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H. CAMINEZ
METHOD OF FORMING WIRE COILS

2,371,674

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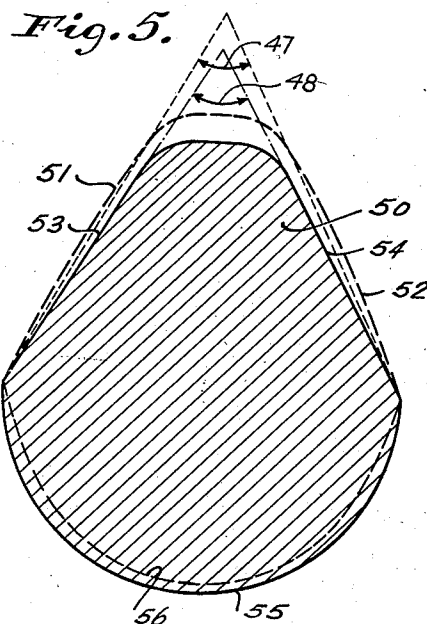
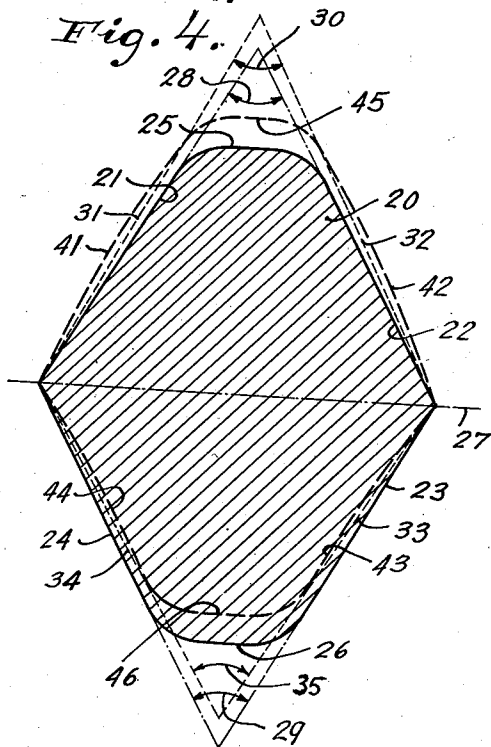
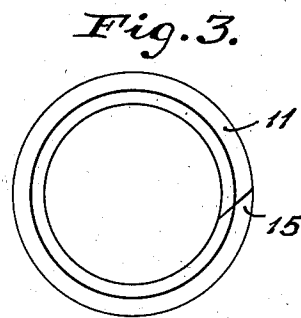
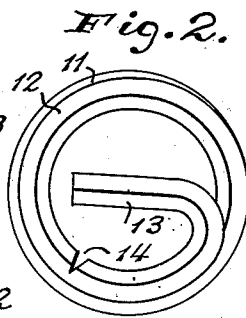
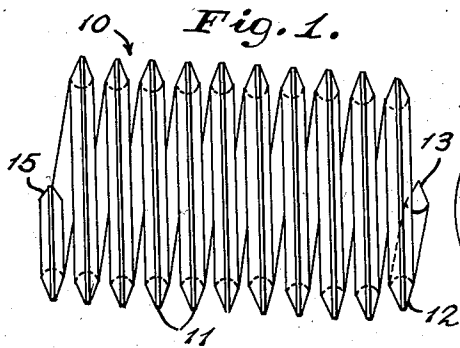
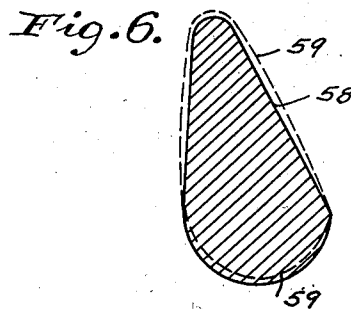
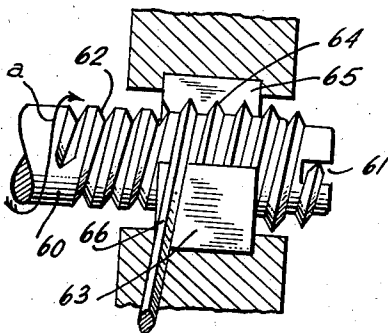


Fig. 7.



INVENTOR.
HAROLD CAMINEZ
BY *Walter S. Bleston*
ATTORNEY

UNITED STATES PATENT OFFICE

2,371,674

METHOD OF FORMING WIRE COILS

Harold Caminez, Williamsport, Pa., assignor to
Aircraft Screw Products Company, Inc., Long
Island City, N. Y., a corporation of New York

Application December 24, 1942, Serial No. 470,042

3 Claims. (Cl. 153—64)

This is a continuation in part of my co-pending application, Serial No. 429,023, filed January 31, 1942.

The present invention relates to a method for making wire coils of great exactness as e. g. coil inserts which have been frequently suggested for use in screw connections of a male and a female member, wherein the coil wire is in engagement with the external and internal threadings of the respective parts. A wire coil of the mentioned type has been described, for instance, in my U. S. Patent No. 2,150,876.

Whereas ordinary coil springs in general require only a minor degree of homogeneity and exactness of the dimensions of the wire material of which the coil is made, and also a minor degree of exactness as to the external and internal dimensions of the finished article, the wire coils or inserts of the type here under consideration must have the features of a coil spring and, in addition thereto, must be true to the desired cross-section and inclination of the wire within unusually narrow tolerances. The invention aims, therefore, to provide a method whereby a wire coil can be made so as to fulfill the high requirements as for instance those of an insert for a screw connection. These requirements are substantially as follows:

The wire useful for an insert coil must be hard but ductile and of good resiliency. The material should be anti-corrosive and must have low friction qualities with respect to the materials of the members of the connection for which the insert is destined. In certain cases it must also be resistant to the attack by the products of combustion in gas engines. Materials such as a hard bronze and stainless steel have been found particularly suited to the purpose. The wire cross-section of the insert, depending on the cross-sections of the threads in the female and male members between which the insert is intended to be used, may be round or square or it may be one of those cross-sections which have converging side portions as for instance, a cross-section of diamond shape or of pear shape as described in my aforementioned Patent No. 2,150,876. In the finished insert the wire should be smooth and closely fit the thread grooves of the male and female members. Similarly located points of similar cross-sections respectively of an insert should be equally spaced from the axis of the insert coil. In particular, if in wire cross-sections as for instance, of diamond or pear shape, a line of symmetry of one cross-section coincides with a radius of the coil, then the lines of symmetry in

other similar cross-sections should also be coincident with corresponding radii. In many instances, the outer diameter of the insert before insertion should be larger than the tapped hole so as to provide for adequate spring tension but must not be too large so as to render insertion difficult or even impossible. The coil may have a tang to be gripped by a tool and at least the front half of the first convolution may be undersized to facilitate the insertion. In many instances, it is also recommended to apply a notch close to the root of the tang where the latter may be broken off after the insertion of the coil in a female threaded member.

Now, I have found that it is practically impossible to meet the mentioned requirements in an insert coil wound in the conventional manner from wire available on the market if the original wire cross-section is like that desired in the finished insert. In general, the cross-section of the coil wound in the customary manner differs from the original shape, and, moreover, different cross-sections of the same coil differ from each other even if taken at the same angle to the coil axis. Usually there are three major reasons for such happening. First, the wire in its original form is, in general, not sufficiently homogeneous as to its material and shape over a length to be coiled. Second, the wire shipped in the conventional manner, i. e. spooled on drums or reels of not very large diameter, is bent from the start and owing thereto has, what is generally termed a "cast," that means, the particles of the wire which should be arranged, so to say, in straight lines parallel to the wire axis, actually form large-pitched helices. Third, the tension and bending stresses to which the wire is subjected during the coiling are not equally distributed over the entire area of the wire cross-section. Every single one of these causes is frequently sufficient to interfere with the production of a useful insert. In most instances, however, all three of them act at the same time to render a customarily made wire coil unfit as an insert for screw connections of the type herein considered or for other purposes where high precision as to the cross-sectional shape is required.

It will be clear that the least difficulties are encountered with wire of round cross-section, although even an originally round cross-section will no longer be truly circular in the finished coil. Similarly, in most instances, an originally square cross-section will be other than rectangular and in addition thereto, tilted when coiled. Inserts of diamond and pear-shaped cross-sections are

among the most difficult ones to produce so as to be true to the desired dimensions. For this reason, I shall describe the method according to my invention mainly with reference to such shapes.

However, I wish it to be understood that this method with or without variations or modifications is equally well applicable to wire of other cross-sections, symmetrical or asymmetrical, and that the scope of my invention shall not be limited but by the appended claims.

Further objects and details of my invention will be apparent from the description given hereinafter and the accompanying drawing.

In the drawing:

Figs. 1 to 3 are side elevation, front and rear views, respectively, of an insert of the type under consideration.

Figs. 4 to 6 are different cross-sections at a greatly enlarged scale of a substantially diamond-shaped, a pear-shaped and an asymmetrical wire, respectively, and in each of these figures, the solid lines show the cross-section in the finished insert whereas the dashed lines show the cross-section prior to the coiling.

Fig. 7 is a diagrammatic illustration of a tool for accomplishing the coiling according to the invention.

Referring to the drawing, Figs. 1 to 3 illustrate an example of the finished article, that means, an insert coil 10 of a form which may be used in a screw connection between a tapped boss or nut and an externally threaded bolt or stud. Whereas the convolutions 11 of the major portion of the coil are of the same diameter, the first convolution 12 is narrower in order to facilitate the insertion. A tang 13 is formed at the front end which can be gripped by an inserting tool, and which is also useful for holding the wire during the coiling operation as it will be described hereinafter. A notch 14 may be provided near the root of the tang in order to facilitate the removal of the latter after the insertion of the coil. The other end 15 of the coil may be cut at a slant with respect to the wire axis to produce a sharp edge which may engage the material of the boss or nut member, thereby increasing the resistance of the coil to a force which might tend to screw the coil backward. The wire of the illustrated coil 10 is of a pear shape more clearly shown in Fig. 5. However, it will be obvious that a coil similar to that illustrated in Figs. 1 to 3 may as well be made of a wire having the cross-section of Fig. 4 or of Fig. 6 or any other suitable cross-section if so desired, and that a method applicable for making the coil according to Figs. 1 to 3 will, in general, be applicable to wire of any desired cross-section. It will be further noticed that the pear-shaped cross-section of Fig. 5 is truncated at its top. Similarly the diamond cross-section of Fig. 4 is truncated as to its top and lowermost corners. This is done because sharp edges of the convolutions are undesirable in a wire coil insert. For other purposes, of course, the wire cross-sections may include the corner formed by a pair of converging sides. Whether or not such corners are present is immaterial as to the principle of my invention, and I shall refer, therefore, hereinafter and in the appended claims, to such cross-sections as shown in Fig. 5 as diamond-shaped regardless of whether the cross-sectional figure is geometrically a complete diamond or a truncated one.

No matter, now, what wire cross-section is desired in the finished coil, I found it advisable to

start from a circular cross-section wire. If the material is a stainless steel containing, e. g. 18% chromium and 8% nickel, the wire may be first annealed, pickled and then cleaned and provided with an oxide coating; the cleaning step of operation to take place also if the material is a suitable bronze. Thereafter, the clean wire may be reduced in diameter by drawing it through a die preferably of one of the carbide materials, as for instance, a die of the material which is on the market under the name of "Carboloy." This cold working simultaneously smoothens the surface and increases the homogeneity of the material and also the tensile strength, e. g. from 90,000 p. s. i. in the annealed wire to 150,000 p. s. i. in the wire of reduced diameter. Any flaws in the original wire will also be detected during this step of operation. The required size to which the round wire is to be reduced can be experimentally determined. The wire may then be provided with another oxide coating by heating. This pretreatment removes one of the abovementioned causes for faulty production described in the preceding paragraph.

The so-prepared round wire of stainless steel, or if the material is a bronze, the wire cleaned and reduced to the required diameter and having the desired qualities may then be shaped by suitable means, for instance by drawing it through grooved rollers so adjustable that the wire thickness can be controlled. For measuring the thickness of a wire of other than circular or square cross-section I found a micrometer useful which has a lower and an upper anvil, each grooved to match the desired shape of wire.

For the reasons hereinbefore given, the shape to which the wire is reduced by the last-mentioned drawing operation must be different from that required in the finished insert to compensate for later changes owing to the coiling. In general it can be said that the portion of the cross-section above the neutral axis in the bending should originally be larger and the portion below that axis should be smaller than in the finished insert. The difference required depends on various factors, particularly on the shape of the wire cross-section, the diameter of the coil, and also on the wire material. It can be found by calculation but is better established by experimentation.

Considering, for instance, Fig. 4, it is assumed that the truncated diamond 20 shown in solid lines is the shape desired in the finished coil. The diamond has an upper pair of converging sides 21 and 22 and a lower pair of converging sides 23 and 24. The border lines of the upper and lower truncations are denoted by 25 and 26, respectively, and the horizontal diagonal by 27. The sides 21 to 24 are of equal length, and the angles of convergence 28 and 29 are approximately 60° in the illustrated example. It will be clear that in bending a wire of diamond cross-section in a plane comprising the top and lowermost corners, the diagonal transversing that plane, i. e. the diagonal 27 in the present case, will define the neutral zone. Consequently, when forming the wire into a coil, the portion above the diagonal will be subjected to tensile stress causing a decrease of the cross-sectional area whereas the portion below the diagonal will be compressed and the corresponding cross-sectional area will be increased in size. Furthermore, the ratio of the change in size increases approximately according to the distance of a contemplated partial area from the neutral zone. Now, in order to obtain a coiled, i. e. a continuously

bent wire of diamond cross-section, I provide an original wire cross-section which consists of two triangles on the same base, wherein however, the upper one has a greater height than the lower one, or in other words wherein the angle of convergence of the upper triangle is smaller than that of the lower triangle. This is indicated in Fig. 4, where the angle 30 included by the dotted triangle sides 31 and 32 is approximately as much smaller than the angle 28 as the angle 35 included by the sides 33 and 34 is greater than the angle 29. However, I have found that an original diamond cross-section having the sides 31 to 34 will not always obtain the desired shape of the diamond 21 to 24 by merely bending or coiling a so-shaped wire. In most instances it is necessary to make the sides of the upper triangle very slightly convex as shown at 41 and 42, and the sides of the lower triangle slightly concave as shown at 43 and 44 in order to form the desired diamond 20 by bending. Furthermore, it will be seen that the border lines 45 and 46 of the truncations in the original cross-section are located above the desired lines 25 and 26, respectively, and that they are respectively longer and shorter than the latter. It will be clear that the desired cross-section can be accurately obtained by bending wire of another original cross-section only if extreme care is taken in selecting the latter according to all prevailing circumstances in each instance, and if the wire is absolutely homogeneous. However, according to the foregoing it is possible to establish the original wire cross-section with sufficient approximation to the ideal.

In a similar manner the pear-shaped cross-section 50 of Fig. 5 can be obtained if the wire is originally shaped with a cross-section substantially according to the dash line contour. This comprises two slightly convex sides 51 and 52 converging at an angle 47 somewhat smaller than angle 48 of the sides 53 and 54 of the triangular upper portion of the cross-section 50. The lower portion 55 of the desired outline in the illustrated example is an arc of a circle. In this case, the corresponding portion 56 of the original wire cross-section is a curve in which the radius of curvature of any point is larger than the radius of the arc 56. However, the radius of curvature of the deepest, i. e. the middle part of the curve 56 is shorter than the radii of laterally located points. It will be clear that such a shape is consistent with what has been said with regard to the sides 43 and 44 of the lower truncated triangle of Fig. 4. If the desired shape of the lower portion of the pear-shaped cross-section is an arc of 180°, it is of course similar to the lower portion of a round cross-section. Hence, in order to obtain a coil of circular cross-section, the wire prior to the coiling should have a portion smaller than a semi-circle on the one side of a diameter, and another portion larger than a semi-circle on the other side of said diameter; and the curvature of the first mentioned portion should be according to what has been said with respect to the arc 56 in Fig. 5, whereas in the other portion the radius of the curvature of the middle part of the curve should be larger than the radii of points laterally thereof. Fig. 6 shows a wire cross-section of asymmetrical shape, wherein the contour of the desired cross-section is denoted by 58 whereas 59 is the circumference of the original shape of the wire. No further explanation seems to be necessary with regard thereto in view of the foregoing statements relating to Figs. 4 and 5.

When the wire has been provided with the cross-section required to obtain the desired cross-section of the finished coil, any cast of the wire occurring as hereinbefore explained, owing to the original winding of the wire on a drum or reel of relatively small diameter and/or owing to other causes for a lack of uniformity, should be removed or at least so far removed that the wire will be free from twist over an appreciable length. This can be accomplished by passing the wire through straightening rollers grooved according to its cross-section. The wire so treated may then be wound on drums or reels of relatively very large diameter, that means, a diameter several hundred times the height of the wire cross-section, to avoid strain on the wire, which is now ready to be worked in the desired insert 10 such, for instance, as illustrated in Figs. 1 to 3. For this purpose, the free end of the wire may be gripped and held straight so as to form the tang 13 shown in Fig. 2; then by rotating the gripped end, the wire may be coiled into the shape the insert is intended to take when in position between the thread grooves of a threaded female and a threaded male member. When a length of wire sufficient for one insert has been coiled, the wire may be cut off at 15. When the torque applied to the tang in coiling the wire is released and the finished insert is also free in other respects, it will spring to an outer diameter larger than that it had during the coiling. This larger diameter can be used as a measure in gauging the insert in respect to both the required dimensions and the required elastic properties of the material. This is important because the friction of the wire during its insertion in the tapped hole of the member for which it is destined will be inadmissibly high if the diameter of the free coil is too large, and the desired wedging action of the wire between the convolution flanks of the tapped thread of the female member will be too low if that diameter is undersized. Finally, the insert may be notched as at 14 near the root of the tang for the above-stated purpose.

As stated hereinbefore, according to my invention, an originally selected cross-section of the wire is changed during and by the coiling to the desired shape, and if the cross-section is originally correctly selected no additional measures need be applied in order to obtain the desired shape. However, in cross-sections such as e. g. illustrated in Figs. 5 to 7, there is a certain danger of the wire convolutions tending to tilt under the bending stresses of the coiling. For this reason, it is advisable to guide the wire during the coiling so that similar points of all wire cross-sections are correctly and similarly located in relation to the coil axis. This may be accomplished by winding the wire into a thread groove of the desired pitch and root diameter provided on a mandrel, and simultaneously guiding the outer wire portion along stationary flanks which prevent the wire from tilting.

This method can be still further improved by shaping the groove of the mandrel according to the thread groove of the male member for which the insert is destined, and by guiding the outer wire portion in a tapped thread groove of a shape according to that of a corresponding female member. In other words, the wire may be coiled between two members grooved complementary to at least a portion of a coil of the desired shape. In this manner, the wire can be calibrated during the coiling. Moreover, if the grooved mandrel and the tool provided with a tapped hole

are of sufficiently hard and resistant material, they may be used to act as dies in the coiling and simultaneously shaping operation. This is of particular advantage, because it is not always quite easy to find the correct cross-section which will transform into the desired shape merely by coiling the wire. If, however, the coiling is accomplished in a die the wire will readily take the desired shape notwithstanding a slight incorrectness in the selection of the original cross-section, because in order to render the coil form permanent, the wire must any way be stressed beyond its original elastic limit, that means, it must be brought into a molecular state where it is sufficiently ductile to snugly fit the walls of the grooves of the mandrel and tapped die.

Fig. 7 illustrates diagrammatically how the coiling may be accomplished in the aforesaid manner. A rotatable mandrel 60 is provided with a slot 61 in its front end. This slot opens in a thread groove 62 which is shaped similarly to the inner portion of the desired wire cross-section. For instance, if a wire according to Fig. 4 is to be coiled, the groove 62 should have flanks converging at the same angle as the sides 23 and 24 of the diamond of that figure. The bottom of the groove need not be according to the line 25 of Fig. 4. On the contrary, in the present example it is advisable to continue the flanks of groove 62 to a sharp edge, whereby a certain clearance will be provided for the wire should the latter be slightly oversized. The mandrel 60 is arranged in a stationary die member 63 provided with a tapped groove 64. Groove 64 is shaped according to the sides 21 and 22 of the diamond of Fig. 4. For the same reason as stated above, groove 64 may have a sharp edge at its bottom. Grooves 62 and 64 are of equal pitch, and the die may be recessed at 65 so that the wire 66 may be fed through said recess. Now it will be clear that the front end of the wire 66 may be inserted in the slot 61 when the front end of the mandrel is within the die member 63 and the slot is in registry with the recess 65. By rotating the mandrel 60 in the sense of the arrow α , the portion of the wire in the rear of its front end can be caused to engage the thread groove 62 of the mandrel and simultaneously the thread groove 64 of the die 63 as clearly shown in the drawing. Thereby, the wire will be drawn between the walls of said grooves and simultaneously act as a threading to shift the mandrel axially during its rotation. Thus, the coil of desired shape and cross-section will be produced. It will be understood that it has been hereinbefore suggested to use the die member 63 like a drawing tool. It is also conceivable to provide this member 63 with cutting edges as in a conventional die nut in order to do with less accuracy in the selection of the original wire cross-section. However, I have found that such method is less advisable because it is extremely difficult to obtain sufficiently smooth surfaces of the wire if some cutting operation occurs during the coiling. I recommend, therefore, first to make the original wire cross-section as correctly as reasonably pos-

sible according to what has been stated hereinbefore, and, then to coil it on a grooved mandrel in a suitably grooved nut or die member of the type of a drawing tool.

Although I have hereinbefore described the method according to my invention mainly as applied to an insert for a screw connection it will be apparent to those skilled in the art that the same method is useful also in the production of wire coils for other purposes. Furthermore, it will be clear that alterations and modifications are possible within the essence and spirit of my invention which, therefore, shall not be limited but by the scope of the appended claims.

I claim:

1. A method of making a wire coil of a cross-section having two outwardly converging straight-lined sides which comprises the steps of providing the wire to be coiled with a cross-section similar to but differing from the desired in that the angle of the converging sides is smaller than desired in the coil and that the converging sides are slightly convex in the portion above that wire axis which is the neutral axis of the cross-section in the subsequent coiling step, coiling the wire and confining it on all sides over an appreciable length during the coiling so as to compel all points of each wire cross-section to travel on helical paths of constant and equal pitch, thereby insuring symmetrical locations of all wire cross-sections of the coil with respect to the axis of the latter.

2. A method of making a wire coil of a cross-section having two outwardly converging straight-lined sides which comprises the steps of providing the wire to be coiled with a cross-section similar to but differing from the desired in that the angle of the converging sides is smaller than desired in the coil and that the converging sides are slightly convex in the portion above that wire axis which is the neutral axis of the cross-section in the subsequent coiling step, coiling the wire and simultaneously passing it with said converging sides through a die groove of the desired cross-section.

3. A method of making a wire coil of a cross-section having a pair of converging straight-lined sides as the contour of its outer portion and an arc of a convex curve as the contour of its inner portion, which comprises the steps of providing the wire to be coiled with a cross-section similar to but differing from the desired in that the angle of the converging sides is smaller than desired in the coil and the sides are slightly convex, and that the contour of the inner portion of the cross-section is a curve in which the radius of curvature of any point is larger than that of the desired arc and the radius of the middle portion of the curve is shorter than the radii of laterally located points, coiling the wire and simultaneously guiding the wire on both converging sides between two straight-lined flanks converging at the desired angle while guiding the curved portion in a groove of a cross-section according to the desired arc of a curve.

HAROLD CAMINEZ.