April 25, 1933. H. W. WEBB 1,905,197

FLEXIBLE CABLE

Filed Feb. 6, 1929

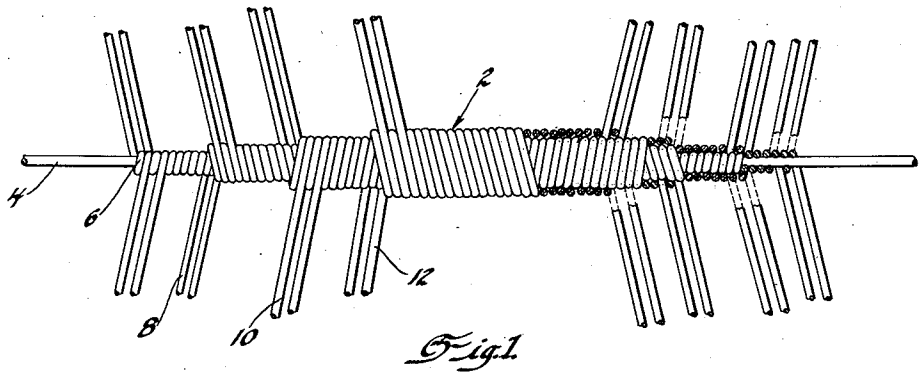


Fig. 1.

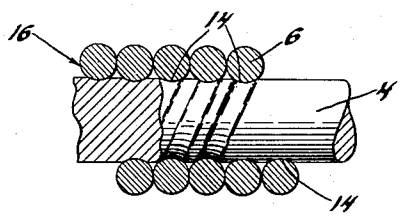


Fig. 2.

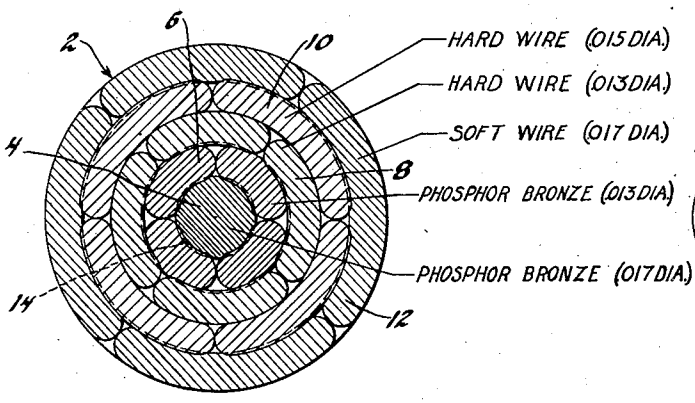


Fig. 4.

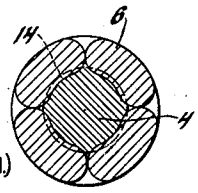


Fig. 3.

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UNITED STATES PATENT OFFICE

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FLEXIBLE CABLE

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This invention relates to improvements in flexible shafting or flexible cables and is particularly adaptable for use on speedometer drives, drives for dental drills, etc. The improvements relate to flexible cables having a core wire and a plurality of successive layers of wire wound thereabout. In the present instance four successive layers are wound about the core wire.

Flexible shafts now in use either use no core wire at all or a core wire made of steel. It has been determined experimentally that flexible shafts using a core wire of steel are objectionable for the reason that the steel core breaks down first due mainly to fatigue in the metal. The core wire of a flexible shaft is subjected to a very large number of bends in the course of its use and it is therefore highly necessary that the core stand up under all degrees of tension and possible demand in the trade. Steel is also objectionable for the reason that it does not readily lend itself to uniform elongation, and this uniform elongation is a desirable feature in the art of flexible cable manufacture. A tinned steel wire was also used as a core wire but tests also showed that the tinned core wire broke down first. These experiments led to the use of a phosphor bronze core which is relatively much softer than steel and has the property of greater elongation than steel wire, and at the same time has high tensile strength. In addition phosphor bronze is capable of uniform elongation while the elongation in steel is liable to be irregular. A soft bronze wire is also extremely resistant to fatigue and is well able to stand up under all requirement of actual use.

A chrome vanadium wire might be used as a core wire as well as a phosphor bronze wire. However the objection to chrome vanadium steel is that it is costly and it is also understood that it is difficult to draw this wire fine enough for use in flexible cables. Chrome vanadium steel has the desired anti-fatigue properties but not the anti-friction properties.

Another reason for the use of a phosphor bronze core and a first layer of phosphor bronze is to provide an anti-friction bearing between the first and second layers. It is between the phosphor bronze core and the second layer that the main portion of the internal heat in the shafting is generated and the greater friction developed. At the median point on the radius of a cross section of the cable, the alternate tension and compression strains have no means of relief by corresponding change from circular to oblate section of the individual coils as have the outer layers and metal to metal friction must be as little as possible at this point.

The core wire of phosphor bronze is preferably of a larger diameter than the diameter of phosphor bronze wire wound thereabout. The core wire and phosphor bronze layer form a core and over the phosphor bronze core there are wound two successive layers of relatively hard wire, or what is known as 0.43 carbon wire. Over the outer layers there is wound a single layer of relatively soft wire, or what is known as 0.10 carbon wire.

The use of a soft outer wire is for the purpose of making it easier to retain the ends of the cable together after it is severed. If a hard wire is used on the outside and the cable severed, there is a great tendency for the ends to unravel in fascicular form.

If the outer soft wire layer is wound on the outermost hard wire layer, there is a tendency for the harder wire to embed itself in the softer wire. This embedding is increased as the wire passes through the withdrawal rollers which pull the product from the cable winding machine and is further increased in the wire straightener. When a cable having an outer layer of soft wire is severed there is a tendency for the inner hard steel layers to unwind out against the outer soft wire layer, which is additive to the embedding of the two layers into each other, to thereby prevent unraveling. Unraveling is prevented by the fact that the inner layer has a tendency to unravel and the outer layer has not.

The old way of manufacturing cable is shown and described in the patents to

Webb, 887,159 and 887,160, May 12, 1908. These patents describe a coreless flexible shaft in which the shaft as a whole is stretched after it is completed. In stretching, the inner or smaller diameter layers are diminished in diameter a greater amount than the outer layers which leaves a relatively small space between adjacent layers and accordingly decreases friction. This progressively increasing rate of decrease in diameter from the outer to the inner layer is valid only where the wires are of nearly the same gage of wire. For reasons of economy and to provide equal crossing angles in successive layers it is desirable to progressively increase the gage of the wire as the layers are built outwardly and the formula in which space is obtained between successive layers therefore no longer holds. Accordingly in the present invention use is made of wires having different diameters.

Hence it is advisable, after applying each layer, to mechanically massage that layer upon the surface of its subjacent layer. This effects a stretching of the layers, oblates the wire section to give the long diameter axis longitudinal with the structure, and as the friction points, which it is necessary to lubricate, are between the individual wires themselves and between the layers, the process of oblating the wire section, gives lubrication space between the wires and the layers. The stretching and massaging is accomplished by the wire straightened in use on the cable winding machines.

In passing the successive layers of wire through a pair of withdrawing rollers and through the wire straightener the softer wires are either caused to dig into each other or become somewhat flattened at their contacting surfaces, or the harder wire will dig thereinto. This is true with reference to the phosphor bronze core and first layer, between the phosphor bronze layer and hard wire layer, and between the outer hard wire layer and outermost soft wire layer.

On the drawing:

Figure 1 shows a view of the flexible cable with the individual strands in separate relation to show the composite nature of the shafting.

Figure 2 is an enlarged view of the core wire and first layer of phosphor bronze wire.

Figure 3 is a section through the phosphor bronze core and phosphor bronze layer.

Figure 4 is a section through the completed shaft.

Referring to the drawing the numeral 2 indicates a flexible shaft as a whole. The flexible shaft comprises the phosphor bronze core wire 4, the layer 6 of phosphor bronze wire wrapped therearound, the succeeding layers 8 and 10 of hard wire, and the outer layer 12 of soft wire.

The core 4 of phosphor bronze wire preferably has a diameter of .017 inch while the phosphor bronze layer 6 wrapped thereabout is preferably composed of wires having a diameter of .013 inch. This core wire and phosphor bronze layer are shown in Figures 2 and 3, the proportions being considerably exaggerated for purposes of clearer illustration.

In wrapping the layer 6 on the core wire 4 the cable winding machine tightly wraps the wire 6 about the core wire and causes a slight deformation at their contacting surfaces. This deformation may be described as one wire digging into the other or as the flatening of the wires at their contacting surfaces. As the wire leaves the wrapping nose or head it is passed through a pair of withdrawing rolls which tightly press the wire between them and cause a further oblation or deformation indicated generally at 14 in Figures 2, 3, and 4.

As the wire leaves the withdrawing rolls it is passed through a rotary wire straightener which further oblates and elongates or stretches the product and provides space for lubrication. See patents to Stone, 359,410, and Sisum, 488,227, for illustrations of the applications of a wire straightener and withdrawal or take-up rollers.

The core wire 4 and the layer of phosphor bronze wire 6, after passing through the withdrawing rolls and the wire straightener are quite intimately united and are relatively immovable and form a phosphor bronze core comprising the core wire and the phosphor bronze layer.

The core, indicated as a whole at 16, is then passed through a machine and the layer 8 of hard wire of a diameter of preferably .013 inch wrapped therearound. The hard wire is tightly wrapped and due to the difference in hardness between the hard wire layer 8 and the phosphor bronze core 6 the hard wire digs into the phosphor bronze. This deformation or digging is further accentuated as the product passes through the withdrawing rolls and the wire straightener.

A second layer 10 of hard wire of a diameter of preferably .015 inch is then wrapped about the layer 8 which is followed by the layer 12 of relatively soft wire of a diameter of preferably .017 inch. Owing to the difference in hardness between hard wire layer 10 and soft wire layer 12 the harder wire digs, imbeds itself into or slightly deforms the softer wire to thereby form a more intimate connection between the two. This is of advantage when cutting the wire to length in that it prevents unraveling at the end. There is a slight unraveling due to the outward pressure of the hard wire layer, but the unraveling is only slight because of the rather intimate interconnection between the two outer layers and to the fact that they are wrapped in opposite directions.

As will be noted from Figure 1 the successive layers are wrapped in opposite directions in a well-known manner.

Owing to the fact that each successive layer after it is wrapped on its subjacent layer is passed through a pair of withdrawing rolls and a wire straightener the cable is stretched or elongated to the desired degree and when the final or outer soft wire layer 12 is added the cable will be finished and ready for use after it leaves the machine. No stretching will be required as in the Webb Patents 887,159 and 887,160, previously referred to.

Exactly the same result as regards the separation of adjacent coils has previously been secured by stretching the cable when completed to about 1½ times its own diameter per foot in a device whereby it is run through two pairs of rolls, the second pair of which rotate at greater speed than the first pair. The result was satisfactory but caused an extra operation and did not oblate the wire so that hard spots remained in the cable.

The completed cable has also previously been swaged in a rotary swage. This was satisfactory in oblating the wire and giving space between super and subjacent layers, but caused the wires of a layer to close on each other resulting in short life under load.

The rotary massaging of each layer as it is formed, on the subjacent layer, effects both these objects of stretching and oblation satisfactorily and as phosphor bronze has extremely high and uniform elongation combined with great tensile strength it was adopted for the core wire, and for the first layer because of its anti-friction properties with hard steel.

After the final product leaves the cable winding machine it is cut to length in accordance with the disclosure of the Webb Patents 1,808,193 and 1,808,194.

While I have shown and described four layers of wire, it is within the scope of the invention to use more or less layers and the process of forming the cable may be stopped after winding any of the hard wire layers. The cable may also be made by using two outer layers of soft wire, or one hard wire and one soft wire layer.

I claim:

1. In a flexible driving shaft, a phosphor bronze core comprising a plurality of tightly interwound wires, said wires digging into each other or having flattened contacting sides so as to prevent relative movement, and one or more layers of wire over said core.

2. In a flexible driving shaft, a phosphor bronze core wire, a layer of phosphor bronze wire over said core wire, and two layers of hard steel wire over said layer of phosphor bronze wire.

3. In a flexible driving shaft, a phosphor bronze core wire, a layer of phosphor bronze wire over said core wire, said core and layer being relatively immovable, two layers of hard steel wire over said layer, and an outermost layer of soft steel wire.

4. In a flexible driving shaft, a phosphor bronze core wire, a layer of phosphor bronze wire over said core wire, said core and layer being relatively immovable, a plurality of layers of hard steel wire over said layer, and an outermost layer of soft steel wire.

5. In a flexible driving shaft comprised of a plurality of wires, a phosphor bronze core wire, and a plurality of layers of wire wound in alternately opposite directions over said core wire.

6. In a flexible driving shaft comprised of a plurality of wires, a phosphor bronze core comprising a plurality of wires, and a plurality of layers of wire wound in alternately opposite directions over said core.

7. In a flexible driving shaft comprised of a plurality of wires, a phosphor bronze core comprising a core wire and a layer of wire wound thereover, and a plurality of layers of wire wound in alternately opposite directions over said core.

8. In a flexible driving shaft comprised of a plurality of wires, a phosphor bronze core comprising a plurality of relatively immovable wires, and a plurality of layers of wire wound in alternately opposite directions over said core.

9. In a flexible driving shaft comprised of a plurality of wires, a phosphor bronze core comprising a plurality of wires having different diameters, and a plurality of layers of wire wound in alternately opposite directions over said core.

10. In a flexible driving shaft comprised of a plurality of wires, a phosphor bronze core, and one or more layers of hard wire wound in alternately opposite directions over said core.

11. In a flexible driving shaft comprised of a plurality of wires, a phosphor bronze core wire, a layer of phosphor bronze wire over said core wire, and one or more layers of hard wire wound in alternately opposite directions over said phosphor bronze layer.

12. In a flexible driving shaft comprised of a plurality of wires, a phosphor bronze core comprising a plurality of wires, and one or more layers of hard wire wound in alternately opposite directions over said core.

13. In a flexible driving shaft comprised of a plurality of wires, a phosphor bronze core, and two layers of hard steel wire wound in alternately opposite directions over said core.

14. In a flexible driving shaft comprised of a plurality of wires, a phosphor bronze core, one or more layers of hard wire wound

in alternately opposite directions over said core, and an outermost layer of soft wire wound in a direction opposite to its adjoining layer.

15. In a flexible driving shaft comprised of a plurality of wires, a phosphor bronze core comprising a plurality of wires, one or more layers of hard wire wound in alternately opposite directions over said core, and an outermost layer of soft wire wound in a direction opposite to its adjoining layer.

16. In a flexible driving shaft comprised of a plurality of layers of wire wound in alternately opposite directions, a phosphor bronze core wire, a layer of phosphor bronze wire wound over said core wire, the wire of said layer having a diameter different from the diameter of the core wire, a plurality of layers of hard steel wire wound in alternately opposite directions over said phosphor bronze wire, the wire of one hard steel wire layer having a diameter different from the diameter to the wire of the adjacent hard wire layer, and an outermost layer of soft steel wire wound in a direction opposite to the winding of its adjacent layer.

17. In a flexible driving shaft comprised of a plurality of wires, a phosphor bronze core wire, and a plurality of layers of wire wound in alternately opposite directions over said core wire, not more than two of said layers having their wires of the same diameter.

18. In a flexible driving shaft comprised of a plurality of layers of wire wound in alternately opposite directions, a phosphor bronze core, a plurality of layers of wire wound in alternately opposite directions over said core, the wire of one layer having a diameter different from the wire of the adjacent layer, and an outermost layer of soft wire wound in a direction opposite to the winding of its adjacent layer.

In testimony whereof I affix my signature.

HARTWELL W. WEBB.