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W. R. JOHNSON ETAL

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SLOTTED BELLEVILLE SPRING

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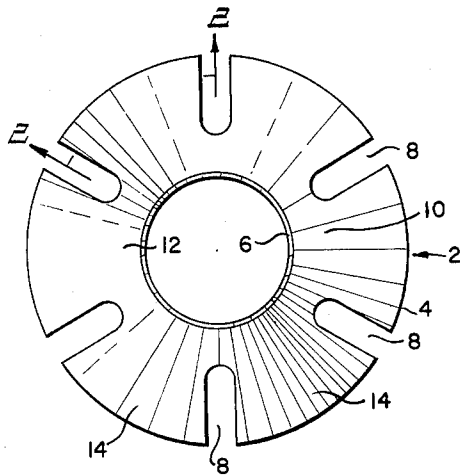


Fig. 1 Prior Art

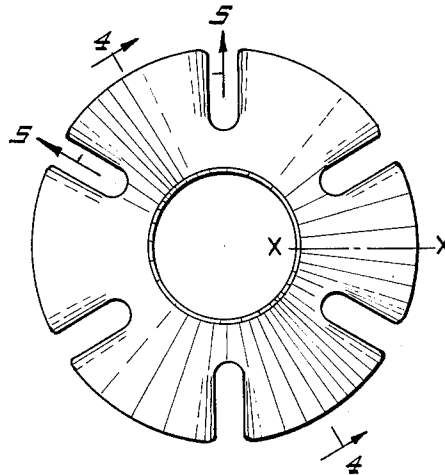


Fig. 3



Fig. 2 Prior Art

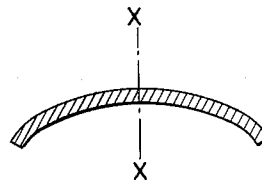


Fig. 5

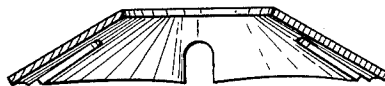


Fig. 4

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SLOTTED BELLEVILLE SPRING

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3 Claims. (Cl. 267—1)

This invention relates generally to springs and, more particularly, to those springs known as Belleville springs. A Belleville spring is in the form of a frusto-conical disc formed of spring metal having a central aperture, and which resists axially opposite forces applied at its inner and outer peripheries.

Such springs are often modified in structure by cutting radial slots from either the inner or the outer periphery or both which extend partially toward the other periphery, the purpose of such slotting being to reduce the rate of the spring. The spring rate of such a slotted Belleville spring has two components which act together, these being the rate of the unslotted part of the spring, which may be referred to as the Belleville ring, and the rate of the fingers lying between adjacent slots, which bend as cantilever beams as the spring is operated. The rate of a slotted or unslotted Belleville spring may be further modified by the provision of stop incorporated into the apparatus for operating the spring and by means of which either the bending effect of the Belleville ring or that of the bending fingers may be reduced or increased.

United States Letters Patent to Becker, No. 2,169,787, which was issued to the assignee of this Letters Patent, described and claims an invention having to do with the configuration of the slots of a slotted Belleville spring in order to affect the rate of the spring and to prevent failure of the Belleville ring in areas in the prolongation of the slots. The present invention indicates the continuing interest of the common assignee in the problems of slotted Belleville springs and reference is hereby made to the earlier patent for further discussion of this problem.

As indicated in the Becker patent it has long been well known that slotting increases the stress concentration in the Belleville ring portion of the slotted spring, and that patent points out that loading of a slotted spring may cause an undulating or wave-like deflection in the Belleville ring part of the spring due to the alternate effects on the ring caused by the stiffness of the fingers and the weakening effect of the slots. According to the Becker patent this effect is alleviated by slot configuration, particularly by the shape of the aperture which terminates the slot.

We have confirmed the statement in the earlier Letters Patent that the wave-like deflection of the Belleville ring part of the spring does, in fact, decrease the fatigue life of the spring. However, we found that this wave-like deflection results wholly or in part from the nature of the bending of the flat spring which constitutes each finger. When a flat spring is bent about one axis it will also bend about an axis at right angles to the original bending axis, this being known as anticlastic bending, for a discussion of which reference is made to pages 253, 254 and 289 of "Theory of Elastic Stability," by Timoshenko, McGraw-Hill, 1936. A simple way to describe anticlastic bending is to say that when a strip of spring steel is bent about an axis at right angles to the length of the strip the edges of the strip will curl up. We have found that when the Belleville spring is operated the bending of the spring fingers between adjacent slots causes the edges of the finger to curl, and that this curling forces the Belleville ring part of the spring to deflect in a wave-like shape, increasing the tensile stresses in portions of

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the lower outside edge of the Belleville ring part of the spring.

The prior art and the invention are described in this specification and are illustrated in the accompanying drawings, in which:

FIG. 1 is a top plan view of a slotted Belleville spring according to the prior art;

FIG. 2 is an enlarged cross sectional view of one of the fingers of the spring shown in FIG. 1, shown during deflection of the spring and taken on the line 2—2 of FIG. 1;

FIG. 3 is a top plan view of a slotted Belleville spring according to the invention;

FIG. 4 is a sectional view of the Belleville spring according to the invention, taken on line 4—4 of FIG. 3, and

FIG. 5 is an enlarged cross sectional view of one of the fingers of the spring provided by the invention, taken on line 5—5 of FIG. 3 and showing the cross curvature of the spring fingers as provided by the invention.

The effect of anti-clastic bending in a slotted Belleville spring is illustrated in FIGS. 1 and 2 of the drawings forming part of this specification, in which the Belleville spring 2 has the circular outer periphery 4 and the circular inner periphery 6, the spring between these two peripheries having the frusto-conical shape shown in FIG. 4. The spring is provided with a plurality of slots 8 which extend inwardly from the outer periphery of the spring radially of the spring and which terminate short of the inner periphery in the locus indicated by the dotted line 10. The Belleville ring part of the spring is the un-slotted annular part 12 lying between the locus 10 and the inner periphery of the spring, while the spring fingers 14 are those portions lying between adjacent slots 8. While, in the example described and illustrated in this specification, the slots extend inwardly from the outer periphery of the spring, it will be understood that the invention is not limited in any way to a spring having such inwardly extending slots, but applies equally to a spring in which the slots extend outwardly from the inner periphery, with the Belleville ring portion of the spring lying at and adjacent the outer periphery 4.

When a slotted Belleville spring of hitherto known construction is deflected by axial loading, the fingers 14, each of which forms a segment of a frusto-conical surface of increasing radius in cross section as the spring is deflected, will be subjected to anti-clastic bending stress, causing it to assume a cross-sectional curvature having its concave side outward of the frusto-conical surface of the spring, as shown in FIG. 2. As stated above, the effect causes wave-like deflection of the adjacent Belleville ring part of the spring, with resulting increased tensile stress.

In accordance with this invention, means are provided to cause the Belleville ring part of the spring to deflect uniformly and without wave-like configuration, thus increasing spring life. In accordance with the invention, each finger 14 of the spring is crowned or transversely curved about an axis extending radially through the circumferential center line of the finger, one of these center lines being shown as the line X—X in FIGS. 3 and 5. The direction of such curvature is opposite to the direction of anti-clastic bending and may be observed by comparing the curvature of the finger due to anti-clastic bending as shown in dotted lines in FIG. 2, with the imposed curvature of the finger which is provided by the invention and which is shown in FIG. 5. When a finger which has been given this permanent curvature bends under load imposed axially of the Belleville spring the finger, which is a flat spring, tends to flatten transversely, that is between adjacent slots, because of the compensating effect of the imposed curvature on the anti-clastic bending of the finger.

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The stresses tending to produce cross curvature due to anti-clastic bending are thus neutralized, and the effect of the imposed curvature is to cause the finger to tend to assume a straight or flat cross sectional shape under bending load. The amount of crown, or imposed curvature, is made sufficient to achieve uniform deflection and to compensate for the anti-clastic bending which would occur if the curvature had not been imposed.

While we have described and illustrated a number of forms which our invention may take, it will be apparent to those skilled in the art to which it relates that other embodiments, as well as modifications of those disclosed, may be made and practiced without departing in any way from the spirit or scope of the invention, for the limits of which reference must be made to the appended claims.

What is claimed is:

1. A Belleville spring formed of spring strip metal in the shape of a frusto-conical washer having a central opening and having a plurality of circumferentially spaced

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slots extending radially of the spring from one of its peripheries and defining spring fingers between adjacent slots which are subject to anti-clastic bending on axial deflection of the spring, each of said fingers being transversely curved in the un-stressed condition of the spring in a direction opposite to the curvature produced by anti-clastic bending thereby to compensate for anti-clastic bending of the fingers and cause each of the spring fingers to maintain frusto-conical shape as the spring is deflected.

2. A Belleville spring according to claim 1, in which the slots extend inwardly from the outer periphery of the spring.

3. A Belleville spring according to claim 1, in which the slots extend outwardly from the periphery of the central opening.

No references cited.

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