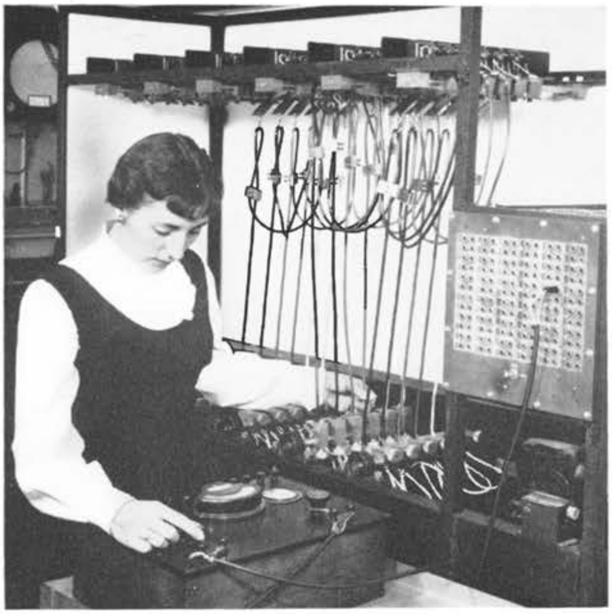

Testing Telephone Cords

W. S. ENO *Station Apparatus Development*

Every time you use the telephone, the cord is stretched, twisted and abraded. The amounts are very small but their cumulative effects can eventually render the cord unserviceable. For this reason, the Laboratories is continually striving to improve the various types of cords, in performance, in length of life and in appearance. Two specially-designed machines are the chief tools used by the engineers who test all types of existing and developmental cords. Cords are pulled, stretched, twisted, kinked, bent and abraded in accelerated tests to determine their serviceability.

How many times have you seen a telephone handset cord, through handling by several different people – some left-handed, perhaps – twisted and kinked until you had to straighten it before you could use the telephone? If your telephone set is on a table, desk, or file cabinet, how many times have you inadvertently closed a drawer on the cord? These are but two of the many things that can happen to a handset cord in normal usage. Add to these the possibility of rain from an open window wetting the cord, heat from a too-close radiator baking it, a dog biting it, a cat scratching it, a dropped handset stretching it, or any one of hundreds of unforeseen occurrences and you begin to realize that a handset cord takes a lot of punishment during its life.

The handset cord is the one with which telephone customers are most familiar, but several other equally important types of cords are used in the Bell System. A mounting cord connects your telephone set to its terminal, operators use switchboard and head telephone set cords, maintenance men use patching and test cords, and there is a group of miscellaneous cords used for special purposes. Western Electric anticipates a total production of all types of cords this year in the neighborhood of 38 million. Of these, over 29 million are handset and mounting cords.

To a casual observer, a telephone cord appears to be merely a piece of flexible cordage with suitable plugs or terminals on each end; actually, it is relatively complex. Much design, development and test work has gone into the construction of each type. The size and type of conductors, the insulating material, the jacket material, the type of terminals, the length of terminating leads, even the size, shape and means of fastening the protective grommet at the end – all these must be considered. The materials used must be strong and stable, so that the cords will be flexible and will withstand years of service without breakage of the conductors or wearing through of the jacket or outer braid, yet the cords must be capable of being easily cleaned and must be pleasing in appearance.

Although a few mounting cords such as those on telephone key-sets having access to several lines,* and perhaps a few other special cords, use stranded wire to achieve minimum size, most cords use what is known as "tinsel" to obtain maximum flexibility together with long life. Several methods of producing tinsel conductors are available, but the most common method is to wrap two bronze alloy ribbons about 0.001-inch thick and 0.020-inch wide around a cotton-thread core. Four or six of these tinsel strands are then twisted together around another cotton core to form a bare tinsel conductor. Usually, the conductor is protected by a knitted cotton barrier before the application of rubber or vinyl-plastic insulation. The required number of insulated conductors are laid parallel and covered with an external neoprene or vinyl jacket. Neoprene or vinyl jacketed "cordage" is manufactured by the mile; when cut to length and finished with the appropriate terminals, plugs and other accessories, it becomes a cord.

Both during the development and afterward, the cords are put through exhaustive tests to determine how they will stand up in service. Although the tests cannot duplicate the normal service life of a cord, special testing machines have been designed to simulate, as nearly as possible but at greatly accelerated rates, some of the things that can happen to cords. These same testing machines and methods are also used in the continual search for better materials. While these laboratory tests cannot simulate all the different kinds of wear and abuse cords receive, they give a good indication of the relative merits of various types of cord and conductor construction. Supplementing these tests, field trials are held in typical heavy-traffic locations in large and medium-sized cities, and also in hot, humid locations. Cords to be used on coin telephone sets are usually placed on trial in busy locations such as are encountered in railroad stations and subway stations.

Two machines have been designed and built to test these cords, one for wear and abrasion of the jackets and braid, and the other, a bending machine, for evaluating conductor life. In the machine shown in Figure 1, several transverse bars located on different vertical levels are alternately moved toward one end of the machine and then the other. One end of each cord to be tested is fastened to one of the bars, and the other end is either left free or attached to a spring-loaded tension indicator. Although sometimes called a "kinking" machine, it is used to test resistance of cords to abrasion. Cords with one end free can be dragged across different types of materials, such as wood, to simulate the edge of a desk, to test abrasion of the jacket. Retractile cords are tested for abrasion in a similar way, except that both ends are clamped.

When one end is attached to the indicator, a cord can be alternately put under tension and released. For retractile cords, this simulates the stretching occurring in normal service. For straight cords, each cord is given a sufficient number of twists to make it "kink" into various shapes before it is placed in the machine. A specified length of cord is used and the number of twists is adjusted so that the machine applies the same maximum tension to all cords under test. The indicator shows how many ounces of tension are being applied. This test combines tension with abrasion, subjecting the cords to two types of strain at once.

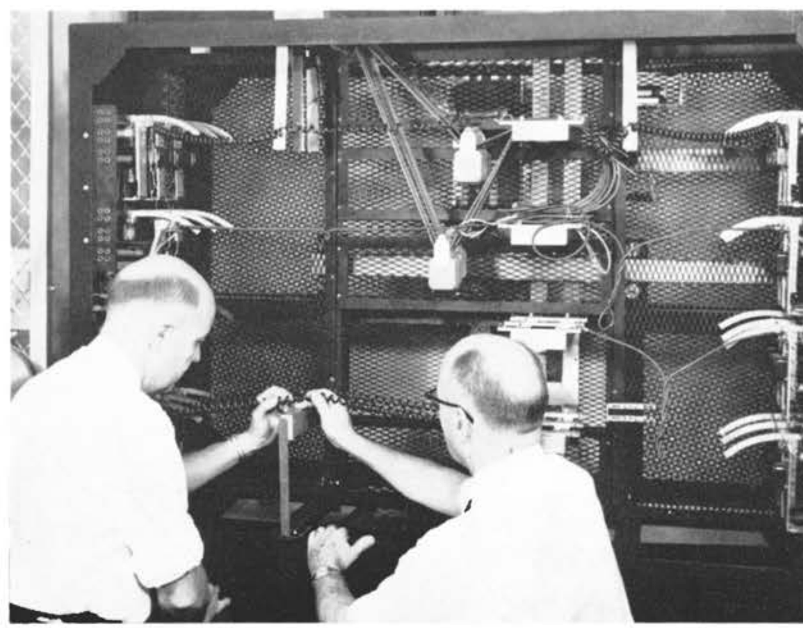

Fig. 1 — The author (left) and C. A. Webber examine a retractile cord being tested for abrasion.

This machine, then, is used primarily to test abrasion and the resulting wear of jackets and braids, as opposed to the bending machine, which evaluates conductor life. A check of conductor life is maintained during wear abrasion tests, but conductor performance is usually still satisfactory when the abrasion test indicates failure of the jacket.

* RECORD, *June*, 1940, *page* 315.

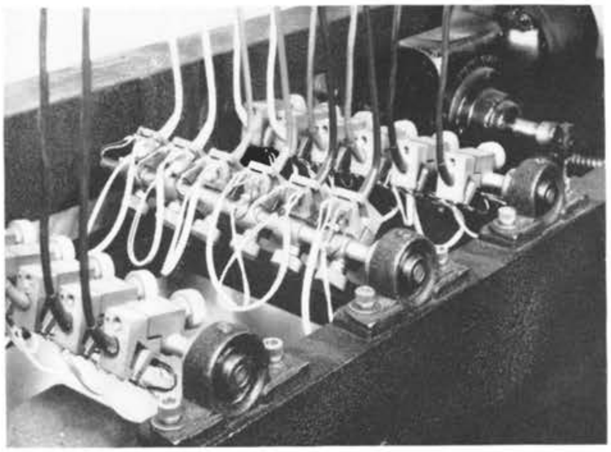

Fig. 2 — Close-up of the bending machine showing cord holders that are employed.

The "bending" machine, shown in the headpiece, simulates the use a cord gets in service. A metal cord holder shaped to exactly duplicate the entry hole holds the handset end of the cord, Figure 2. The cord holder is mounted on a motor-driven shaft, so arranged that the cord must bend from side to side as the cord holder rotates 90 degrees in each direction from normal. About two feet above the cord holder, the other end of the cord is attached to a metal spring that applies tension to a section of the cord. A weight, usually one pound, is hung from one of the springs to give a standard spring deflection, and the cord length is adjusted to give that spring deflection at each extreme of rotation of the cord holder. The cords under test are flexed through a complete 180-degree cycle at the rate of 36 times a minute. The bending machine also tests the serviceability of the protective grommet associated with the cord.

Cords are placed in the machine with a predetermined twist, either right or left. A line marked on the untwisted cord indicates the direction and amount of twist when the cord is in the machine. Although this simulates the twisting a cord may be subjected to in normal service, it cannot give the final answer as to the best construction for all conditions, since there is no way to predetermine in which direction a customer will twist the cord. This is where the Laboratories' supervised field trials play an important part. In addition, detailed examination and study of other cords removed from service and sent to the Laboratories present a good opportunity to determine how cords could be improved for longer service. As with the other test machine, the conductors are electrically checked during the bending test.

To check for conductor life, the two conductors of each pair are connected at the end attached to the moving part of the machine being used. The other ends are brought out through a plug and cable to a test panel where a Wheatstone bridge can be connected across the pair that is to be tested.

After a given number of bends or stretches, as the case may be, the machine is stopped and the bridge is balanced with the cord serving as one of the bridge arms. Physical manipulation of the cord will then indicate any variations in resistance of the cord. The meter of the bridge is calibrated in fractions of an ohm, and variations indicated by the meter result from resistance changes that may be heard as cord "noise" in a telephone receiver. The number of test machine operations before the noise exceeds a predetermined amount gives a relative measure of the conductor life.

THE AUTHOR

WILBER S. ENO received his degree in Mechanical Engineering from Rensselaer Polytechnic Institute in 1935 and joined the Laboratories early the following year. His work has been primarily in the field of station apparatus development on such items as combined telephone sets, explosion-proof telephone sets, and other customer apparatus. He also engaged in the engineering and design of telephone sets, headsets and loudspeakers for the Armed Forces. From 1938 to 1942, Mr. Eno was a member of the Quality Assurance Department, including an assignment to Cleveland as Assistant Field Engineer. He also spent the years from 1945 to 1948 in Quality Assurance, working with teletypewriter apparatus. From 1948 to 1956 he was engaged in the design of all types of telephone cords. In January, 1956, he transferred to the Laboratories location at Indianapolis where he is now engaged in the design of telephone sets. Mr. Eno is a licensed Professional Engineer and a member of Sigma Xi.