

Jan. 24, 1950

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2,495,314

BOURDON SPRING AND LOAD ELEMENT

Filed July 16, 1947

2 Sheets-Sheet 1

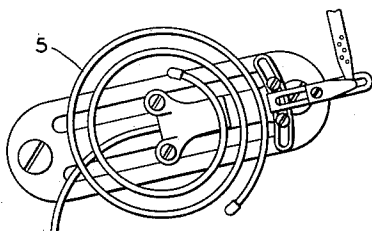


FIG. 1

FIG. 2

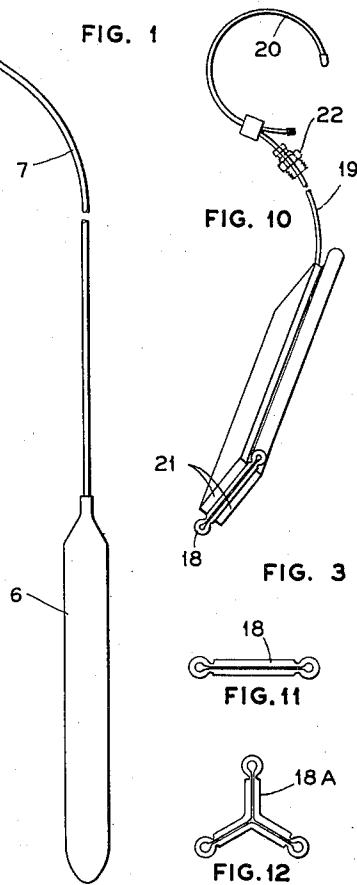
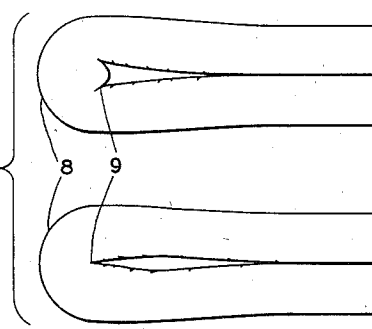


FIG. 10

FIG. 3

FIG. 11

FIG. 12

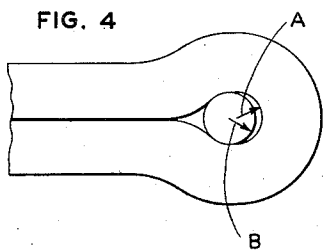
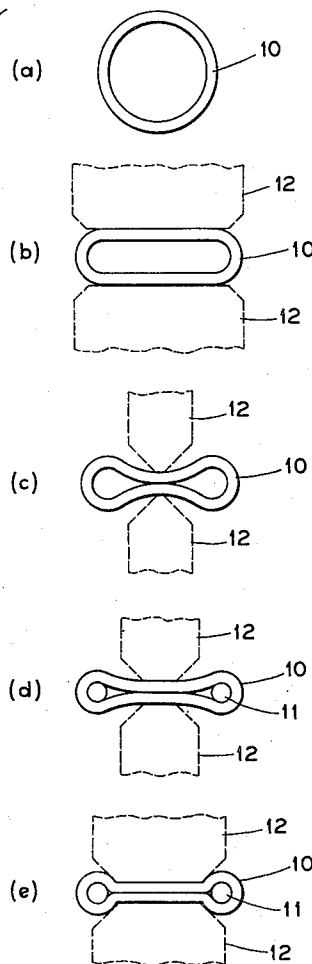


FIG. 4



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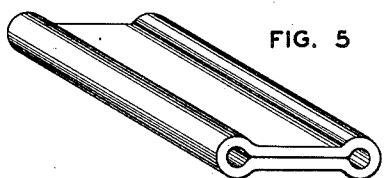


FIG. 5

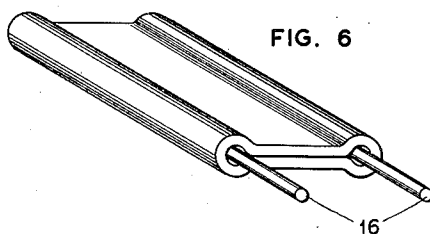


FIG. 6

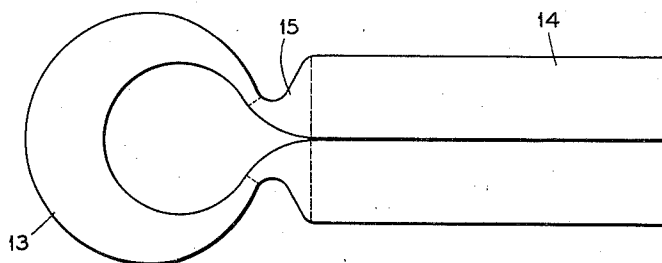


FIG. 7

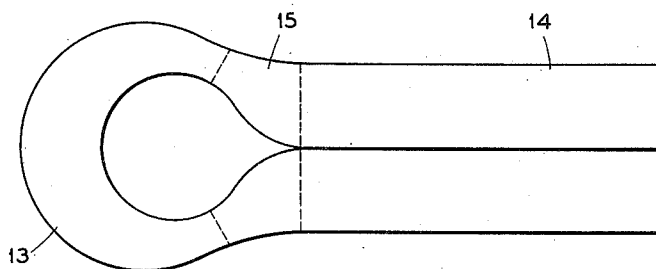


FIG. 8

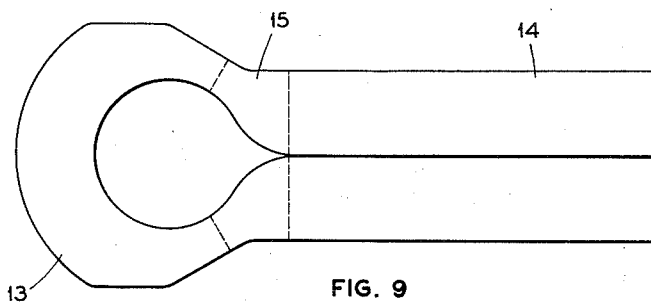


FIG. 9

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BOURDON SPRING AND LOAD ELEMENT

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Application July 16, 1947, Serial No. 761,284

4 Claims. (Cl. 73-418)

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This invention relates to responsive elements such as Bourdon springs and load elements.

This invention has for its purpose a novel construction of Bourdon springs and load elements which have greater reliability as well as longer life, and also has for its purpose a novel method of making them. The various features and advantages of the invention will appear from the detailed description and claims when taken with the drawings in which:

Fig. 1 is a perspective view of a conventional tube system including a Bourdon spring;

Fig. 2 shows half cross-sections through a conventional Bourdon spring illustrating the usual defects therein;

Fig. 3 illustrates steps in the method of making Bourdon springs in accordance with the present invention;

Fig. 4 shows a partial cross-section of a Bourdon spring;

Fig. 5 shows an uncoiled section of the Bourdon spring;

Fig. 6 is an uncoiled section of a Bourdon spring similar to that of Fig. 5 but with wires introduced therein to decrease the volume thereof;

Fig. 7 shows greatly enlarged one form of a theoretically ideal half-section of a Bourdon spring;

Figs. 8 and 9 show half sections of commercial embodiments of Bourdon springs following the teachings of the theoretical form of Bourdon spring shown in Fig. 7;

Fig. 10 illustrates the invention applied to a tube system provided with a load element used for measuring force or weight; and

Figs. 11 and 12 illustrate sections that might be used when the invention is applied to load elements used for measuring pressures.

A common use of a Bourdon spring 5 is in a fluid-filled tube system which comprises a bulb 6 communicating through a capillary tube 7 with one end of the Bourdon spring usually made of metal.

A liquid filled tube system is generally understood to mean a measuring tube system that is so filled with a liquid that no vapor space exists therein in its operating range. Such tube systems are used to indicate and record temperature, pressure, load, etc. For example, a temperature measuring system might consist of a bulb in which a temperature change causes a differential volume expansion of the bulb body and the liquid therein, which volume change is essentially all conducted through a connecting capillary to a Bourdon spring. This volume change causes the

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Bourdon spring to deflect, that is, to coil or uncoil thereby providing an indication of the temperature change. Ambient temperature changes of the Bourdon spring also causes differential volume expansion with consequent deflection. This deflection may be compensated for by a number of means including bimetallic strips so placed between the Bourdon spring take-off arm and the temperature scale, that ambient temperatures will not affect the indication. The use of compensators generally reduces the energy available for overcoming friction in the instrument movement and for operating control devices. To minimize this energy loss, Bourdon springs are commonly made of tubing flattened so that the inner walls thereof are very close together which makes their internal volume small and therefore, the needed compensation is small. The cross sections of the Bourdon springs used up to the present time for liquid filled systems have had small radii of curvature at their edges with consequent high stresses that frequently led to premature failures. Moreover, the process of forming, generally caused folds 9 (Fig. 2) to occur in the highly stressed region, which folds increased the stress and the tendency to fail.

I have found that the difficulties referred to above can be largely overcome by forming the tubing 10 (which eventually is made into a Bourdon spring) over wires 11 in such a way that one wire is at each inner edge of the tubing (Fig. 3). When properly formed, the section of the tubing has nearly the same radius A (Fig. 4) at the edges as the radius B of the wires used in forming it. One procedure for forming the section is to draw or roll the tubing 10 until it has a figure-eight-like section (Fig. 3c) with sufficient space remaining to insert the wires 11. Then the tubing is passed through sets of rolls with progressively wider faces that flatten the tubing between the wires and forces them to the edge. After forming, the wires may be withdrawn. The Bourdon springs so formed, as shown in Fig. 5, have relatively large radii at the edges and no folds produced by forming, both of which reduce the stress, without having excessively large volumes that need to be compensated.

In accordance with this invention wires 16 may be used in the Bourdon spring to further reduce the volume and the need for compensation, as shown in Fig. 6. These wires may be those used in forming the tubing. Preferably, they are wires of smaller diameter than those used to form the tubing. Moreover, the wires

may be made of material having a low coefficient of expansion such as Invar (36% nickel steel) which will further reduce the need for compensation of the Bourdon spring.

Also, in accordance with this invention additional gain in operation and in longer life of the Bourdon spring is made possible by the use of sections having non-uniform wall thickness as shown in the theoretically ideal section of Fig. 7. By reducing the overall thickness of the section, the flexural rigidity of the section can be reduced. Consequently, for a given available energy, pressure change, volume change, coil form, and length of tubing, reduction in the overall thickness of the section by locally reducing the thickness of the tubing, permits heavier tubing to be used which will increase the thickness of material at the edge, thereby reducing the stress there. Such sections are readily produced by passing the tubing containing wires, through rolls having the desired contour machined in their faces. By this process it is possible to form sections having uniform strength at the edge portion 13 (similar to a beam of uniform strength), while leaving the central portion 14 of the section with thick walls to produce a large available energy, the portions 13 and 14 being connected by a transition portion 15 located between the several pairs of dotted lines. A combination of a relatively large internal radius and section with uniform stress at the edge, together with uniformly thick walls in the central portion of the section, as shown in Fig. 7, appears to be the most desirable theoretical section.

In the modified forms of the invention illustrated in Figs. 8 and 9, there are disclosed sections of Bourdon springs adapted for quantity production.

In Fig. 10, the invention is illustrated as applied to a load element 18 used for measuring or controlling force, weight, or total load. The element comprises a straight tube which may have any of the cross sections referred to above. The passageways in the tube may be provided with filler wires or not as in the case of Bourdon springs described above. The element 18 is completely sealed except that its interior communicates with a capillary tube 19 which in turn communicates with a Bourdon spring 20 or the like. The element 18 as well as the capillary tube 19 and the Bourdon spring 20 are filled with a suitable filling medium. The load may be applied to the element through anvils such as 21.

The load element illustrated in Fig. 10 may also be used to measure or control pressure. When so used, the anvils 21 are not required. Often a pressure tight fitting such as a union connection 22 shown in dotted lines Fig. 10 would be auxiliary equipment when the element is used to measure or control pressure. When used to control pressure, the element may be coiled or straight as convenient and may have rosette sections with two, three or more lobes as shown at 18 in Fig. 11 and at 18a in Fig. 12.

The term Bourdon spring as herein used includes any tube which functions by a deflection thereof, in response to differential pressures. The Bourdon spring herein referred to may be wound in spiral, helical or other forms as disclosed in the British patent to Cowper #12,889 of 1849.

The term load element as used herein is a sensing element used to sense pressure, weight, or force or to sense changes therein.

The term responsive element is intended to be inclusive of Bourdon springs and load elements.

The term rosette refers to sections having bulbular lobes of which Fig. 3c is a particular example having two lobes.

What I claim is:

1. A hollow element which changes its volume in response to the resultant or difference between pressures applied to its inner and outer surfaces, the wall of said element being continuous and in cross section comprising opposed central portions having their inner surfaces close together, said wall also comprising marginal portions merging with said central portions through transition portions, each marginal portion at its thickest part being substantially as thick as a central portion and progressively decreasing in thickness to its regions of merger with said transition portions whereby each marginal portion is essentially a beam of uniform strength, each marginal portion also defining an internal passageway generally circular in cross section.

2. A hollow element which changes its volume in response to the resultant or difference between pressures applied to its inner and outer surfaces, the wall of said element being continuous and in cross section comprising opposed central portions having their inner surfaces close together, said wall also comprising marginal portions merging with said central portions through transition portions, each marginal portion at its thickest part being substantially as thick as a central portion and progressively decreasing in thickness to its regions of merger with said transition portions whereby each marginal portion is essentially a beam of uniform strength, each marginal portion also defining an internal passageway generally circular in cross section, and a wire contained in each passageway substantially filling the same.

3. A hollow element which changes its volume in response to the resultant or difference between pressures applied to its inner and outer surfaces, the wall of said element being continuous and in cross section comprising opposed central portions having their inner surfaces close together, said wall also comprising marginal portions merging with said central portions through transition portions, each marginal portion at its thickest part being substantially as thick as a central portion and progressively decreasing in thickness to its regions of merger with said transition portions whereby each marginal portion is essentially a beam of uniform strength, each marginal portion also defining an internal passageway generally circular in cross section, and a wire contained in each passageway, the diameter of said wire being slightly smaller than that of the largest wire that can be inserted therein.

4. A hollow element which changes its volume in response to the resultant or difference between pressures applied to its inner and outer surfaces, the wall of said element being continuous and in cross section comprising opposed central portions having their inner surfaces close together, said wall also comprising marginal portions merging with said central portions through transition portions, each marginal portion at its thickest part being substantially as thick as a central portion and progressively decreasing in thickness to its regions of merger with said transition portions whereby each marginal portion is essentially a beam of uniform strength, each marginal portion also defining an internal passageway generally circular in cross section, and a wire made of a material having a low coefficient

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of thermal expansion contained in each passageway, the diameter of said wire being slightly less than the diameter of said passageway.

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