United States Patent [19]

Foster

[11] **3,738,634**

[45] **June 12, 1973**

[54] **COMPOUND CURVED SPRING**

[76] Inventor: **Edwin E. Foster,** P.O. Box 714, 1801 Camp Craft Road, Austin, Tex. 78767

[22] Filed: **July 13, 1971**

[21] Appl. No.: **162,185**

[52] **U.S. Cl.** **267/156**

[51] **Int. Cl** **F16f 1/06**

[58] **Field of Search** 267/156, 167

[56] **References Cited**

UNITED STATES PATENTS

3,363,891 1/1968 Foster 267/156

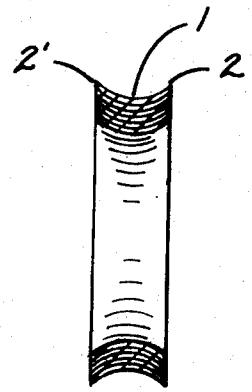
Primary Examiner—James B. Marbert

Attorney—Ralph E. Kalish

[57] **ABSTRACT**

A spring formed from an unstressed ribbon having an applied cross curvature with the center portion under compression; said spring being formed into a normal coiled state and being stress relieved whereby upon movement of said spring from its state of repose to wound condition the same will retain a cross curvature throughout its extent.

14 Claims, 14 Drawing Figures



PATENTED JUN 12 1973

3,738,634

SHEET 1 OF 3

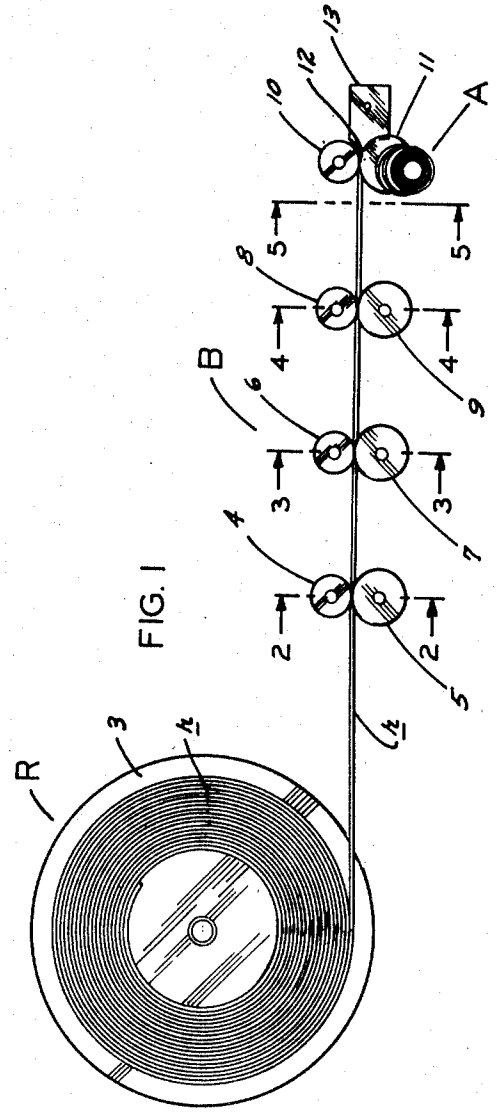


FIG. 1

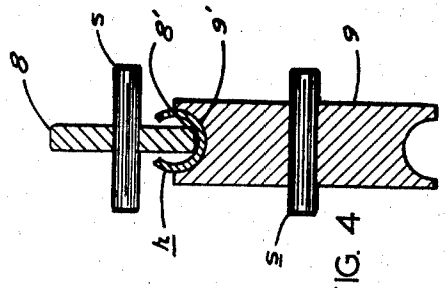


FIG. 4

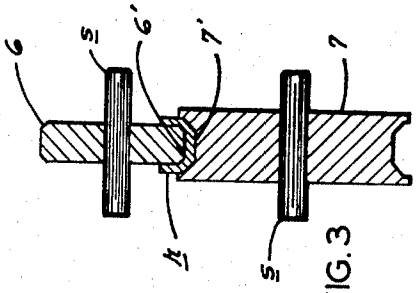


FIG. 3

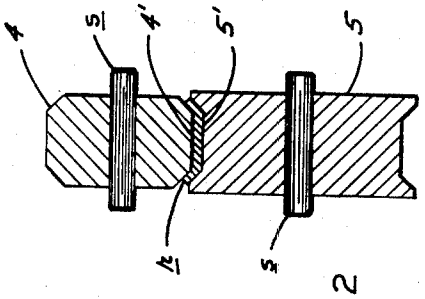


FIG. 2

INVENTOR
EDWIN E. FOSTER

BY Ralph N. Kalish

ATTORNEY

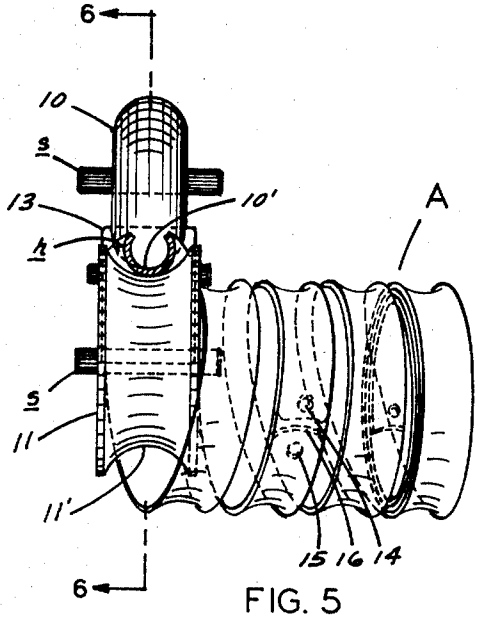


FIG. 5

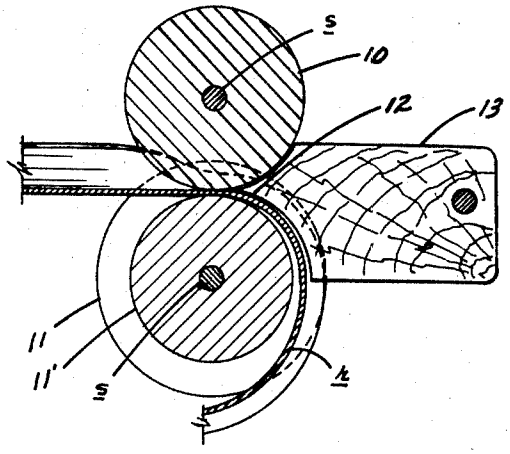


FIG. 6

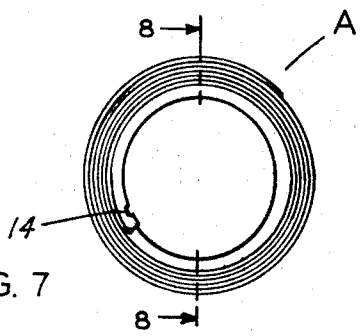


FIG. 7

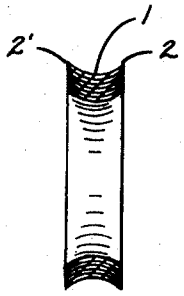


FIG. 8

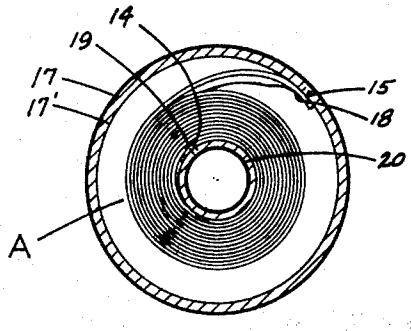


FIG. 9

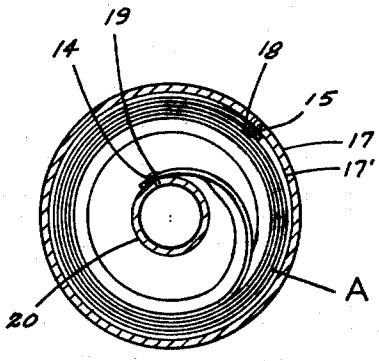


FIG. 10

INVENTOR
EDWIN E. FOSTER
BY Ralph W. Kalish
ATTORNEY

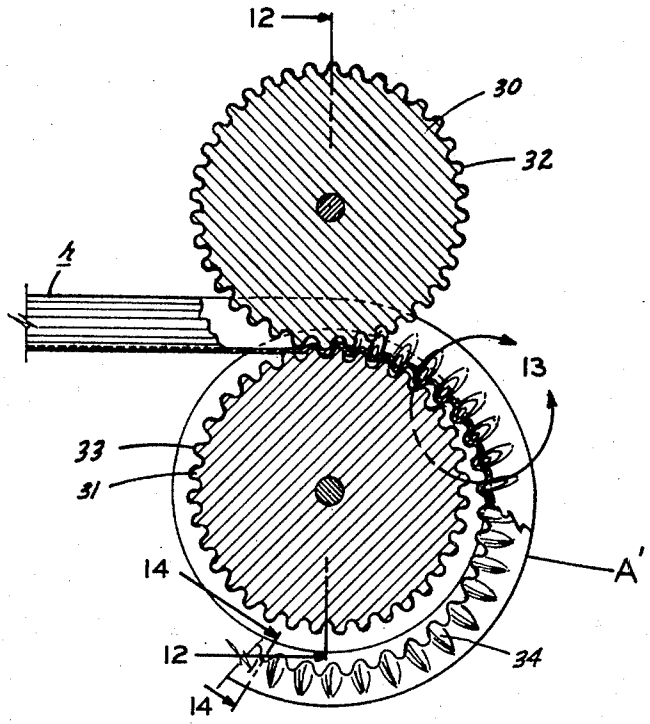


FIG. 11

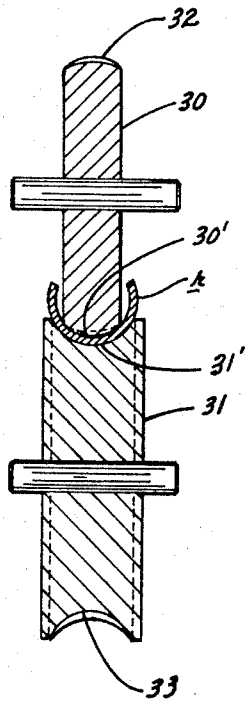


FIG. 12

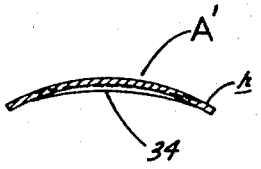


FIG. 14

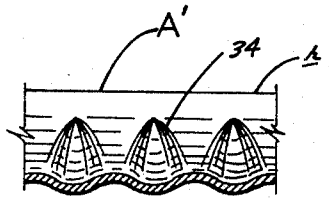


FIG. 13

INVENTOR
EDWIN E. FOSTER

BY Ralph W. Kalish

ATTORNEY

COMPOUND CURVED SPRING

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates in general to springs and, more particularly, to a formed coil spring of enhanced motive power characteristics.

It is an object of the present invention to provide a spring of the character stated which is produced from unstressed material and being so formed as to be endowed with power equal to springs of greater size and thickness.

It is another object of the present invention to provide a spring of the character stated which is of compound curved character, being adapted to continuously provide both longitudinal curvature and a cross curvature regardless of the particular state or condition of use of the spring.

It is a further object of the present invention to provide a spring of the character stated which is formed into a normal coil state and wherein the center portion is under compression.

It is another object of the present invention to provide a spring of the character stated which is formed for facile reception within a motor case thereby obviating heretofore accepted preliminary procedures for backwinding, additionally preloading, or the like for rendering the spring acceptable within such case.

It is a still further object of the present invention to provide a spring of the character stated which is so uniquely formed as to present its entire length for effectively expending its force in substantially a constant manner.

It is another object of the present invention to provide a spring of the character stated which when moving between normal or repose condition and wound condition, as within a case, a storing of energy is brought about by reason of the longitudinal force and the substantial cross curvature wherein the spring edges are stretched beyond their elastic limit.

It is a still further object of the present invention to provide a spring of the type stated which is simple in construction, obviating any pretreatment of the material of construction prior to applying the cross curvature; which may be most economically produced, as through suitable forming apparatus; which spring is extremely durable and reliable in usage having more fatigue life than springs of like size and weight; and which spring has a myriad of usages and applications.

It is a still further object of the present invention to provide a spring of the character stated which is not stressed into a state of repose but is suitably formed or bent so that the same does possess stability in such state to thereby eliminate the danger of the convolutions of the spring assuming a haphazard state when being released from wound condition for return to repose.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic side elevational view illustrating apparatus used in the production of a spring constructed in accordance with and embodying the present invention.

FIG. 2 is an enlarged transverse sectional view taken on the line 2—2 of FIG. 1 illustrating the first set of cross curving rolls.

FIG. 3 is an enlarged transverse sectional view taken on the line 3—3 of FIG. 1 illustrating the second set of cross curving rolls.

FIG. 4 is an enlarged transverse sectional view taken on the line 4—4 of FIG. 1 and illustrating the third set of cross curving rolls.

FIG. 5 is a vertical transverse sectional view taken on the line 5—5 of FIG. 1.

FIG. 6 is a veRtical transverse sectional view taken on the line 6—6 of FIG. 5.

FIG. 7 is a side elevational view of a compound curved spring constructed in accordance with and embodying the present invention.

FIG. 8 is a vertical transverse sectional view taken on the line 8—8 of FIG. 7.

FIG. 9 is a side elevational view of the compound curved spring of the present invention in wound condition upon the arbor of a case.

FIG. 10 is a side elevational view of the compound curved spring of the present invention in unwound condition within a case.

FIG. 11 is a vertical transverse sectional view taken substantially on the line 6—6 of FIG. 5 but showing the formation of another form of a spring constructed in accordance with and embodying the present invention.

FIG. 12 is a vertical transverse sectional view taken on the line 12—12 of FIG. 11.

FIG. 13 is an enlarged sectional view as taken at 13 in FIG. 11.

FIG. 14 is a vertical transverse sectional view taken on the line 14—14 of FIG. 11.

DESCRIPTION OF THE PRACTICAL EMBODIMENTS

Referring now by reference characters to the drawings which illustrate the practical embodiments of the present invention, in FIG. 7 thereof, A designates a compound curved spring as formed from a flat unstressed ribbon which may be spring steel, brass, or the like, and which, if desired may have been previously annealed. Spring A is preloaded and thus assumes a coiled condition in its state of repose and has had applied thereto a cross curvature, as indicated at 1, whereby the convex side of such cross curvature is directed toward the center of spring A in its normal state and with the other or concave side being directed outwardly of spring A, or away from the coil center. The longitudinal edges of spring A, as indicated 2,2′ are stretched beyond their elastic limit. By reason of the character of spring A, each convolution of the same will be concave-convex in cross section possessing the applied cross curvature while in its state of repose so that the inner convolutions are as transversely curvate as are the outer convolutions. Thus, in the normal state of spring A the convolutions thereof do not have a tendency to flatten, but on the contrary retain the applied cross curvature.

Referring now to FIGS. 1 to 6 inclusive the steps performed in the development of spring A will now be described whereby a more complete comprehension of the unique characteristics of the spring A should result. Springs made in accordance with the present invention are formed from a length of unstressed flat ribbon *r* provided in a reel R from which the same is fed through process apparatus designated generally B in a continuous forming operation. It will be appreciated that apparatus B, being shown in general schematic character, is

but exemplary of equipment adapted to provide the requisite sequential operations for producing spring A. Means for uniformly pulling ribbon *r* from reel R, for effecting appropriate rotation of the forming rolls, for punching and die cutting lengths from ribbon *r* into springs A are not a part of the present invention and may be effected by currently known expedients.

Reel R is disposed upon a rotatably mounted drum **3** and ribbon *r* is led therefrom through a series of rolls of a forming roll train for applying a developed, relatively substantial cross curvature to the originally unstressed ribbon *r*. Said train includes a first set of rolls **4,5** which, as shown in FIG. **2**, are provided with mating die portions **4',5'**, respectively for applying an initial relatively shallow cross curvature to ribbon *r* with the same being upwardly concave as viewed in FIG. **2**. A second set of rolls **6,7** sequentially accept ribbon *r* and incorporate mating die portions **6',7'** (see FIG. **3**) which being convex and concave, respectively, and of relatively greater depth, cooperate to enhance the initial cross curvature of ribbon *r*. A third set of rolls, as indicated **8,9** (see FIG. **4**) then receive ribbon *r* and by their respective mating portions **8',9'**, respectively, substantially complete the cross curvature formation by transversely curving ribbon *r* so as to approach a tubular form in cross section. Thus, the three sets of rolls **4,5**; **6,7**; and **8,9** progressively deepen the applied cross curvature or increase the arc thereof so that as ribbon *r* leaves rolls **8,9** the applied cross curvature is of relatively considerable depth. It is of course understood that the rolls of forming roll train are each mounted upon shafts *s* which are appropriately rotated by suitable means (not shown). Ribbon *r* proceeding from rolls **8,9** is then directed between a pair of forming pulleys **10,11**, respectively, which are marginally convex and concave as at **10',11'**, respectively (see FIG. **5**) so that ribbon *r* will retain its applied cross curvature by conforming to the concavity of pulley **11** but with the longitudinal margins of ribbon *r* being stretched beyond their elastic limit so that the said edges are thus stretched greater than the central portion. As ribbon *r* moves through forming pulleys **10, 11** the same is engaged by the complementary end portion **12** of a forming shoe **13** which, while causing ribbon *r* to retain the applied cross curvature causes the said ribbon *r* to be turned downwardly about the normally forward end portion of pulley **11** in general conformance to the shape thereof. By such operation ribbon *r* is bent, as it were, into a coiled form being thus preloaded by such operation. By reason of the relative extent of the complementary portion **12** of shoe **13** ribbon *r* as it loses contact with shoe **13** will tend to assume a slightly greater radius than that of pulley **11** (see FIG. **6**) so that said ribbon *r* may thus be directed laterally of pulley **11** as at an angle in the neighborhood of 45° whereby the now formed ribbon can be led from apparatus B for die punching, as at **14, 15** with intervening severance as by conventional means, so as to establish springs A of predetermined length; the line of severance being indicated at **16.**

It will thus be seen that the sets of forming rolls, together with pulleys **10, 11** progressively stretch the ribbon from the center to the outside edges. Thus, the forming operation is more than a mere application of a cross curvature as heretofore considered in the spring art, since ribbon *r* is being stretched so that the edges **2,2'** are stretched beyond their elastic limit. In a state of repose spring A will have a cross curvature and a lengthwise curvature as developed by cooperation of shoe **13** and pulley **11** so that said spring may be considered as of the compound curvature type; that is wherein the spring when in repose will have two directions of curvature. With springs disclosed in the prior art it has been shown only that the cross curvature will be present when the spring is in a straight line condition. When such springs are wound the cross curvature is lost as by flattening of the ribbon so that such prior art structures have only a single curvature in one particular state. Accordingly, in view of the foregoing it will be seen that spring A is uniquely developed through forming action to present the novel compound curved condition and thus being readily distinguishable from springs made from ribbons having applied stresses so that the same will tend to assume a tightly wound coil or wherein a backwinding is required to apply desired longitudinal stress.

The diameter of pulley **11** is such that springs A passing therefrom will assume a loose coil such as illustrated in FIG. **7** and which coil will have an outside diameter of suitable dimension for free reception of the same into a cylindrical motor case as indicated generally at **17** having a circular side wall **17'**. Thus, spring A is not tightened, backwound, or additionally preloaded in some particular fashion for reception within case **17** but is merely, as it were, freely dropped thereinto. However, it should be understood that previous to reception within case **17** spring A is stress relieved in accordance with commonly known techniques as where such springs are made from stainless steel, heating in an oven at about 400° for 30 minutes is adequate for suitable stress relief.

Within case **17** the loose coil is anchored at what might be considered its normally outer end to wall **17'** by a rivet **18** extending through die opening **15.** The normally inner end of the coil of spring A is secured as by rivet **19** through opening **14** to an arbor or hub **20** located centrally within case **17.** Thus, as it is received within case **17** spring A will have its full cross curvature **1.** Said arbor or hub **20** is adapted for rotation by commonly known means and upon such rotation spring A will be wound thereabout as illustrated in FIG. **9.** During such winding the cross section of spring A will tend toward flattening but will definitely not become fully flattened since the edges **2,2'** will remain in a slightly turned up state, as by reason of the stretching described above, so that when in fully wound condition spring A will retain its compound spring character in that it contemporaneously is cross curved throughout its entire extent as well as being longitudinally curved through winding. Thus, by reason of the stretching of the edges of spring A the cross curvature therein will at all times be maintained whether wound or in repose which endows the spring with the capability of giving and taking energy when moving from repose to wound condition and the reverse thereof. With spring constructions heretofore known the same have flattened in cross section when in wound condition thereby, perforce, being of considerably less strength than the present spring and accordingly having a greatly reduced capacity in the transfer of energy from one condition to the other.

Manifestly, as spring A unwinds from wound condition upon arbor **20** for return to disposition adjacent wall **17'** the increased crossed curved condition as indicated at **1** will be restored, thus returning spring A to

its condition of marked potential power by reason of the substantial stiffening brought about by its normal deep concave-convex cross curvature. Thus, as spring A is wound upon arbor **20** a substantial storing or taking of energy is developed through the depressing of the cross curvature to a more shallow arc. The marginally stretched edges **2,2'** of spring A which are normally under tension conduce to the capability of spring A in giving and taking energy.

It must be remembered that ribbon *r* in the production of spring A is in no way prestressed and does not possess any natural cross curvature; the same not being subjected to tension devices or the like. Thus, spring A as formed has a preloaded longitudinal curve and with marginal edges stretched beyond their elastic limits.

Extensive testing has demonstrated that springs made in accordance with the present invention have a power which approximates, and in many cases exceeds, that developed by springs which have been prestressed and then backwound such as of the type set forth in Foster U.S. Pat. No. 3,363,819, which latter has been extensively tested for comparison with springs of the type described in Anderson U.S. Pat. No. 1,922,921 and Geyer U.S. Pat. No. 2,622,700. Springs made in conformation with the last two mentioned patents are markedly inferior to springs embodying the present invention as the same do not possess the compound curved character of the present spring.

Referring now to FIGS. **12–14**, A' generally designates a compound curved spring which is formed of the same material as spring A hereinabove described and is in all respects similar thereto except that the edges are not stretched beyond their elastic limit but the center is compressed by transversely extending corrugations. Thus, spring A' is fabricated of the same ribbon stock as spring A and has applied thereto the same cross curvature, as by the three sets of forming rolls **4, 5, 6, 7,** and **8, 9.** The cross curved ribbon *r* is then directed between a pair of cooperating dies **30, 31** which are marginally convex and concave **30', 31'**, respectively, but which are also edgewise provided with cooperating serrations as at **32,33,** respectively, which are adapted to cause longitudinally spaced, transversely extending depressions **34** which by reason of their spacing cause the central portion of spring A' to be of corrugated configuration. Said depressions **34** are relatively deep in their center portions and then tend to become shallow as they progress toward the edges of said spring A' and do terminate spacedly from the edges. The transverse curvature of spring A' is immediately comparable to that of spring A but, as state above, is devoid of the edge stretching. Depressions **34** thus effect a compressing of the center portion of spring A' but the formation of the same does not lessen the metal thickness.

It is apparent that various means may be utilized for applying the corrugations to the spring including depressions of initially the same depth which would tend to be deepened upon winding as the same will move more closely together.

Springs of this type may both stretch or compress the corrugations during winding or unwinding, thus adding another force to the spring operation. By such construction there would be brought into play a longitudinal force, a crosswise flattening force, the stretching of the portion near the edges of the ribbon, and the compression of the center portion thereof.

In view of the foregoing springs can be constructed in accordance with the present invention wherein a combination of center compression and edge stretching could be adopted. Also the depressions **34** may be of sufficiently small character so as not to interfere with the inter-friction of the coils.

Having thus described my invention, what I claim and desire to obtain letters patent for is:

1. A spring comprising a body formed from a flat ribbon of unstressed metal, said spring having an initially applied concave-convex cross curvature of relatively substantial arc to render same transversely curvate throughout its length, said spring having secondarily been bent into a loosely wound coil condition providing a longitudinal stress and wherein each convolution retains the transversely curvate condition by means of the applied cross curvature, the convex side of said cross curvature being directed toward the center of such coil when said spring is either in wound or unwound condition.

2. A spring as defined in claim **1** and further characterized by the central longitudinal portion of said spring being under compression.

3. A spring as defined in claim **1** and further characterized by said spring having longitudinally spaced apart, transversely extending depressions.

4. A spring as defined in claim **2** and further characterized by said depressions being relatively deep in their central portions and shallow in their outer portions.

5. A spring as defined in claim **1** and further characterized by said ribbon having longitudinal edge portions, said edge portions being stretched beyond their elastic limit whereby when said spring is unwound from its coil condition the same will retain a concave-convex cross curvature throughout its extent.

6. A spring as defined in claim **5** and further characterized by a pair of concentric relatively rotatable drums, the normally inner end of the spring ribbon being secured to the outer face of the inner of said drums, and the normally outer end of the spring ribbon being secured to the internal surface of said outer drum whereby upon winding of said spring upon said inner drum said spring will retain a concave-convex curvature with the convex side therefor directed toward the center of said inner drum.

7. A spring as defined in claim **6** and further characterized by the maximum diameter of said spring in a state of repose being less than the inside diameter of the outer drum for facile disposition therein.

8. A spring motor comprising a resilient body of concave-convex cross sectional configuration and capable of maintaining a concave-convex cross section when in wound condition.

9. A spring comprising a resilient body formed to be in general coiled condition and in repose, said spring having an applied concave-convex cross curvature throughout its extent with the convex side being directed toward the center of the coil, said spring being capable of retaining a concave-convex cross curvature when moving from repose to wound condition.

10. A spring as defined in claim **9** and further characterized by the said resilient body having longitudinal edges, said edges being stretched beyond their elastic limit whereby said edges are normally under tension and the intervening portion of said spring is under compression.

11. A spring as defined in claim 1 and further characterized by said ribbon having longitudinal edge portions, said edge portions being stretched beyond their elastic limit, the portion of said ribbon between said longitudinal edges being provided with longitudinally spaced apart depressions.

12. A spring comprising a body formed from a ribbon of unstressed metal, said ribbon having an applied concave-convex cross curvature of relatively substantial arc, said spring being formed into a coil configuration so that when said spring is in a state of repose it will be curved longitudinally and transversely throughout its extent with the convex side directed toward the center of said coil configuration, said spring having longitudinally spaced-apart transversely extending depressions.

13. A spring as defined in claim 12 and further characterized by said depressions being relatively deep in their central portions and shallow in their outer portions.

14. A spring comprising a body formed from a ribbon of unstressed metal, said ribbon having an applied concave-convex cross curvature of relatively deep substantial arc, said spring being formed into coil configuration so that when said spring is in a state of repose it will be curved longitudinally and transversely throughout its extent with the convex side directed toward the center of said coil configuration, said ribbon having longitudinal edge portions, said edge portions being stretched beyond their elastic limit, the portion of said ribbon between said longitudinal edges being provided with longitudinally spaced apart depressions.

* * * * *