This invention relates to spring bars employed as stock from which helical springs are manufactured.

The principal object of the invention is the devising of a bar of novel characteristics adapted for use as stock in the manufacture of a range of helical springs of various diameters within predetermined limits, while maintaining the required accuracy and preventing distortion and deformation of the bar stock. The bar stock of this invention is intended to be used for a mandrel to form a helical spring considered deformation or upset of the metal in the bar takes place. The upset in the square bar is represented in dotted lines in Fig. 5.

In the bi-axially symmetric types of bars the neutral axis or so-called axis of torsion (the axis in which the center of gravity is located) is coincident with the geometrical axis. Its point of intersection with the axes a and b being represented by the reference letter x.

Referring again to the upset shown in Fig. 5, it will be seen that there is a considerable change in the configuration which is of a detrimental character. The overall height of the bar is increased. This will necessitate increasing the free length of the finished spring to provide for a given amount of deflection. This is an objectionable characteristic of many conventional bars, as for instance all bars having polygonal upper and lower faces.

It is well known that during spring deflection the greatest torsional stress is upon the inner face of the spring. When the square section bar has been coiled into a spring it is no longer bi-axially symmetric, and furthermore the axis of torsion no longer coincides with the geometrical axis but has been shifted, on account of the redistribution of metal, toward the inner face of the spring. In other words, this axis, instead of being at equi-distances from the sides 2 and 3 (inner and outer faces), is now nearer the inner face, as indicated at x' where the line z crosses the axis a (the line z is employed only to show the position of the axis of torsion).

It has been discovered that in a bi-axially non-symmetric bar, the torsional stress is greatest at that surface fibre element which is nearest the axis of torsion. Therefore the axis of torsion x' being nearer the inner face of the spring, this face, on account thereof, will be subjected to further torsional stresses. While this inner face 2 receives the greatest torsional stresses, it is however, the face least capable of withstanding such stresses for the reason that when coiling the bar this face is likely to be marked or scored by the mandrel, fractures often starting at such points.

It is the purpose of this invention to devise a bar of novel cross-sectional contour so that a single bar (a bar of a definite cross-sectional area) may be employed for making any one of a num-
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The number of springs that can be made from any one-sized bar is dependent upon the limiting qualifications—that the bar must have sufficient strength; that the maximum upset must not effect an over-all increase in the height of the bar; and that the axis of torsion of the bar of the spring must be nearer the outer face than the inner face.

While, with given cross-sectional dimensions, the rectangular bar provides maximum metal for the spring, and to cut away the corners, as in the case for instance of hexagonal and octagonal sectional bars, weakens the bar, nevertheless there are certain advantages gained by eliminating metal from the inner corners of the bar of the spring, when done according to the present invention, outweighing the benefits gained by the presence of such metal.

Fig. 2 shows a preferred exemplification of the cross-sectional contour of a bar of the present invention, and this is also shown in full lines in Fig. 4. The horizontal and vertical axes are denoted respectively by the reference letters c and d.

The sides 6 and 7, designated respectively, for convenience, the inner side of the bar and the outer side of the bar, will, when the bar is coiled into the helical spring, constitute the inner face and the outer face respectively of the spring. The sides 8 and 9 of the bar will constitute the upper and lower faces of the bar of the spring. The sides 6, 7, 8, and 9 however, will be of somewhat different shapes when the bar is coiled into a helical spring, as will later appear. The geometrical axis is indicated by the reference letter o', and is located similarly to that of the bar of square section of Fig. 5 at the intersection of the axes. These geometrical axes do not change their positions when the bars are coiled.

In the present invention there is an unbalance of the metal of the bar at the opposite sides of the medial plane passing through the vertical axis d, the part to the right of this plane, as viewed in Fig. 2, containing more metal than the part to the left. This unbalancing is preferably accomplished by making the side 6 considerably shorter than the side 7, which results in the axis of torsion being disposed to the right of the geometrical axis o'. The axis of torsion, indicated by the letter y, is positioned at the intersection of the line z' with the axis c. When the bar is coiled the axis of torsion will move toward the inner face of the spring to a position indicated by the reference letter y' (in Figs. 3 and 4) where the line z' intersects the axis c.

It will be noted that in this shifting of the axis of torsion it approaches the geometrical axis o', and it has been found that the extent of its displacement increases as the diameter of the spring decreases.

It is the purpose of the present invention to produce a sufficient unbalance of the metal to insure this axis of torsion not passing the geometrical axis, and preferably not reaching the geometrical axis, in the manufacture of any of the springs that the particular bar is designed for. This will be determined by the extent that the side 6 is shortened, that is to say the amount of metal eliminated from the inner corners.

Therefore, within the range of spring sizes that the particular bar is designed for, the axis of torsion will always be nearer the outer side or face 7 than the inner side or face 6, and, as previously stated, during deflection of the spring, the outer face 7 will take the torsional stress instead of the inner face 6 due to the position of the axis of torsion being nearer the outer face 7. It will be seen, by reference to Fig. 1, that the portion of the spring which is subject to deflection is shaped, in cross section, as shown in Fig. 3, only the extremities of the spring bar which do not deflect, being tapered to provide flat upper and lower spring seat surfaces, according to usual practice. In the description and claims this tapering portion is not treated as part of the spring.

It will be noted that with the square sectional bar of Fig. 5, the upset, when the bar is coiled, results in the bar sides 4 and 5 assuming the spring bar face tilted positions illustrated by the dotted lines 4' and 5' respectively. These faces tilt in opposite directions about points substantially in the axis b, which results in the inner portions (portions to the left of axis b) diverging from the axis a, thereby increasing the over-all height of the bar, necessitating, for a given amount of designed spring deflection, a corresponding increase in the free length of the finished spring. This is detrimental especially where, as for example in railroad practice, the space for the spring is generally limited. The outer portions (portions to the right of axis b) converge toward the axis a, which is not detrimental.

Therefore in the preferred embodiment of the bar of the present invention the portion of the bar outwardly from the axis d is preferably made rectangular bar shown (Figs. 2 and 4) and the portions of the sides 8 and 9 extending from the axis d toward the side 7, after the bar has been coiled, converge as shown at 8' and 9' in Fig. 3 and in dotted lines in Fig. 4. The side 7 becomes contracted and slightly concave, as shown at 7' in Fig. 3 and in dotted lines in Fig. 4.

Close adherence to the rectangular bar is not necessary. The only requirement here is that should the proportions of the sides 8 and 9 outwardly from the axis d be given a divergence from the axis c, the degree of such divergence should be within the proper limits so that, when the spring is designed for, these should not be greater than desired, is to say greater than the height along the axis d. On the other hand these portions should not be given a convergence to an extent that would defeat the amount of balance necessary. In practice the rectangular contour, for manufacturing reasons, is preferable for the portion of the bar disposed outwardly from the axis d.

The sides 8 and 9 are directed inwardly to meet the extremities of the side 6 respectively at the points e and f. The portions of the sides 8 and 9 extending inwardly, indicated respectively by 8'' and 9'', are preferably somewhat curved to provide convex faces on the bar. These portions 8'' and 9'' can, if desired, be of other shapes, such as curved in the opposite direction or straight. In any event, they will, in general direction, converge toward the axis c and should begin substantially at the axis d. Assuming the side 6 to be straight, which is the preferable shape, the amount of metal to the left of the axis d will depend upon the length of this side and the shape of the portions 8'' and 9''. The degree of convergence of these portions 8'' and 9'' will be governed by the length of the side 6.

The upset of the bar produced by coiling re-
sults in lengthening the side 6, which is illustrated by the line 12 of Fig. 3 and by the corresponding dotted line of Fig. 4, the points e and f being extended to the positions e' and f', and the degree of less convergence, shown respectively by the lines 3'' and 4'' of Fig. 3 and by the corresponding dotted lines of Fig. 4. The requirements here are that the amount of convergence of the portions 5' and 6' should be sufficient so that the portion of the length 6 of the bar outwardly from the axis d shall be larger than the portion inwardly from the axis d, for all springs for which the particular type of bar is designed. Furthermore the degree of convergence of the portions 5' and 6' should be sufficient to insure that the upset produced in making any spring will not result in bringing any part of these portions beyond the respective horizontals at the extremities of the axis d, for in any such event the overall height of the bar would be increased, it being understood that this limitation is approached as the springs for which the bars are designed decrease in diameter. To prevent this the portions 5' and 6' preferably begin to converge approximately at the axis d, or more strictly at the points that will determine the height of the bar when coiled, and these points should not be at the left of the axis d.

From the foregoing it will follow that the contour of the section of the bar, made according to this invention, is non-symmetrical on opposite sides of the axis d, and, on account of the respective contours of the sections on opposite sides of the axis d, that portion of the section outwardly from the axis d is of greater area than the portion inwardly of the axis. Therefore considering the medial plane through this axis d, this plane divides the bar into two unequal portions, the larger portion being that outwardly from the plane. This unbalancing of the metal brings the axis of torsion nearer to the outer face than to the inner face of the bar. The extent of the unbalancing of the metal is such as to space the axis of torsion sufficiently from the said plane of the axis d to prevent its crossing this plane when coiled for any spring of the range of springs the bar is designed for. Likewise the respective contours at opposite sides of this plane of the axis d are such that for any upset the height of the bar, defined by the axis d, will not be increased. That is to say the height of the bar will not be increased beyond the length of the axis d.

The maximum upset takes place when the bar is coiled for the spring of smallest diameter. Therefore the characteristic of the invention, as to the respective relative weights of the metal of the bar at opposite sides of the aforesaid plane through the axis d, and the contours given the two portions of the bar on opposite sides of the plane through the axis d, are suitably designed for the spring of smallest diameter within the range for which the bar is designed. One size of bar, made in accordance with the present invention, being and being for springs within a predetermined range of diameters, a relatively few sizes of bars will be required by a manufacturer for all sizes of springs.

It should be here remarked that Figs. 2-5 are merely diagrammatic, and no attempt is made to show the exact contours of the bars before and after coiling; extent of upset, or exact positions of the axes of torsion.

The invention claimed and desired to be secured by Letters Patent is:

1. A spring bar for coiling into a helical spring comprising an inner face adapted to provide the inner face of said spring; an outer face adapted to provide the outer face of said spring; and connecting faces respectively connecting corresponding ends of said inner and outer faces, said connecting faces changing their directions at substantially the geometrical medial plane between said inner and outer faces, the portions of said connecting faces extending from said plane to said inner face converging toward said inner face, the contour of said bar being thereby rendered non-symmetrical at opposite sides of said plane, the portion of said bar at the outer face side of said plane being of greater weight than the portion of said bar at the inner face side of said plane, whereby the axis of torsion of said bar is correspondingly disposed between said plane and said outer face, said connecting portions being of sufficient widths and converging to a sufficient extent to maintain said axis of torsion between said plane and said outer face and to prevent the over-all height of said bar from increasing beyond the height at said plane when said bar is upset due to the coiling thereof to form a helical spring of predetermined diameter.

2. A spring bar for coiling into a helical spring comprising an inner face adapted to provide the inner face of said spring; an outer face adapted to provide the outer face of said spring; and connecting faces respectively connecting corresponding ends of said inner and outer faces, the portions of said connecting faces extending from the geometrical medial plane between said inner and outer faces to said outer face being at right angles to said plane, and the portions of the connecting faces extending from said plane to said inner face converging toward said inner face, the contour of said bar being thereby rendered non-symmetrical at opposite sides of said plane, the portion of said bar at the outer face side of said plane being of greater weight than the portion of said bar at the inner face side of said plane, whereby the axis of torsion of said bar is correspondingly disposed between said plane and said outer face, said connecting portions being of sufficient widths and converging to a sufficient extent to maintain said axis of torsion between said plane and said outer face and to prevent the over-all height of said bar from increasing beyond the height at said plane when said bar is upset due to the coiling thereof to form a helical spring of predetermined diameter.

3. A spring bar for coiling into a helical spring comprising an inner face adapted to provide the inner face of said spring; an outer face adapted to provide the outer face of said spring; and connecting faces respectively connecting corresponding ends of said inner and outer faces, said connecting faces changing their directions at substantially the geometrical medial plane between said inner and outer faces, the portions of said connecting faces extending from said plane to said inner face being convexly curved and converging toward said inner face, the contour of said bar being thereby rendered non-symmetrical at opposite sides of said plane, the portion of said bar at the outer face side of said plane being of greater weight than the portion of said bar at the inner face side of said plane, whereby the axis of torsion of said bar is correspondingly disposed between said plane...
and said outer face, said converging portions being of sufficient widths and converging to a sufficient extent to maintain said axis of torsion between said plane and said outer face and to prevent the over-all height of said bar from increasing beyond the height at said plane when said bar is upset due to the coiling thereof to form a helical spring of predetermined diameter.

4. A spring bar for coiling into a helical spring comprising an inner face adapted to provide the inner face of said spring; an outer face adapted to provide the outer face of said spring; and connecting faces respectively connecting corresponding ends of said inner and outer faces, the portions of said connecting faces extending from the geometrical medial plane between said inner and outer faces to said outer face being at right angles to said plane, and the portions of said connecting faces extending from said plane to said inner face being convexly curved and converging toward said inner face, the contour of said bar being thereby rendered non-symmetrical at opposite sides of said plane, the portion of said bar at the outer face side of said plane being of greater weight than the portion of said bar at the inner face side of said plane, whereby the axis of torsion of said bar is correspondingly disposed between said plane and said outer face, said convexly curved portions being of sufficient widths and converging to a sufficient extent to maintain said axis of torsion between said plane and said outer face and to prevent the over-all height of said bar from increasing beyond the height at said plane when said bar is upset due to the coiling thereof to form a helical spring of predetermined diameter.

5. A spring bar for coiling into a helical spring having an inner face adapted to provide the inner face of said spring and an outer face adapted to provide the outer face of said spring, and having maximum height at substantially the geometrical medial plane intermediate said faces, said inner face being of sufficiently less width than said outer face to maintain in said bar, when coiled to form a helical spring of predetermined diameter, the said height of the uncoiled bar and the axis of torsion of the bar disposed nearer said outer face than said inner face.

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