DEPARTMENT OF COMMERCE AND LABOR

CIRCULAR

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 37

ELECTRIC WIRE AND CABLE TERMINOLOGY

[1st Edition]
Issued January 15, 1913

WASHINGTON
GOVERNMENT PRINTING OFFICE
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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. It is also desired to express the thanks of the Bureau to the American Steel & Wire Co., the Western Electric Co., and the Standard Underground Cable Co., who kindly loaned electrotypes for the illustrations.

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 cable, 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.

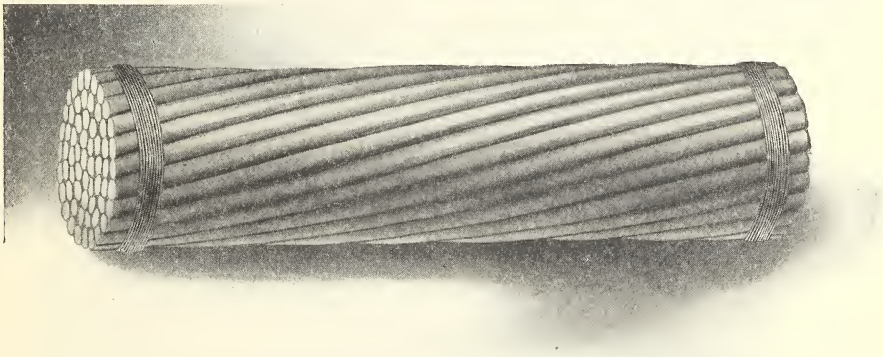

Fig. 1.—*Bare stranded conductor; or, bare single-conductor cable*

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.

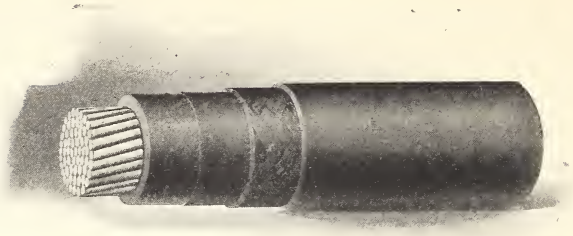

Fig. 2.—*Insulated stranded conductor; or, insulated single-conductor cable*

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

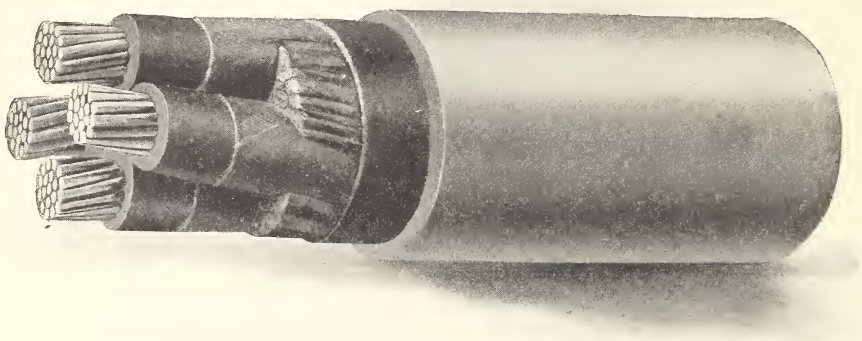

Fig. 3.—*Multiple-conductor cable*

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-

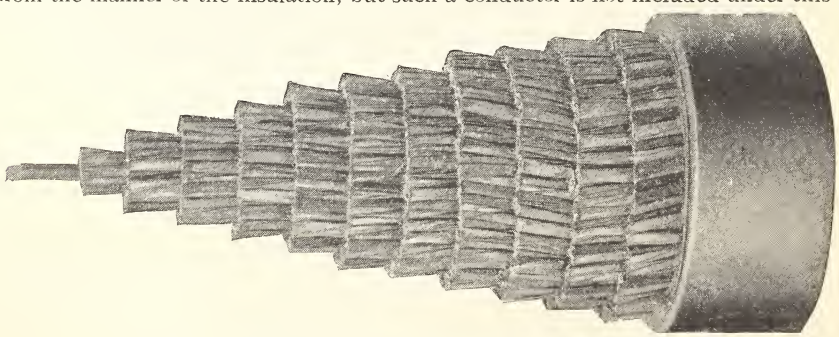

Fig. 4.—*Multiple-conductor cable (600-pair telephone cable)*

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.—(1) 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 "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." Usually the insulation of a cord contains rubber.

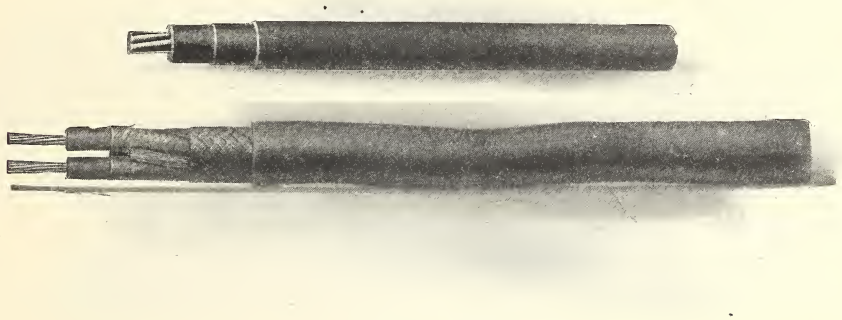

Fig. 5.—*Cords*

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

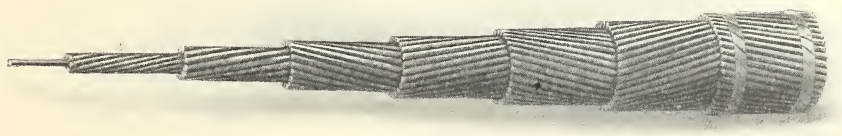

Fig. 6.—*Bare concentric lay cable*

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

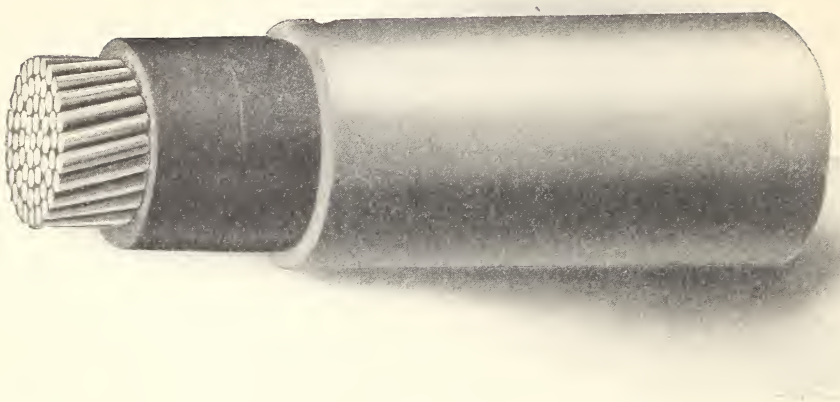

Fig. 7.—*Lead-covered, rubber-insulated, concentric lay cable*

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*

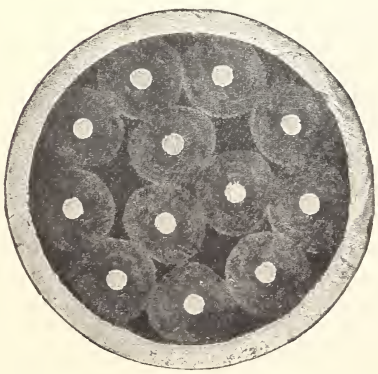

Fig. 9.—*12-conductor cable*

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).

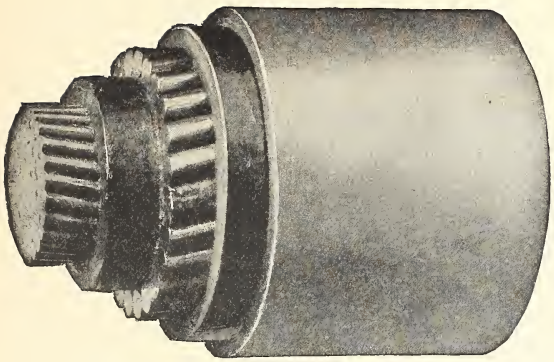

Fig. 10.—*2-conductor concentric cable*

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.

Usually only 2-conductor or 3-conductor. Such conductors 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.

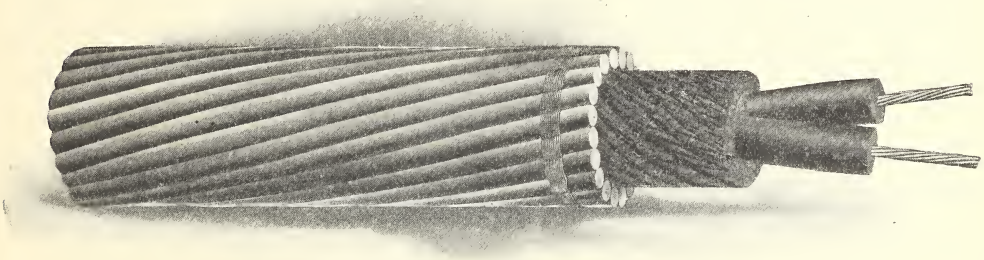

Fig. 11.—*Armored duplex cable*

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

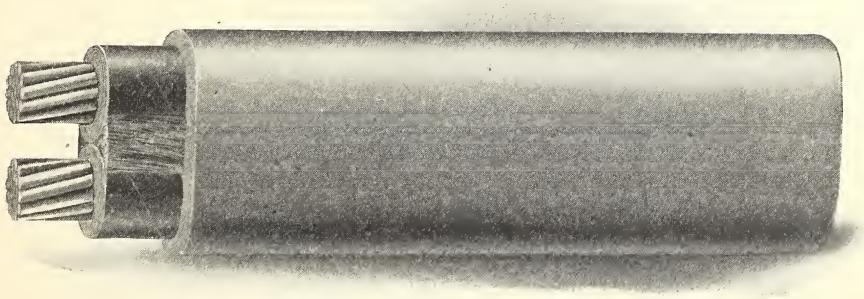

Fig. 12.—*Twin cable*

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

They may or may not have a common insulating covering.

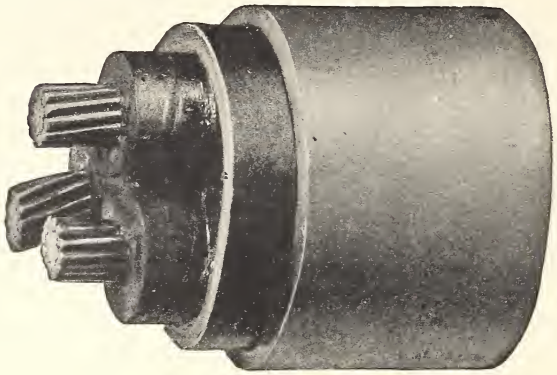

Fig. 13.—*A triplex cable*

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.

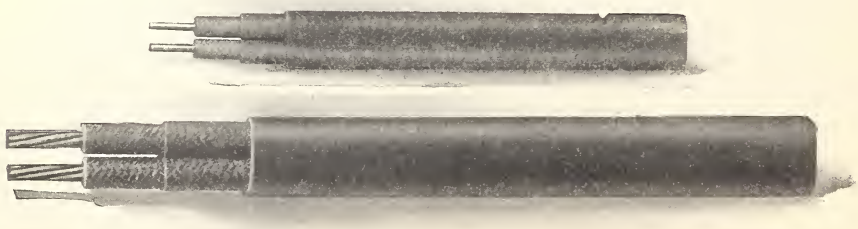

Fig. 15.—*Twin wires*

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. A common type of cord is the *twisted pair,* used with many portable electric devices.

EXAMPLES

There are given herewith references to descriptions of conductors, so that the reader may compare the standard terminology of this circular with the former varying usages presented by the names as given in the various catalogues, etc.

(From American Steel & Wire Co., Handbook of Electrical Wires and Cables, 1910)

Page	Standard name	Company's old name
27	Concentric lay cable, or concentric strand	7-layer strand
33	Concentric lay cable, or concentric strand	Rope strand
129	Twisted pair	Twisted pair
129	Cord	Triple conductor
139	Twin cable	Duplex parallel flexible conductor
139	2-conductor concentric cable	Duplex concentric stranded cable
153	4-conductor cable	4-conductor stranded cable
154	Twin wire	Duplex cable.
162	Triplex cable	3-conductor cable
	3-conductor cable	

(From Standard Underground Cable Co., Handbook, 1906)

Page	Standard name	Company's old name
24b A	Stranded wire	Cable
C	Concentric lay cable	Cable
D	Concentric lay cable	Flexible cable
E	N-conductor cable (of $\frac{N}{2}$ twisted pairs)	Twisted pair cable
28a B	2-conductor concentric cable	Duplex concentric cable
C	Triplex cable	3-conductor
	3-conductor cable	
38b C	12-conductor cable	12-conductor cable

(From General Electric Co., Wires and Cables, 1910)

Page	Standard name	Company's old name
38	4-conductor cable	4-conductor cable
38	Twin cable	Flat twin cable
50	N-conductor cable (of 6 concentric layers)	Cable

STANDARDIZATION OF STRANDING

In addition to the names of conductors, an important descriptive word has often been the source of confusion. That is the term "flexible." Some manufacturers have used "flexible" to describe a strand or a cable containing the same number of individual wires as other manufacturers would describe by the name "extra flexible." The desirability of having a definite meaning for the term "flexible" as applied to concentric strands and concentric lay cables led the Standards Committee of the American Institute of Electrical Engineers, in January, 1912, to define the two classes "standard concentric strands" and "flexible concentric strands." They are defined by stating the number of individual wires composing the strand for each size of strand. The ranges of sizes for the various numbers of wires are so chosen as to give strands of a smooth gradation of flexibility. They are as follows:

Range of size	Number of wires	
	Standard concentric strands	Flexible concentric strands
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

It may be added that if in any size of concentric strand the number of wires considerably exceeds the number given for "flexible concentric strand" the strand may be called "extra flexible."

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. (The equivalent solid rod is assumed 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 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 total cross section. While this is a matter which is not directly concerned in cable terminology, it nevertheless may be useful information to those who have to do with cables. The cable tables, Nos. XII and XIII, in this Bureau's Circular No. 31 were computed in accordance with the foregoing definitions of "standard concentric strands" and "flexible concentric strands."

S. W. Stratton,
Director.

Approved:

Benj. S. Cable,
Acting Secretary.

COPPER WIRE TABLE (ENGLISH AND METRIC)

Working Table, International Standard Annealed Copper

American Wire Gage (B. & S.)

ENGLISH UNITS

Gage No.	Diameter in Mils	Cross Section		Ohms per 1000 Feet		Pounds per 1000 Feet
		Circular Mils	Square Inches	25° C (=77° F)	65° C (=149° F)	
0000	460.	212 000.	0.166	0.0500	0.0577	641.
000	410.	168 000.	.132	.0630	.0727	508.
00	365.	133 000.	.105	.0795	.0917	403.
0	325.	106 000.	.0829	.100	.116	319.
1	289.	83 700.	.0657	.126	.146	253.
2	258.	66 400.	.0521	.159	.184	201.
3	229.	52 600.	.0413	.201	.232	159.
4	204.	41 700.	.0328	.253	.292	126.
5	182.	33 100.	.0260	.319	.369	100.
6	162.	26 300.	.0206	.403	.465	79.5
7	144.	20 800.	.0164	.508	.586	63.0
8	128.	16 500.	.0130	.641	.739	50.0
9	114.	13 100.	.0103	.808	.932	39.6
10	102.	10 400.	.008 15	1.02	1.18	31.4
11	91.	8230.	.006 47	1.28	1.48	24.9
12	81.	6530.	.005 13	1.62	1.87	19.8
13	72.	5180.	.004 07	2.04	2.36	15.7
14	64.	4110.	.003 23	2.58	2.97	12.4
15	57.	3260.	.002 56	3.25	3.75	9.86
16	51.	2580.	.002 03	4.09	4.73	7.82
17	45.	2050.	.001 61	5.16	5.96	6.20
18	40.	1620.	.001 28	6.51	7.51	4.92
19	36.	1290.	.001 01	8.21	9.48	3.90
20	32.	1020.	.000 802	10.4	11.9	3.09
21	28.5	810.	.000 636	13.1	15.1	2.45
22	25.3	642.	.000 505	16.5	19.0	1.94
23	22.6	509.	.000 400	20.8	24.0	1.54
24	20.1	404.	.000 317	26.2	30.2	1.22
25	17.9	320.	.000 252	33.0	38.1	0.970
26	15.9	254.	.000 200	41.6	48.0	.769
27	14.2	202.	.000 158	52.5	60.6	.610
28	12.6	160.	.000 126	66.2	76.4	.484
29	11.3	127.	.000 099 5	83.4	96.3	.384
30	10.0	101.	.000 078 9	105.	121.	.304
31	8.9	79.7	.000 062 6	133.	153.	.241
32	8.0	63.2	.000 049 6	167.	193.	.191
33	7.1	50.1	.000 039 4	211.	243.	.152
34	6.3	39.8	.000 031 2	266.	307.	.120
35	5.6	31.5	.000 024 8	335.	387.	.0954
36	5.0	25.0	.000 019 6	423.	488.	.0757
37	4.5	19.8	.000 015 6	533.	616.	.0600
38	4.0	15.7	.000 012 3	673.	776.	.0476
39	3.5	12.5	.000 009 8	848.	979.	.0377
40	3.1	9.9	.000 007 8	1070.	1230.	.0299

NOTE 1.—The table is based on the international standard of resistance for copper, which takes the fundamental mass resistivity = 0.15328 ohm (meter, gram) at 20° C, the corresponding temperature coefficient = 0.00393 at 20° C, and the density = 8.89 grams per cc at 20° C. The temperature coefficient is proportional to the conductivity, whence the change of mass *resistivity* per degree C is a constant, 0.000597 ohm (meter, gram).

NOTE 2.—The values given in the table are only for annealed copper of the standard resistivity. The user of the table must apply the proper correction for copper of any other resistivity. Hard-drawn copper may be taken as about 2.7 per cent higher resistivity than annealed copper.

NOTE 3.—Ohms per mile, or pounds per mile, may be obtained by multiplying the respective values above by 5.28.

NOTE 4.—For complete tables and other data see Circular No. 31 of the Bureau of Standards.

BUREAU OF STANDARDS, Washington, D. C., 1914

COPPER WIRE TABLE (ENGLISH AND METRIC)

American Wire Gage (B. & S.)

METRIC UNITS

Gage No.	Diameter in mm	Cross Section in mm^2	Ohms per Kilometer		Kilograms per Kilometer
			25° C	65° C	
0000	11.7	107.	0.164	0.189	953.
000	10.4	85.0	.207	.239	756.
00	9.3	67.4	.261	.301	599.
0	8.3	53.5	.329	.379	475.
1	7.3	42.4	.415	.478	377.
2	6.5	33.6	.523	.603	299.
3	5.8	26.7	.659	.761	237.
4	5.2	21.2	.831	.959	188.
5	4.6	16.8	1.05	1.21	149.
6	4.1	13.3	1.32	1.53	118.
7	3.7	10.5	1.67	1.92	93.7
8	3.3	8.37	2.10	2.43	74.4
9	2.91	6.63	2.65	3.06	58.9
10	2.59	5.26	3.34	3.86	46.8
11	2.30	4.17	4.21	4.86	37.1
12	2.05	3.31	5.31	6.13	29.4
13	1.83	2.62	6.70	7.73	23.3
14	1.63	2.08	8.45	9.75	18.5
15	1.45	1.65	10.7	12.3	14.7
16	1.29	1.31	13.4	15.5	11.6
17	1.15	1.04	16.9	19.6	9.23
18	1.02	0.823	21.4	24.7	7.32
19	0.91	.653	26.9	31.1	5.80
20	.81	.518	34.0	39.2	4.60
21	.72	.411	42.8	49.4	3.65
22	.64	.326	54.0	62.3	2.89
23	.57	.258	68.1	78.6	2.30
24	.51	.205	85.9	99.1	1.82
25	.45	.162	108.	125.	1.44
26	.40	.129	137.	158.	1.14
27	.36	.102	172.	199.	0.908
28	.32	.0810	217.	251.	.720
29	.29	.0642	274.	316.	.571
30	.25	.0509	345.	398.	.453
31	.227	.0404	435.	502.	.359
32	.202	.0320	549.	634.	.285
33	.180	.0254	692.	799.	.226
34	.160	.0201	873.	1010.	.179
35	.143	.0160	1100.	1270.	.142
36	.127	.0127	1390.	1600.	.113
37	.113	.0100	1750.	2020.	.0893
38	.101	.0080	2210.	2550.	.0708
39	.090	.0063	2780.	3210.	.0562
40	.080	.0050	3510.	4050.	.0445