A suspending arrangement for moving coils of electrical instruments of the type wherein the coil is suspended between two coaxial tensioned torsion wires which tend to maintain the coil in a zero position. Each torsion wire is provided with two spaced clamping members which engage springy retainers provided on a support on the one hand and on the coil on the other hand. Each clamping member includes two sections whose inner faces engage the wire and whose external surfaces meet the inner faces along sharply defined edges abutting against the respective retainers. The clamping members are disks, spheres or rollers and can be centered in sockets or recesses of the respective retainers.

9 Claims, 12 Drawing Figures
BACKGROUND OF THE INVENTION

The present invention relates to suspending arrangements for moving coils or like devices which are turnable about a predetermined axis. The invention also relates to a method of assembling certain parts of such arrangements prior to suspension of turnable devices.

It is already known to suspend the moving coil of an electrical measuring instrument between two flexible filamentary torsion elements, called torsion wires, which tend to maintain the coil in a predetermined angular position but can yield when the circuit of the coil is completed to thereby permit angular displacement of the coil. Such angular displacement is indicative of the strength and/or another characteristic of the current.

In accordance with presently prevailing practice, each torsion wire is provided with two integral spherical enlargements or beads which serve to facilitate mounting of the wire in a support on the one hand and on one end of the coil on the other hand. The length of that portion which extends between the two beads is the effective length of the torsion wire. Such effective length must be selected with utmost accuracy because it influences the restoring force of the tensioned wire and hence the accuracy of readings furnished by the moving-coil instrument. As a rule, the beads are formed by deforming selected portions of the wire; such method is not entirely satisfactory because the effective length of successively formed torsion wires deviates excessively from an optimum length. Therefore, the fully assembled instrument must be adjusted by changing the effective length of each torsion wire. Such calibration consumes much time and must be carried out by skilled workmen. It cannot be avoided because the torque exerted by a torsion wire on the moving coil is a function of the third power of the effective length and is thus an important factor which can exert a pronounced influence on the accuracy of readings.

SUMMARY OF THE INVENTION

An object of the invention is to provide a novel and improved suspending arrangement which need not be calibrated subsequent to completed assembly of its parts and wherein each torsion wire produces a predictable restoring torque.

Another object of the invention is to provide the suspending arrangement with novel and improved suspending units which can oppose turning of a moving coil or the like with an accurately determined force and which can be assembled and mounted with substantial savings in time and equipment.

A further object of the invention is to provide a novel and improved method of selecting the effective length of torsion wires for use in suspending arrangements for moving coils or the like.

An additional object of the invention is to provide a method according to which each of a series of successively produced and mounted suspending units for moving coils or the like exhibits the same resistance to twisting so that such units can be used in assembly of moving-coil instruments or the like each of which exhibits the same sensitivity and can be used without extensive adjustments.

One feature of the present invention resides in the provision of a suspending arrangement for moving coils or like devices which are turnable about a predetermined axis. The arrangement comprises a preferably U-shaped support, two outer retainers which preferably consist at least in part of springy material and are mounted on the support, two inner retainers disposed between the outer retainers and secured to the turnable device (e.g., to the end faces of a moving coil), and a pair of suspending units each turnably securing one of the inner retainers to one of the outer retainers. Each suspending unit comprises an elongated tensioned torsion wire of polygonal or circular cross section and a cylindrical, spherical or disk-shaped clamping member for each end portion of the torsion wire. In accordance with a presently preferred embodiment of the invention, each of the clamping members has an external surface abutting against one of the corresponding retainers and each such clamping member comprises two sections having inner faces flanking and clampingly engaging the respective end portion of the torsion wire. The external surfaces of the clamping members meet the respective inner faces along sharply defined edges extending substantially transversely of the respective torsion wire and the edges of the two clamping members are disposed at a predetermined distance from each other. Such distance corresponds to the effective length of the torsion wire.

Another feature of the invention resides in the provision of a method of connecting a substantially flat clamping member to a torsion wire for suspension of moving coils or like devices in a moving-coil instrument or the like. The method comprises the steps of providing the clamping member with a slit and upsetting the material of the clamping member at least at one side of the slit to form a tongue and to thereby convert the slit into a slot wide enough to permit passage of the wire, introducing a portion of the wire into the resulting slot, and returning the tongue into the general plane of the clamping member to thereby secure the wire to the clamping member. The width of the tongue preferably at least approximates the maximum transverse dimension of the torsion wire and the first method step preferably comprises providing the tongue with a sharp edge which is flush with one major surface of the clamping member when the tongue is returned into the general plane of such clamping member.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved suspending arrangement itself, however, both as to its construction and the mode of assembling the same, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a partly elevational and partly sectional view of a suspending arrangement which embodies one form of the invention and serves to turnably support a moving coil;

FIG. 2 is an enlarged central vertical sectional view of the part within the circle A shown in FIG. 1, the sec-
tion being taken in the direction of arrows as seen from the line 2—2 of FIG. 3;

FIG. 3 is a plan view of the structure shown in FIG. 2;
FIG. 4 is a fragmentary central vertical sectional view as seen in the direction of arrows from the line 4—
4 of FIG. 5 and illustrates a portion of a modified suspending arrangement;
FIG. 5 is a plan view of the structure shown in FIG. 4;
FIG. 6 is a fragmentary central vertical sectional view as seen in the direction of arrows from the line 6—
6 of FIG. 7 and illustrates a portion of a third suspending arrangement;
FIG. 7 is a plan view of the structure shown in FIG. 6;
FIG. 8 is a perspective view of the sections of a cylindrically clamping member of the type utilized in the suspending arrangement of FIGS. 1—3;
FIG. 9 is a similar perspective view of a spherical clamping member of the type utilized in the suspending arrangement of FIGS. 4 and 5;
FIG. 10 is an enlarged sectional view of a disk-shaped clamping member similar to those utilized in the suspending arrangement of FIGS. 6 and 7;
FIG. 11 is an enlarged sectional view of a clamping member which is identical with the one shown in FIGS.
6 and 7; and
FIG. 12 is a sectional view of a machine which is used to connect end portions of torsion wires with clamping members of the type shown in FIGS. 10 and 11.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIGS. 1 to 3, there is shown a suspending arrangement which forms part of a moving-coil instrument including a coil 41. The arrangement comprises a substantially U-shaped support or holder 11 having two parallel legs 13, 15 and a central portion 11a. The legs 13, 15 are respectively provided with coaxial bearing bores 17, 19 for slotted cylindrical carriers 21, 23. The carrier 23 is a tight fit in the bore 19 and the carrier 21 is received in an insulating sleeve 25 which is fitted into the bore 17. A first springy U-shaped outer retainer 27 is clamped between the flanges of the carrier 21 and sleeve 25 (see particularly FIG. 2), and a similar second springy U-shaped outer retainer 27 is clamped between the underside of the leg 15 and the flange of the carrier 23. Each of the outer retainers 27 has an arm 29 which is flexible and is thus movable toward or away from the outer side of the respective leg 13, 15. The outer side 29a of each arm 29 serves as an abutment for a cylindrical clamping member 37 forming part of a suspending unit which further includes a torsion wire 31. Each of these suspending units comprises a torsion wire 31 and two spaced clamping members 37. The cylindrical external surface 38 of one clamping member 37 in each unit abuts against the surface 29a of the respective arm 29.
The arms 29 are slotted, as best shown in FIG. 3. Furthermore, each of the carriers 21, 23 is provided with a radially extending slot 35 (see FIG. 2). The slot 35 of the carrier 21 registers with a slot in the cylindrical part and flange of the insulating sleeve 25 (see FIG. 3). This enables the operator to mount the suspending units in the corresponding inner and outer retainers. The legs 13, 15 of the support 11 are provided with slots 33. During introduction of torsion wires 31 into the slots 33, these slots register with the slots 35; the carriers 21, 23 are thereupon turned so that the slots 35 are out of registry with the slots 33 (see FIG. 3).
The moving coil 41 is turnable between two skirts 39 which extend from the central portion 11a of the support 11. The torsion wires 31 tend to maintain the coil 41 in a starting or zero position in which an index or needle 43 of the coil registers with the zero graduation of a fixed scale 45. When the circuit of the coil 41 is completed, the coil tends to change its angular position against the opposition of the torsion wires 31 and the extent of such angular displacement is indicated by the needle 43. The latter is provided with a counterweight 47 and is attached to one of the two inner retainers 49. The other inner retainer 49 is adjacent to the other axial end of the coil 41. The inner retainers 49 are similar to the outer retainers 27, i.e., they also comprise slotted elastic arms which engage the inner clamping members 37 of the respective suspending units. The terminals of an electric circuit (not shown) are connected to the two outer retainers 27 which are connected to the outermost ends of the respective torsion wires 31 by conductors 31a. These conductors are soldered to the respective outer retainers 27, as at 51. Similar connections 51 are provided between the ends of the coil 41 and the conductors 31b secured to the inner ends of the torsion wires 31.

As stated before, the clamping members 37 are rolls or cylinders whose cylindrical external surfaces 38 respectively abut against the outer sides 29a of the arms 29 on the outer retainers 27 and against the inner sides of arms on the respective inner retainers 49. FIG. 8 shows that each clamping member 37 comprises two semicylindrical sections 53 having flat inner faces 53a which engage and clamp the respective sides of the corresponding end portion of the torsion wire 31 (here shown as a narrow strip of current-conducting metallic material). The external surface 38 of a fully assembled clamping member 37 meets the corresponding inner faces 53a along two sharply defined edges 53b which extend transversely of the torsion wire 31 and determine the end of the effective length of such wire. The edges 53b are immediately adjacent to the respective retainers 27, 49. The effective length of the upper wire 31 shown in FIG. 1 is that length which extends between the edges 53b of the uppermost clamping member 37 and the edges 53b of the clamping member 37 engaging the lower end portion of the upper wire 31 and the arm of the upper inner retainer 49. This effective length can be determined with a high degree of precision during assembly of the clamping members 37 to thus insure that the resistance which the wires 31 offer to turning of the moving coil 41 is within a predetermined range. As known, such resistance is a function of the third power of the effective length of a torsion wire. The exact manner in which the sections 53 of each clamping member 37 are joined to form a cylindrical rolling element forms no part of the present invention. FIG. 2 shows that the clamping members 37 may consist of synthetic plastic material; therefore, the sections 53 can be joined in response to the application of heat and/or pressure, always in such a way that a certain length of the wire 31 is clamped between the faces 53a without any clearance.
Once the suspending units are fully assembled independently of the coil 41 and support 11, the wires 31 are caused to pass through the slots of the arms on the inner retainers 49, the slots 33 of the legs 13, 15, the slots 35 of the carriers 21, 23, and the slots of arms 29 on the outer retainers 27. The carriers 21, 23 are then turned to move the slots 35 out of registry with the slots 33 and to thus prevent accidental removal of the coil 41. This completes the mounting of the coil 41 between the skirts 39 whereby the axis of the upper wire 31 of FIG. 1 coincides with the axis of the lower wire 31 and constitutes the turning axis of the coil 41. It was found that the clamping members 37 render it possible to select the effective length of each torsion wire 31 with a very high degree of precision, i.e., with an accuracy which cannot be matched by the presently known suspending arrangements for moving coils or like devices.

The sections 57 of each clamping member 37 are assembled in such a way that their faces 57a engage a portion of the torsion wire 31 without any clearance. This insures that the effective length of the wire 31 in a fully assembled suspending unit extends between the edges 57b of the two clamping members 37. The cross section of the wire 31 is constant all the way between the respective clamping members 37 to permit for accurate determination of restoring torque.

FIGS. 4, 5 and 9 illustrate a portion of a second suspending arrangement wherein all such parts which are clearly analogous to those shown in FIGS. 1 to 3 are denoted by similar reference characters. The main difference between the two suspending arrangements is that the arrangement of FIGS. 4-5 and 9 employs different clamping members 55 and slightly modified retainers including two outer retainers 127. The clamping members 55 are spherical rolling elements each of which is assembled of two semispherical sections 57 (shown in FIG. 9) having inner faces 57a meeting the external surface of the fully assembled clamping member along sharply defined edges 57b extending substantially transversely of the respective end portion of the torsion wire 31. The arm 129 of each outer retainer 127 is provided with a socket 59 whose concave surface 59a abuts against the external surface of the respective clamping member 55 and the edges 57b.

The inner retainers (not shown) are preferably identical with the outer retainers 127. The retainers 27, 49 and 127 preferably consist of spring steel. The sockets 59 serve as a means for centering the respective clamping members 55 so that the common axis of the wires 31 coincides with the desired turning axis of the moving coil (not shown in FIGS. 4 and 5). The material of the clamping members 55 is preferably a synthetic plastic substance.

FIGS. 6 and 7 illustrate a portion of a third suspending arrangement which employs disk-shaped ductile clamping members 237. The outer retainers 2 for the clamping members 237 include current-conducting terminals 227 having portions secured to slotted receptacles 61 extending into depressions provided therefor in the respective legs 13, 15 (only the leg 13 is shown in FIGS. 6 and 7). Each outer retainer further comprises a metallic part 63 consisting of a ring-shaped portion 65 and a meandering web 67 extending substantially diametrically of the respective ring-shaped portion 65.

This is best shown in FIG. 7. The web 67 is formed with a recess 68 serving as a means for centering the respective clamping member 237 in the outer retainer. Each metallic part 63 preferably consists of spring steel. As shown in FIG. 6, the web 67 is not supported by the receptacle 61 so that it can flex inwardly and outwards and subjects the respective torsion wire 31 to requisite tension when the corresponding suspending unit is properly connected to the support and to the respective end of the moving coil (not shown in FIGS. 6 and 7). The inner end portions of the torsion wires 31 are connected with inner retainers (not shown) on the moving coil, preferably by way of clamping members which are similar to or analogous to the member 237 shown in FIGS. 6 and 7.

FIG. 7 shows that the clamping member 237 comprises a flat disk-shaped body 71 which is formed with an H-shaped slit to provide two tongues 73 (see FIG. 11). The tongues 73 and the H-shaped slit can be formed by means of a suitable punching tool, not shown, and the tongues are thereupon bent out of the general plane of the disk 71 in a manner best shown in FIG. 11 whereby the central part of the H-shaped slit is converted into a slot wide enough to permit passage of a torsion wire 31. This slot is then flanked by the inner faces 73a of the tongues 73 and its narrowest part is disposed between their sharply defined edges 73b. In the next step, the tongues 73 are returned into the general plane of the disk 71 whereby the inner faces 73a engage and clamp the adjacent sides of the torsion wire 31 and the edges 73b return into the plane of the lower major surface 72 of the body 71. Such method of connecting a disk-shaped clamping member 237 to the corresponding end portion of the torsion wire 31 has been found to permit exceptionally accurate determination of the effective length of the wire prior to mounting of the corresponding suspending unit in the support.

FIG. 10 illustrates a slightly modified disk-shaped body 71' which is formed with a U-shaped slit so that it provides a single tongue 73' having an inner face 73'a cooperating with the inner face 73' of the right-hand section of the body 71' to properly engage and clamp the end portion of the torsion wire 31 when the tongue 73' is returned into the general plane of the body. The edges are shown at 73' b and 73' c. It will be noted that the tongues 73 of FIG. 11 correspond to the sections 53 or 57 of a cylindrical or spherical rolling element and that the tongue 73' and the right-hand part of the body 71' shown in FIG. 10 also form two sections of a disk-shaped clamping member having an external surface and two inner faces meeting with the external surface along two sharply defined edges which extend transversely of the torsion wire.

The method of connecting two disk-shaped clamping members with the corresponding end portions of a torsion wire 31 can be carried out by resorting to a machine of the type shown in FIG. 12. Prior to being inserted into the machine of FIG. 12, the clamping members 237 are provided with the aforementioned H-shaped or U-shaped slits and the tongues 73 or 73' are bent outwardly in a manner as shown in FIGS. 10 and 11. For the sake of clarity, FIG. 12 shows a disk-shaped body 71 and a body 71' (i.e., a disk with two tongues 73 and a disk with a single tongue 73'). The machine of
FIG. 12 comprises a table 81 having a vertical slot 83 for introduction of a torsion wire 31 and two recesses 85 respectively provided in its upper side and its underside in accurate vertical alignment with each other. The bodies 71, 71' are respectively inserted into the lower and upper recesses 85 so that their slots receive the respective end portions of the torsion wire 31. The outermost ends of the wire 31 extend into slots 87 provided in two vertically movable deforming rams 89 which are theretofore moved in the directions indicated by arrows to return the tongues 73, 73' into the general planes of the respective bodies 71, 71' and to thus establish a strong and reliable connection between the clamping members and the end portions of the wire 31. The distance L between the bottom surfaces of the recesses 85 corresponds to the effective length of the torsion wire 31 in the fully assembled suspending unit. It is clear that the width of the slot 83 is exaggerated in FIG. 12 for the sake of clarity; this slot is just wide enough to accommodate the median part of the wire 31 and to theretofore prevent twisting of such median part during deformation of the tongues 73 and 73'. The machine of FIG. 12 insures that the edges 73b, 73b' return into the planes of the respective major surfaces of the bodies 71, 71' and that such major surfaces are free of projections which could prevent proper seating of bodies 71, 71' in the corresponding centering recesses 68. The width of the slot 83 in the table 81 is selected in such a way that the material of the tongues 73, 73' cannot penetrate into the respective ends of the slot 83 when the rams 89 perform working strokes. The width of slots in the bodies 71, 71' preferably equals or approximates the maximum transverse dimension of the wire 31.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of our contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. In a suspending arrangement for moving coils or like devices which are turnable about a given axis, a combination comprising a support; two outer retainers mounted on said support; two inner retainers disposed between said outer retainers and secured to a turnable device; and a pair of suspending units each turnably securing one of said inner retainers to one of said outer retainers, each of said units comprising an elongated tensioned torsion wire having two end portions and a clamping member for each of said end portions, each of said members having an external surface abutting against one of the corresponding retainers and each of said members comprising two portions having faces flanking and clampingly engaging the respective wire end portion, and means for connecting said two portions and for maintaining said faces in engagement with respective wire end portion, said faces meeting the respective faces along sharply defined edges extending substantially transversely of the respective wire and the edges of said members being disposed at a predetermined distance from each other to thus exactly determine the active length of each torsion wire.

2. A combination as defined in claim 1, wherein each of said clamping members is a rolling element.

3. A combination as defined in claim 2, wherein each of said retainers consists at least in part of springy material and is provided with a socket for the respective rolling element.

4. A combination as defined in claim 1, wherein each of said clamping members is a disk.

5. A combination as defined in claim 4, wherein each of said retainers comprises means for centering the respective disk.

6. A combination as defined in claim 5, wherein each of said retainers consists at least in part of springy material and includes an elastically deformable portion engaging the respective disk.

7. A combination as defined in claim 1, wherein each of said retainers comprises a ring-shaped portion and a meandering web extending substantially diametrically of said ring-shaped portion and engaging the respective clamping member, said retainers consisting at least in part of springy material and said webs having means for centering said clamping members within the respective ring-shaped portions.

8. A combination as defined in claim 1, wherein each of said clamping members is a disk having a peripheral edge and being formed within said peripheral edge with a substantially U-shaped slot dividing said disk into a tongue portion connected at one end with the remaining portion of said disk, said faces which flank and clampingly engage a respective wire end portion being constituted by a face at the other end of said tongue portion and the opposite face on the remaining portion of said disk.

9. A combination as defined in claim 1, wherein each clamping member is a disk having a peripheral edge and being formed within said peripheral edge with a substantially H-shaped slot providing in said disk a pair of tongue portions each connected at one end to the remainder of said disk, said faces which flank and clampingly engage a respective wire end portion being constituted by end faces at the other ends of said tongue portions.