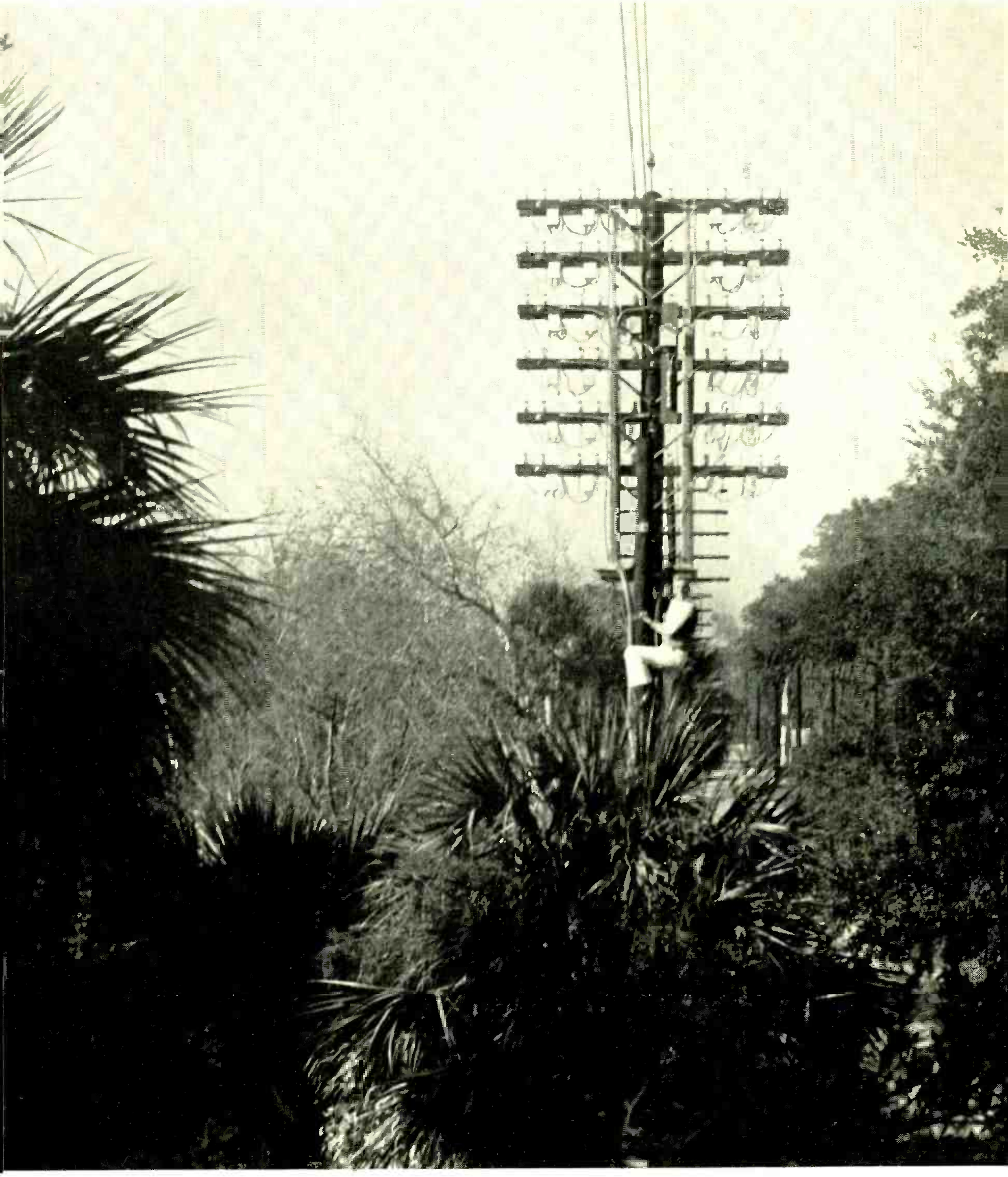
For transmission in the other direction, the received current passes through the composite set, the carrier-line filter, the receiving-directional filter, and through a repeating coil and receiving pad into an equalizer. Loss over the open-wire line is greater at the higher frequencies than at the lower, and the equalizer—designed to produce a complementary loss—is incorporated to bring all frequencies to the same level. The equalizer, however, is designed to correct for a long-line section, so that to avoid over-equalization, the line must be "built out" to the length for which the equalizer is designed. The length of a line as measured by its loss, however, depends on the weather. In dry weather, it will appear to be electrically shorter than in wet weather.

The artificial line used for "building out," therefore, is made adjustable and put under control of the regulator, which adjusts it in accordance with the level of the received pilot frequency. As the attenuation of the line increases, the receiving level of the pilot current is reduced, and the regulator automatically cuts out attenuation until the level is restored to normal at the output of the amplifier.

From the regulating amplifier, the three channels pass to the receiving amplifier where they are further amplified. They are then separated by the three demodulator band filters, and each band is passed to its respective demodulator. The demodulator is similar to the modulator in circuit and operation, and, with the oscillator frequency, produces the original speech frequencies. A low-pass filter is incorporated in the demodulator to reduce the unwanted products of modulation. The speech frequencies are then amplified by a single-tube amplifier and pass to the four-wire terminating set.

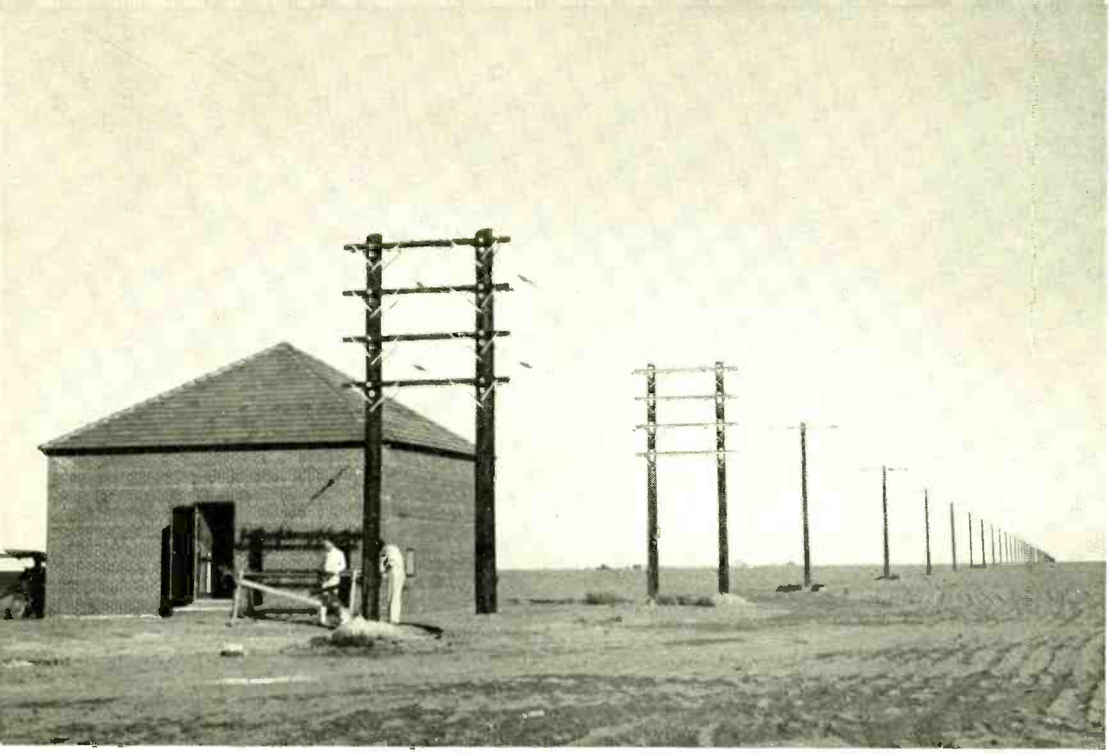
Only two types of tubes are used in the C5 terminal—a voltage pentode and a power pentode. Each is available in two types of filament: a ten-volt filament and a 7½-volt filament. Two of the 10-volt filaments and a resistance are used in series when the voltage of the filament battery is held to close limits, while two of the 7½-volt filaments and a ballast lamp are used when the battery is not so closely maintained. The latter arrangement is also available for operation with a 22-volt transformer where power is taken from an a-c source. Plate supply is furnished by a 130-volt battery. The cathode return of the transmitting and receiving amplifier circuits is made to the negative end of the filament battery. Dry cells are used for grid biasing in these amplifiers, while the other circuits are self-biased. Where power is taken from an a-c source, regulated tube rectifiers are employed for the plate supply and a copper-oxide rectifier for signal battery supply.

The C5 terminal consists of all the equipment indicated by solid lines in Figure 2, and may as previously noted be mounted on a single eight-foot eight-inch bay. When the terminal is mounted on a ten-foot six-inch bay, as shown in Figure 1, space is available at the top for the four-wire terminating sets. The top panel in Figure 1 mounts the equalizer and has place for dry cells used with the amplifier. Below it, in the order named, are the transmitting and receiving directional filters, the transmitting amplifier, pilot oscillator, regulating amplifier, and a jack field. The three bottom panels include the six modulator and demodulator band filters, and the three panels above them carry the modulators and demodulators. Each of these latter panels includes the equipment for the modulator and demodulator and their respective oscillators, together with the demodulator amplifier. Between these and the jack field is a panel carrying the receiving pad and repeating coil and part of the networks of the regulating amplifier.

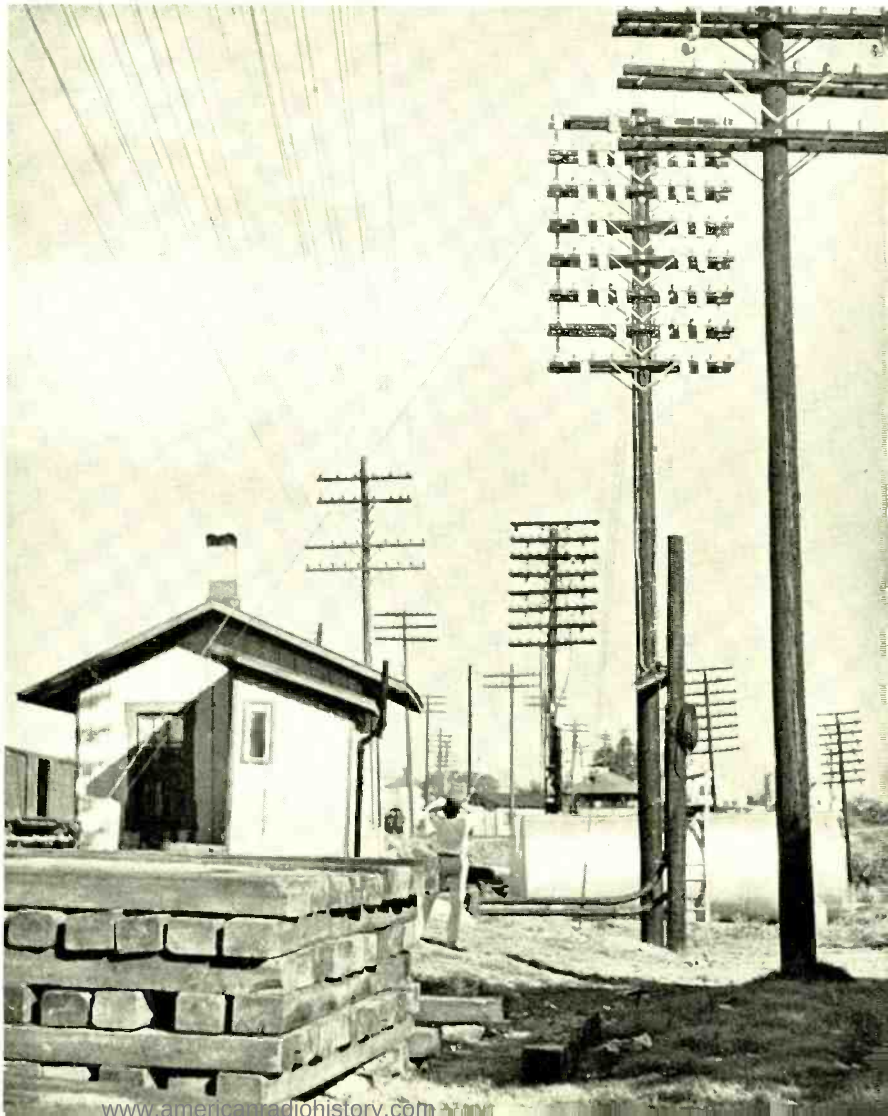


J CARRIER IN THE FIELD

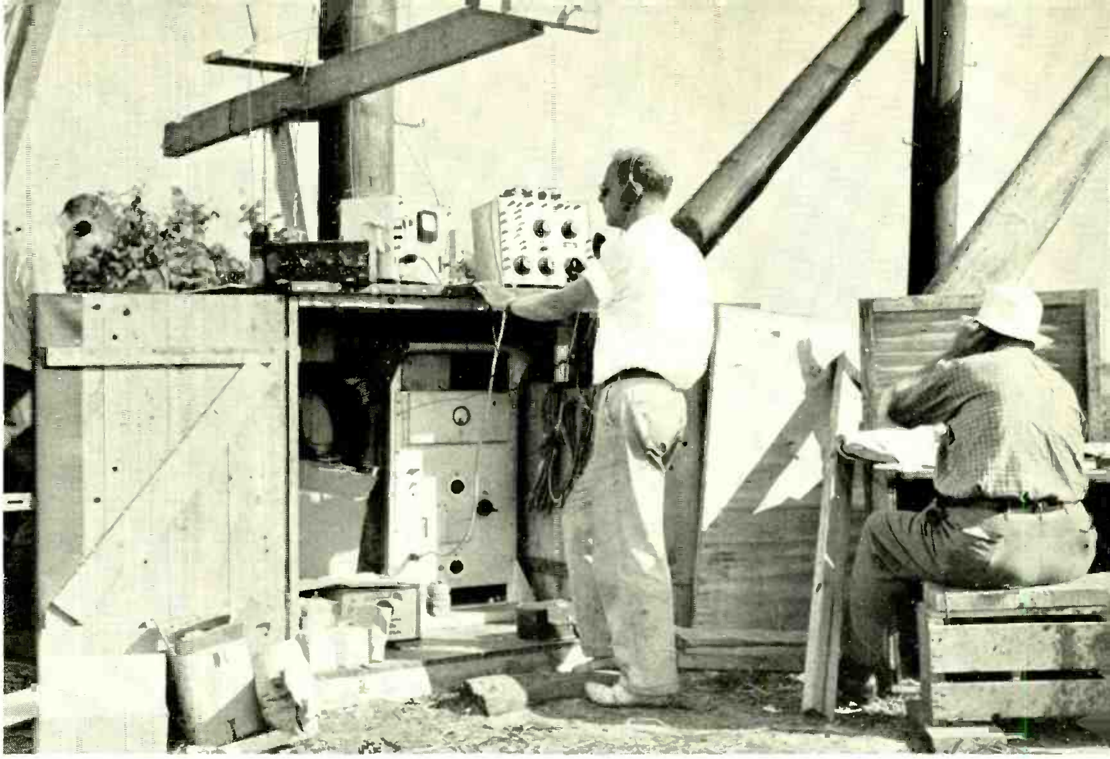
Testing for open-wire crosstalk at the Daytona Beach terminal pole, on the Charlotte-West Palm Beach system. Photo by L. L. Lockrow.



Auxiliary repeater station at Adrian, Texas, on the Fourth Transcontinental Line. This station is part of the type-J carrier system between Oklahoma City and Whitewater, California. Photo by T. J. Maitland, A. T. & T.

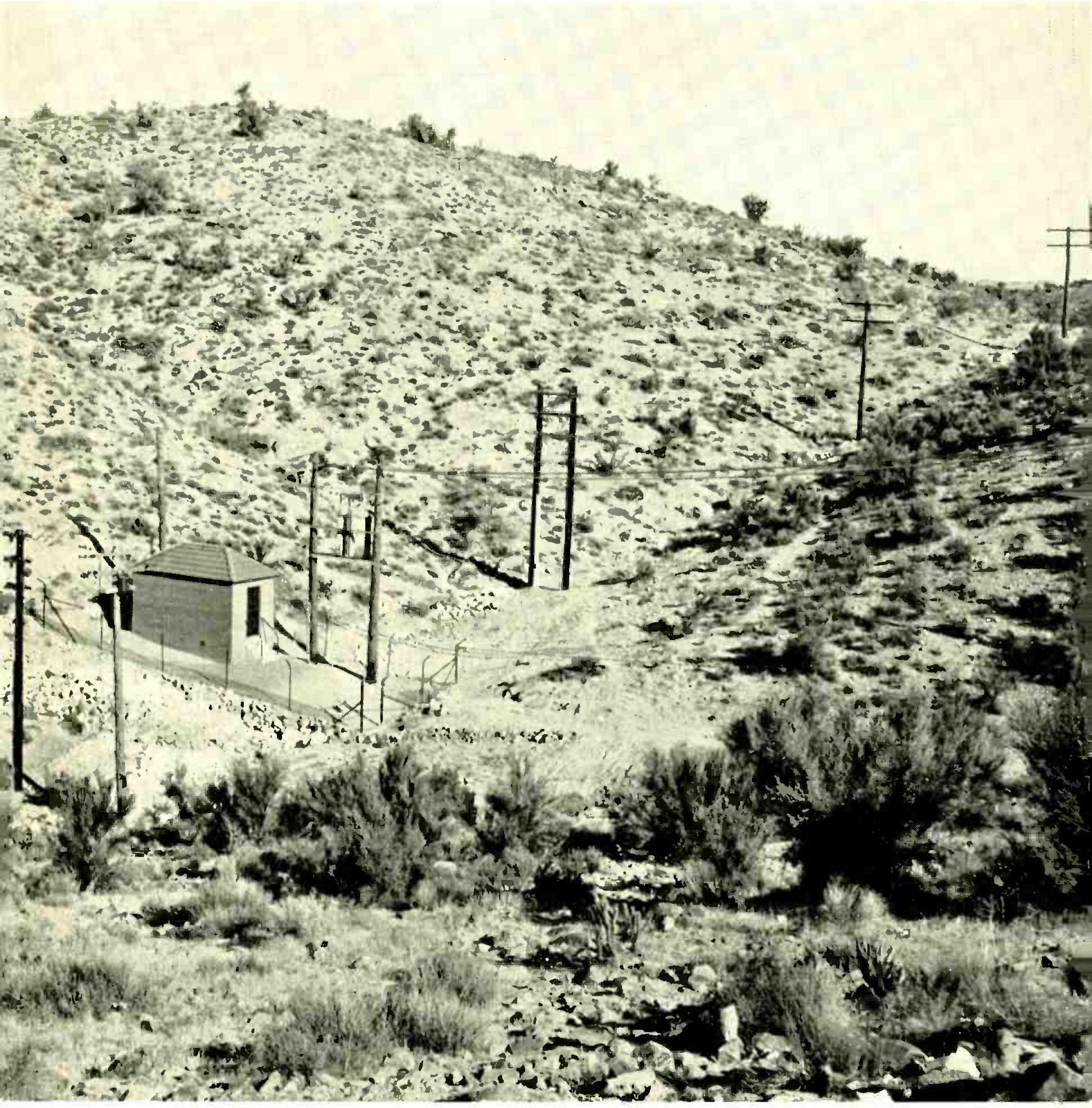


North and south terminal poles at Austin, Texas; the type-J circuits are carried by cables to a filter hut on the other side of the railroad tracks. Photo taken by W. C. Babcock.



A 1500-foot cable crossing of the Loxahatchee River, on the Charlotte-West Palm Beach system, presented unusual loading problems. The cable is the four-wire disc-insulated type. Loading is being adjusted and the cable is being balanced, in this photograph by W. H. Tidd.

Measuring impedance at a point where transmission irregularities were caused by insulation required to protect the wire from lines cast by wayside fishermen. Photo by W. H. Tidd.



Filter hut in the desert near Kingman in western Arizona, on the Fourth Transcontinental Line (Oklahoma City-Whitewater system). Photo by M. Kirkwood, A. T. & T.

Universal Phonograph Reproducer

By H. A. HENNING
Electromechanical Development

A RECORDED voice is tireless, always available when needed, and of constant quality. These characteristics led to an early recognition of its value for telephone testing, but it could not be used for this purpose until the quality of the records and the reproducing system had been radically improved. It became possible in the 1920's when the Laboratories developed its electrical method of recording and reproducing. Not only was there greatly improved quality, but also the possibility of recording such phenomena as electrical interference.

A considerable library of records was then created by the Laboratories for telephone testing and for educational uses. These records were lateral cut on discs; the recording was a spiral groove of constant depth which the needle follows. More recently, further improvements were made by the development of vertical recording.* The higher quality and longer playing time obtainable with records of this type led to a library of vertical-cut records. It became necessary therefore to have reproducers of both types available not only for telephonic purposes but also for the large number of broadcasters who in recent years have been using both lateral and vertical electrical transcriptions in their program broadcasts.

It is inconvenient to change reproducers when records cut by the two methods are selected successively, and a reproducer which would respond with equal facility to either type was obviously desirable. Its development was undertaken by the Laboratories. The idea of a two-purpose reproducer was not new but in previous devices it was necessary to alter their position or change the stylus when going from

*Record, *July*, 1932, *p.* 389.

one type of reproduction to the other. The quality was usually poorer than that of single-purpose reproducers and the problem therefore was to devise one that could be used with either type of record without any adjustment whatever, and would equal the best single-purpose reproducer of each type.

During the early stages of design a reproducer was developed which met all the above requirements, but a field trial disclosed an unexpected difficulty. Some of the lateral records encountered in the field had so much vertical surface noise that it completely blanketed the laterally recorded sound when reproduced by a device which was responsive to both types of motion. Accordingly the original requirements had to be modified and a reproducer, the 9A, developed which would select the desired type of reproduction.

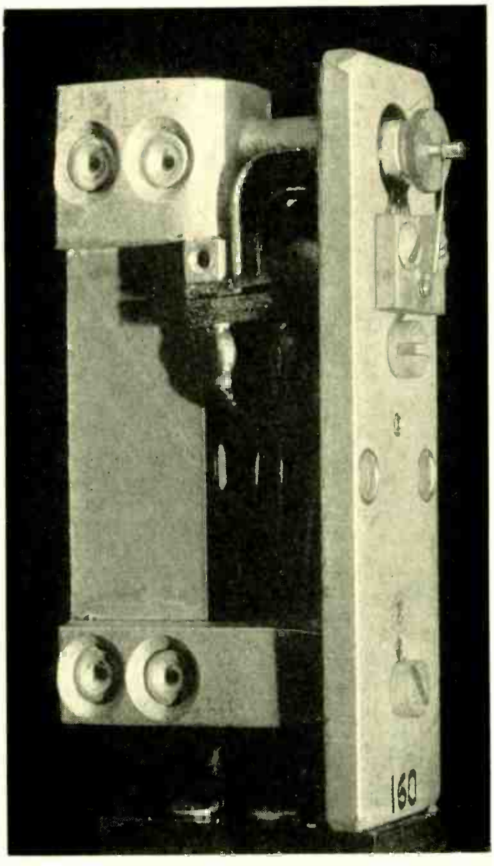


Fig. 1—The 9A reproducer is very small. Its diamond stylus is at the base of a T lever with minute coils on each arm

The external appearance of the Western Electric 9A reproducer and its associated arm are shown in the headpiece. A much enlarged view of the moving element appears in Figure 1. Because the vibrating system is very small, it was designed as a separate unit to be attached as an assembly to the magnetic system. This unit consists of two voltage-generating coils mounted on a duralumin framework, which is supported by two cantilever springs. The fundamental design is the same as that used on straight vertical reproducers.

Two very small coils of insulated wire are wound on a duralumin cup and the four fine lead wires are coiled loosely around miniature terminals located directly above the cup. To achieve flexural strength and proper inertia, these coils are wound in an odd oval shape best suited to fit within the magnetic poles of the reproducer. The coil forms one part of a duralumin cup which is drawn to shape in a complicated series of operations and braced by a minute cross-rib as well as by its own contours. Supporting the moving structure and mounted midway between the two coils is a flat triangular-shaped spring that can readily flex up or down but not sideways because of its wide cross section. This spring restricts all motions of the cup except the straight lift required in vertical reproduction and the rotation required for lateral reproduction. A very small thin duralumin tube is riveted to the cup and to its cross brace so that it also supports the spring. This tube carries a vane of viscous material proportioned to damp out unavoidable high-frequency resonances caused by the elastic properties of the record. Into the other end of this tube is cemented the diamond stylus. The stylus is thus at the base of a T and the coils are at the extremities of its crossarm. One other support, a fine steel wire, connects the stylus end of the T to the frame of the reproducer. This wire flexes readily in any direction but holds the stylus from being pulled forward by the motion of the record.

In operation each coil moves axially in a radial magnetic field. This motion is substantially the same whether the coils are moving vertically or are being rotated from the drive of a lateral-cut record. The only difference in the voltages induced in the coils is a reversal in phase. If the coils are connected series aiding, the voltages in the two coils will add for vertical motion and cancel for rotary motion. When connected series opposing, the voltages due to vertical components are cancelled. This cancellation is not perfect but provides about 20 db of discrimination against the unwanted signal. A switch placed near the turntable changes the connection. At the change-over from one type of record to another, throwing this switch is the only operation required; if this is overlooked at the moment, it can be put right without stopping the record.

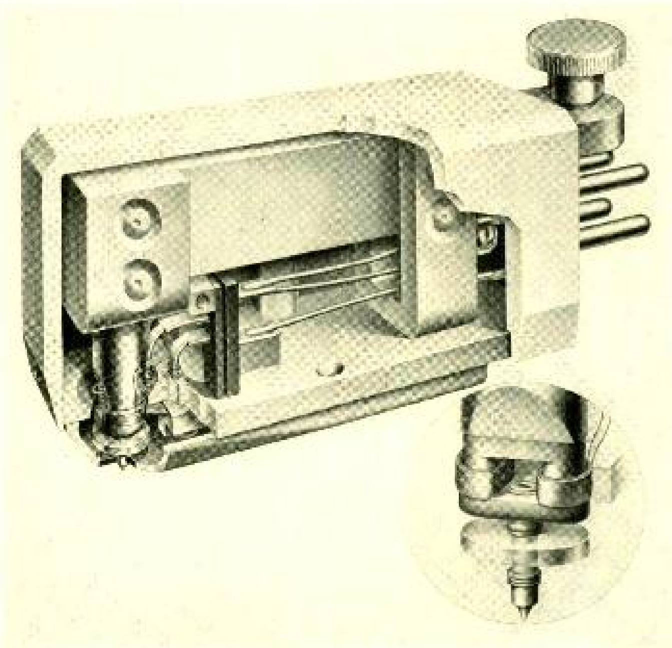


Fig. 2—The two pick-up coils are wound on a duralumin cup. A flat triangular spring between these coils supports them and the stylus. This spring flexes readily up or down but not sideways because of the wide cross section of the coils, thus restricting all motions except the lift required for vertical reproduction and the rotation of lateral reproduction

The magnetic circuit consists of a rectangular bar of magnetic material to which are riveted two soft-iron U-shaped yokes, one of which carries the center pole piece. The two yokes are secured directly to the outside pole plate, which serves as a mounting for the reproducer and for all its elements. A small terminal block and a protective housing surround the center pole piece and guard the lead wires. These details disassembled, and also the shape of the magnetic gap, show clearly in Figure 2. A dust-tight aluminum housing or nose piece prevents dust or dirt getting in the small air gap in which the coil moves; the diamond stylus passes through a molded rubber diaphragm which fits the stylus tightly but flexes readily without hampering its motion.

No matter how faithfully a recording is reproduced, the overall result would be unsatisfactory if there was any very appreciable "surface" noise. This noise, which varies with the material used for the record, consists for the most part of higher frequencies. To decrease its effect, the recording is made through an equalizer that raises the relative amplitude of the higher frequencies. This increases the signal-to-noise ratio of the recorded material, and by being reproduced through an equalizer whose characteristics are complementary to those of the recording equalizer, the higher frequencies are restored to their proper relative values, while the surface noise is decreased by the amount of the equalization.

The characteristics required of the equalizer will depend not only on the material of the record but on whether it is lateral or vertical cut. For the 9A reproducer, therefore, an adjustable equalizer was desirable, and one was developed under the direction of E. T. Mottram. It is known as the 171A repeating coil, controlled by the KS-10066 switch. It serves not only as an adjustable equalizer but as a means of matching the impedance of the reproducer to the input of an amplifying system, which may be 30, 250, 500, or 600 ohms. The equalizer characteristics desired are selected by a rotary-type switch, which is also used to interchange the reproducer connections for vertical or lateral reproduction. These units, the 9A reproducer, the 5A arm, the KS-10066 switch, and the 171A repeating coil form what is known as the reproducing group.

The response of the 9A reproducer, shown in Figure 3, is essentially flat up to nearly 10,000 cycles for both types of records. Most lateral-cut records are recorded at a slightly higher level than vertical records because they are intended for acoustic reproduction. To compensate for this difference in level the 9A reproducer is designed to have greater sensitivity for vertical records and the output volume is thus made approximately the same for both. This 9A reproducer, which has performed excellently both for lateral and vertical service in commercial fields, meets all of the varied requirements of present-time phonograph reproduction.

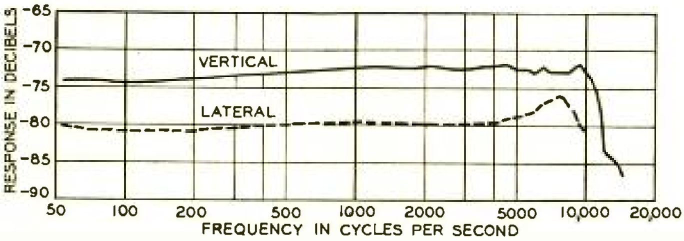


Fig. 3—The response of the 9A reproducer is essentially flat—up to nearly 10,000 *cycles per second. It is made more sensitive for vertical reproduction to compensate for the lower level at which vertical-cut records are usually recorded*

Engineering an Improvement in Panel Clutches

By C. C. BARBER
Dial Apparatus Development

INCREASINGLY important in the Laboratories' work are analyses of existing telephone apparatus and design improvements to secure better and more economical performance. When equipment is originally developed, there are utilized the best technical information and design techniques available at the time. It is often difficult, however, to foresee all possible conditions that may arise over an extensive period of operation. In addition new materials and techniques come into use. It frequently happens, therefore, that a small inexpensive modification some time after the original development will result in very appreciable advantages in the operation and maintenance of the apparatus.

An interesting example is a recent improvement in the clutches which move the elevators of panel selectors. Their essential elements are shown diagrammatically in Figure 1, where the upper sketch shows the clutch released. The cork roll rotates continuously, and the separation between it and the rack and clutch roller indicates that no driving action is taking place. When the magnets are energized, the armature moves up and the clutch roller presses the rack against the cork roll as indicated in the middle sketch. With continued motion of the armature, the pressure of the rack against the cork roll is increased. In the initial adjustment, the reed spring is given a tension away from the roller arm by the lower nut of the adjusting screw; and when the pressure against the cork roll becomes great enough to overcome this tension, a gap begins to open between the roller arm and the end of the adjusting screw. From then on, until the armature strikes the end of the core, the armature and end of the reed spring move up faster than the roller arm, and the pressure on the cork roll can increase only by the added ten-

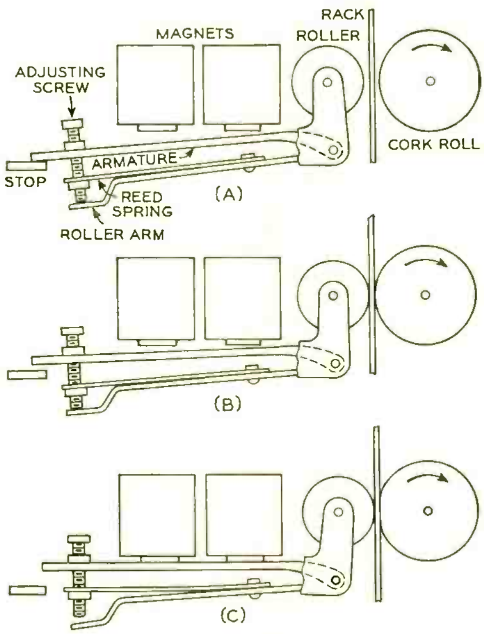


Fig. 1—Diagrammatic representation of the original clutch from the open position, above, to the fully operated position, below

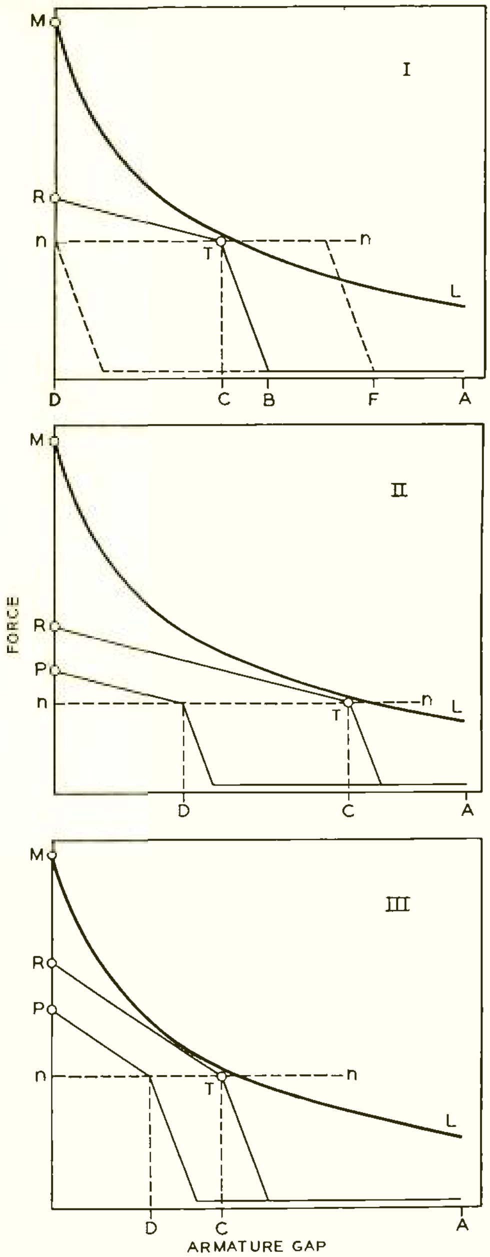


Fig. 2—Force-displacement diagram for the original clutch for various conditions

sion of the reed spring. The completely operated position is shown in the lower sketch.

A force-displacement diagram for the operation of such a clutch is shown in the upper sketch of Figure 2. The curved line represents the available pull of the magnets, which becomes smaller and smaller for larger core gaps. The width of the initial core gap is set by the position of the armature stop, and is indicated by A. During the initial stage of operation, the only load on the magnets is the weight of the armature structure, indicated by the horizontal straight line near the bottom of the graph. At gap B, the rack is pushed into contact with the cork roll, and load builds up rapidly because of the resistance of the cork roll to compression. When the pressure against the cork roll is sufficient to overcome the initial tension of the reed spring, indicated by the horizontal dotted line *nn*, the spring starts to deflect, and the load follows the line TR, R corresponding to the final pressure against the cork roll.

The speed with which the clutch operates depends on the margin between the force available from the magnets and the total load, which includes the force exerted by the reed spring and the pressure against the cork roll. While operating speed is very important, it is not one of the limiting factors in the design of these clutches because adequate speed can usually be obtained with the means available. Control of the releasing speed, however, is very important. The brushes must be stopped accurately on the desired bank terminals, and if the clutch is slow to release, the brush will overthrow. Some overthrow necessarily exists, and is allowed for in timing the release of the clutch, but it must be small. What is particularly important, however, is that this release time remain essentially constant under all types of variations that may occur under normal operating conditions.

When the clutch is fully operated, the force tending to release it is R on Figure 2. The magnets are exerting a force M, however, which is considerably larger, and is mostly absorbed as pressure against the pole faces. When the circuit to the magnet is opened, the magnetic flux must decrease, therefore, to a value equivalent to the force R before the clutch will start to release. The effective opening force will then be the difference between the decreasing force of the magnetic flux and the decreasing opening force, which is a combination of the force of the spring, the pressure of the cork roll, and the weight of the armature.

The gap B, at which pressure against the cork roll begins, varies in service. The rolls flex somewhat under the force of the adjacent clutches, and they change in diameter with temperature and humidity. Moreover, the distance between them and the clutch rollers will change with wear, both of the surface of the roll and of the bearings. Also the thickness of the rack will vary throughout its length, and it will change with wear. In addition the cork roll may be slightly eccentric, resulting in a varying separation from the rack depending on the time at which the clutch is operated. Since all of these factors may affect the position of B, the clutch should be designed to give satisfactory operation even though B occurs at widely different positions. On the other hand, the permissible value for the final pressure R cannot be allowed an indefinite range. Its lowest value must be great enough to give the required release time, and its highest value must be kept as low as possible so as not to produce too great a deflection of the roll or excessive wear on the cork rolls and bearings. Within these limits, the optimum adjustment of the clutch will be that giving the widest range of screw-gap opening. The range in opening pressure should be as small as possible and the range in screw-gap opening, as large as possible.

The earliest point at which the screw-gap may be allowed to open is determined by the intersection of the horizontal line of initial tension, *nn*, and the curve of magnet force ML. If the rack should make contact with the roll at a point, such as F, that would tend to result in the opening of the screw gap before C, the pressure against the roll would become equivalent to the pulling force of the magnet before the initial tension of the reed spring was attained. Movement of the armature would stop where the line F-*n* crossed the curve of the pull of the magnet. Under these conditions, the magnets would not fully operate, and adequate pressure against

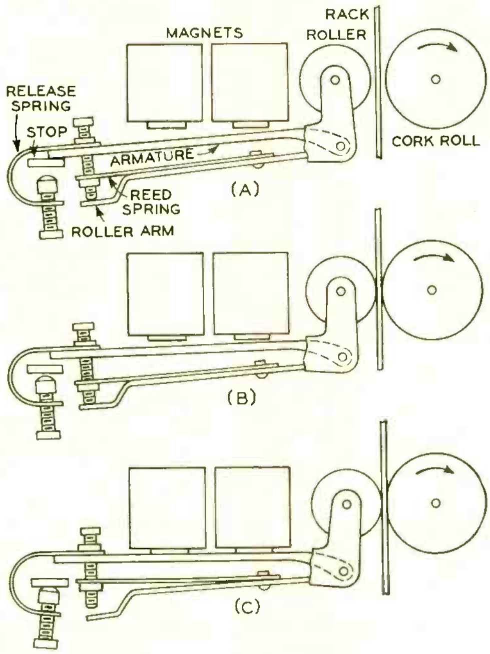


Fig. 3—Diagrammatic representation of the clutch with release spring—open position, above, and fully operated position, below

the roll would never be attained. If *n* is taken as the minimum pressure for satisfactory release, the latest permissible opening of the screw gap

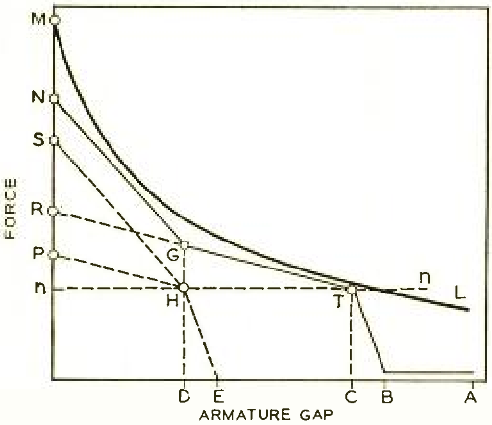


Fig. 4—Force-displacement diagram for clutch with release spring

would be at D, and the range of screw-gap opening would thus be indicated by the distance from C to D.

The two controllable variables affecting the range of screw-gap opening and the range of final pressure are the initial tension of the reed spring, represented by *n-n*, and its stiffness, which is included in the steepness, or slope, of the pressure "build-up" T-R. For the same range in final pressure, the earliest and latest opening of the screw gap, C and D, may be moved to the right or left by lowering or raising the initial tension *n-n*, but the distance between C and D will not be changed as long as the slope of TR remains the same. The screw-gap range C-D may be made wider, however, by decreasing the slope of T-R, and it will be narrowed by increasing the slope of TR. At II of Figure 2, for example, a lower initial tension is used, but the slope of TR is the same as for I. Both C and D are moved to the right, but their separation is the same if the range in final pressure, RP in II, is the same as R*n* in I. At III a steeper slope is used for TR, with the result that for the same distance RP, the range of screw-gap opening, CD, becomes less.

In general the final pressure will be raised or lowered as the initial tension is raised or lowered, but the ratio of the range in final pressure to range in screw gap will not be changed. An increase in stiffness of the reed spring, however, will increase both the final pressures and the ratio of pressure range to screw-gap range, and a decrease in the stiffness of the spring will lower both. These rules, of course,

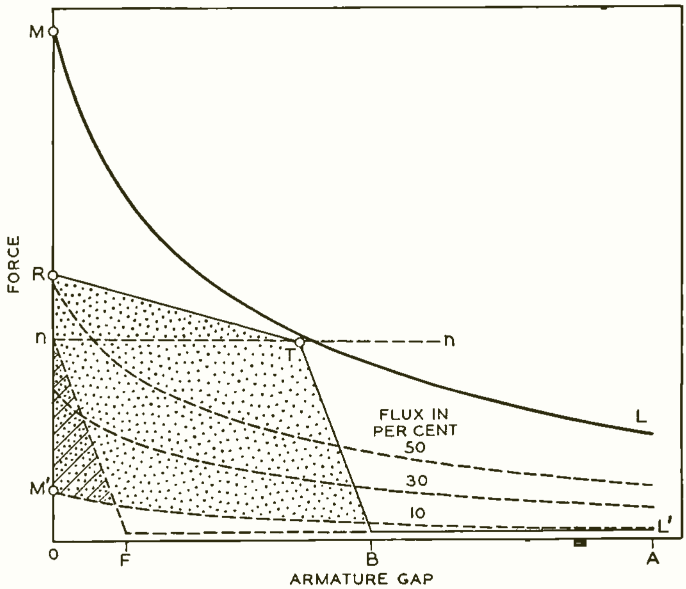


Fig. 5—Force-displacement designed for original clutch with a series of curves to show decreasing magnetic force

assume that RT will not cross the curve ML. A consideration of these factors leads to the use of as weak a spring as possible, and a value of initial tension that will give sufficiently quick release, although the actual adjustment is complicated by a number of factors. The best adjustment, however, will always leave R well below M, and thus leave a considerable reserve of force in the magnet in excess of the releasing load.

Consideration of this fact, and of the general form of the force-displacement diagram, led to the conclusion that more satisfactory operation — particularly more rapid release — could be secured by adding the U-shaped spring shown in Figure 3. This spring is not in action during the first part of the armature travel, but is picked up where the adjusting screw on the end of the spring hits the stop. Up to this point the action of the clutch is the same as without the additional spring, but beyond this point a releasing pressure is built up in the release spring that does not affect the pressure against the cork roll.

The force-displacement diagram would be as shown in Figure 4, where the point of pick-up of the release spring is D. The operating cycle of the clutch up to this point is the same as in II of Figure 2, following the solid line ABTG. The picking up of the releasing spring at this point results in a rapidly increasing load GN, and an opening force N that is well above R of Figure 2. The pressure against the roller, however, remains proportional to R since it is exerted only through the reed spring. As a matter of fact, the final pressure on the cork roll, R, can be made less than in Figure 2, because it is not so essential to quick release, and thus there will be less wear and consequently less maintenance. The potential range of screw-gap opening is wider because the initial tension no longer acts as the minimum opening force, and can thus be made smaller. This will permit the position of C to be moved farther to the right. Also, the releasing time is shorter because of the higher releasing pressures, which range from S to N.

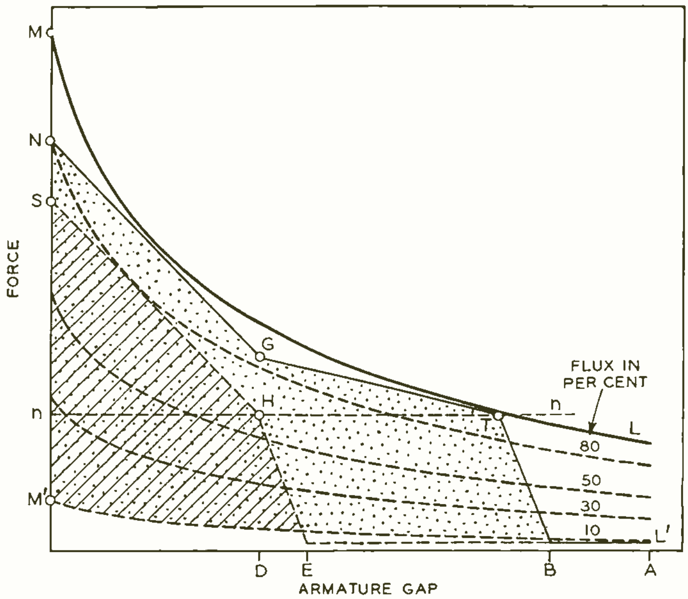


Fig. 6—Force-displacement diagram for clutch with release spring with a series of curves to show decreasing magnetic force

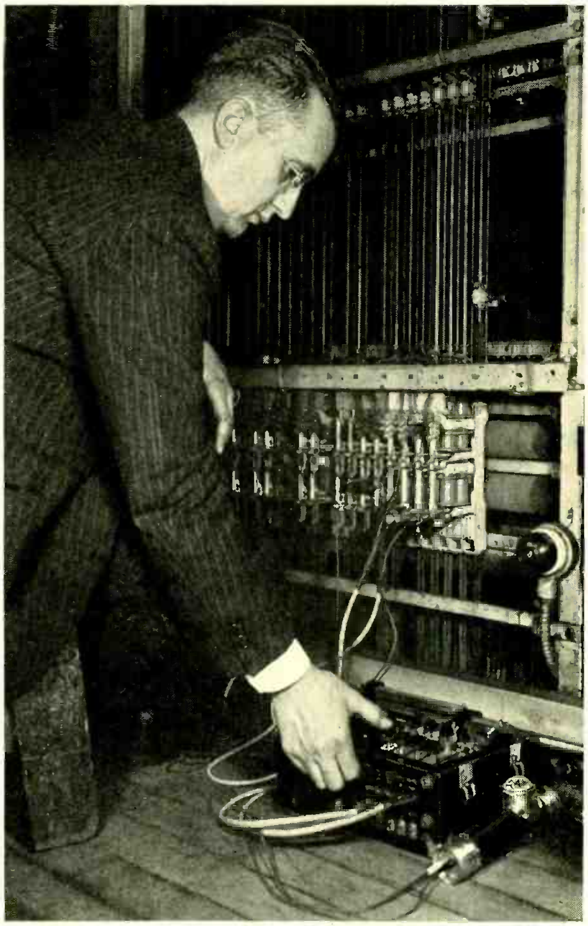
Probably the most important improvement, however, is the decrease in the range of the release time. The release time depends on the releasing force and the time during which it acts. It is thus a function of the area between the curve of releasing force, such as RTB of Figure 2 or NGTB of Figure 4, and the curve of the force of the magnet as it decreases following the opening of the circuit. Figure 5 is a replot of I of Figure 2, but with a series of curves to represent the force of the magnet as its flux decreases after the opening of its circuit. The clutch will not begin to release until the force of the magnet has decreased to R. From here on, the width of the armature opening is given by distance to the right, parallel to the horizontal axis, and the effective releasing force at any instant is the vertical distance between RTB and the curve of magnetic force, which is steadily falling toward the horizontal axis. This force will vary from instant to instant both because of the opening of the armature, which causes the ordinate of the force to move to the right along RTB, and because of the falling of ML. A rough estimate of its integrated effect, however, may be obtained by assuming it to be equal to the area between RTB and some one of the ML curves, say that for ten per cent of original flux. For maximum gap this is the area between RTB and M′L′, while for minimum gap, it is the area between *n*E and M′L′. The difference between these two areas represents approximately the difference in release time for the two extreme gaps, the greatest force area giving the shortest release time.

The equivalent conditions for the clutch equipped with a release spring are shown in Figure 6. The area here between NGTB and M′L′ is much greater than the corresponding area of Figure 5, and thus the release time is shorter. Much more important, however, is that the areas representing the maximum and minimum release times, that is the area between NGTB and M′L′ for quickest release, and that between SHE and M′L′ for slowest release, differ much less than do the corresponding areas of Figure 5. The range in release time is thus much less. To bring out the comparison better, the areas in Figures 5 and 6 for shortest and longest release are shown single and double shaded, respectively.

One of the common causes of unsatisfactory operation with the original clutch was that if a clutch operated before an adjacent one released, its added pressure would increase the deflection of the cork roll and thus reduce the opening pressure for the adjacent clutch, and also reduce the release time. This effect is much reduced with the modified clutches because of the lower pressures on the roll. Another disadvantage of high pressure on the roll is that the elastic reaction at opening is greater; the roll tends to follow the rack even beyond the normal position, and thus extends the driving period and lengthens the release time by the same amount. This effect also is reduced with the modified clutches. Because of the changes made in the clutch, a new maintenance procedure has become possible, as described in an accompanying article (page 67), which gives better results and is more easily carried out.

Testing the Behavior of Improved Panel Clutches

By J. O. JOHNSON
Central-Office Switching Development



IN THE panel system, clutches are used to drive the brush rods up and down over the multiple banks. As described in another article (page 61), these clutches press a flat bronze strip, or rack, attached to the brush rod against a revolving cork roll, which provides the driving power. The essential features of one of these clutches is shown in Figure 1. The armature and the L-shaped bracket called the roller arm are pivoted at the same point. The reed spring, which is fastened to the roller arm near the pivoted end, is linked to the armature through a screw and adjusting nut. Through this linkage, the roller on the roller arm is forced against the rack when the armature is attracted by the magnets, and the rack, in turn, is forced against the revolving cork roll. As the armature is pulled up, pressure is exerted against the roller and a gap is opened between the lower end of the adjusting screw and the roller arm. The pressure exerted by the roller against the rack depends on the width of this gap and on the initial tension in the spring as determined by the position of the adjusting nut.

Once adjusted, this arrangement provides satisfactory driving pressure, but after a clutch has been in service some time, the clutch bearings and the cork roll will wear, so that the clutch armature will have to travel farther before the end of the adjusting screw leaves the roller arm. Another factor which affects the clutch is the contraction or expansion of the cork roll due to changes in humidity. This means that the gap between the adjusting screw and the roller arm varies from season to season and that at times the gap resulting from wear and periods of low humidity is considerably less when the armature has fully operated than it was before, with the result that less pressure is exerted against the rack. Besides reducing the driving pressure, this also decreases the force tending to release the clutch, because the only releasing force besides the weight of the armature and roller arm is the force against the roller. If the clutch does not release promptly, the brush rod will overtravel so that the brush may not be in contact with the proper bank terminals when the rod comes to rest.

Another factor affecting the pressure on the roller is the deflection of the cork roll itself. The deflection caused by the operation of a single clutch is taken into account in the original adjustment, but where two or more clutches are operated simultaneously, the screw gaps may in rare cases be reduced sufficiently to increase the releasing time beyond the safe limits, or to reduce the pressure against the rack to the point where slipping may occur. To insure proper action of these clutches, strict installation and maintenance requirements have been placed on the minimum permissible screw-gap opening, and the conditions under which it is measured have been carefully specified. A long life between adjustments can be obtained only by decreasing the lower limit to which the gap can depreciate or by increasing the gap at the time of adjustment. To increase the gap requires that the rack be brought in contact with the cork roll earlier in the travel of the armature. If this is made too early the force built up against the cork roll will be greater than the pull of the magnet at this wide gap, and the armature will not fully operate. Another factor affecting this upper limit to the gap is that the greater the pressure on the cork roll, the faster will it and the bearings wear. It is these opposing factors that have necessitated rather narrow maintenance limits and the consequent relatively frequent readjustments.

It is now possible to improve these conditions by adding a U-shaped release spring, the design features of which have been described (page 61). This spring, which is shown mounted on the clutch in Figure 2, makes the releasing force largely independent of the force exerted by the roller on the rack. It is attached to the armature by the adjusting nut already on the clutch, and on the other end of the U is an adjusting screw that hits a stop fastened to the frame of the clutch as the armature moves upward. The pressure this spring exerts is changed by moving the adjusting screw shown on the bottom part of the U spring in Figure 2, to vary the point of travel at which it hits the stop.

One benefit of the release spring is that, on the average, the tension of the reed spring is less than that obtained with

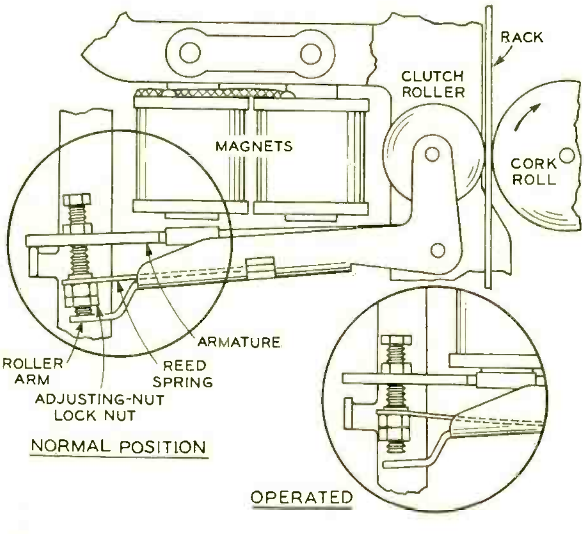


Fig. 1—Arrangement of clutch showing reed spring and adjusting screw

the previous adjustment. The higher reed spring tensions obtained with the previous adjustment resulted in large pressures against the racks with a consequent tendency to produce gradual curvature of the racks. This condition is appreciably improved due to the lower spring tensions. Besides reducing the wear of the clutch bearings and cork roll, lower tensions also result in a decrease in the deflection of the cork roll when a second clutch operates. With lower final pressures on the cork roll, moreover, the operation of another clutch will have less effect, and will therefore be less likely to cause the rack to slip. These considerations make it possible to safely permit the screw gap to become smaller before readjustment of the screw is necessary.

clutch and is set so that a contact is opened and a lamp extinguished when the non-freezing plate on the clutch armature is up against the core of the magnet. A test set is used to adjust the value of current through the

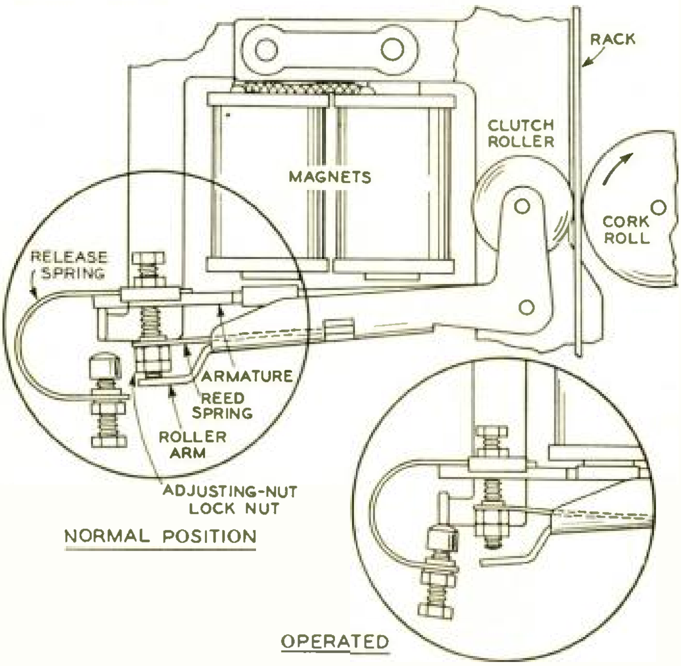


Fig. 2—A clutch equipped with release spring to provide a releasing force regardless of the screw-gap opening

The effect of adding the release spring is indicated graphically in Figure 3, which gives results from measurements on brush overthrow for various screw-gap openings for clutches with and without the release springs. The excess overthrow is entirely eliminated, and in fact the release is so quick that the overthrow is less than for the original adjustment without the release spring.

To facilitate adjustment of these clutches, two electrical gauges have been developed to indicate when the adjustment is correct by the lighting or extinguishing of lamps. One, shown on page 67, clamps on the frame of the winding to the operate and non-operate values, and the release spring adjusting screw is set so that the lamp goes out on the operate current and does not go out on the non-operate current. The other gauge, arranged in a somewhat similar manner, is mounted on the roller arm and used for checking the opening of the screw gap when the clutch is operated. With these two gauges accurate adjustment can be made more easily, and it is possible to check and adjust the clutches with the rack free to move when the clutch is operated and thus to adjust the clutches on a basis comparable to actual service conditions. Heretofore, the rack has been blocked to check the screw gap and the operate and non-operate adjustments.

Each elevator rod on a panel frame is operated by a clutch equipped with

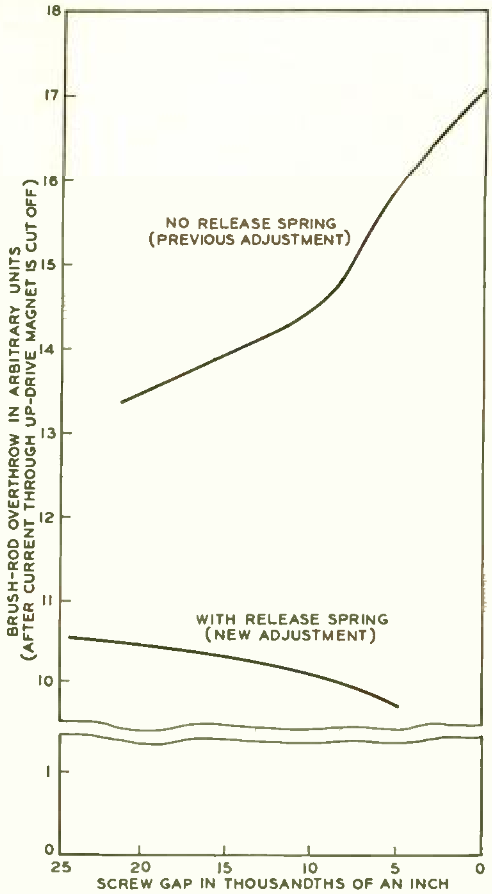


Fig. 3—Brush overtravel for various screw-gap openings with and without the spring

two or three driving units depending on the type of frame. One is used to drive the rod up and one to drive it down, while the third—used only on certain frames—is used with a third cork roll to give a slow-speed up drive. The requirements for the down-drive clutch are much less severe than those for up-drive clutch because the pressure required is very small, and promptness of release is less important. The brush rods will move down under the influence of their own weight, and the down-drive roll is used chiefly as a brake to control the down-drive speed. For this reason the down-drive clutches are not equipped with release springs.

The major advantage of the new arrangement is that the clutch adjustment can depreciate more than twice as much, due to wear, cork roll changes, and other considerations, before the clutch should be readjusted. This is accomplished by adjusting to a wider screw gap which will insure driving the brush rod over a longer interval, and by a greater spread between the electrical values that are used for testing purposes and those used for adjusting.

Another advantage is that the condition of the clutch adjustment can be more easily determined by the new gauges than is possible with the gauges used before. These release springs are intended for attachment only to clutches of the reed spring type. The provision of a release spring for clutches of the helical spring type is under consideration.

The release spring is intended only for use on the up-drive mechanism because the driving action must be more closely controlled in setting up a call than in returning the apparatus to normal. Similar adjustments, based upon having the brush rod in motion when the requirements are being checked, will, however, be applied to both up- and down-drive mechanisms.

Contributors to this Issue

G. W. Cowley was graduated from the University of Nebraska in the early spring of 1930 with the degree of B.Sc. in Electrical Engineering. He was employed by the Lincoln Telephone and Telegraph Company in the fall of 1923. About one year was spent in outside plant maintenance and from that time until he was transferred to the Laboratories in 1930, he was engaged in maintenance work on step-by-step equipment. He is now engaged in development of open-wire carrier terminal equipment in the Transmission Development Department.

H. A. Henning graduated from the Pennsylvania State College in 1926 with the degree of B.S. in Electrochemical Engineering. Joining the Laboratories in the same year, he was associated with the group developing methods and instruments for the recording and reproduction of sound. He was engaged in this work until about two years ago, when he transferred his activities to the development of coin-collector equipment in the Station Apparatus Development Department.

After several years of experience elsewhere in the engineering field, C. C. Barber became associated with the Bell System in 1916, entering the Panel Apparatus Drafting Department at West Street. In April of 1918 he was made supervisor of this department. In 1920 Mr. Barber transferred to the panel apparatus design group. Here a number of his ideas became the subject of patents, notably the method now in current use of attaching springs to centrifugal governors on the cork roll drive, and the oil-circulating pump used on this drive. The use of cork compression discs to take up thermal expansion in the 153-type interrupter is also his idea. Since August of 1930, Mr. Barber has been engaged in the supervision of a group of engineers whose activities are identified with the design of panel and crossbar apparatus. He is also an instructor in the Out-of-Hour course, *Manufacturing Methods*.

After receiving the B.S. degree from Harvard in 1930, R. O. Grisdale joined the Chemical Department of the Laboratories. There, until 1939, he was concerned with investigation of the preparation, structure and properties of varistors, semi-conducting materials and ceramics.

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At that time he transferred to the Physical Research Department where he is now engaged in fundamental studies of microphonic action. His work deals in part with the correlation between the structure and the properties of carbon which are of importance to its use as a microphonic material and as a resistance element for use at high frequencies.

H. I. BEARDSLEY received private instruction in engineering for several years while employed in the drafting department of the Crocker Wheeler Company with which he was associated from 1908 to 1920. In 1916 he received an LL.B. degree from New Jersey Law School but continued in an engineering capacity. In 1920 he joined the Laboratories and for two years prepared apparatus specifications. In 1922 he was transferred, as a supervisor, to the apparatus design group responsible for the design of central office and station keys, and in 1923 he became supervisor of a station apparatus design group. In this latter capacity he has been associated with the design of telephone and subscriber sets, telephone booths, cable terminals, protectors, dial mountings, connecting blocks, etc. More recently his responsibility has been related primarily to the design of the new combined type telephone sets of desk and wall types for both associate and non-associate use.

J. O. JOHNSON spent three months with the Southwestern Bell Telephone Company in the summer of 1926, and after graduating from Kansas State College with a B.S. degree the following year, at once joined the Technical Staff of Bell Laboratories. Here he first engaged in tests and analyses of panel selector circuits, and later in tests and analyses of various problems connected with the operation of the "fundamental" circuit of the panel dial system. He subsequently worked on Bell System Practices, particularly those concerned with the panel and crossbar systems. He also investigated difficulties in the operation of panel clutches, and conducted extensive field trials of the new clutch requirements.