Oct. 3, 1950 T. LINDSTROM 2,524,293

TENSION SPRING

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Fig.1.

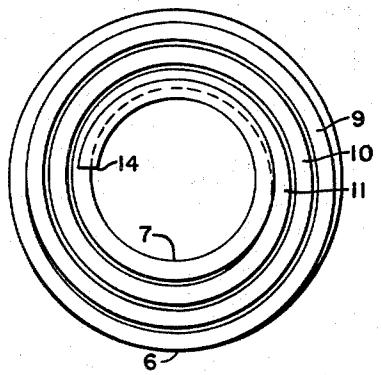


Fig.2.

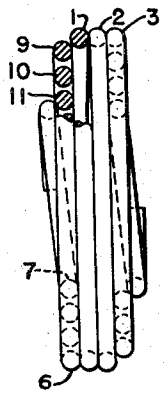


Fig.3.

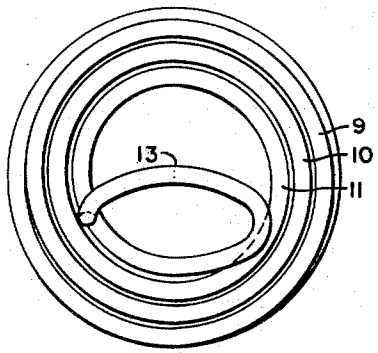
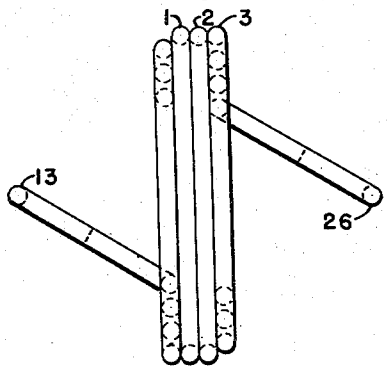


Fig.4.



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TENSION SPRING

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2 Claims. (Cl. 267—1)

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My invention relates to springs and more particularly to helical springs.

One broad object of my invention is the provision of a spring having uniform operating characteristics both over the entire range of spring deflection and the entire time period of its use.

Another object of my invention is the provision of a calibration spring that has a low fibre stress, manifests permanence in service, has uniform operating characteristics over a wide range of adjustment, occupies a minimum of space for the service to which the spring is put, and is low in manufacturing costs.

Devices, such as electric contact trip devices using calibration springs are being made in smaller and smaller units, but the requirement of the spring used is not correspondingly reduced with the reduction in size of the trip device.

I am aware that the art of springs is well worked and old, but the very nature of the problem that confronted me gave rise to a novel spring for solving the problem encountered. It is seldom that the operating requirements of a spring are as varied and exacting as for a calibrating spring. These requirements comprise low fibre stress, permanence in service, wide range of adjustment, minimum space requirements, and low cost.

My novel spring satisfies the requirements mentioned.

The objects recited are merely illustrative. Other objects and advantages will become more apparent from a study of the following more detained description and the drawing, in which:

Figure 1 is an end view of one end portion of my novel spring in one stage of manufacture;

Fig. 2 is a side view of a complete spring with parts at the upper left thereof broken away, and again showing my spring in the same stage of manufacture as shown in Fig. 1;

Fig. 3 is an end view of one end of a completed spring; and

Fig. 4 is a side view of a completed spring.

It is not a particularly easy problem to calculate and predimension a good calibration spring and for some applications it appears nigh impossible to produce a satisfactory design.

The useful work stored in a spring is a function of the weight of the active part of the spring disregarding the Wahl correction factor and the decrease in efficiency for the spiral turns. In all types of special end hooks for tension springs to reduce the free length, my novel spring is the only spring, to my knowledge, which has added

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weight to the active part of the spring without an increase in spring length.

Further, distortion and added internal stresses in forming the hooks are at a minimum, and the common danger of breaking the hooks during operation is entirely eliminated.

In constructing my spring, which is of the helical wire type, I shape the mid-portion of the spring namely, the full-diameter portion, along conventional lines. This requires for the most compact spring at least one-half helical loop of full diameter, but as many more full diameter loops as may be needed may fall in the cylindrical surface of the spring, that is, form the cylindrical parts of the spring. This part is evidenced by the loops 1, 2, 3, etc.

Then at each end I spiral the turns inwardly, that is, toward the spring axis. The number of spiral turns I provide is determined by the wire thickness and other design requirements.

In the showing of Fig. 1 three full spiral turns 9, 10, and 11, counting the turns from point 6 to point 7, are disposed at the left end of the spring. A similar number of spiral turns is disposed at the other end of the spring.

My spiralling is, however not confined to merely bringing successive turns nearer the spring axis, but the turns are also depressed toward the mid region. This means that turns 9, 10, and 11 all fall generally in the same plane. A like structure appears at the other end of the spring. This is readily apparent from Figs. 2 and 4.

To form the hooks I bend the last three-quarter of a turn at one end, counting from point 7 to point 14, outwardly at an angle of 60°, and similarly bend the last three-quarter of a turn at the other end outwardly at an angle of 60°. The 60° angle at the hooks thus places the center part of each hook 13 and 26 squarely on the center line or axis of the spring. This construction eliminates excessive fibre stresses in any part of the spring.

Since the hook bend is much nearer the spring axis, the bending moment arm is relatively short, and hook breakage is entirely eliminated. Further, the spiral turns and the still larger outside turns will all be substantially uniformly loaded all around and the axis of the spring will be kept straight or very close to a straight line during operation.

Further, in forming the hook before the part is bent out at 60° the diameter is kept uniform so that the end 14 will ride up on top of the turn 11.

The showing in Fig. 4 is particularly illustrative of the fact that the center portion of each

hook, comprising the three-quarter turns mentioned as turned up, falls in the axis of the spring. Further, the spring is thus compact, it can hold more stored energy than prior art springs of like weight and size, and this novel spring of mine is more dependable in service, has more deflection, and less expensive to produce without increase in size or without producing dangerous stress concentrations at any place.

To obtain a still better understanding of my contribution to the art an inquiry into the manner of solving spring problems may be quite helpful. For a load of a spring in pounds where the other dimensions are in inches I found:

1. $$P=\frac{Gd^4y}{64N_1r_1^3+16N_2(r_1+r_2)(r_1^2+r_2^2)}$$

where
G=torsional modulus of elasticity,
d=diameter of the wire in inches,
y=total deflection,
N_1=number of large turns as 1, 2, and 3 in Fig. 2,
r_1=mean diameter of large turns,
N_2=number of active end turns as 9, 10, and 11 where the mean radius gradually changes from r_1, to r_2, and
r_2=minimum of mean radius of smallest active turn, as the three-quarter of a turn 13.

The total deflection is

2. $$y=\frac{16P[N_2(r_1+r_2)(r_1^2+r_2^2)+4N_1r_1^3]}{Gd^4}$$

The torsional fibre stress in large turns in pounds per square inch, is

3. $$S=\frac{16r_1PK_1}{\pi d^3}$$

where K_1 is the Wahl correction factor based on relation $2r_1:d$.

The final length of the spring for the full range of its use is expressed by

4. $$L=L_{FR}+y$$

where L_{FR}=free length of spring, namely a spring not subject to tension as the spring shown in Fig. 4.

The free length is expressed by

5. $$L_{FR}=d\left[N_1-1+.5\left(1-\frac{r_2}{r_1}\right)\right]+3.464r_2$$

The projected size of the hook is expressed by

6. $$H=1.732r_2-d$$

The developed length of the wire is expressed by

7. $$L_W=[2r_1N_1+(r_1+r_2)N_2+2.9\,r_2]\pi$$

The values of G for spring materials in use are known to be as follows:

Carbon steel	11,400,000
Stainless steel	10,500,000
Phosphor bronze	6,000,000

With the formulae given and the values of G given any one skilled in the art should, after also having had the benefit of the other teachings of my specification, be able to make, construct and compound my invention.

While I have confined the showing to a single embodiment, I do not wish to be limited to the showing made. Obviously, the number of spiral turns may vary, the number of uniform diameter turns may vary, and still other features may vary all within the spirit of my invention.

I claim as my invention:

1. A helical tension spring including, a plurality of generally circular turns constituting the mid-portion of the spring, the continuation of each end turn of the generally circular configuration gradually going over into several inwardly spiralling turns all of which at each end fall generally in the planes normal to the spring axis, and the last half of the innermost spiral turn at each end being bent outwardly to form a hook at each end the bight of which falls substantially in the axis of the spring.

2. A helical wire spring including at least two generally circular turns constituting the mid-portion of the spring with the turns, when the spring is not subject to tension, lying snugly against each other to thus keep the axial length a minimum, the outward continuation of each outer generally circular turn going over into several inwardly spiralling turns with the turns being depressed toward the adjacent circular turn that all the spiral turns at each end fall respectively in parallel planes normal to the axis of the generally circular turns, the end of the smallest spiral turn at each end being bent outwardly so that the bight falls in the spring axis, whereby a spring is formed such that the tension force acts in the axis of the spring and a maximum energy may be stored in a spring per spring weight.

TURE LINDSTROM.

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