Feb. 26, 1963 R. E. EMMONS 3,078,878

CAPILLARY ELEMENT

Filed May 25, 1959

FIG. 1

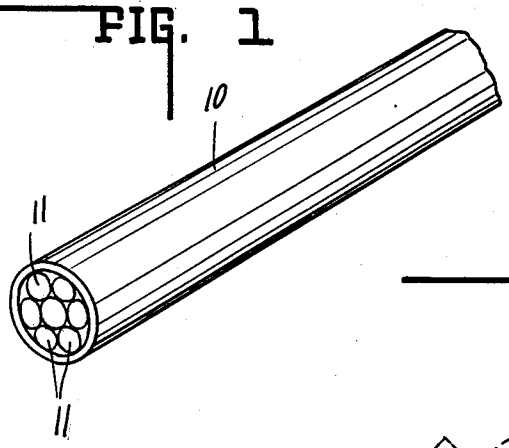


FIG. 2

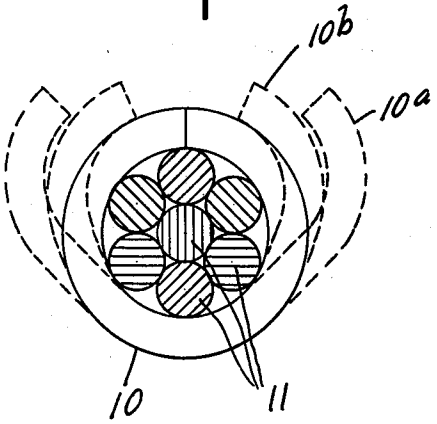


FIG. 3

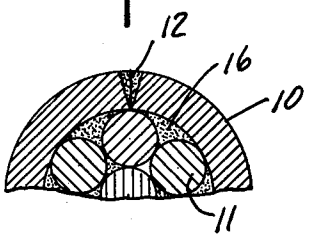
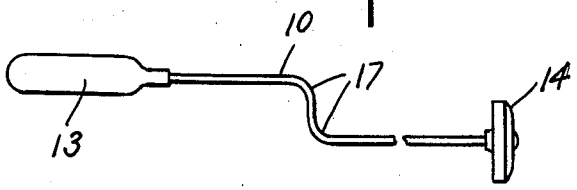


FIG. 4



INVENTOR.
ROBERT E. EMMONS.

BY
Lockwood, Woodard, Smith & Weikart.
ATTORNEYS.

United States Patent Office 3,078,878 Patented Feb. 26, 1963

3,078,878

CAPILLARY ELEMENT

Robert E. Emmons, Goshen, Ind., assignor to Penn Controls, Inc., a corporation of Indiana

Filed May 25, 1959, Ser. No. 815,660
1 Claim. (Cl. 138—46)

The present invention relates generally to capillary elements used as fluid transmission elements to solid fill power elements forming a component of automatic controls such as temperature responsive switches or the like. The invention relates particularly to capillary elements of the type referred to which are ambient temperature compensated.

It is conventional to operate automatic control devices by power elements or sealed diaphragms whose expansion in response to temperature change provides the required mechanical movement. The interior of the power element communicates with a bulb, exposed to the temperature which is to be controlled, by means of an elongated capillary tube. Conventionally, the bulb, capillary and power element are provided with a solid liquid charge. The charging liquid is chosen so as to have the required thermal coefficient of expansion so that expansion of the fluid in the bulb provides a hydraulically transferred impulse to the power element. Accurate temperature response in such an arrangement requires that local or generalized heating of the capillary itself have only a minimum effect on the total fluid expansion, that is, the response of the power element should, under optimum conditions, be a function of the change in temperature of the fluid in the bulb alone.

Persons Patent 2,363,140 discloses a capillary construction in which a grooved core extends within a fabricated tubular sheath, the sheath and core having differing thermal coefficients of expansion. The Persons capillary construction provides satisfactory results in the fluid fill systems for which it is designed, that is, in systems in which the charging fluid has characteristics such that only a very small portion of the cross-sectional area of the capillary assembly need accommodate the charging fluid. The present invention provides an improved compensated capillary construction which can accommodate fluids, such as mercury, requiring a much greater free cross-sectional area of the capillary.

It is, therefore, the primary object of the present invention to provide a capillary construction of the sheath and core type in which a relatively large portion of the total cross sectional area of the capillary is unobstructed, this being accomplished while retaining a multi-point mutual support between the sheath and the core.

It is a further object of the present invention to provide a capillary construction which is thermally compensated and suitable for liquid mercury fill.

It is a further object of the present invention to provide a capillary construction having internal support whereby the capillary may be subjected to relatively sharp, multiple bending without collapsing or deforming the capillary sheath cross-section.

It is a further object of the present invention to provide a capillary which can be economically fabricated by a continuous process.

It is a further object of the present invention to provide a capillary construction which can be readily calibrated after fabrication by a swaging operation.

The full nature of the invention will be understood from the accompanying drawings and the following description and claim:

FIG. 1 is a perspective view of a section of a capillary structure embodying the present invention.

FIG. 2 is an end view of the capillary structure illustrating the placement of the wire members and the formation of the sheath component.

FIG. 3 is a fragmentary sectional view showing the sealed juncture of the sheath margins.

FIG. 4 is a side view of a typical bulb and power element joined by the capillary structure of the present invention.

Proper use of certain conventional fluid fills requires the presence in the capillary structure of a relatively small fluid accommodating passage or groove, the cross sectional area of the passage being of the order of 6% of the total cross sectional area enclosed by the tube sheath. The use of mercury or similar fills, however, requires a much larger fluid accommodating passage, having a cross sectional area of the order of 25% of the total cross sectional area enclosed by the sheath. Providing this additional unobstructed cross sectional area by merely enlarging the core groove of conventional structures, such as that shown in the forementioned Persons patent, leaves a large portion of the sheath unsupported by the core and is otherwise unsatisfactory. The structure of the present invention provides the required unobstructed cross sectional area without weakening the capillary structure.

Referring to the drawings, the capillary structure includes a sheath **10**, circular in cross section, and enclosing a core structure formed of elongated rods or wires **11**. The wires are disposed in manually tangential relation with their axes parallel. The sheath **10** is formed from a sheet of material such as stainless steel, the cross sectional configuration of the sheath being provided by successive forming operations. The intermediate stages in the formation of the circularly cross-sectioned sheath are indicated in FIG. 2 by broken lines at **10***a* and **10***b*. When the formation of the sheath is complete, the wire members **11** are totally enclosed thereby, and the inner face of the sheath tangentially engages the outer ones of the wire members.

Referring particularly to FIG. 3, the abutting margins **12** of the sheath are fused or joined by any suitable means, such as welding. The welding operation may be performed by any one of several known methods including heli-arc welding, and, under some circumstances the interior of the sheath may require the presence of an inert gas backup during the welding operation.

The completely assembled capillary, which may be continuously formed by suitable forming and welding machinery, may then be cut to the required lengths and installed between the bulb **13** and the diaphragm-type power element **14** indicated diagrammatically in FIG. 4. The fluid system thereby provided may be conventionally charged with a thermally expansive liquid, such as mercury, the liquid completely filling the bulb, power element and the interior of the capillary structure, such mercury fill being indicated at **16** in FIG. 3.

It will be noted that the tangential engagement of each of the wire members **11** and the sheath **10** provides mutual support for the sheath and core structure so that in installing the capillary, relatively sharp deforming bends may be made in the capillary structure, as indicated at **17** in FIG. 4.

In automatic control assemblies, such as that illustrated in FIG. 4, it is desirable that the mechanical movement produced at the power element be a function of the change in temperature of the fluid in the bulb **13** only. It is, therefore, necessary to compensate the response of the system for any expansion of the fluid in the capillary structure itself due to localized or generalized heating of the capillary. In the structure of the present invention this is accomplished by forming the sheath **10** of a material, such as stainless steel having a large thermal coefficient of expansion as compared to that of the wire

elements. For the classes of fills herein referred to, forming the sheath of stainless steel and the wire members of invar provides the proper expansion coefficient ratio. Thus, for example, upon a localized increase in temperature at a portion of the capillary structure, the resulting expansion of the capillary structure components will enlarge the fluid accommodating volume of the capillary to substantially the same degree as the increase in volume of the fluid within the locally heated area. The net effect of this localized expansion of the fluid charge is thus cancelled from the response of the power element.

While the capillary structure has herein been disclosed as including seven wire members to provide a core structure suitable for a mercury fill, it will be understood that more or fewer wire members might be utilized to provide differing ratios of unobstructed cross sectional area to totally enclosed cross sectional area according to the requirements of the particular fill being used. Wire members having differing diameters might also be used without eliminating the feature of mutual, multiple support of the core structure and the sheath. It will be further understood that the multiple support feature might also be retained in a structure which is not temperature compensated, or in a structure which is reversely compensated, that is, a structure in which the sheath has a lower thermal coefficient of expansion from that of the wire members. While the fluid expansion system illustrated in FIG. 4 includes a diaphragm type power element, this element might be replaced by a Bourdon tube, a bellows type element or any further means for converting fluid pressure change to mechanical movement, as design conditions may require. In the description and claims the elongated cylindrical members or wires **11** are referred to as having their axes in parallel relation. It will be understood that this description of the wire axes relationship is intended to include the spirally axial relationship which would occur if the wires were twisted within the sheath. It will be further understood that certain features of the present invention, such as the multiple support feature might also be retained in a structure wherein the sheath takes the form of a seamless tube

which may be swaged into engagement with the wires forming the core structure.

While the invention has been disclosed and described in some detail in the drawings and foregoing description, they are to be considered as illustrative and not restrictive in character, as modifications may readily suggest themselves to persons skilled in this art and within the broad scope of the invention, reference being had to the appended claim.

The invention claimed is:

A fluid pressure transmission tube having a fluid volume adapted to be filled with a thermally responsive fluid having a thermal coefficient of expansion, comprising: a core structure including a multiplicity of cylindrical wires disposed in mutually tangential relationship with their axes substantially parallel and composed of a material having a first thermal coefficient of expansion, and a circular cross sectional sheath surrounding said core structure with its internal face tangential with the outermost ones of said wires and composed of a material having a second thermal coefficient of expansion greater than said first coefficient, said first material, said second material and said fluid coefficients of expansion having values which maintain the fluid volume of the tube substantially equal to the volume of the thermally responsive fluid contained therein as the temperature is varied.

References Cited in the file of this patent

UNITED STATES PATENTS

705,258	LePelletier	July 22, 1902
756,977	Nagel	Apr. 12, 1904
1,215,229	Willson	Feb. 6, 1917
2,152,934	Trent	Apr. 4, 1939
2,328,302	Simison	Aug. 31, 1943
2,363,140	Persons	Nov. 21, 1944
2,398,262	Swart	Apr. 9, 1946
2,722,451	Wilson	Nov. 1, 1955

FOREIGN PATENTS

706,197	Great Britain	Mar. 24, 1954