Stranded Conductor and Method of Making Same

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Strands of material along selected segments of an indeterminate length of stranded conductive material are welded together and severed to provide predetermined lengths of stranded conductive material having the strands at the ends thereof secured together to prevent unraveling. Each strand comprises a plant fiber core about which is wrapped a conductive foil. Such pieces of conductive material are secured to one or more coil lead wires to form a pair of terminal leads in a coil assembly.

5 Claims, 3 Drawing Figures
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STRANDED CONDUCTOR AND METHOD OF MAKING SAME

This is a division of application Ser. No. 765,791 filed Oct. 8, 1968 now U.S. Pat. No. 3,579,165. This invention relates generally to conductors and more particularly to an improved flexible conductor comprised of a plurality of strands of material with the strands at the ends thereof secured together to prevent unraveling and to a method of making same.

In the assembly of various types of electrical devices and systems it is often desirable to use flexible electrical conductors for interconnecting various component parts of such device or system. Generally, flexible conductors are needed when two or more components in a system must be free to move or vibrate relative to each other. In such a system, it is extremely desirable to use a flexible conductor that will not become brittle, crack, or be otherwise adversely affected by vibrations imparted thereto. In electro-mechanical transducer systems, such as loudspeakers and some types of microphones, flexible conductors are used as a terminal lead to establish an electrical connection between a movable member or diaphragm and one or more other components that are designed to vibrate in rather precise modes relative to each other. In such systems it is desirable, if not necessary, that the flexible conductor exert a minimum amount of damping on the vibratory movement of the movable member. In addition, it is desirable for the flexible conductor to have an extremely small mass so that the natural frequency of such system will not be substantially affected because of the added mass of the conductor.

One material that has been found to be generally suitable for use as a flexible conductor in electro-mechanical transducers is comprised of a plurality of strands of electrically conductive material twisted together with each of the strands comprising a thin strip of conductive material wrapped around a light-weight cotton, linen, or synthetic material core. This material, commonly referred to as "tinsel," is relatively expensive but is used nonetheless because it is very supple and is characterized by a low mass per unit volume. In actual practice, however, pieces of stranded material are extremely difficult to handle and to connect with other materials because the individual strands in such material become unraveled at the ends thereof. This unravelling of individual strands has resulted in the waste of large amounts of material and has also been the cause of faulty connections between various electrical components. It has also been very difficult to provide automated systems for handling determinate lengths of stranded conductors because of the unraveling problem.

In the loudspeaker manufacturing art, the ends of relatively fine voice coil lead wires are normally connected to a piece of stranded conductor of determinate length. Suggested solutions for the unraveling problem have included the technique of manually wrapping a voice coil lead wire around one end of a stranded conductor and then soldering the stranded conductor and voice coil lead wire together. This technique, however, has been expensive in practice and has failed to solve the basic unraveling problem because many pieces of stranded conductor can still become unraveled before being connected to the voice coil lead wires and other pieces of stranded conductor can become unraveled during the operation of wrapping a voice coil lead wire around an end of each conductor. In addition, even when pieces of this material have been successfully handled without unraveling the strands at the ends thereof, the flexibility of the pieces of the material has often been impaired by the capillary flow of solder therealong during the soldering operation. The capillary flow of solder along a stranded conductor has also been one of the major problems encountered when molten solder has been applied to pieces of stranded conductive material either before or after pieces of stranded material have been severed from an indeterminate length of such material.

It will be appreciated, therefore, that it would be desirable to provide an improved stranded conductor wherein the individual strands along the ends thereof are restrained from unraveling and to devise a method of making such improved conductors. Accordingly, it is an object of the present invention to provide a new and improved method of making, from an indeterminate length of stranded conductive material, stranded conductors of any desired determinate length with the strands along the ends thereof restrained from unraveling. Another object of the present invention is to provide a method of manufacturing pieces of stranded material having the individual strands at the ends thereof secured together. A more specific object of the present invention is to provide a method of making pieces of stranded conductive material and welding together the strands along the end portions thereof without deleteriously affecting the core of the material.

A further object of the invention is to provide a new and improved method of making stranded conductors wherein the strands at the ends thereof resist unraveling. Still another object of the present invention is to provide an improved stranded flexible conductor having the strands along the ends thereof welded together to prevent unraveling of the individual strands. Further objects and advantages of the present invention will become apparent as the following description proceeds, and the features of novelty characterizing the invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

Briefly, the present invention is concerned with an improved stranded flexible conductor and method of making the same. The stranded flexible conductor has the strands along the ends thereof welded together to prevent unraveling. Since the strands are welded, it is not necessary to bond the strands together with an adhesive material and thereby increase the mass of the conductor. The welded end portions of the conductor are also less conductive to the capillary flow of solder therealong than unwelded portions of the stranded conductor. When one or more pieces of conductive material are assembled with a pair of coil lead wires to form a pair of terminal leads in a coil assembly, the welded end portions prevent the stranded conductive material from unraveling.

For a better understanding of the present invention, reference may be had to the accompanying drawings wherein:

FIG. 1 illustrates a stranded conductor having the strands at one end thereof welded together in accord with the invention;
FIG. 2 schematically represents the performance of the method of the invention; and
FIG. 3 illustrates a coil assembly embodying the invention.

FIG. 1 illustrates a flexible stranded conductor comprised of a plurality of strands 11-15 of conductive material such as silver-plated copper foil. Since it is desirable in many applications for the conductor 10 to be very supple, each of the strands 11-15 are formed by wrapping foil around plastic cores 16 of material such as cotton. The end 17 of the conductor 10 is illustrated as being frayed with the strands therein unraveled as is frequently the case when the teachings of the present invention are not followed. The end 18 of the conductor 10 is illustrated with the strands therealong welded together to resist unraveling in accord with the invention.

According to the method schematically represented in FIG. 2, individual strands of material along selected segments of an indeterminate length of stranded conductive material are welded together and then severed to prevent the individual strands of conductive material from unraveling. The method may be carried out manually or by any suitable automatic means. In either event, the method of the present invention includes the steps of positioning a selected segment of an intermediate length of stranded conductive material and welding means adjacent to each other, welding together individual strands of conductive material in the selected segment, and thereafter severing the indeterminate length of stranded material along the selected segment. The indeterminate length of material may be manually positioned adjacent to the welding means and then manually severed with shears, a knife, or some other severing tool. With particular reference to FIG. 2, an indeterminate length of stranded conductive material 19 is supported on a drum 21 and material advancing means 22 advances the conductive material 19 past a welding station 23 and severing station 24. It being understood that the advancing means 22 includes any suitable apparatus such as a pair of pinch rollers. When the conductive material 19 has been advanced a desired amount the advancing means 22 dwells and the individual strands along a segment of the material 19 are welded together at the welding station 23 when welding head 24, supported for reciprocative movement relative to a stationary welding support 26, moves toward the support 26 and compresses a segment 19a of material therebetween. When the material 19 is welded by cold pressure welding, the conductive material in the strands thereof flows together along the interfaces between the various strands; and when the material 19 is welded by the process illustrated in FIG. 2, an electrical potential is applied across a segment 19a of the conductive material by a power supply means 27 such that a pulse of welding current flows through the individual conductive strands of conductive material located between the welding head 24 and support 26. The power supply means 27 comprises any suitable circuitry and is connected to an electrode portion 28 of the welding head and an electrode portion of the support through a conductor 29 and a not shown ground connector, respectively. When welding current is applied to the stranded conductive material 19, the strands thereof are fused together and it is to be expressly understood that such fusing can be accomplished with welding electrodes positioned on radially opposite sides of the conductive material as illustrated in FIG. 2, or with electrodes spaced longitudinally along the conductive material.

After the strands along a predetermined segment of conductive material have been welded together, the segment is severed. In FIG. 2, a severing means 24 is illustrated as including a table 31 and a cutter 32 supported for movement toward and away from the table 31. By locating the cutter 32 a distance from the welding station 23 equal to the distance the conductive material advances each time that the material advancing means 22 is actuated, the cutter 32 will automatically sever the stranded material along welded segments thereof. In view of the foregoing, it will be understood that by repeating the steps of advancing, welding, and severing the stranded conductive material 19, a plurality of pieces of stranded conductors having a predetermined length will be obtained having the individual strands along the ends thereof welded together to prevent unraveling.

In the coil assembly 32 of FIG. 3, a pair of flexible conductors 33, 34 having the individual strands of conductive material along the ends thereof welded together to prevent unraveling, are connected to coil lead wires 36, 37 to form terminal leads 38, 39. The coil assembly 32 includes a winding support in the form of a bobbin 41 with a coil 42 of magnet wire wound thereon and is particularly suitable for use as a voice coil assembly in an electro-mechanical transducer such as a loudspeaker. When molten solder is used to reinforce the illustrated connection between the coil lead wires 36, 37 wrapped around conductors 33, 34, the welded portions of the conductors provide the added advantage of inhibiting or retarding the capillary flow of solder and other wetting agents therealong.

From the foregoing description of the invention, it will be apparent that a new and improved method has been provided for making discrete pieces of stranded conductive material that retain a desired degree of flexibility, that have the strands at the ends thereof welded together to prevent unraveling, and that may be economically handled in automated equipment without fraying the ends of the individual stranded conductors. It will also be apparent that stranded conductors embodying the invention have, in addition to the above desirable characteristics, the characteristic of inhibiting the capillary flow of wetting agents therealong.

It will be understood that the particular embodiments of the invention described herein are intended as illustrative examples of the invention and that the invention is not necessarily limited to such embodiments. It will be understood therefore that other modifications of the invention described herein may be made, and that it is intended by the appended claims to cover all such modifications that fall within the true spirit and scope of the present invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A method of forming, from an indeterminate length of stranded material, a plurality of pieces of stranded material each having a predetermined length and each having the strands along the ends thereof welded together, said method comprising the steps of
advancing an indeterminate length of stranded material to a welding station, each of the strands comprising a pliant core of electrically nonconductive material and conductive foil wrapped around the core, welding together the conductive foil of the individual strands of material in a first segment of the indeterminate length of stranded material, maintaining the pliant core of nonconductive material within the conductive foil of each strand, including the welded portion, severing the indeterminate length of stranded material along the welded first segment thereof, welding together the individual strands of material in a second segment of the indeterminate length of stranded material, and severing the indeterminate length of material along the welded second segment thereof.

2. The method of claim 1, wherein the step of welding together the individual strands of material in a first segment of the indeterminate length of material comprises the steps of contacting the indeterminate length of stranded material with a pair of welding electrodes thereby to locate between the electrodes the first segment of stranded material and passing electric current through the electrodes and through the first segment of stranded material, and the step of welding together the individual strands of material in the second segment of the indeterminate length of stranded material comprises the steps of contacting the indeterminate length of stranded material with a pair of welding electrodes thereby to locate between the electrodes the second segment of stranded material and passing electric current through the electrodes and through the second segment of the stranded material.

3. A method of treating conductive material comprised of a plurality of strands of material, said method comprising the steps of advancing an indeterminate length of the conductive material to a welding station thereby to locate a first segment of the conductive material at the welding station, each of the strands comprising a pliant core of electrically nonconductive material and conductive foil wrapped around the core, welding together the individual strands of material in the first segment of the indeterminate length of conductive material, advancing a second segment of the indeterminate length of conductive material to the welding station, welding together the conductive foil of the individual strands of material in the second segment of the indeterminate length of conductive material, maintaining the pliant core of nonconductive material within the conductive foil of each strand, including the welded portion, and thereafter severing the conductive material along the welded second segment thereof to produce a predetermined length of stranded conductive material having the strands therein fused together at the end portions thereof.

4. A piece of conductive material having a predetermined length and comprised of a plurality of strands of conductive material twisted together with the individual strands of material welded together along the ends thereof to inhibit unraveling of the individual strands of material at the ends of the piece of conductive material each of the individual strands comprising a pliant core of electrically nonconductive material, and conductive foil wrapped around the core and having a welded end portion, the pliant core being within the welded end portion of the conductive foil.

5. The structure of claim 4, wherein the individual strands of material are fused together along the interfaces thereof adjacent the ends of the conductor.

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