Sept. 24, 1935. H. J. CRABBS 2,015,619

ELECTRICAL APPARATUS

Filed July 8, 1932 2 Sheets-Sheet 1

Fig. 1.

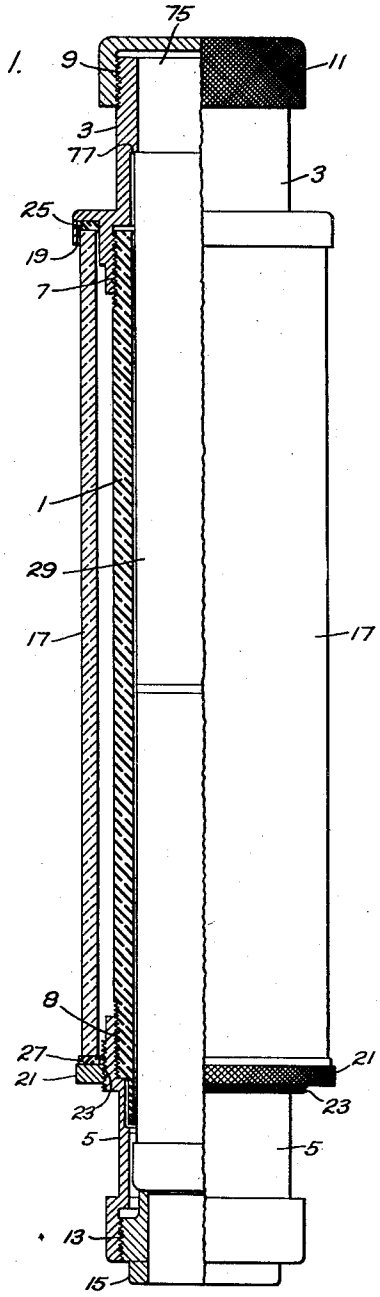
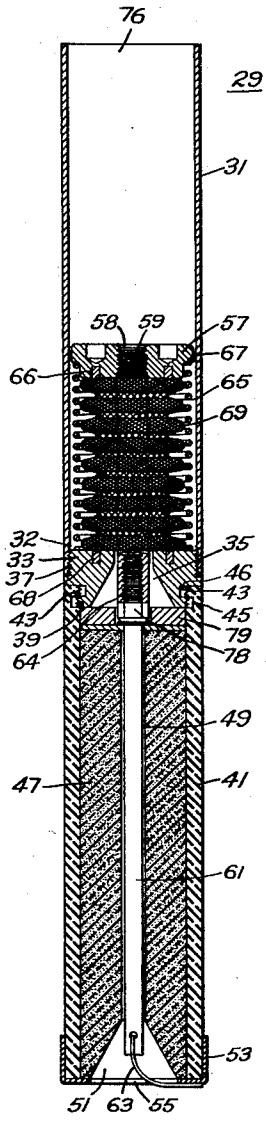


Fig. 2.



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Fig. 3.

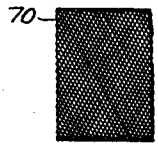


Fig. 4.

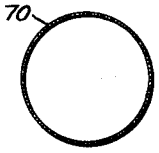


Fig. 5.

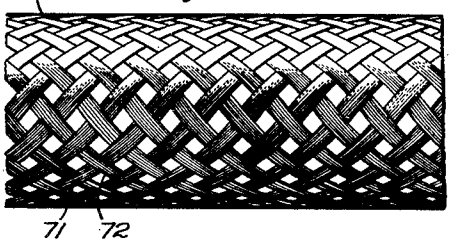


Fig. 6.

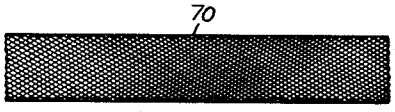


Fig. 7.



Fig. 8.

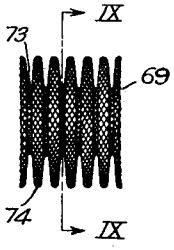


Fig. 9.

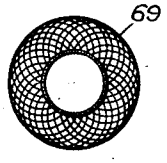


Fig. 10

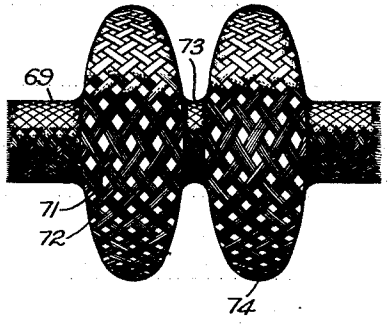


Fig. 11.

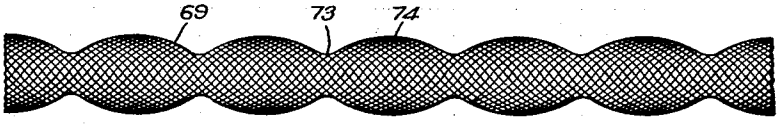
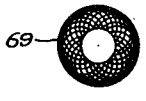


Fig. 12.



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UNITED STATES PATENT OFFICE

2,015,619

ELECTRICAL APPARATUS

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Application July 8, 1932, Serial No. 621,439

11 Claims. (Cl. 173—324)

My invention relates to flexible conductors, and particularly to longitudinally extensible and contractible conducting shunts having a large ratio between the extended and the contracted length.

One object of my invention is to provide an improved means for electrically connecting two relatively movable members of conducting material that shall be simple in design, economical to manufacture, and more reliable and more effective in operation than previous structures.

Another object of my invention is to provide a longitudinally extensible and contractible conducting shunt for connecting the separable parts of electrical apparatus that shall have a very large ratio between its extended and its contracted length.

A further object of my invention is to provide a high capacity tubular shunt having circumferential pleats so that it shall be capable of very great longitudinal extension and contraction.

A further object of my invention is to provide an improved longitudinally extensible and contractible conducting shunt in which a plurality of individual flexible conductors form a bias-woven tube and are subjected chiefly to torsional stresses during the normal functioning of the connected apparatus.

A further object of my invention is to provide an improved simplified method for manufacturing a longitudinally extensible conducting shunt from a plurality of flexible conductors arranged in a substantially tubular form.

A further object of my invention is to provide an improved longitudinal extensible and contractible conducting shunt that may be used for connecting relatively movable parts in close proximity to an enclosing wall or an encircling spring without the possibility of contacting the wall or interfering with the free movement of the spring by getting between its turns during the movement of the parts.

A still further object of my invention is to provide a longitudinally extensible and contractible conducting shunt comprising a plurality of flexible conductors, each of which is restrained from moving more than a predetermined distance from the longitudinal axis of the shunt.

One field for immediate application of my invention is in connection with high voltage expulsion fuses that utilize boric acid as the source of the expulsion gas, and I shall hereinafter describe an embodiment of my invention as applied to such devices, without, however, in any way intending to restrict the scope of my invention, except as indicated in the appended claims. With this type of fuse, a short fusible link is connected to the lower end of a movable rod; the other end of the rod is affixed to a piston member of conducting material which is biased upwardly by a coiled spring. An extensible conducting tubular shunt having a central opening therein to permit passage of the rod completes the electric circuit to the stationary contact. Upon the fusion of the link, the rod moves upwardly and establishes the arc in a chamber that is lined with boric acid. The boric acid decomposes and the resulting outwardly flowing vapor extinguishes the arc. The fuse is restored to an operative condition by forcing the rod carrying member downwardly and then attaching a new fuse link and chamber unit. It is immediately apparent that the expansible conducting shunt must be capable of considerable longitudinal expansion in order to secure a sufficient movement of the rod, and it must also be capable of numerous operations without in any way interfering with the operation of the coil spring. Both of these requirements are fully met by the conducting means of my invention.

The features of my invention which I believe to be new are particularly pointed out in the appended claims. For a fuller understanding of the principles of my invention and the best mode of applying those principles, reference may be had to the accompanying drawings, in which

Figure 1 is a side view, partly in elevation and partly in section, of an expulsion fuse embodying the principal features of my invention.

Fig. 2 is a detailed view, partly in section and partly in elevation, showing the removable unit containing the moving parts of the expulsion fuse illustrated in Fig. 1.

Fig. 3 is a side view showing a loosely bias-woven tubular conducting shunt in the fully compressed position.

Fig. 4 is an end view of the conducting shunt shown in Fig. 3.

Fig. 5 is an enlarged detailed view of the conducting shunt shown in Figs. 3 and 4.

Fig. 6 is a side view showing the tubular conducting shunt of Fig. 3 in the fully extended position.

Fig. 7 is an end view of the tubular conducting shunt shown in Fig. 6.

Fig. 8 is a side view showing a pleated, tubular, bias-woven shunt, which is the preferred embodiment of my invention.

Fig. 9 is a sectional view taken along the line IX—IX of Fig. 8.

Fig. 10 is an enlarged detailed view showing the

arrangement of the various component parts of the structure illustrated in Fig. 8.

Fig. 11 is a view corresponding to Fig. 6 showing the extensible conducting shunt of the preferred form of my invention, shown compressed in Fig. 8, in the fully extended position.

Fig. 12 is an end view of the conducting shunt shown in Fig. 11.

The fuse shown in Fig. 1 consists essentially of a cylindrical fibre tube 1 having relatively heavy side walls and threaded ends. Two tubular terminal members 3 and 5, of conducting material, which have internally threaded portions 7 and 8 respectively, are provided for engaging the threaded ends of the main fibre tube 1, and for contacting the fuse clips (not shown). Contact member 3 has a second threaded portion 9 which is engaged by an internally threaded cap 11, of conducting material. This cap closes the upper end of the fuse and at the same time provides the guide means for positioning the fuse in the clips. The other tubular contact member 5 has an internally threaded portion 13 for receiving the hollow restraining plug 15. A glass tube 17 is provided for protecting the main fibre tube 1 from the weather. This glass tube 17 fits in a suitable annular recess 19 in the upper contact terminal 3 and is held in that recess by a knurled nut 21 which screws on a threaded portion 23 on the lower contact member 5. Two rubber gaskets 25 and 27 are provided for securing a weather tight connection. The working parts of the structure are removable as a unit and are shown particularly in Fig. 2. The working parts of unit 29 are held in the fuse structure proper by the hollow restraining plug 15.

The upper portion of the working parts unit 29 comprises a round metal tube 31 having an internally threaded portion 32 on the lower end. This internally threaded portion 32 engages an annular member 33 of conducting material which has a central opening 35 therein and threaded portions 37 and 39. The lower portion of the working parts unit 29 comprises a fibre tube 41 having a threaded portion 43 for engaging the threaded portion 39 of the annular member 33 and an undercut portion 45—the function of which will be explained in a subsequent paragraph. The fibre tube 41 has a cylindrical body member 47 of boric acid having a centrally disposed circular passage 49 positioned therein. The passage 49 terminates in a funnel shaped opening 51. A cap 53 of conducting material encloses the lower end of the fibre tube 41 and serves the double function of providing a conducting means for engaging the lower contact member 5, and providing a restraining means for holding the boric acid member 47 within the tube 41. The cap 53 has an opening 55, the dimensions of which are substantially the same as the outer end of the opening 51 in the boric acid member 47.

The moving parts of the fuse include the round plunger member 57 which is adapted to move inside of the tube 31. A threaded opening 58 is provided in the plunger member 57 for the reception of the upper end of the stud 59 which is threaded on both ends. The other end of the stud 59 engages a threaded opening 64 in the rod 61. Both the stud 59 and the rod 61 are of conducting material. One end of the fuse link 63 is affixed to the lower end of the rod 61, and the other end is electrically connected to the cap 53. A coil spring 65 is provided for biasing the plunger member 57 in an upward direction—this spring abuts against a suitable shoulder 67 on the plunger member 57. The upward movement of the plunger member 57 and the connecting rod 61 is prevented by the fuse link 63.

The longitudinally extensible conducting shunt 69 which is used for completing the electrical circuit from the plunger member 57 to the annular member 33 is composed of a plurality of flexible conductors arranged in a substantially tubular form, and it is with this feature that my invention is particularly concerned.

An annular groove 66 in the plunger member 57, and a similar groove 68 in the annular member 33 are provided for securing a good electrical connection between the expansible conducting shunt 69 and the separable conducting members. One end of the expansible conducting means 69 is positioned in each of these annular grooves and then soldered securely in place.

In apparatus of this type, it is essential, in the interests of economy and operating efficiency, that the expansible conducting means shall have a very large ratio between the extended and the contracted lengths; it is also necessary that the extensible conducting means shall not interfere with the operation of the spring by becoming entangled therewith or by unduly impeding the free movement thereof by getting between the turns of the spring. My invention accomplishes both of these objects by providing an extensible and contractible conducting shunt which possesses a much larger ratio of extended and contracted length than has been heretofore attained, and at the same time, it provides a conducting shunt, the component parts of which are restrained to move in definite paths. Thus, my invention might be used for the connecting of two reciprocating members moving within a restraining body without any danger of contacting the adjacent walls of the restraining member. Also, in the preferred embodiment of my invention which I shall hereinafter describe in detail, the stresses incident to the extending and contracting of the conducting means are chiefly of the torsional variety. This is of great value in prolonging the life of the individual conductors, especially when those conductors are made of copper.

The enlarged detailed view of Fig. 5 illustrates the positioning of the individual conductors in a simplified tubular conducting shunt 70 having bias-woven side walls, that is, the warp 71 and woof 72 form opposed helices. Each of the threads 71 and 72 is made up of a number of fine copper wires to give added flexibility. Figs. 3 and 4 show a woven tubular conducting shunt 70, such as is shown in detail in Fig. 5, in the fully compressed position. Figs. 6 and 7 show the corresponding dimensions of such a tube in the fully extended position.

A bias-woven tubular shunt such as is shown in Figs. 3 to 7 is extensible due to the change in angle between the warp threads 71 and the woof threads 72. When the shunt is compressed the threads run more nearly circumferentially around the tube (as shown in Fig. 3), thus the length of the tube is short and its diameter large. When the tube is extended the threads 71 and 72 run more nearly along the tube, the longitudinal length is thereby increased and its diameter is reduced (Fig. 6). With a shunt of this type having relatively heavy wires a change in length of about three times may readily be obtained.

Figs. 8 and 9 are views comparable to Figs. 3 and 4 showing an extensible conducting shunt 69 constructed according to the preferred form of my invention. The shunt 69 has substantially

the same dimensions in the fully compressed position as those of the tube shown in Fig. 5 but has a much greater extended length. In this modification the bias-woven tube is restricted, as at 73, at spaced intervals along its length and is expanded, as at 74, between the restricted portions, thus forming what may be termed accordion pleats, along the length of the tube. From the enlarged detail view of Fig. 10, which shows the tube partially extended, it will be noted that the conductors 71 and 72 in the restricted portions 73 tend to position themselves in a direction substantially parallel with the axis of the tube, and it will also be noted that the conductors along the maximum periphery of the expanded portions 74 are disposed in a plane which is substantially normal to the longitudinal axis of the tube when the tube is fully contracted. Thus, during the expansion and contraction of the conducting members, the individual conductors are subjected to a twisting action (or torsional stress) of a comparatively slight magnitude. This is very effective in reducing the total stress imposed by the movement of the connected members. Furthermore, this pleated construction makes possible a greater maximum extended length for a given contracted length since the greater length of wire thread necessary for the greater extended length is taken up, when contracted, not only in running circumferentially around the tube, but also in running radially of the tube from one restricted portion 73 to the adjacent expanded portion 74. Each of the wire threads 71 and 72, therefore, changes from a circumferential in-and-out form when the shunt is compressed to a straighter longitudinal form when the shunt is extended. Figs. 11 and 12 are views similar to Figs. 6 and 7 and show (Fig. 11) the great gain in expansion which is possible through the use of my invention. The expansion secured may be as much as six times the contracted length, or substantially double that secured by the simple tubular conducting means shown in Fig. 6. This, however, is a very conservative comparison of the relative expansions because, in actuality, without placing undue stress upon the individual conductors, it is possible to secure a much greater ratio of expanded to contracted length.

The pleated bias-woven tubular shunt 69 may very advantageously be made by placing a bias-woven tube such as shown in Fig. 5 on a straight rod and restricting the tube in planes perpendicular to the axis of the tube at intervals along its length. The tube is then compressed longitudinally along the rod so that it becomes pleated as shown in Fig. 8.

The operation of my device is substantially as follows: Upon the occurrence of an overload condition in the controlled circuit, the fusible link 63 melts thus permitting the plunger member 57 to move upwardly under the bias of the coil spring 65 and thereby withdraw the plunger rod 61 up into the passage 49 within the body of boric acid 47—the arc being established between the end of the rod 61 and the cap 53. The heat of the arc decomposes the boric acid liberating water in the form of vapor which must of necessity flow downwardly to escape from the interior of the fuse. This outflowing gas thoroughly mixes with and transfuses itself into the arc and by the provision of a very great number of uncombined ions and neutral molecules effectively deionizes the arc path during the interval of current zero, thereby extinguishing the arc.

To secure the most effective operation of this type of circuit interrupter, it is necessary that the passage 49 be of very nearly the same diameter as the plunger rod 61. Therefore, due to the enlarging of this passage during each operation of the fuse, it is desirable to renew the boric acid member 47 following each interruption of the circuit. This operation is a comparatively simple and inexpensive process, primarily because of the great gain in mechanical efficiency and increased reliability of operation of the moving parts made possible by my improved extensible and contractible conducting shunt. It might be well to mention at this point that the opening 75 in the upper contact member 3 is of substantially the same dimensions as the opening 76 in the cylindrical upper portion 31 of the working parts unit 29. This opening 75 appreciably increases the maximum possible upward movement of the plunger member 57 and at the same time, due to the shoulder 77 provides a means for completing the electrical circuit from the annular member 33 to the upper contact member 3.

The first step in the restoring of the fuse to an operative condition following an interruption of the controlled circuit is the unscrewing and removal of the restraining plug member 15. This makes possible the complete withdrawal of the working parts unit 29. The lower portion of this unit comprising the tube 41, the boric acid member 47 and the cap 53 is then unscrewed from the annular member 33. Next, the plunger member 57 is pushed downwardly and held in the lowermost position and the rod 61 is unscrewed from the stud 59. The replacement unit consists of a new tube 41 having integral therewith a new boric acid member 47, a fuse link 63, a cap 53, and a rod 61 all positioned substantially as shown in Fig. 2. The upper end of the rod 61 has a hexagonal projection 78 which engages a similarly shaped opening in a metal plate 79 which is rigidly held in the top of the tube 41. This hexagonal enlarged portion prevents the rod 61 from turning during the replacement operation. This refill is screwed onto the bottom of the annular member 33, it being noted that the annular member 33 and the top of the tube 41 have corresponding recesses 45 and 46 which make possible the free rotation of the bottom part of the working parts unit 29 with respect to the annular member 33 after the lower portion has been secured in place. This is necessary because the threaded portion of the rod 61 which engages the threaded end 64 of the stud 59 has a much greater number of threads than could be conveniently placed upon the annular member 33 and the upper portion of the tube 41. The tube 41 is rotated until the end of the stud 59 is securely seated in the threaded opening in the rod 61. The entire working parts unit 29 is then reinserted in the fuse holder proper and the bottom restraining plug 15 is replaced. This plug 15 completes the electrical circuit from the lower contact member 5 to the cap 53 on the moving parts unit 29, and also aids in maintaining contact pressure between the end of the tube 31 and the engaging shoulder 77 of the upper contact member 3. The fuse is now in an operative condition and may be put back into service.

It will thus be seen that I have disclosed a new type of extensible and contractible conducting shunt which has a number of very desirable properties: It possesses a very large ratio of extended to contracted length, it is capable of handling unusually heavy current with a very

wide separation of the connected members—it being possible to use a plurality of these tubular conducting members concentrically disposed to increase the current carrying capacity; the individual flexible conductors of the preferred embodiment of my invention are subjected chiefly to torsional stresses during the expansion and contraction of the conducting means; the individual conductors are restrained from moving more than a specified distance from the axis of the conductor to the conducting means thus making it possible to use this invention in applications where the contacting of nearby parts is to be avoided; and furthermore my invention is economical to manufacture, it is simple and effective, and it is reliable in operation.

While, in accordance with the patent statutes, I have given the foregoing details of a preferred, practical embodiment of my invention, it is to be understood that many variations from the precise form disclosed are possible and may for some applications be desirable. I desire, therefore, that the language of the accompanying claims shall be accorded the broadest reasonable construction, and that my invention be limited only by what is explicitly stated in the claims and by the prior art.

I claim as my invention:

1. In electrical apparatus, two relatively movable current conducting members, and a flexible conducting means for electrically connecting said members, said conducting means including a plurality of flexible conductors which are interwoven into a substantially tubular form, said tubular conducting means having a plurality of spaced, constricted portions, each of which has the substantial form of an annular pleat, formed therein when said relatively movable members are in one position.

2. In electrical apparatus, two relatively movable members of conducting material, and an extensible conducting means for electrically connecting said members at all times, said conducting means comprising a plurality of flexible conductors which are interwoven into a substantially tubular form, said tubular conducting means having a plurality of annular pleats, disposed substantially normal to the axis of said tubular conducting means, for maximizing the ratio between the extended length and the contracted length of said conducting means.

3. In electrical apparatus, two relatively movable members of conducting material, means including a coiled spring for biasing said separable members to one position, and extensible conducting means for electrically connecting said relatively movable members, said conducting means comprising a plurality of flexible conductors arranged in a substantially tubular form and restricted at intervals from free movement, said restricting of said flexible conductors preventing the entangling of said coiled spring means and said conductors during the operation of said apparatus, said tubular conducting means having one or more constricted portions for increasing the ratio between the extended length and the contracted length of said conducting means.

4. In electrical apparatus, two relatively movable members of conducting material, means including a coiled spring for biasing said relatively movable members to one position, and extensible conducting means for electrically connecting said separable members, said conducting means comprising a plurality of flexible conductors which are interwoven into a substantially tubular form having a central opening extending therethrough and having one or more constricted portions for increasing the ratio between the extended length and the contracted length of said conducting means, one of said separable members having an outwardly projecting rod member which moves through said central opening during the operation of said apparatus.

5. In electrical apparatus, two relatively movable members of conducting material, means including a coiled spring for biasing said separable members to one position, and extensible conducting means for electrically connecting said relatively movable members, said conducting means comprising a plurality of flexible conductors arranged in a substantially tubular form and restricted at intervals from free movement, said tubular conducting means having a centrally disposed passage wherein a rod that is affixed to one of said separable members moves, said biasing spring enclosing a considerable portion of said tubular conducting means, said restricting of said flexible conductors preventing the entangling of said spring and said conductors during the operation of said apparatus, said tubular conducting means having one or more constricted portions for increasing the ratio between the extended length and the contracted length of said conducting means.

6. In electrical apparatus, a current carrying extensible and contractible member of conducting material comprising a plurality of flexible conductors which are woven into a substantially tubular form, the warp and the woof of said member taking the substantial form of opposed spirals, said member having a plurality of constricted portions for increasing the ratio between the expanded length and the contracted length, the constricted portions of said member being so disposed that substantially all the stresses placed upon the individual conductors during the extension and contraction of said member are torsional in nature.

7. The method of manufacturing an extensible and contractible member of conducting material from a bias-woven tube which includes the following steps: first, the placing of the bias-woven tube over a suitable mandrel; second, the circumferential restriction of said tube upon said mandrel at spaced intervals and in planes substantially perpendicular to the axis of the tube; and third, the compressing of said tube.

8. In electrical apparatus, the combination of two relatively movable members of conducting material, a longitudinally extensible and contractible, hollow conducting means for electrically connecting said separable members, a rod member which extends through at least a portion of said hollow conducting means, and a member disposed about and adjacent to at least a part of said extensible conducting means, said conducting means including a plurality of flexible conductors woven into a substantially tubular form which has one or more annular pleats, disposed substantially normal to the axis of said tubular conducting means, for maximizing the ratio between the extended and the free lengths, said flexible conductors being restrained from moving more than a predetermined distance from the axis of said tubular conducting means, thereby preventing the contacting of said conductors and said adjacently disposed member.

9. In electrical apparatus, a current carrying member of conducting material comprising a plu-

rality of sets of flexible conductors which are interwoven into a substantially tubular form, the individual conductors of at least one of the sets of conductors which form the cross threads of said tubular member being positioned so as to form substantially helical curves with the longitudinal axis of said tubular member, said tubular member having a plurality of annular pleats, disposed substantially normal to the longitudinal axis of said tubular member, for maximizing the ratio between the extended length and the contracted length of said member.

10. In electrical apparatus, a current carrying member of conducting material comprising a plurality of flexible conductors which are interwoven into a substantially tubular form, the individual conductors of at least one of the sets of conductors which form the cross threads of said tubular member being positioned so as to form spiral curves with the longitudinal axis of said tubular member, said tubular conducting member having a plurality of constricted portions, each of which has the substantial form of an annular pleat, formed therein for maximizing the ratio between the extended length and the contracted length thereof.

11. In electrical apparatus, a current carrying member of conducting material comprising a plurality of flexible conductors which are interwoven into a substantially tubular form, the individual conductors which make up the warp and the woof of said tubular member being positioned so as to form spiral curves with the longitudinal axis of said tubular member, said tubular member having a plurality of annular pleats, disposed substantially normal to the longitudinal axis of said tubular member, for maximizing the ratio between the extended length and the contracted length of said member.

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