

Dec. 26, 1939.

W. LOWE

2,184,392

HOLLOW CONDUCTOR

Filed Jan. 7, 1937

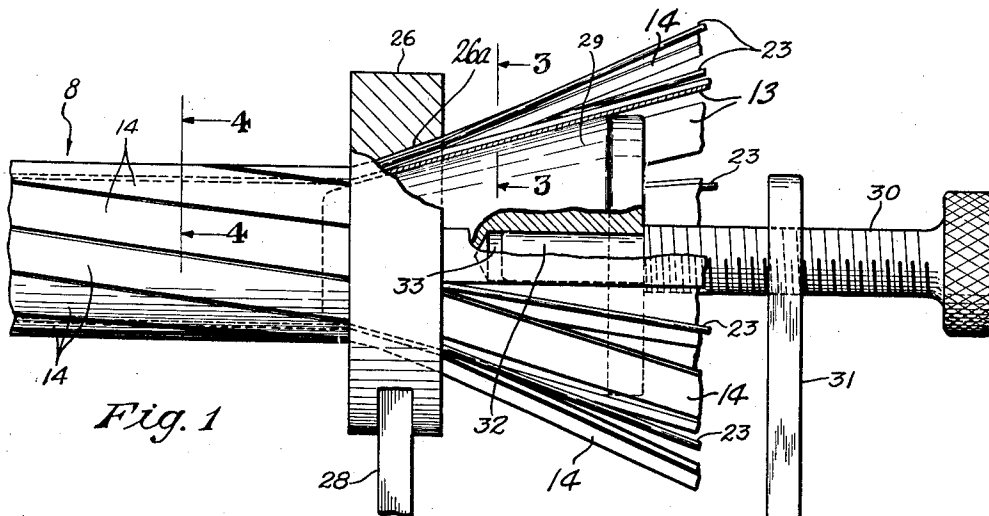


Fig. 1

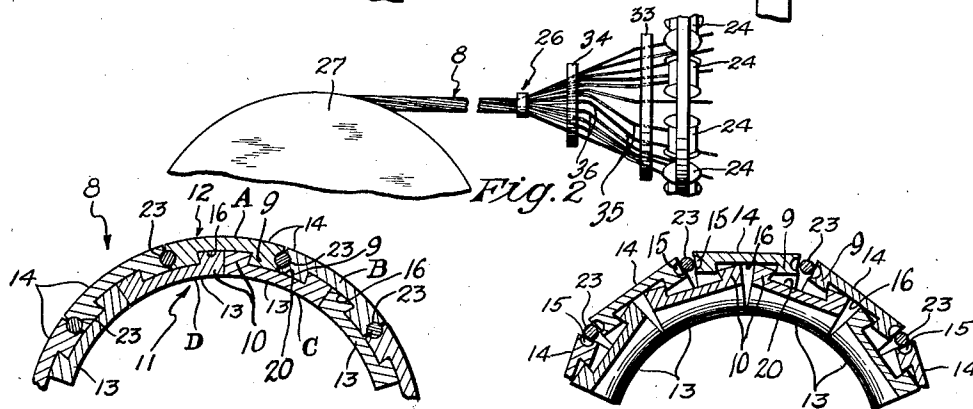


Fig. 2

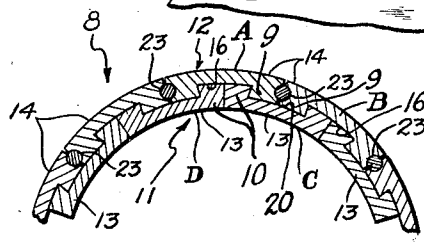


Fig. 3

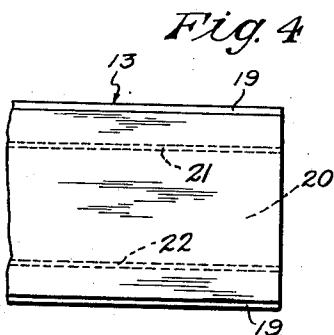


Fig. 4

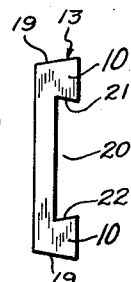


Fig. 5

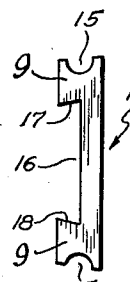


Fig. 6

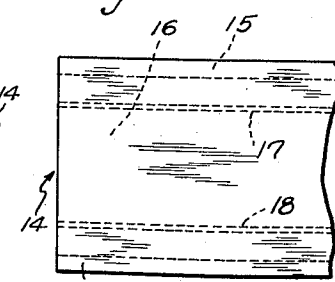


Fig. 7

Fig. 8

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2,184,392

HOLLOW CONDUCTOR

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Application January 7, 1937, Serial No. 119,436

6 Claims. (Cl. 174-130)

This invention relates to new and useful improvements in hollow electrical conductors, especially conductors for power transmission lines for high voltage alternating currents, and has particular relation to such hollow conductors as are made up of a plurality of strands or segmental wires of suitable metal, such for example as copper and copper alloys, or other alloys or metal having the desired strength and/or electrical conductivity. The present construction is of a similar type to that disclosed in my copending application Serial Number 119,435, filed January 7, 1937.

An object of the invention is to provide a hollow conductor of the type indicated which is of improved construction, has better flexibility, has continuous smooth circular inside and outside surfaces, in which the walls are of uniform thickness, and in which for the same thickness of wall has thinner strands.

Another object is to provide a hollow conductor of such construction that tension tends to close or pull the strands in instead of opening out or spreading so it will not bird-cage or open radially, and which will have long useful life.

A further object is to provide a structure of hollow electrical conductor or cable which is a composite tube and which for a given metal can be made about 30% stronger with only about 5% reduction in conductivity.

A still further object is to provide a hollow cable construction in which the full strength of the metal used in the cable is utilized to resist stresses and deformation of all kinds to a greater extent than previous constructions; that is, to produce a construction in which, while permitting longitudinal movement between the segmental wires, the assembly approaches the characteristics of a solid tube in resisting section deformation.

Other objects and advantages will become apparent from a consideration of the following detailed description taken in connection with the accompanying drawing wherein a satisfactory embodiment of the invention is shown. However, it is to be understood that the invention is not limited to the details disclosed but includes all such variations and modifications as fall within the spirit of the invention and the scope of the appended claims.

In the drawing:

Fig. 1 is a view illustrating the method of making the improved conductor, the view being taken at the die employed;

Fig. 2 is a view on a smaller scale and illustrating the method more completely;

Fig. 3 is an enlarged detail sectional view taken substantially along the line 3-3 of Fig. 1;

Fig. 4 is an enlarged detail sectional view taken as along the line 4-4 of Fig. 1;

Fig. 5 is an end elevational view on an enlarged scale of one type of strand or flat wire employed;

Fig. 6 is a side view of a portion of the strand or wire of Fig. 5;

Fig. 7 is a view similar to Fig. 5 but showing another type of wire; and

Fig. 8 is a side view showing a portion of the wire of Fig. 7.

Referring in detail to the drawing, the improved cable generally designated 8 is made up of inner and outer layers 11 and 12, each layer comprising a plurality of abutting segmental wires. The inner layer 11 of the conductor is made up of individual wires or segments 13 shown more particularly in Figs. 5 and 6 while the outer layer 12 is made up of wires or segments 14 shown more particularly in Figs. 7 and 8. Due to the difference in diameter of the inner and outer layers the segments in the outer layer are somewhat wider than those of the inner layer.

Segmental wires 14 have a semi-circular groove 15 extending along each longitudinal edge and in one side each such segment has a channel 16, the respective edges of which are undercut as at 17 and 18 so that these edges overhang. This channel forms spaced longitudinal ribs 9 along the opposite edges on the side of the channel. Segments 13 have their longitudinal edges inclined or tapered as at 19 and in one side each such segment has a channel 20 the longitudinal edges 21 and 22 of which are undercut so that these edges overhang. This channel forms spaced ribs 10 along the opposite side edges. The edges of the channels of the respective segments being undercut as described, such channels are wider at the inner or closed side than at the outer or open side.

In the completed conductor the segmental wires 14 have their adjacent edges held against relative movement or separation in a direction radially of the conductor by round wires 23, one of which is disposed between the adjacent edges of each pair of segments 14. It will be understood that the segmental wires of either one or both the inner and outer layers are of electrical conducting material, such for example as copper or a copper alloy, although of course they may be of other metals. Therefore these segments may not have as great strength as they would have if made of

other materials having greater strength. The round wires 23 are preferably of metal of higher strength such for example as steel, stainless steel and so forth, and so strengthen the conductor in addition to securing the segments of the outer layer 12 against separation in a direction radially of the conductor by seating in the semi-circular grooves 15 in the edges of such segments. If preferred copper could be used for the flat or segmental wire or strands and a bronze or higher strength alloy could be used for the round wire. Or if the round wires are used merely for securing the segmental wires then the two could be of the same material.

The segmental wires 13 of the inner layer 11 form a supporting arch for the segments of the outer layer and secure the segments of the outer layer in such relation that the edge of one such segment can not move away from the adjacent edge of the next adjacent segment, so that the round wires 23 are kept in place securing the adjacent edges of the segments 14 against separation radially of the conductor. The outer and inner layers are also secured together by the ribs 9 in the outer layer being nested in the channels 20 of the inner layer and the ribs 10 of the inner layer nested in the channels 16 of the outer layer, and due to the overhang of the edges of the channels the two layers cannot separate in a direction radially of the conductor.

In the complete conductor the segmental wires are all transversely curved and the inclined edges 19 of each inner segment 13 are in abutting relation with the corresponding edges of the next adjacent inner segments. It will be seen from Fig. 4 that the walls of the conductor are of uniform thickness and that the outer and inner surfaces are continuous, smooth and circular. Each segmental wire of each layer spans a joint between a pair of the segmental wires of the other layer and receives in its channel the portions or ribs 9 or 10 of such pair located between the channels thereof.

That is, referring particularly to Fig. 4, considering segmental wires A and B as a pair, the segmental wire C spans the joint between segments A and B and the portions or ribs 9 of segments A and B between their channels 16 are received in the channel 20 of segment C. The segment A functions in the same manner with respect to segments D and C if the latter are considered a pair. Since the channels of each segmental wire have their edge walls undercut, when the segments are assembled into the complete conductor, coacting means is provided whereby the segments of each layer are connected to the segments of the other layer in addition to securing such segments of the other layer to one another against separation in a direction circumferentially of the conductor.

The method of making the improved conductors forms no particular part of the present application since it constitutes the subject matter of a separate application which issued as Patent Number 2,136,388 November 15, 1938. Therefore the method is referred to but briefly herein. In making the conductor the inner and outer segments 13 and 14 as well as the round steel wires 23 are taken from stationary reels 24 and passing through guides 25 pass through a die 26 wherein the various segments are laterally curved to the form they have in the complete conductor and the latter is wound onto a rotating drum 27. However, if preferred instead of segmental wires 13 and 14 being flat before passing into the die they

may be formed transversely curved to substantially their curvature in the finished conductor.

As the drum 27 is rotated to wind the finished conductor thereon it also serves to pull the wires through the die 26. The die is shown as a ring mounted on a support 28, and extending into the tapered opening 26a in the die is a tapered plug 29 adjustable on manipulation of a screw 30 threaded through a support 31. The forward end 32 of the screw 30 is smooth and of reduced diameter and is received in a socket 33 in the plug 29. Obviously by adjusting the screw forwardly the plug is forced further into the opening in the die ring.

As the segmental wires approach the die they are flat in the form shown in Fig. 3, but in passing through the die they are forced into a transversely arch shape. In the movement to the die the wires fall naturally into proper relative positions engaging with one another to form the completed conductor shown in Fig. 4. As the conductor is drawn from the die by the rotating drum 27 the segments are all twisted to extend spirally in the same general direction as shown best in Fig. 1 as the drum 27 is rotated bodily about the axis of the conductor. This provides for the desired flexibility of the conductor. As the segments pass through the die the outer segments or layer are supported and held to form by the inner layer. This is because as the inner segments are guided into the die by the plug these segments 13 form an arch which is self supporting and thus forms a support for the outer layer which holds this outer layer to form. The various segments from which the conductor is made may be drawn. Between the reels 24 and the die 26 the segments pass through guide openings in the guide members 33 and 34. These openings in the member 34 are offset from those in member 33 so that as the segments pass through they are first bent or curved in one direction as indicated at 35 and then are bent or curved in another direction as indicated at 36, so that the segments are given a preliminary bend or twist, similar to their final spiral shape in the cable or conductor, before they pass through the die 26.

Before the segmental wires pass into the die they and the wires 23 are guided into nested and interengaging relation as indicated in Fig. 3, the die and plug serving to curve the strands laterally and form the continuous smooth outer and inner circular surfaces. The tapered plug running into the tapered die acts as a guide that carries the inner layer of grooved flat wires into the die. The plug also guides the wires so that the edges naturally come together and the inner layer forms a supporting arch for the outer layer of wires as described above.

With the construction disclosed a conductor of great strength, as compared with other conductors containing the same amount of metal may be secured. Thus with this construction it is not necessary to add surplus metal in order to have the conductor of the required strength. The wires 23 may be of high strength steel, so that the composite tube is about 30% stronger with only about 5% reduction in conductivity.

The adjacent segments may slide longitudinally on each other to permit the cable to flex. If desired the contacting surfaces may be lubricated by graphite or similar material to improve this action. This cable or conductor therefore, although the segmental wires are all securely connected, is flexible, has round smooth inner and outer surfaces and is of uniform wall thickness

throughout. The flexibility is further improved because with this construction for the same thickness of cable wall and for the same cable strength, thinner segmental wires may be used.

5 The inner layer of segments as will be seen from Fig. 4 forms an arch support for the outer layer and holds it to form. Tension on the cable tends to pull the segments in instead of opening out or spreading. The fact the segments are on
10 a spiral helps this. However, as the outer layer of segments tends to pull in it is supported by the arch shaped inner layer which cannot yield inwardly as it is self supporting because of the arch effect. Therefore tension on the cable tends
15 to pull and hold the segments together instead of separating them or opening out the cable. This together with the securing of the segments together resists or withstands vibration much better and with much less danger of the segments
20 separating or "bird-caging". This has been a serious objection to previous cable conductor constructions, with which it has been necessary to add auxiliary devices to these conductors to keep them from opening up.

25 Although a self-supporting hollow conductor has been known, it has been found to be mechanically weak, particularly with respect to compressive strength. High compressive strength is necessary for clamping and splicing, and it is also
30 desirable to facilitate handling in construction. In addition to the above weakness the known conductors have mechanical weakness in withstanding radial and longitudinal stresses imposed in construction and in service. It will therefore be
35 seen it is desirable that the full strength of the metal used in the cable be used to resist stresses and deformation of all kinds. In other words, while permitting longitudinal movement between the segmental wires, the assembly should approach
40 the characteristics of a solid tube in resisting section deformation. The present construction has accomplished these results and overcome the previous objections to a marked degree. The edges of adjacent segmental wires provide
45 a substantial abutment between the segments and the wire 23 seating in the grooves in the adjacent edges retain them in the proper relative positions and secure them against separation in a direction
50 radially of the conductor. Also, the ribs 9 and 10 in the grooves 20 and 16 secure the segmental wires against separation in a direction circumferentially of the conductor. The overhang of the inner edges of these ribs or grooves securely
55 secures the two layers against separation in a direction radially of the conductor. These features all assist in securing the improved results and advantages.

Another advantage of the present construction is that after assembly this cable can, within
60 limits, be reduced in cross sectional area, that is, wall thickness and to some extent in overall diameter, by drawing in dies, as in a tube mill. This is accomplished without undue deformation of the individual segmental wires, and appears to
65 reduce the sectional area of all of them proportionately. This is believed to have distinct novelty in conductor manufacture and commercial application in minimizing the number of separate dies and sizes of wire which must be used. It
70 further has the feature that wall thickness of the hollow conductor can be reduced below thicknesses obtainable by any other manufacturing method.

It will also be seen from the above disclosure
75 that the segments of both layers lie or are stranded

in the same spiral direction. Therefore the joint between any two adjacent segments of either layer is always covered by a segment of the other layer, and the overlapped segments of the two layers are effectively secured together throughout
5 their entire lengths.

This construction of cable has the further advantage that one layer can be made of material having much higher strength and hardness than the other layer, which latter layer may be of a
10 metal of high electrical conductivity. Thus, for example, the inner layer can be made of bronze or other high strength material while the outer layer is made of copper to obtain satisfactory
15 electrical conductance.

This also has the advantage where the cable is to be used for high voltage alternating currents in placing the metal of higher conductivity at the portion of the cross section of largest diameter. Conversely, if the cable is to be used in a
20 location where it might be subjected to severe abrasion, the outer layer could be composed of bronze or other suitable metal while the inner layer could be of copper to supply satisfactory
25 conductive properties.

Having thus set forth the nature of my invention, what I claim is:

1. A self supporting flexible hollow conductor comprising inner and outer layers of segmental wires, said wires being preformed before assembly
30 to substantially their shape in the finished conductor, the adjacent segments of one layer having aligned grooves in their longitudinal edges, wires at the edges of said latter segments received in said grooves and securing adjacent segments
35 against separation in a direction radially of the conductor, and the segments of the other layer spanning the joints between the segments of said first layer and engaging the segments thereof and holding them in engagement with said wires
40 and against separation circumferentially of the conductor and also holding the layers against separation in a direction radially of the conductor, and adjacent wires being longitudinally slidable relative to each other to permit flexing of the
45 conductor.

2. A self supporting flexible hollow conductor comprising inner and outer layers of segmental wires, said wires being preformed before assembly
50 to substantially their shape in the finished conductor, the adjacent segments of the outer layer having aligned grooves in their longitudinal edges, wires between the edges of each pair of said grooved segments and received in the grooves of the adjacent edges of said pairs and securing
55 such edges against separation in a direction radially of the conductor, said segments of the outer layer each having a single longitudinal dovetail channel in their inner sides, the segments of the inner layer each having a single longitudinal
60 dovetail channel in their outer sides, and the segments of the inner layer being connected with the segments of the outer layer to hold the layers against separation in a direction radially of the conductor by each receiving in its channel the
65 portions of a pair of the segments of the outer layer intermediate the channels of such pair, and the adjacent wires being longitudinally slidable relative to each other to permit flexing of the conductor.

3. A self supporting flexible hollow conductor comprising inner and outer layers of segmental wires, said wires being preformed before assembly
70 to substantially their shape in the finished conductor, the segments of the outer layer having
75

- grooves in their longitudinal edges, wires between the edges of each pair of said grooved segments and received in the grooves of the adjacent edges of said pairs and securing such edges against separation in a direction radially of the conductor, and the segments of the inner layer spanning the joints between the segments of the outer layer and engaging with the segments thereof and holding them in interlocking relation with said wires and also having cooperating means holding the layers against separation in a direction radially of the conductor, and the adjacent wires being longitudinally slidable relative to each other to permit flexing of the conductor.
4. A preformed strand for a hollow conductor comprising a wire of elongated cross section having a groove in each longitudinal edge extending throughout the length of the wire, and said wire in one side having a single longitudinal channel forming ribs at the opposite sides thereof provided with undercut edges forming the sides of the channel, said channel being of a width to receive the adjacent ribs of two adjacent strands each having a similar channel and ribs placed at one side of the first strand in reversed relation to the first strand and to hold them against separation.
5. A self supporting hollow flexible conductor comprising inner and outer layers of segmental wires, said wires being preformed before assembly to substantially their shape in the finished conductor, the adjacent segments of the outer layer having aligned grooves in their longitudinal edges, wires seated in said grooves between adjacent segments and securing such segments against separation radially of the conductor, the layer of inner segments forming a supporting arch for the outer segments, and cooperating means on the two layers for securing the layers against separation radially of the conductor and also holding the segments of the outer layer against separation in a direction circumferentially of the conductor, and the adjacent wires being longitudinally slidable relative to each other to permit flexing of the conductor.
6. A self supporting flexible hollow conductor comprising inner and outer layers of segmental wires, said wires being preformed before assembly to substantially their shape in the finished conductor each segment of one layer having a longitudinal groove in each side edge, a wire seated in the aligned grooves of adjacent segments, each segment having in one side a single longitudinal channel providing longitudinal ribs on said side having overhanging edges for the channel, and the segments of each layer being reversed with respect to the other layer and assembled with the ribs of adjacent segments in a layer seated in a side channel of a segment of the other layer to hold the layers against separation in a direction radially of the conductor and also hold the segments against separation in a direction circumferentially of the conductor, and the adjacent wires being longitudinally slidable relative to each other to permit flexing of the conductor.

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