DEPARTMENT OF COMMERCE

CIRCULAR

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 37

ELECTRIC WIRE AND CABLE TERMINOLOGY

[2d Edition]
Issued January 1, 1915

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ELECTRIC WIRE AND CABLE TERMINOLOGY

INTRODUCTION

In every art a body of terms becomes established by gradual growth, describing the materials and usages of that particular art. Generally the terms used are common words, and in their new application they retain much of their original significance but are invested with additional technical meanings. If words are employed with meanings inconsistent with their usual meanings, the technical terminology of a subject may become confused. Confusion is especially likely to arise when the technical meanings have grown up without any unifying influence, as when different manufacturers define their terms independently of one another.

The electrical arts have developed with great rapidity, and a new terminology has grown up simultaneously. Terms have sometimes been given electrotechnical meanings, based chiefly on local or individual practice. It is fortunate, and indeed remarkable, that greater confusion has not resulted; for this, credit is largely due to the national electrical engineering societies, which have done much to standardize the terminology pertaining to electrical machinery. However, no serious effort has been made to systematize the nomenclature of electrical wires and cables, and in this branch of the electrical arts some confusion of terminology still remains. On this account misunderstandings have sometimes occurred between manufacturers and purchasers of wires and cables. Recently an effort has been made to standardize this terminology. The Standards Committee of the American Institute of Electrical Engineers, assisted by certain engineers[1] not members of the committee, have investigated the subject, and the result has been that the Bureau was requested to prepare this circular. The Standards Committee furnished the Bureau with the information it had gathered, and the Bureau has since consulted with numerous persons and companies concerned. Several different sets of definitions proposed by those interested in the subject have been compared, and the best ideas contained therein utilized.

The main purpose of this circular is to set forth a standard set of definitions of the principal terms involved. The investigation and correspondence upon which the circular is based have resulted in securing a very nearly

[1] Special acknowledgment is due to Mr. W. A. Del Mar, who took the initiative in this movement.

unanimous agreement upon these principal terms. Few departures from existing general practice are proposed, and yet a reasonably consistent body of definitions has been formulated. However, in the case of certain of the terms there has been in the past considerable variation in usage. The list of definitions recommended herein does not of course include all the styles of wires and cables that are manufactured, and it is not thought desirable to attempt to extend the list to cover all the ramifications of conductor terminology. Some latitude is possible in applying the principal terms as given here, but if the definitions given are carefully followed it is believed that the subsidiary terms will in general take care of themselves and the greater part of the confusion will disappear.

DEFINITIONS

The definitions, together with the remarks, given below, are intended to be sufficiently explicit so that no mistake will be made in their use. Being descriptive, the definitions do not follow one another with the direct sequence of geometrical propositions. They form, however, as logically consistent a group of definitions as it has been found possible to frame, without departing too much from actual practice.

The technical meanings of most of the terms are not far from the original common meanings of the words. In attempting to formulate satisfactory definitions of the various terms, especial difficulty has been found in securing agreement upon the words *strand* and *cable*. Some manufacturers use the word "strand" for what others call a completed single-conductor "cable," and it was found extremely difficult to formulate satisfactory definitions if this usage were continued. A great many persons consulted have agreed that "strand" implies to them a component part of a cable, or a single wire of a stranded conductor, and it fortunately happens that this is precisely in accordance with the common or nontechnical meaning of the word. This is shown by the following definitions of "strand" which are quoted from Webster's, the Standard, and the Century Dictionaries:

Webster's New International Dictionary, 1910:

Any of the three or more twists, or strings, of which a rope is made; also, a single filament or string.

Standard Dictionary, 1910:

1. One of the principal twists or parts of a rope, consisting of fibers, yarns, or wires twisted together.
2. Hence, a fiber, hair, filament, string, small cord, or the like.

Century Dictionary and Encyclopedia, 1902:

1. A number of yarns or wires twisted together to form one of the parts of which a rope is twisted; hence, one of a number of flexible things, as grasses, strips of bark, or hair, twisted or woven together. Three or more strands twisted together form a rope.
2. A single thread, a filament; a fiber.

The definition of the word "strand" in electric terminology, as given below, is in agreement with these definitions. That is, a strand is one of the component parts of a stranded conductor, each part being either a single wire or a combination of wires. If the latter, then each wire of the combination is itself a strand of the composite strand, the principal idea in the word "strand" being that it is a component part of a larger unit.

The following definitions are in accordance with this idea of a strand, which, as stated above, is the meaning understood by a majority of those consulted. Explanatory remarks are given in connection with the definitions, and in the following pages the terms are applied to a variety of electrical conductors to illustrate their use and to test their consistency.

DEFINITIONS AND EXPLANATORY REMARKS.

1. Wire.—A slender rod or filament of drawn metal.

The definition restricts the term to what would ordinarily be understood by the term "solid wire." In the definition, the word "slender" is used in the sense that the length is great in comparison with the diameter. If a wire is covered with insulation, it is properly called an insulated wire; while primarily the term "wire" refers to the metal, nevertheless when the context shows that the wire is insulated the term "wire" will be understood to include the insulation.

2. Conductor.—A wire or combination of wires not insulated from one another, suitable for carrying a single electric current.

The term "conductor" is not to include a combination of conductors insulated from one another, which would be suitable for carrying several different electric currents.

Rolled conductors (such as bus-bars) are, of course, conductors, but are not considered under the terminology here given.

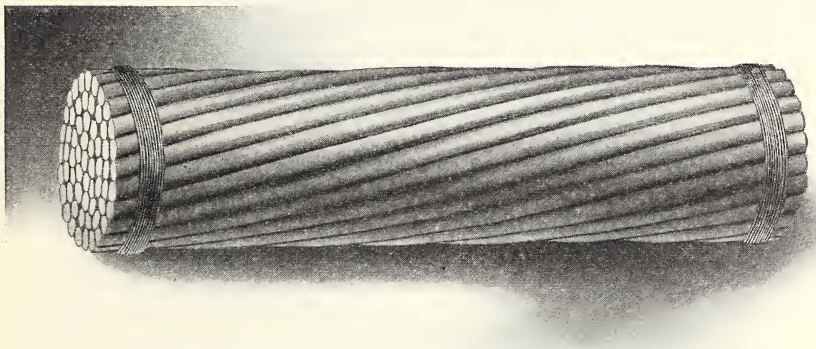

Fig. 1.—*Bare stranded conductor; or, bare single-conductor cable*

3. Stranded Conductor.—A conductor composed of a group of wires or any combination of groups of wires.

The wires in a stranded conductor are usually twisted or braided together.

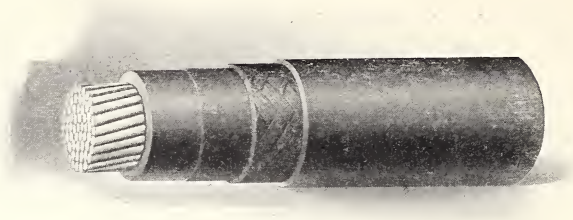

Fig. 2.—*Insulated stranded conductor; or, insulated single-conductor cable*

4. Cable.—(1) A stranded conductor (single-conductor cable); or (2) a combination of conductors insulated from one another (multiple-conductor cable).

The component conductors of the second kind of cable may be either solid or stranded, and this kind of cable may or may not have a common insulating covering. The first kind of cable is

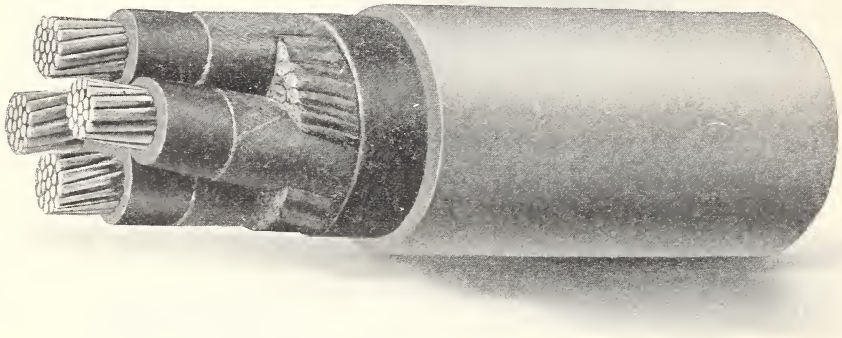

Fig 3 —*Multiple-conductor cable*

a single conductor, while the second kind is a group of several conductors. The term "cable" is applied by some manufacturers to a solid wire heavily insulated and lead covered; this usage arises from the manner of the insulation, but such a conductor is not included under this defini-

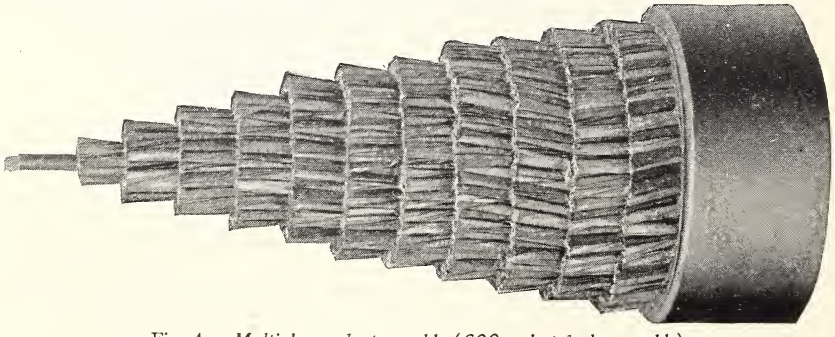

Fig. 4.—*Multiple-conductor cable (600-pair telephone cable)*

tion of "cable." The term "cable" is a general one and in practice it is usually applied only to the larger sizes. A small cable is called a "stranded wire" or a "cord," both of which are defined below. Cables may be bare or insulated, and the latter may be armored with lead, or with steel wires or bands.

5. Strand.—One of the wires or groups of wires of any stranded conductor.

(See remarks and definitions on p. 4.)

6. Stranded Wire.—A group of small wires, used as a single wire.

A wire has been defined as a slender rod or filament of drawn metal. If such a filament is subdivided into several smaller filaments or strands, and is used as a single wire, it is called a "stranded wire." There is no sharp dividing line of size between a "stranded wire" and a "cable." If used as a wire, for example in winding inductance coils or magnets, it is called a stranded wire and not a cable. If it is substantially insulated, it is called a "cord," defined below.

7. Cord.—A small cable, very flexible and substantially insulated to withstand wear.

There is no sharp dividing line in respect to size between a "cord" and a "cable," and likewise no sharp dividing line in respect to the character of insulation between a "cord" and a "stranded wire." Rubber is used as the insulating material for many classes of cords.

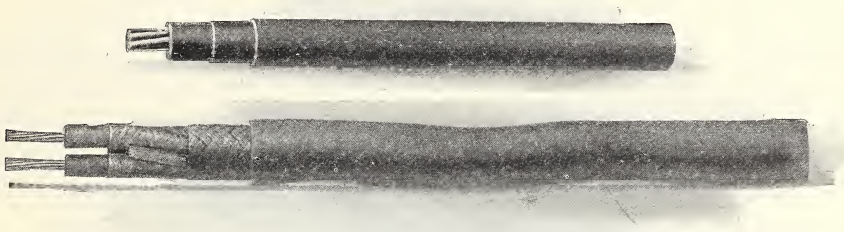

Fig. 5.—*Cords*

8. Concentric Strand.—A strand composed of a central core surrounded by one or more layers of helically laid wires or groups of wires.

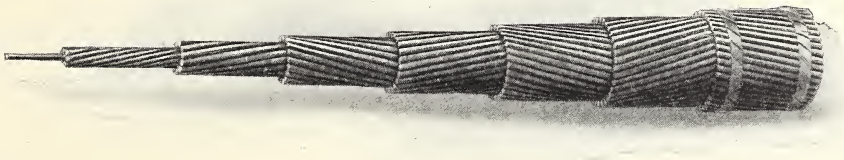

Fig. 6.—*Bare concentric-lay cable*

9. Concentric-Lay Cable.—A single-conductor cable composed of a central core surrounded by one or more layers of helically laid wires.

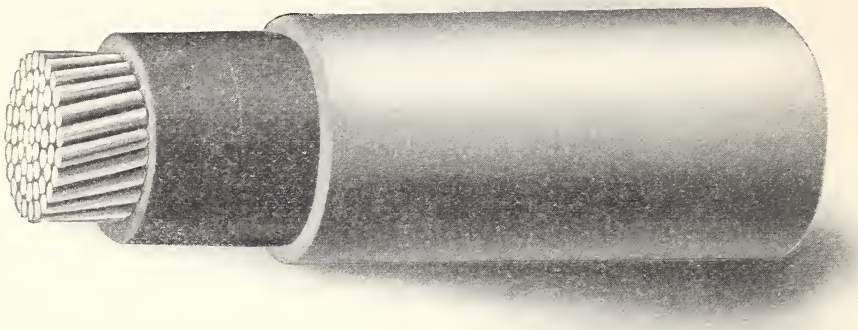

Fig. 7.—*Lead-covered, rubber-insulated, concentric-lay cable*

10. Rope-Lay Cable.—A single-conductor cable composed of a central core surrounded by one or more layers of helically laid groups of wires.

This kind of cable differs from the preceding in that the main strands are themselves stranded.

Fig. 8.—*Bare rope-lay cable*

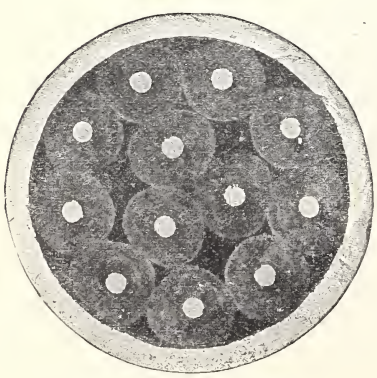

Fig. 9.—*12-conductor cable*

11. N-Conductor Cable.—A combination of N conductors insulated from one another.

It is not intended that the name as here given be actually used. One would instead speak of a "3-conductor cable," a "12-conductor cable," etc. In referring to the general case, one may speak of a "multiple-conductor cable" (as in definition No. 4, above).

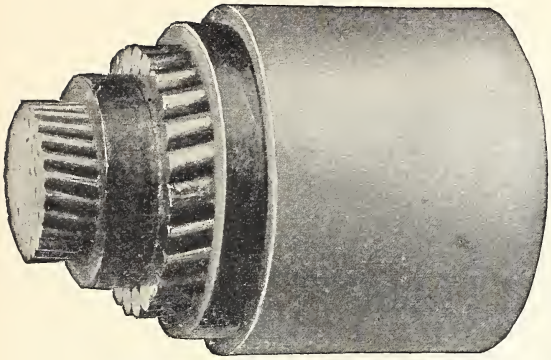

Fig. 10.—*2-conductor concentric cable*

12. N-Conductor Concentric Cable.—A cable composed of an insulated central conducting core with (N-1) tubular stranded conductors laid over it concentrically and separated by layers of insulation.

This kind of cable usually has only two or three conductors. Such cables are used in carrying alternating currents. The remark on the expression "N-conductor" given for the preceding definition applies here also.

13. Duplex Cable.—Two insulated single-conductor cables twisted together.

They may or may not have a common insulating covering.

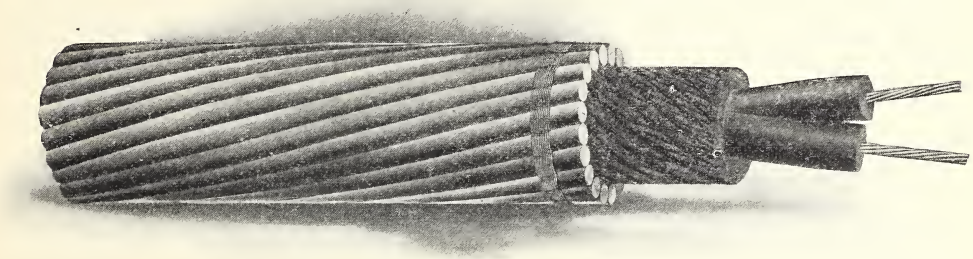

Fig. 11.—*Armored duplex cable*

14. Twin Cable.—Two insulated single-conductor cables laid parallel, having a common covering.

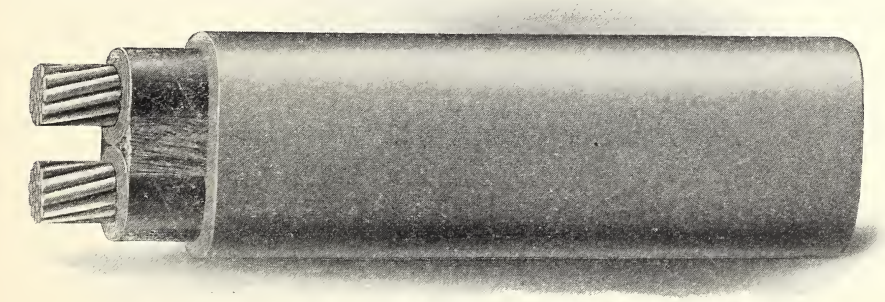

Fig. 12.—*Twin cable*

15. Triplex Cable.—Three insulated single-conductor cables twisted together.

They may or may not have a common insulating covering.

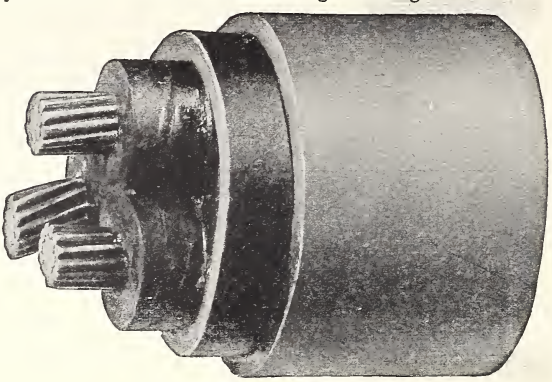

Fig. 13.—*A triplex cable*

16. Twisted Pair.—Two small insulated conductors twisted together, without a common covering.

The two conductors of a "twisted pair" are usually substantially insulated, so that the combination is a special case of a "cord."

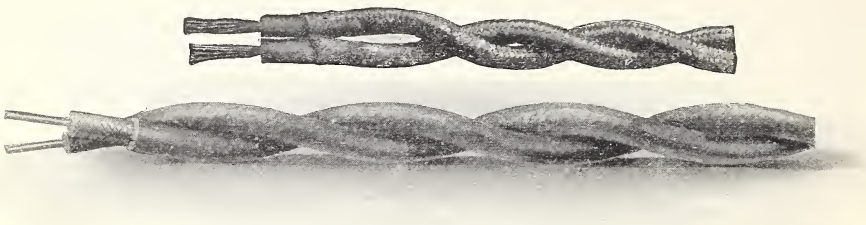

Fig. 14.—*Twisted pairs*

17. Twin Wire.—Two small insulated conductors laid parallel, having a common covering.

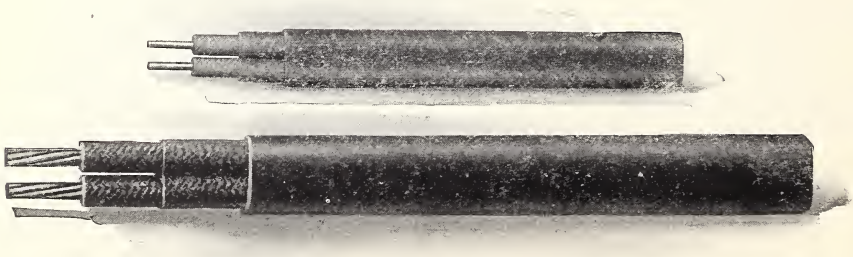

Fig. 15.—*Twin wires*

ILLUSTRATIVE DISCUSSION

The following discussion is given merely to bring in the various terms and illustrate their proper use by means of the context.

Electric *cables* are used for a great many purposes, such as the transmission of electric power, the conduction of telephonic and telegraphic currents, etc. In some cases a cable carries a great many separate currents, and in some cases only a single current. The use of a cable in the transmission of a single current is in general restricted to the cases where the current is large. This requires a large *conductor*, which for practical reasons is *stranded*. It may be either a single group of solid *wires*, or it may have a more complex structure. A seven-*strand* cable may be a single conductor made up of seven solid wires, or a single conductor made up of seven groups of wires, or a combination of seven conductors insulated from one another. In the latter case, each of the seven strands may be either solid or itself stranded. When one of the strands of a conductor is composed of more than one wire, each element of the strand is also called a strand. Stranded conductors are very commonly formed of *concentric strands*, which consist of a central core surrounded by one or more layers of helically laid wires. If used as a completed cable, such a conductor is called a *concentric-lay cable*. Such a group may be combined with others in the same way in which the wires are combined in the group, thus forming a concentric strand composed of elements each of which is a concentric strand. If a concentric strand so formed is used as a completed cable, it is known as a *rope-lay cable*.

In the long-distance transmission of power, overhead bare cables of copper or aluminum are extensively used. For underground conduit transmission, cables are heavily insulated and protected by a covering of lead. The insulation may be rubber, varnished cambric, paper, or special compounds. Single-conductor cables of this kind are frequently used for direct current mains. For single-phase alternating service *duplex cables* are in considerable use. Flat *twin cables* are most convenient and cheapest where the cable is not unusually large. For alternating currents, two-conductor and *three-conductor concentric cables* are in great favor. Cables that are to be buried in the earth or used under water have a jute and asphalt covering over the lead, and over that an armor of steel wires or band steel.

Telephone and telegraph cables consist of many wires, each separately insulated with paper, fiber, or rubber, the whole having a light insulating wrapping and a lead sheath. The size of the wires used is more or less standardized, so the size of the cable is roughly indicated when the number of wires is stated, as, e. g., when one speaks of a *200-conductor cable*. In a telephone cable the wires are twisted together in pairs.

There are, of course, many special kinds of electric cables, for which trade names have been adopted according to their construction or uses. This holds true also of smaller electric conductors, to which the term "cable" does not apply. The smaller conductors are usually either single wires, *stranded wires*, or *cords*. There is a great range of flexibility and of kind of insulation in the various divisions, such as magnet wire, heater cord, lamp cord, etc. The *twisted pair* is used with many portable electric devices.

STRANDING

The sizes of solid wires are stated by their diameters in mils, the American Wire Gage (Brown & Sharpe) sizes being taken as standard. The sizes of stranded conductors are stated by their cross-sectional area in circular mils. For brevity, in cases where the most careful specification is not required, the sizes of solid wires may be stated by the gage number in the American Wire Gage, and the sizes of stranded conductors smaller than 250 000 circular mils (i. e., No. 0000 A. W. G. or smaller) may likewise be stated by means of the gage number in the American Wire Gage of a solid wire having the same cross-sectional area. Furthermore, an exception is made in the case of "flexible stranding," in the next paragraph. The cross-sectional area of a cable is the sum of the cross-sectional areas of all its component wires, taking the cross-sectional area of each wire perpendicular to the axis of the wire.

The most common modes of subdividing stranded conductors are included under (*a*) *concentric stranding* and (*b*) *flexible stranding*. Concentric stranding implies a definite structure, while flexible stranding does not, the characteristic feature of the latter being that a large number of wires are used to give flexibility. An additional difference between the two classes of stranding is that "flexible" strands are made up of wires having a deflnite gage size, while in the case of "concentric" strands it is the more usual practice to use special wires of a calculated diameter such as to give a specified total cross section. The sizes of flexible strands or conductors are stated by giving the number of wires and their size. The sizes of such strands or conductors may also be stated by the approximate equivalent gage number or approximate total circular mils.

The different kinds of stranding are exemplified both by parts of conductors and by complete conductors. In other words, a type of stranding may be the same for a strand and for a cable. A concentric-lay cable is the common example of concentric stranding. In its standard form, it is made up of a straight central wire surrounded by layers of helically laid wires, the alternate layers having a twist in opposite directions. In the first layer about the central wire, 6 wires of the same diameter are used; in the next layer, 12; then 18, 24, etc. The number of layers thus determines the number of individual wires in the cable.

The table below gives the numbers of wires used in concentric-lay cables in this country. The practices of manufacturers vary, but cables of this type are commonly made up as shown under "Standard concentric stranding." The Standards Committee of the American Institute of Electrical Engineers have adopted the "Standard concentric stranding" here given. For greater flexibility, concentric-lay cables are sometimes made up as shown under "Flexible concentric stranding." What was described above as flexible stranding should not be confused with flexible *concentric* strand-

ing. The stranding given in this table is standard both for a strand used as one of the constituents of a rope-lay cable and for a strand used as the whole of a concentric-lay cable. The ranges of sizes for the various numbers of wires are such as to give a smooth gradation of flexibility.

Standardization of Concentric Stranding

Range of size	Number of wires	
	Standard concentric stranding	Flexible concentric stranding
2 000 000 to 1 600 000 circular mils	127	169
1 500 000 to 1 100 000 circular mils	91	127
1 000 000 to 550 000 circular mils	61	91
500 000 to 250 000 circular mils	37	61
No. 0000 to No. 1 A. W. G	19	37
No. 2 to No. 8 A. W. G	7	19

In the calculation of the resistance or mass of any length of concentric strand or cable it is necessary to know the pitch of the twist, or the "lay" as it is called. By extensive inquiry among companies and persons of experience, it was learned that both the resistance and mass of a concentric strand are, on the average, 2 per cent greater than the resistance and mass, respectively, of a solid rod of the same length and total cross section. Assuming this equivalent solid rod to consist of copper of the same resistivity as that in the actual cable, this means that the "lay" of the strands usually made averages about 1 in 16, i. e., each wire makes one complete revolution about the axis of the cable in a length equal to about 16 times the diameter of the helical path of the wire. Accordingly, the Standards Committee of the American Institute of Electrical Engineers adopted 2 per cent as the standard increment to use in calculating the resistance and mass of a concentric strand from the resistance and mass of a solid rod of the same cross section. The cable tables, Nos. XII and XIII, in this Bureau's Circular No. 31 were computed in accordance with the foregoing definitions and table. That circular should be consulted for values of resistance and other information on wires and cables.

S. W. Stratton,
Director.

Approved:
E. F. Sweet,
Acting Secretary.