Dec. 3, 1935. A. O. AUSTIN 2,022,839

ELECTRICAL CONDUCTOR

Filed Dec. 27, 1932

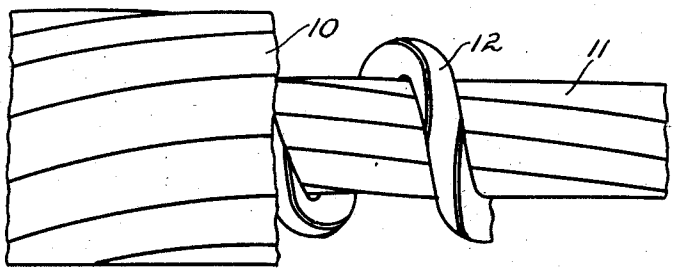


Fig.1.

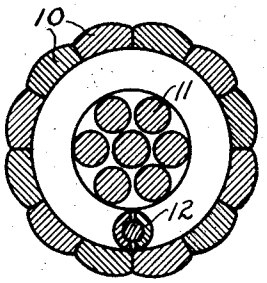


Fig.2.



Fig.3.

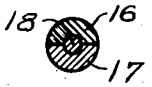


Fig.4.



Fig.5.

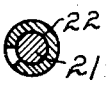


Fig.6.

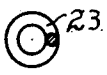


Fig.7.

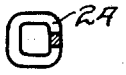


Fig.8.



Fig.9.



Fig.10.



Fig.11.

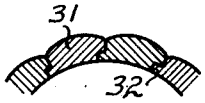


Fig.12.



Fig.13.



Fig.14.

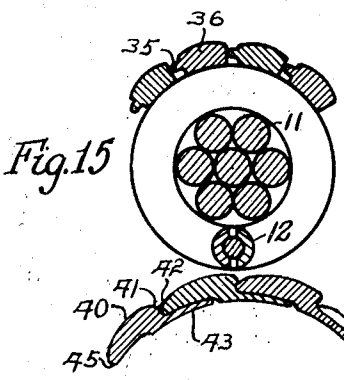


Fig.15



Fig.16.



Fig.19



Fig.17.

Fig.18.

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ELECTRICAL CONDUCTOR

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Application December 27, 1932, Serial No. 648,850

5 Claims. (Cl. 173—13)

This invention relates to conductors for electricity and particularly to high voltage conductors, especially for heavy loads.

One object of the invention is to provide a conductor cable which will operate at high voltage without the production of corona discharge.

A further object is to provide a conductor which will have the necessary flexibility, even for large diameters, and one in which the amount of conducting material will be small for a given diameter and strength of conductor.

A further object of the invention is to provide a conductor which will tend to throw off drip water to provide a high corona point for wet conditions.

A further object of the invention is to provide a cable which will not be easily damaged by vibration and which will tend to absorb energy of vibration, thereby holding the amplitude of vibration within safe limits.

A further object of the invention is to provide a conductor having a high strength core, a flexible spacer and an outer sheath of high conducting material.

Other objects and advantages will appear from the following description.

The invention is exemplified by the combination and arrangement of parts shown in the accompanying drawing and described in the following specification, and it is more particularly pointed out in the appended claims.

In the drawing:

Fig. 1 is a fragmentary elevation of a portion of a conductor showing one embodiment of the present invention.

Fig. 2 is a transverse section of the conductor shown in Fig. 1.

Figs. 3, 4, 5, 6, 7, 8, and 9 are sections of various forms of spacer members which may be used as a part of the invention.

Figs. 10, 11, 12, 13, 14, 15, 16, 17, and 18 are fragmentary sections of various forms of outer conducting strands or segments which may be used in the present invention, Fig. 15 including also a cross section of the inner portion of the conductor.

Fig. 19 is a fragmentary elevation of a portion of the form of conductor shown in Fig. 15.

The amount of power which can be transmitted over a high voltage conductor of a given size, with a given percentage of loss in the conductor, increases approximately as the square of the voltage. Therefore, it is very important that a high voltage be used where it is desired to reduce the cost per k. w. or k. v. a. transmitted. However, the voltage is generally limited by the loss due to corona or brush discharge from the conductor, or due to radio interference caused by discharge from the conductor.

Where very large blocks of power are involved, it may be possible to provide a conductor of large enough cross section of the usual stranded type so that a high voltage can be used. Where the transmission distance is very long, however, it would generally be more economical to go to a considerably higher voltage and reduce the cross section of the copper, aluminum or other conducting material used in making up the conductor. If the voltage is sufficiently high, it is also possible to use higher strength materials even though they have poorer conductivity.

In my prior Patent #1,626,776, I have shown means for increasing the diameter of the conductor and also its mechanical strength. In Patent #1,626,777 I have shown a coating of insulating paint or varnish for part or all of the outer members of the conductor so as to raise the voltage at which corona will start. In the present invention, further improvements have been made to provide conductors of better economic possibilities. In this improved conductor, particular attention has been given to the provision of a conductor which may be easily fabricated and in which the amount of effective conducting material may be reduced without affecting the mechanical reliability or desired electrical properties.

In the form of the invention shown in Figs. 1 and 2, the conductor is formed with an outer conducting layer composed of strands or segments 10. The inner or high strength core 11 is made of galvanized steel or other suitable material. In order to prevent collapse or disarrangement of the outer strands, a spacer member 12 is placed between the high strength core 11 and the outer or conducting layer 10. Any suitable lay or pitch for the various layers or members may be used, depending upon the materials and the result desired. Greater flexibility will be developed where the number of turns about the axis is increased for a given length. The flexibility also will be increased where there is some slight space between the edges of the outer members 10. Means for maintaining this spacing will be described in detail later.

In Fig. 1 the outer layer is made up of sectors 10 which have radial abutting edges. The outer contour of each sector 10 has a smaller radius than that of the conductor taken as a whole. This causes the outer surface of each sector to project

further at its center than at the corners of the sector. This arrangement has certain very material advantages in reducing corona loss and in throwing off drip water. Owing to the fact that the center of the segment projects beyond the edges, the lines of force will be greater at the center points of the segments than they would be if the centers of the segments did not project beyond the edges, as in the case where the outer segment surfaces form a continuous circle. The abrupt outer corners at the edges of the segments will tend to start corona or brush discharge. The center of the segment may be made very smooth and since it may be given a much larger radius of curvature than the corners, the corona point can be greatly raised for a conductor made up in this way. The contour of the outer surfaces of the segments will depend upon the amount of screening desired, the width of the segments, the diameter of the conductor, and the effective concentration of stress or lines of force at the edges of the segments.

The individual segments may be made in a variety of forms for locking in place or to obtain greater flexibility or for other reasons. However, in general where the highest corona voltage is desired, it will be advisable to have the center portion of the segment project beyond the edges so as to effectively screen the latter. This arrangement also has the advantage that drip water which tends to cause streamers from the conductor will be more readily thrown off. If the conductor is coated with an insulating paint, varnish or enamel, as shown in my prior Patent #1,626,777, the projection may be greater than where it is uncoated. The projecting surfaces will greatly facilitate the coating of the conductor as the amount of material required for coating the projecting portions only will be considerably less than where the entire surface is coated.

While various forms of spacers may be used between the high strength core 11 and the conducting layer or segment 10, as shown in my prior Patent #1,626,776, an improved type of spacer 12 is shown in Figs. 1 and 2 which has a particular advantage where the outer diameter of the conductor is large compared to the cross section of conducting material. With this class of conductors, it is desirable to increase, as much as practical, the space between the high strength core 11 and the outer conducting layer made up of segments 10. While one of the forms of spacers shown in my prior patent may be used, a more flexible spacer and one of improved mechanical strength has been used for the larger diameters of conductor.

Spacer 12 is shown in detail in Fig. 3. In this figure an inner core member 13 is made of the same material as the outer elements 14 and 15, or the core member 13 may be made of steel or other material if desired. The outer layer of the spacer is made of two helically wound members 14 and 15. These preferably are of zinc or other material which will protect the core and outer layer from possible damage due to electrolytic action. The members 14 and 15 are simply wrapped around the center member, some slight space being allowed if desired between the edges of the outer members. The two members 14 and 15 therefore are in the form of helical members, the core member 13 preventing them from collapsing under pressure and helping to hold them in position relative to each other. A spacer made up in this manner may be readily wrapped around the high strength core during the fabrication of the conductor. Even though the members 14 and 15 are of relatively brittle material, their flexibility and the use of the core 13 will make it possible to give the spacer members 10 practically any pitch or lay desired.

A somewhat simple form of spacer is shown in Fig. 4 in which the segments 16 and 17 are prevented from slipping by the core member 18. The two members 16 and 17 are twisted about the axis of 18 so as to provide flexibility when the spacer member 12 is wrapped around the core. The core member 18 acts as a key in preventing the two segments 16 and 17 from sliding past each other. The core member 18 may be of the same material as the segments 16 and 17 or may be galvanized steel, or any other suitable material depending upon the result desired. In some cases the key member 18 may be omitted. However, in this case, the pitch for the outer members 16 and 17 will have to be changed to give a greater number of turns per given length of spacer than where the core 18 is used.

Of course, it is possible to use any desired number of segments in forming the spacer strand. However, it should be capable of transmitting considerable force or pressure between the outer layer and the inner core. This makes it possible to develop a tension in the inner member so that the full mechanical strength of the inner core can be utilized. The pressure between the outer and inner layer transmitted through the spacer strand will depend to a considerable extent upon the tension in the conductor. This tends to bind the several component parts together so that all members act as a unit mechanically. Since the cables are very long, it is not necessary to transmit very high pressures at any one point, as accumulative benefit may be obtained. Even should the entire conductor or some of the conductor strands be broken, due to excessive mechanical load or burning from a power arc or other cause, the friction between the several component parts of the conductor will cause all of the members to act as a unit at a comparatively short distance from the break, if the construction has been carried out as above described.

Fig. 5 shows a spacer member made up in two parts 19 and 20 such that the segments interlock. This interlocking and the twisting of the segments will give them the necessary flexibility and mechanical strength, and at the same time develop sufficient mechanical strength for any pressure between the outer and inner members.

Fig. 6 shows a member similar to that of Fig. 3 except that the core 21 is surrounded by a single ribbon or wrapping 22.

Fig. 7 shows a spacer member 23 made up in the form of a helix without a core. A member made up in this way can be given any degree of flexibility and the resiliency provided may be beneficial in some conductors. The helix may be made of a ribbon, or round or square wire.

If desired the construction in Fig. 7 can be modified to that shown in Fig. 8 in which a member 24 is wound in rectangular or square contour to provide increased bearing area. Other forms may be used which would increase the flexibility not only of the spacer member but of the entire cable. A simple cylindrical wire 25, as shown in Fig. 9, may also be used for a spacer where the required amount of spacing is not too great.

A number of different forms of conductor strands may be used for the outer segments in

addition to those shown at 10 in Figs. 1 and 2. Fig. 10 shows a locking type of segment 26 which can be used where it is desired to screen discharge from the abutting edges, as previously explained. The tongue 27 on one edge of each segment meshes with a groove 28 on an adjacent segment.

Fig. 11 shows another form of conductor segment in which alternate strands 29 are made larger than the intervening strands 30. Adjacent strands are interlocked so as to prevent displacement by bending of the cable.

Fig. 12 shows another form of interlocking segment 31 in which each segment is provided with a tongue 32 at one corner engaging a groove in the adjacent segment.

Fig. 13 shows the conducting layer made up of outer members 33 and inner segments 34. This type of construction makes it possible to increase the flexibility of the conductor materially. The construction also has the advantage that the lay or twist may be in one direction for the members 34 of the inner layer, and the other direction for the members 33 of the outer layer. This tends to reduce the reactance of the conductor, particularly where the pitch of the outer members is small in order to obtain flexibility. Any movement such as that due to vibration will tend to cause the inner and outer layers to slide upon each other. The friction between these inner and outer layers will be of material benefit in dampening vibration. The decreased fiber stress, due to the thinness of the members, also will tend to reduce the possibility of damage due to vibration. These thin members may be provided with locking edges similar to those shown in Figs. 10, 11, and 12, or in any other suitable way. In some cases, a very simple lock similar to that shown in Fig. 14 may be used.

If space is provided between the edges of the outer segments, the flexibility of the conductor generally will be materially increased. However, it is difficult to provide uniform spacing or clearance unless some definite means is used for securing this spacing. One method is shown in Figs. 15 and 19 in which a very small burr or rib 35 is placed on the edge of the main segment 36. This member 35 may be continuous or may be in the form of small projections. Owing to the very small section of the member 35, any abnormal pressure will cause the small member to be seated in the adjacent segment or simply to compress. This method provides a uniformly distributed spacing but at the same time permits movement between adjacent segments necessary to increase the flexibility of the conductor. This spacing also permits of moisture running out of the conductor, so that accumulation at a low point will not be possible.

Another way to provide slight spacing while permitting lateral movement is to bend the segments edgewise. If this is done, the bends in adjacent segments should be offset with respect to each other during the fabrication of the conductor, or bent segments may be alternated with unbent segments. This arrangement may be used with any of the segments having radial edges or those having locking means. The number and size of the segments of course can be varied, depending upon the results desired in the cable.

The high strength core makes it possible to reduce the required height of the supporting structures for a given ground clearance at the center of the span. It also makes it possible to use considerably longer spans and reduce the number of structures if desired. The greatly increased strength of the conductor due to the high strength core makes it possible to provide greater effective rigidity in the conductor, due to the increased tension, so that bending of the conductor, due to wind or other conditions, will be less so that greater rigidity in the segments and the outer layer may be used without causing trouble due to bending or flexing. This is evident from the fact that high tensions in the conductor tend to cause it to act as a rigid member.

Steel is one of the most desirable metals for resisting vibration. The use of a high strength steel core, therefore, tends to increase the mechanical reliability of the conductor very materially. In addition, the strength of the core may be several times that of the conducting material so that practically all the mechanical load may be carried by the core if desired, permitting of a very thin outer wall.

In general, the lower cost of material used for the spacer makes it possible to produce a conductor of large diameter and high corona point, and of good mechanical properties at a low cost. This makes it possible to use considerably higher transmitting voltages even where the blocks of power are not very large, as the section of conducting material may be made small without mechanical difficulties. With the construction shown, the thickness of the outer conducting layer may be considerably less, without danger of collapse, than where a simple hollow conductor is used.

Fig. 16 is somewhat similar to Fig. 10 except that in place of ribs 27 of Fig. 10, the segments 37 are provided with V ribs and notches at their engaging edges.

Fig. 17 shows a different form of conductor strands or segments which may be used with or without an internal core and spacer. In this form of the invention, each segment preferably has a bulging face 40 which projects far enough to prevent discharge from the rounded corners at 41 and 42. In a conductor it is quite important that the strands or segments do not become displaced with respect to each other during construction or under operating conditions, and it is also important, particularly where an internal supporting structure is not used, that the members have enough mechanical strength so that the conductor can be clamped at suspension or dead end points. It is highly desirable that the strands of the conductor do not slip by each other under tangential forces produced by the weight of the conductor or by gripping means used in clamping.

In the construction shown in Fig. 17, the segments are provided with tongues 43. These tongues may be of uniform section or tapered to facilitate drawing or forming. In order to prevent the strands from slipping past each other, two means may be employed to advantage. In one arrangement the tangential force on the abutting surfaces tends to cause a slight interlock. This force will increase with the tension on the conductor and as the pitch becomes less or the number of twists become greater for a given length of conductor. One edge of each segment is provided with a slight groove 44 and the other edge with a matching projection or rib 45. It is important that when the two adjacent segments are forced together by tangential stress, they will tend to lock and not become displaced. In order to increase the reliability, the projecting tongue 43 may be extended well under the adjacent segment. If in fabrication of the con-

ductor the lay of the strands is such that there is a tendency for the tongue **43** to move outwardly and for the opposite edge **45** to move inward, the strands will tend to hold themselves together very firmly. This arrangement can be used even though there is no recess **44**. By giving the members a torsional twist which may come about naturally in the fabrication or may be emphasized if desired, a conductor will be formed in which it will be very difficult to dislodge the adjacent sections. Of course it is not necessary that the segments be smooth on the inside, and the tongues **43** may be of any desired thickness or any desired length. However, if these tongues are long it will be exceedingly difficult to dislodge the strands, and if for any cause a strand is dislodged, it will be possible to put it back into position.

This arrangement of segments or strands makes it possible to provide a fairly definite pressure between the tongue **43** and the segment above, regardless of the tangential pressure. This will be a very great advantage in some cases where it is desired to dampen out vibration. It is evident that where the friction is too great between the segments, they will act as a unit. However, if the pressure can be reduced to the point so that vibration will cause slipping, energy will be absorbed and serious vibration will be prevented. Therefore, it is seen that by controlling the pitch of the conductor and the torsional stress in the strand, practically any degree of pressure between the parts may be provided. Owing to the large areas which may be provided between the surfaces, there will be little danger of seizing between the strands, so that a frictional or bearing member will not be necessary although this of course may be provided. Such a bearing member is shown at **46** in Fig. 18, which figure is otherwise like Fig. 17. The bearing surfaces of course can be coated with any lubricant or material which will protect the wearing surface or control the coefficient of friction.

Any tendency for burrs to form in the manufacture of the cable may be taken care of by using a drawing die having the exact contour desired for the outside of the segments. The die will smooth up any roughness as the cable is drawn through. If additional force is needed and an internal core is not used, a drawing mandrel or die may be used inside the cable to increase the force between the segments and the outside die.

I claim:

1. A conductor comprising a tubular shell formed of flattened strips of conducting material placed edge to edge, the edges of said strips being disposed substantially radially of said conductor, one edge of each strip having a rib thereon spaced from the outer and inner extremities of said edge and engaging the edge of the adjacent strip, adjacent edges of said strips being spaced apart by said ribs.

2. A conductor comprising a shell of helically wound flattened strips of conducting material placed edge to edge, the edges of said strips being disposed substantially radially of said conductor, one edge of each strip having a rib thereon spaced from the outer and inner extremities of said edge and engaging the edge of the adjacent strip, adjacent edges of said strips being spaced apart by said ribs.

3. A conductor comprising a core member, an outer shell of conducting material and a spacer helically wound upon said core member between said core member and said conducting shell, said spacer comprising a plurality of ribbon shaped strips bent into arcuate form in cross section and helically twisted together.

4. A conductor comprising a central core member, a spacer helically wound upon said core member and a conducting shell disposed outside of said spacer, said spacer comprising a core member, and a ribbon member disposed upon the surface of said core member and wound helically thereon.

5. A conductor comprising a high strength core member, a spacer wound helically upon said core member and a conducting shell disposed about said spacer, said spacer comprising a plurality of strands wound helically together about its own axis to provide flexibility, said conducting shell comprising a plurality of flattened strips of conducting material disposed edge to edge about the periphery of said spacer, the outer surface of each of said strips being bowed outwardly upon a radius less than the radius of said conductor so that the central portion of each strip projects radially beyond the edges thereof to prevent formation of corona at the edges of said strips.

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