Oct. 6, 1936. F. P. ZIMMERLI 2,056,816

SPRING

Filed March 20, 1931

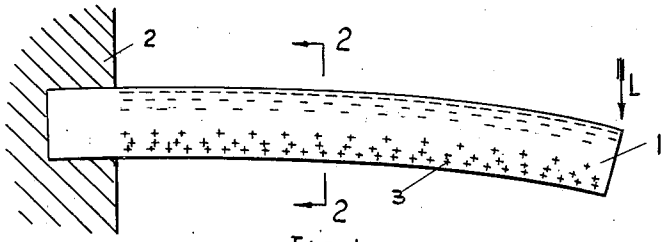

FIG. 1

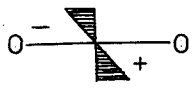

FIG. 2

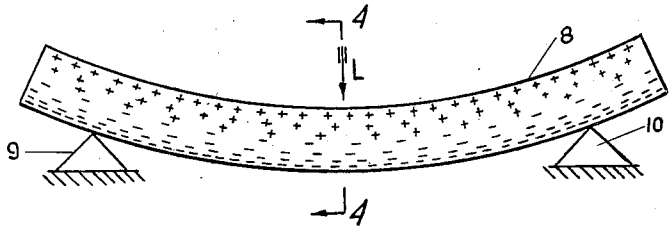

FIG. 3

FIG. 4

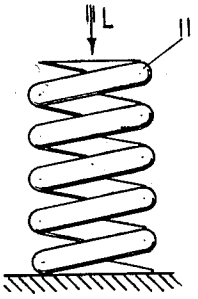

FIG. 5

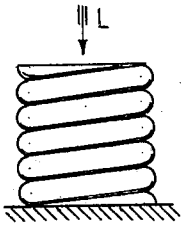

FIG. 7

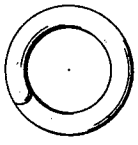

FIG. 6

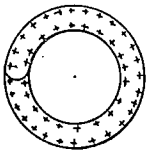

FIG. 8

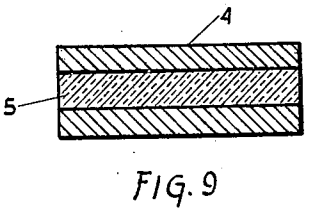

FIG. 9

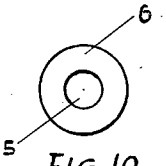

FIG. 10

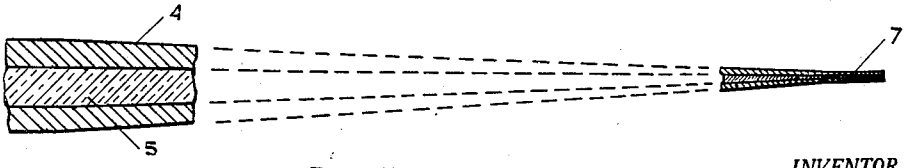

FIG. 11

INVENTOR.
Glenn V. Pickwell
Franz P. Zimmerli
BY
Barnes and Kisselle
ATTORNEYS.

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SPRING

Franz P. Zimmerli, Detroit, Mich., assignor to The William D. Gibson Company, Chicago, Ill., a corporation of Illinois

Application March 20, 1931, Serial No. 523,962

9 Claims. (Cl. 267—61)

This invention relates to a spring.

In either a coil spring or a flat spring the greatest stress due to loading is on the extreme outer fibers. The stress on the fibers decreases as one approaches a definite area within the spring which might roughly be defined as the center of the spring where the fibers are neither stressed nor compressed. With this fact in mind it is the object of this invention to produce a spring which will give an increased performance from a given volume of material. This has been achieved by raising the physical properties of the outer surface of the metals used in spring manufacture. By strengthening these outer fibers and leaving the inner ones more ductile, a higher fatigue limit and greater spring life can be obtained.

In the drawing:

Fig. 1 is a view of a spring supported at one end showing the compression and tension of the spring fibers.

Fig. 2 is a section along the line 2—2 of Fig. 1 illustrating the decrease in tension and compression of the spring fibers as one approaches the center of the spring.

Fig. 3 is an illustrative view of a spring supported at two points with the load at the center.

Fig. 4 is a section along the line 4—4 of Fig. 3 likewise illustrating the decrease in tension and compression as one approaches the center.

Fig. 5 shows an unloaded coil spring.

Fig. 6 is a top plan view of the same.

Fig. 7 shows the same coil spring loaded.

Fig. 8 is a top plan view of the loaded spring showing the tension and compression of the fibers of the spring.

Fig. 9 is a section through a composite ingot, a center portion of which is of ductile material such as copper and the outer portion of which may be steel.

Fig. 10 is a transverse section through the ingot.

Fig. 11 illustrates the method of rolling the composite ingot into wire form.

Since it is an object of the invention to produce a spring in which the physical strength of the spring material varies in proportion to the tension and compression to which the spring fibers are subjected, there is shown in Fig. 1 a flat spring 1 which is supported at one end only in the support 2. In this instance the load L is applied at the outer end as shown by the arrow. In this instance the spring is bent downwardly. Consequently, the lower fibers will be compressed as indicated by the positive signs and the upper fibers will be tensioned as indicated by the negative signs. The degree of compression and tension is illustrated by the size of the positive and negative signs. In other words, the greater the plus sign the greater the compression to which those fibers are subjected and the greater the negative sign the greater the tension to which those fibers are subjected. It will be noted, as brought out by the large plus signs, that the extreme outer layers of fibers adjacent the lower surface 3 of the spring 1 are subjected to the greatest compression as shown by the large positive signs. This compression gradually decreases as one approaches the center 0—0 (Fig. 2) in which theoretical area there is neither compression nor tension. This decrease in compression as one approaches the center 0—0 is illustrated by the decrease in the size of the positive signs toward the center of the spring.

Since, as above described, the tension and the compression is greatest on the extreme outer fibers when the spring is loaded, it is proposed to make the extreme outer fibers of greatest tensional strength and gradually decrease the tensional strength of the fibers as one approaches the center of the spring 0—0 where theoretically there is neither tension nor compression. The tensional strength of these outer fibers and the physical properties thereof may be raised in numerous ways such as by nitriding, case hardening, or carbonizing steel springs. The strength of the outer fibers could likewise be accomplished by cold working of the metal. In any metal it could be accomplished by a variation in analysis from center to outside.

This variation in analysis is brought out nicely in Figs. 9, 10, and 11. In such a case an ingot is formed, the outer layers 4 of which may be of any metal having a high tensional strength such as steel and the center portion 5 of this composite ingot could be formed of any suitable ductile metal or composition of metals such as copper, zinc, or an alloy of the same. This ingot could then be put through suitable rolls such as are used in the production of wire and rolled to increase its length and decrease its cross-sectional area until in the form of a wire 7 of whatever cross-sectional area desired. In such a case the outer fibers 4 would be of great tensile strength and the center fibers 5 very ductile. In such a wire 7, or in a leaf spring similarly formed, the outer fibers would be of greater physical strength than the inner ones which would be relatively more ductile than the strong outer fibers.

In Fig. 3 there is shown the flat spring 8 which is supported at each end by the supports 9 and

10. The load L is applied intermediate the supports 9 and 10. In such a case the upper fibers are compressed as indicated by the plus signs and the lower fibers tensioned as indicated by the negative signs. The degree of tension and compression is indicated by the size of the plus and the minus signs. This compression and tension gradually decreases towards the center 0—0 (Fig. 4) in which area there is neither tension nor compression. In such a spring likewise the fibers having the greatest tensional strength would be those along the extreme outer surface indicated by the large plus and minus signs. The tensional strength of the fibers would gradually decrease towards the center of the bar as indicated by the decrease in size and number of plus and minus signs approaching the center of the road. As shown in Fig. 8, when load L has been applied to the spring 11 the fibers of the outer surface of the wire are placed in torsion and subject to clearing stresses, which are indicated by plus signs and vary from a maximum on the outer surface of the wire to a zero load at the center of the wire. This loading is increased by imposed bending stresses which throw additional load on the wire. The same stress condition will hold good if instead of compressing the spring it were extended. In this instance likewise the outer fibers of the coil spring wire will be nitrided, carbonized, case hardened, cold worked, or varied in analysis so that they will be of relatively great tensional strength. The tensional strength of the fibers, as one approaches the center of the coil spring wire, will be gradually decreased so that the inner core of the wire, such as shown at 5, will be relatively ductile.

From the above description it is evident that there is here produced a coil spring having the fibers which carry the greatest stress, when the spring is loaded, having the highest physical properties and those carrying the less stress, when the spring is loaded, having the lowest physical properties and the fibers intervening those carrying the greatest stress and those carrying the least stress decreasing in tensional strength as they approach the fibers carrying the least stress or increasing in tensional strength as they approach the fibers carrying the greatest stress. More particularly, the invention contemplates a spring essentially characterized by an outer surface of great tensional strength and an inner area that is relatively ductile.

I claim:

1. A metal spring, the outer fibers of the entire surface of which are of greater tensional strength than the inner fibers.

2. A metal spring, the outer fibers of which completely surround the inner fibers and have relatively high physical properties and the inner fibers of which are relatively ductile.

3. A helical steel spring in which the outer fibers carrying the greatest stress have a higher tensional strength than, and completely surround, the inner fibers carrying the lesser stress.

4. A metal spring, the fibers of which vary in tensional strength from the outside to the center of the spring corresponding to the stress to which they are subjected when the spring is loaded, the outer fibers having the greatest tensional strength and the inner neutral fibers having the least tensional strength.

5. A helical steel spring, the outer fibers of which completely surround the inner fibers and have relatively high physical properties and the inner fibers of which are relatively ductile.

6. A metal spring, the extreme outer fibers of which are relatively strong and completely surround the inner fibers and the inner fibers relatively ductile.

7. A metal spring comprising an inner zone of relatively ductile fibers, an outer surface zone of fibers having relatively high physical properties, and a zone of fibers between the outer and inner zones wherein the fibers gradually decrease in tensional strength from the outer to the inner zones from the tensional strength of the outer zone fibers to the tensional strength of the relatively ductile fibers of the inner zone.

8. A helical steel spring comprising an inner zone of relatively ductile fibers, an outer surface zone of fibers having relatively high physical properties completely surrounding and encasing the inner zone of fibers, and a zone of fibers intermediate the outer and inner zones wherein the fibers gradually decrease in tensional strength from the outer to the inner zones from the tensional strength of the outer zone fibers to the tensional strength of the relatively ductile fibers of the inner zone.

9. As an article of manufacture a nitrided steel helical spring.

FRANZ P. ZIMMERLI.