Electrical Drying of Telephone Cable

By L. G. WADE

DRYING equipment has recently been installed at the Kearny Works of the Western Electric Company whereby exchange area telephone cable is heated to a temperature of 270 degrees Fahrenheit by passing direct electric current through the copper wire conductors. Before discussing this installation in detail, however, it might be well first to outline the type of material handled and to review briefly the history of telephone cable drying methods and the reasons for the changes that have occurred.

Telephone cable consists of a number of individual paper ribbon or pulp insulated wires grouped together and the whole then covered with a serving of wrapping paper before being sheathed in lead. Cables may vary in length from a few feet up to several thousand feet, and in number of pairs from 6 to 2121. The size of the wire ranges from 26 American Wire Gauge to 10 American Wire Gauge, with some of the product often containing as many as two or three different sizes of wire in the same cable. One or more cable lengths are wound on a core truck which may be readily moved from one place to another by means of an electric truck.

Early cables were textile insulated and then dried by placing the cores in a heated oven, followed by boiling in a tank containing a sealing mixture or impregnant. The impregnant was used to keep the cable relatively dry in the rather imperfect lead sheath developed at that time. However, with the advent of an improved lead sheath extruded directly on the core, which would guarantee the excluding of any water, it was found desirable to go to a dry paper insulated telephone cable. This change in design reduced capacitance to about one-half of the previous values. The paper insulated cable was dried in a brick oven with gas retorts below a grille floor for maintaining the oven temperature between 215 degrees and 250 degrees Fahrenheit.

This method of drying produced satisfactory results for short-haul cables in use at that time. However, with the possibility of longer lead covered cable circuits replacing open telephone lines, it became necessary to obtain a greater degree of dryness in order to meet the new demand for transmission quality. The toll cables, which were for the longer haul, were therefore given an additional drying after the sheathing operation. This was accomplished by passing calcium chloride dried air at a temperature of 270 degrees Fahrenheit through the heated cable for a period of twenty-four hours. About 1917 the brick ovens were replaced by steam heated vacuum tanks which reduced the drying period to about one-third that used for the brick ovens and very greatly improved the dryness of all types of telephone cable.

Calcium chloride drying of toll cable was continued until 1927. It then became necessary to provide a means of keeping the cable from regaining appreciable amounts of moisture between the vacuum drying operation and lead covering. After considerable investigation a dry core storage room was developed where the dry cable could be held at .3 per cent to .5 per cent relative humidity until ready for covering.[1] With the improvement in vacuum tank drying and with cable stored under such a dry condition until the protective sheath could be applied, transmission quality of the shorter lengths of cable approached the level of the calcium chloride drying while there was some improvement in drying the longer lengths. This change in handling cable resulted in a large reduction in drying cost.

Still further improvements in drying methods have been obtained by heating the cable electrically rather than by radiation from steam coils in the drying chamber. Considerable thought had been given to this method over a number of years and the first unit of equipment was installed experimentally at the Baltimore Works in 1931. This unit has been in successful operation since that time for drying a part of the toll cable output and has furnished most of the data used in engineering the Kearny installation. The choice of the Kearny Plant for the first large scale installation was due largely to reduced operating and maintenance costs. The following discussion covers the type of equipment used in this installation and points out in closing some of the advantages gained in reduced cost and better drying of cable.

In preliminary experimental work on electrical drying a low voltage transformer was used to supply alternating current and the cable rendered non-inductive on its core truck by short-circuiting one end and dividing the other end and attaching to the source of power. However, such a set-up places the full voltage between a considerable portion of the conductors near the clamped ends, a condition not suited for telephone cable. Since, in telephone cable, the conductors are insulated with a thin tube of pulp or ribbon paper, the insulation

[1] Drying and Air Conditioning in Cable Manufacture, J. Wells and L. G. Wade, *Chemical and Metallurgical Engineering*, March 1932.

resistance between wires is low in an undried cable, particularly when moisture is leaving the cable during the drying operation. The choice of direct current not only eliminated the danger of breakdown between conductors (all conductors are grouped in parallel) but simplified the preparation and clamping of the cable for drying. Direct current also makes it possible readily to obtain practically any starting voltage between the maximum and minimum range of the equipment, a requirement necessitated by the great variety of cable lengths.

The electric drying installation at Kearny consists of a motor generator set for supplying the direct current for heating, Fig. 1, control

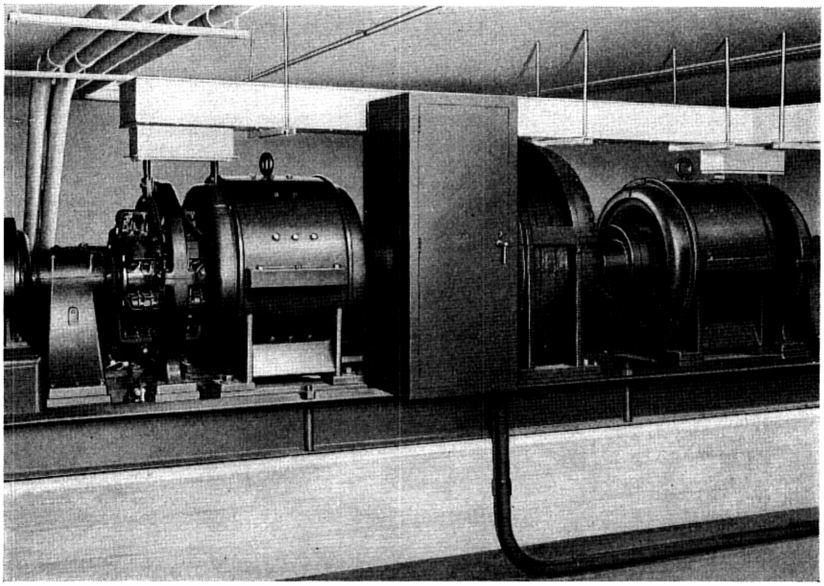

Fig. 1—Power supply set showing two generators for furnishing heating current.

equipment for starting and regulating the motor generator set, Fig. 2, and dome type dryers for holding the cable and its core truck under a vacuum of ½ inch to 1 inch of mercury back pressure during the heating and evacuation period, Fig. 3. A central control panel is located at the dryers on which is mounted apparatus for limiting the heating period to a predetermined amount, as well as visual instruments for indicating information for the operator's use in properly running the drying process.

All cables are dried at the same starting current density per unit of cross-section of the copper wire. With this as a starting point the capacity and type of the motor generator set were determined from the sizes and lengths of cables to be dried, balancing the first cost and efficiency against loss of capacity when handling some cables requiring

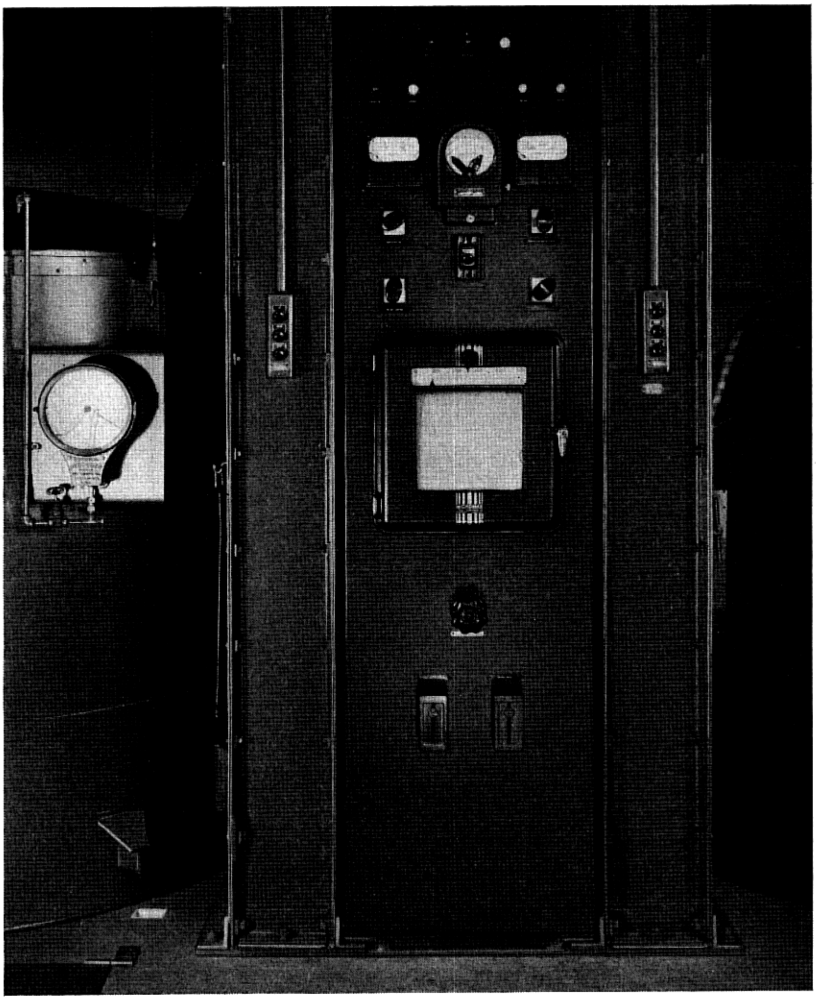

Fig. 2—Control panel for starting motor generator set and controlling the drying operation.

a longer heating period. This latter might be due to too large a cable or too long a length to be heated at the standard rate. In determining the capacity for a fixed starting current density, consideration was given to the cost of equipment, length of heating period and general

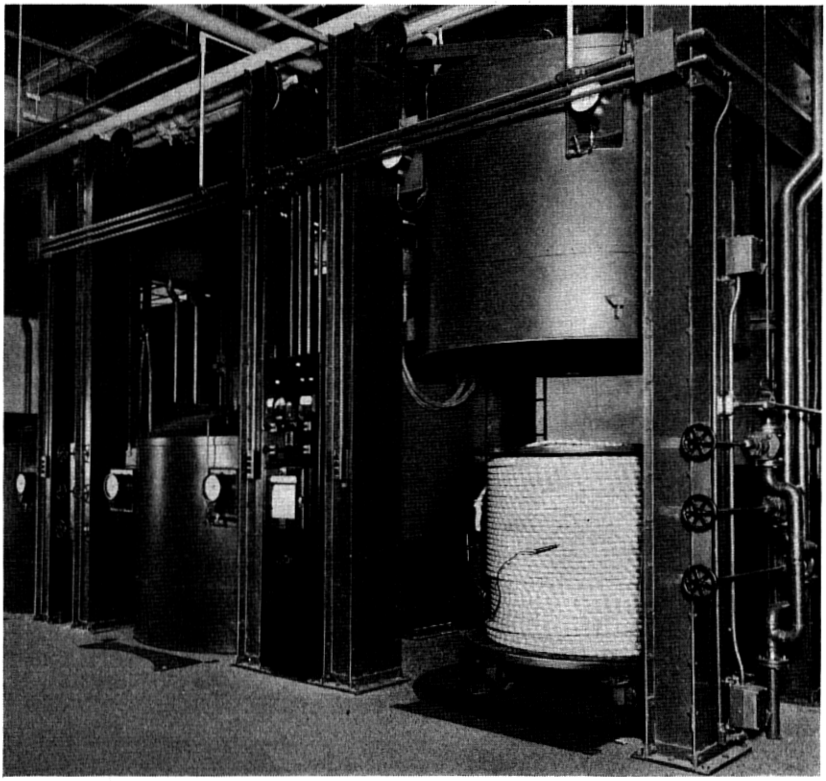

Fig. 3—Dome type dryers for holding cable and its core truck. One dome up, showing core truck in position.

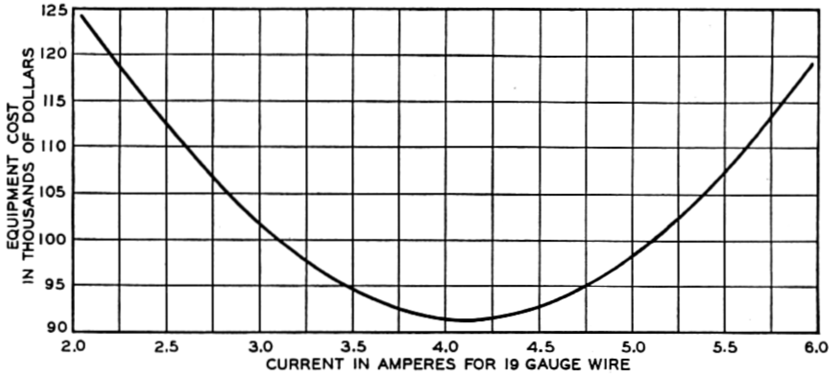

Fig. 4—Curve showing cost of equipment for drying the entire telephone cable output at Kearny Works for various starting current densities for 19-gauge wire or equivalent density for other sizes of wire.

overall efficiency of the drying operation. As shown by the curves in Fig. 4, 4 amperes per 19-gauge wire or equivalent provided about the lowest equipment cost. The heating period under this starting cur-

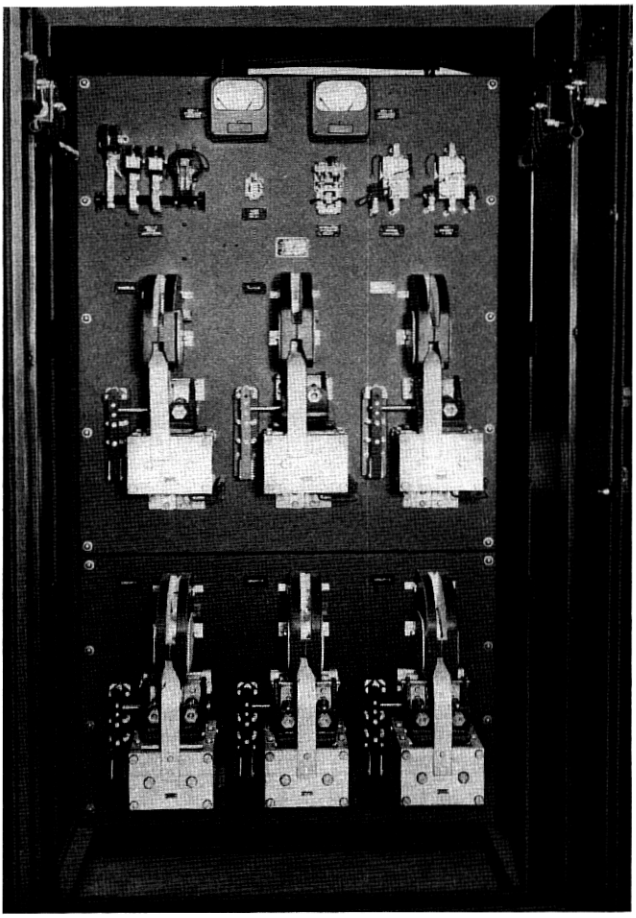

Fig. 5—D-C. power panel. The contactors in the upper row connect the generators either in parallel or in series. The contactors in the lower row connect the power supply to any of three dryers. All contactors are operated by switches on the control panel.

rent density was approximately one-half hour, which fitted very well into the plan for servicing the lead presses with dry cable cores.

In determining the type of equipment it was decided to provide two generators on the set. For the shorter lengths of large cable where low voltage is required, the two generators are operated in parallel. For the long lengths of small cable where higher voltage is required, the generators are operated in series. Suitable switching equipment on the control board provides ready means for changing to either method of operating the generators through large contactors located on the power panel, Fig. 5. Such an arrangement permitted the maximum capacity of the unit to be reduced one-half and the average starting load to be increased to 90 per cent of full load. This not only increased operating efficiency but very greatly reduced installation costs. Three such generating units were provided for handling the entire product at Kearny, one large, one intermediate and one small.

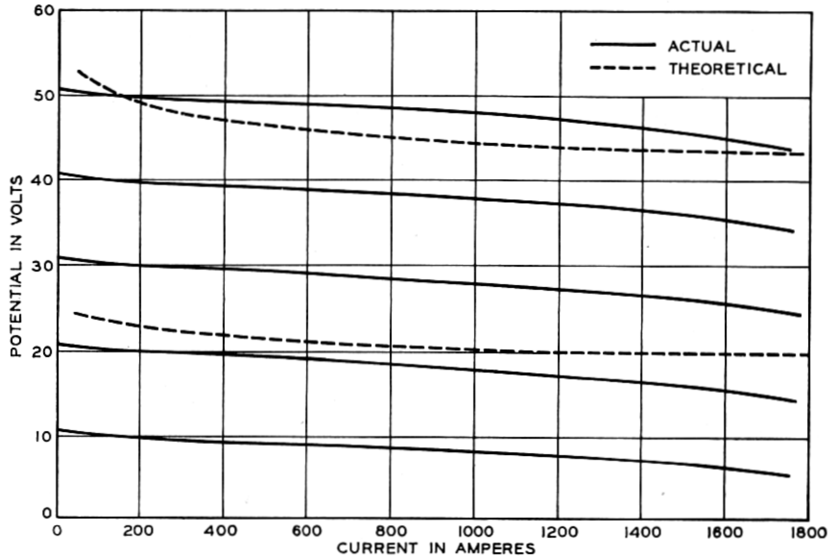

Fig. 6—Curves showing a desired theoretical voltage regulation and actual performance of the d-c. generators.

One of the chief factors contributing to simplification in operating electrical drying is to have the heating period the same for all sizes and lengths of cable. Theoretically, this requires the same voltage regulation at all conditions of the load, from the extreme of high current and low voltage to high voltage and low current. Two such theoretical curves are shown by the dotted lines in Fig. 6. The actual voltage regulation curves for one of the special generators are shown by the heavy lines on the same figure. The maximum amount of variation in the actual voltage regulation for any two load conditions amounted to a change in heating time of approximately one minute. This small difference permits the use of one heating period for all cable as some variation in final temperature is permissible. As will be noted, the generators gave a slightly rising voltage as the current dropped, which contributed to a shortening of the heating period.

The control panel located at the dryers contains switches for starting and stopping the motor generator set, as well as indicating and control equipment for properly conducting the drying operation, Fig. 2. Included in the indicating equipment is a voltmeter and ammeter for showing the potential and current readings for the cable at any time. At the beginning of the heating cycle the operator adjusts the rheostat controlling the field amperage in the generator until the proper voltage is obtained across the cable. This reading is determined from the cable length since the voltage for the specified current density is directly proportional to the cable length. Having established the proper voltage the operator then checks the ammeter for the proper current reading which, in turn, is determined by the size and number of conductors in the cable. To simplify the work, charts are prepared which show the voltage and corresponding starting current for all lengths and sizes of cable to be dried.

As the cable increases in temperature the current falls in direct proportion to the increase in conductor resistance, which in turn is determined by the temperature coefficient of copper (voltage constant). A chart can be used, therefore, to determine the final current for the desired drying temperature. As noted above, the voltage rises slightly as the current falls and the corresponding correction is made in the chart for final current readings for the various sizes of cable.

Such a control by final current readings is all that would be needed if the set were operated manually. However, it is not only more economical to release the operator from watching the ammeter but it has proved advisable for the safety of the product to control the drying cycle automatically. This is accomplished by a time relay and a temperature controller, either of which operates at a predetermined setting to open the field circuit on the direct current generator. The opening of the field circuit operates a signal device to let the operator know that the heating cycle is over so that the next one can be started without delay. The time relay is set from actual experience for a period slightly longer than the required heating time and serves as a protection in case of failure in the heating control circuit. The temperature controller is operated from a thermocouple embedded be-

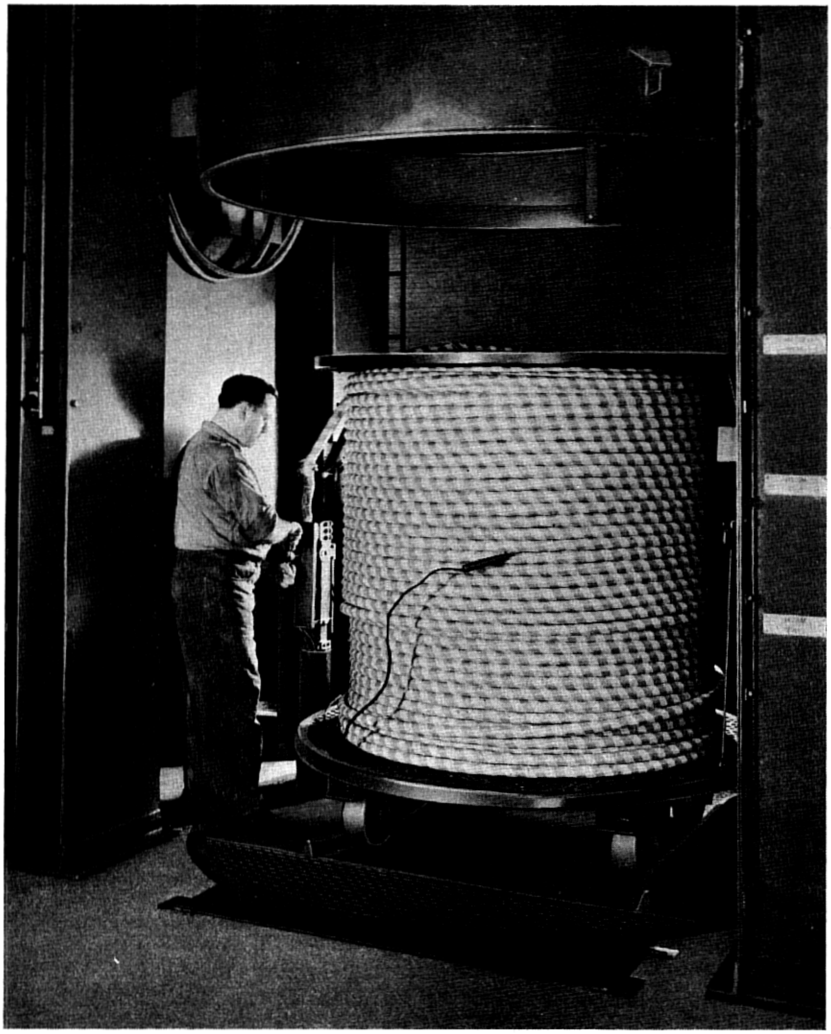

Fig. 7—Close-up of dryer with dome in raised position showing the operator tightening electrode clamp to cable. Thermocouple shown in place between layers of cable.

tween layers of the cable and is set to operate at the final desired temperature.

The drying chamber consists of a dome type shell that can be raised and lowered over a base, Figs. 3 and 7. The base is level with the floor line so that the cable core trucks can be handled readily in and out of the dryer. The dome is fitted with a gasket to provide for sealing with the base during evacuation. Steam coils are also provided inside the dome for keeping the dryer up to temperature during operation and provide a slight amount of heat to the cable during the short electrical heating period. The bus bars, vacuum connections and thermocouple leads enter through the base. The bus bars end in large vise-like clamps for firmly holding the ends of the cable. In the units for drying the larger cables the clamps are water cooled for carrying away the heat due to contact resistance. The core truck and cable are insulated from ground in order to minimize the danger

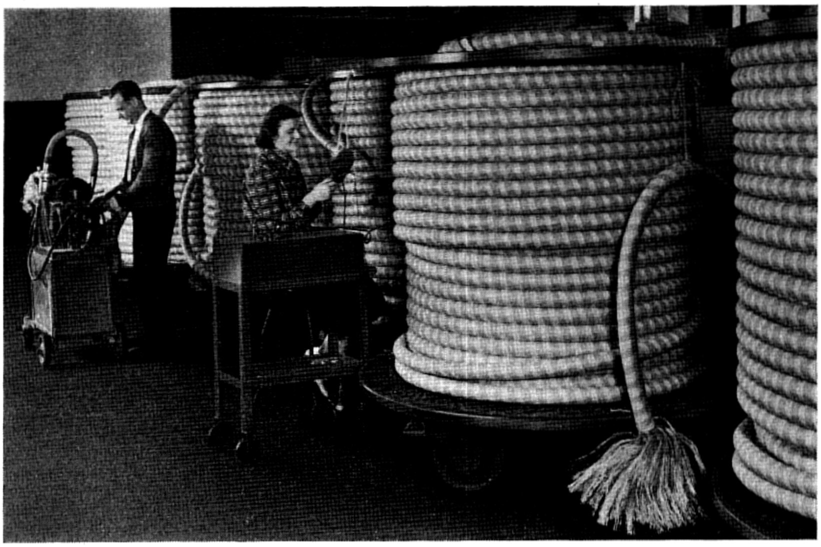

Fig. 8—Removal of paper from cable end and testing of circuits preparatory to drying.

from short circuit should the cable ground on the core truck. The push-button control for raising and lowering the domes is interlocked with the control for the heating cycles so that voltage cannot be applied at the clamp when the domes are up.

For the sizes and lengths of cables to be dried it was found advisable to have three dome dryers to one motor generator set, since all cables need some additional vacuum drying after the heating period is over. This arrangement also permits the removal of the dried cable and the loading of the next cable to be dried while the other two units are in operation. When the current is automatically disconnected at the completion of the heating cycle in progress, the operator turns the rheostat to zero voltage and throws a three-way switch, which connects the set to the next cable to be heated.

In preparing the cable for the regular testing process the insulation is removed from one end for a distance of four or five inches, Fig. 8. After the test shows that the cable is satisfactory for lead covering, the insulation is removed from the other end. At each end the wires are bunched together and tied with cotton string so that the individual wires act together in parallel the same as one large wire. The weight of insulation is sufficiently near enough to the ratio of the wire sizes so that a cable made up of several sizes of individual conductors and their particular insulation will heat satisfactorily by applying heat in proportion to the size of wire.

The electrical drying of cables requires a total of approximately 1½ hours as compared to the process it is replacing, which requires 12 hours or more and necessitates three-shift operation of the vacuum dryers. The short period permits a more rapid turnover of process stock as well as better planning of manufacture. By coordinating the drying and lead sheathing operations cables are lead covered immediately following their removal from the drying tank. The regain of moisture is slight under this condition and therefore the expensive storage oven is unnecessary. As a consequence, the total cost of equipment for the drying operation has been reduced to one-half the former investment value and the floor space from 19,000 square feet to 9500 square feet. Another advantage follows from replacing the continuous three-shift operation by one that operates only in sequence with other operations that may be only on a one- or at most a two-shift basis.

By applying heat to each conductor in proportion to the size of wire, each cable is given an individual treatment which insures a uniformity of drying not possible in the old vacuum tank process. In the replaced system several truckloads of varying amounts of cable were placed in the same vacuum tank and all dried for the same period. It was an averaging process leading to variations in dryness of individual cables and followed of necessity from the fact that a large number of different designs and lengths must be handled each day. To approximate individual handling under such a condition, where the drying period was 12 hours or more, would have involved a large number of dryers and increased floor space and operator-time. Also in the replaced system the layers of cable in the center position on the core truck were not fully up to the temperature of the outer layers, leading to variations in drying throughout the length. Thus, with the tendency in manufacture toward longer and longer lengths on the core truck, the variations in the degree of dryness under the vacuum tank process and the advantages of the electrical drying become more pronounced.