Nov. 21, 1944. L. M. PERSONS 2,363,140

FABRICATED COMPENSATED CAPILLARY ELEMENT

Filed May 26, 1941

Fig. 1.

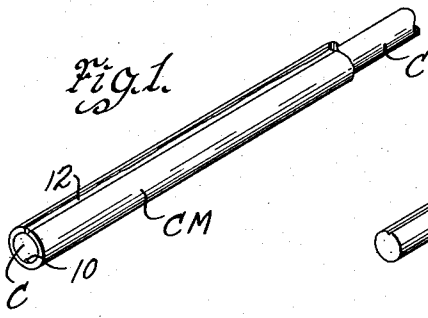



Fig. 2.

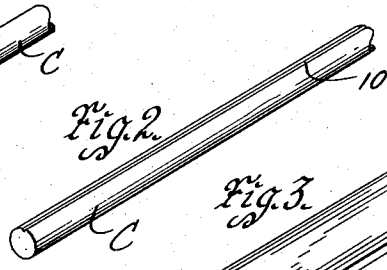



Fig. 3.

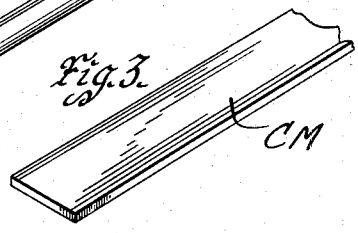



Fig. 4.

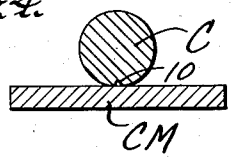



Fig. 5.

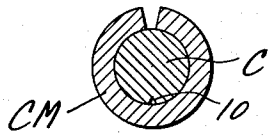



Fig. 6.

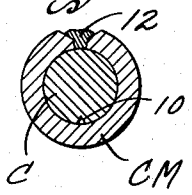



Fig. 7.

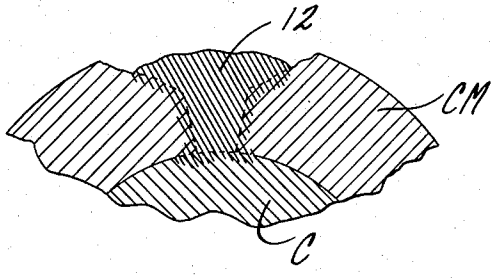



Fig. 8.

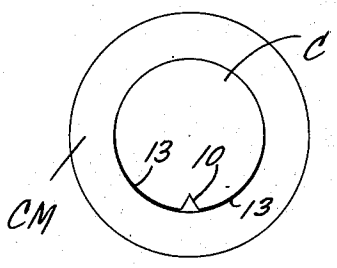
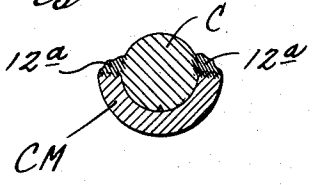



Fig. 9.




Inventor
Lawrence M. Persons
by Baird & Freeman
Attorneys

Patented Nov. 21, 1944

2,363,140

# UNITED STATES PATENT OFFICE

2,363,140

## FABRICATED COMPENSATED CAPILLARY ELEMENT

Lawrence M. Persons, St. Louis, Mo.

Application May 26, 1941, Serial No. 395,319

6 Claims. (Cl. 138—40)

My present invention relates to a capillary element, particularly for use as a fluid transmission conduit between "solid fill" diaphragms or bellows used in automatic controls, such as temperature operated switches and the like.

One object of my invention is to provide a capillary element which may be inexpensively manufactured yet has the desirable characteristic of a uniform capillary passageway, the capillary element being also capable of production in continuous lengths.

Another object is to provide a capillary element which is fabricated from a wire or other core member having a surface groove, the cross sectional area of which is the desired or predetermined cross sectional area of the capillary passageway, the groove being closed by a sheet of metal or the like preferably in tight contact with the surface of the core and sealed relative to the core as by welding the side edges of the sheet to the core.

Still another object is to provide a two piece capillary element which may be fabricated in such manner that it is self compensating and may therefore be used as a fluid transmitting capillary element in any ambient temperature without the operation of the diaphragms or other devices connected with the capillary element being modified by changes in the ambient temperature either as a general change throughout the length of the capillary element or as a local change in temperature at one or more points along the length of the capillary element.

Other objects, purposes and characteristic features of the present invention will be in part obvious from the accompanying drawing and in part pointed out as the description of the invention progresses. In describing the invention in detail, reference will be made to the accompanying drawing in which like reference characters designate corresponding parts throughout the several views, and in which:

Figure 1 is a perspective view of a length of capillary element embodying my invention.

Figure 2 is a perspective view of a length of the core of the element.

Figure 3 is a perspective view of a length of sheet metal used as a closure for a groove in the core.

Figure 4 is an enlarged sectional view of the first step in fabricating my compensated capillary element.

Figure 5 is a similar sectional view showing the second step.

Figure 6 is a similar sectional view showing the third and final step.

Figure 7 is a greatly enlarged sectional view of a welded joint of Figure 6.

Figure 8 is a diagrammatic cross sectional view showing the action of the parts when compensating for a rise of temperature above the temperature at which the capillary element was fabricated; and

Figure 9 is a sectional view of one modification of the invention.

Heretofore attempts have been made to form copper tubes or the like into capillary tubes for the purpose of providing a hydraulic connection as between a control diaphragm and a controlled diaphragm with a "liquid fill" in the diaphragms and the capillary tube. To minimize undesirable response of all or part of the capillary tube to ambient temperature which causes the liquid fill to expand or contract depending on whether the temperature rises or lowers, the capillary tubes have been made with very small bores. It is impossible, however, to secure a smooth small bore as about the only way to provide a small bore at all is to first form a tube with as small a bore as possible with the forming mechanism, and then roll the tube to decrease its diameter and therefore the diameter of its bore. This results in considerable roughness in the bore and furthermore, capillary tubes formed in this manner can be made in short lengths only. Variation in the size of the bore causes considerable variation in the action of heat at various points on the liquid fill in the bore due to irregularities in the diameter of the bore.

Attempts have been made to reduce the diameter of the bore by other methods. One such method consists of drawing a wire through the bore of a capillary tube with the diameter of the wire slightly less than the diameter of the bore. This reduces the cross sectional area of the bore considerably, but it still varies at different points along the capillary tube. Also such a method shortens the possible length in which the capillary tube may be formed and adds greatly to the expense of manufacturing.

One of the main purposes of my invention is to provide a capillary element which is fabricated in such manner that both the desirable results of a uniform but small cross sectional bore is secured, and at the same time by the proper selection of materials of which the two parts of the capillary element are fabricated, compensation for temperature changes anywhere along the length of the capillary element is secured, with

the further desirable result of the possibility of manufacturing the capillary element in continuous lengths at greatly reduced costs.

My fabricated compensated capillary element includes two elements, a core C and a cover member CM. The core C may be formed of any suitable material, such as metallic wire and is provided with a longitudinally extending surface irregularity such as a groove 10 of the desired predetermined cross sectional area corresponding to the area desired for the capillary passageway. The cover member CM consists of a strip of sheet metal or the like constituting a cover for the groove 10.

Referring to Figure 4, during the fabrication of my capillary element, the wire or core C is positioned with relation to the cover member CM as shown in Figure 4. The core and cover member may be unwound from reels and fed into a machine provided with suitable rollers for guiding the core and cover member. The rollers then bend the cover member to the position shown in Figure 5 and exert sufficient pressure on the cover member to cause it to tightly engage the surface of the core.

While the cover member CM is thus tightly engaged with the surface of the core C, its side edges are welded together and/or to the core C as shown at 12 in Figure 6. In place of the weld 12 any suitable means for sealing the side edges of the cover member relative to the core may be used. For instance, brazing might be found suitable and the weld or brazing material at 12 may be either melted from the adjacent side edges of the cover member or may be in the form of a deposit of welding or brazing metal.

I have found the process of atomic welding, which combines electric and oxygen welding, quite satisfactory and adaptable for performing an automatic weld in the machine following the rollers which retain the cover member in tight engagement with the surface of the core. In Figure 7, for instance, the welding is shown as of the atomic type with the metal 12 melted from the side edges of the cover member and fusing with them and with a part of the surface of the core. It is immaterial whether the side edges of the cover member are separately welded to the core or whether they are merely welded together. In either event the desired seal of the groove 10 of the core C within the cover member is secured.

Furthermore, the side edges of the cover member may terminate a considerable distance from each other as shown in Figure 9 with separate welds at 12a and the same result of a seal effected between the groove of the core and the cover member for the groove secured.

The groove 10 may be accurately formed with a uniform cross sectional area throughout its length. The surface of the core C may be relatively smooth and likewise the surface of the cover member CM may be relatively smooth. When the parts are fabricated to the position shown in Figure 6, I am practically assured that the capillary bore is of the same cross sectional area throughout its length, a result impossible to obtain with prior methods above discussed. If the cover CM is not absolutely tight around the core, the sealed capillary element may be passed through an additional pair of rolls to positively form the cover so that contact is tight on the core and the area of the groove 10 thereby constant the entire length of the capillary element.

To secure compensation for ambient temperature, it is merely necessary to have the cover member CM of higher coefficient of expansion than the core C. Accordingly, either a local or general rise in temperature above that at which the capillary element was fabricated, will result in greater expansion of the cover member than of the core as shown diagrammatically and exaggerated in Figure 8. This in effect enlarges the cross sectional area of the capillary bore because of the opened spaces 13 communicating with it. The liquid fill in the capillary element, such as mercury or the like, will likewise be expanded by the ambient temperature and the spaces at 13 will receive part of the liquid.

The desirable relationship of expansion between core, cover member and liquid fill is so selected, of course, that a predetermined rise in temperature expanding the liquid fill to a certain degree will likewise expand the cover member to a greater degree than the core and the spaces 13 will be enlarged to the proper size to receive the exact proportion of the liquid caused by expansion thereof due to ambient temperature rising. For instance, the core C may be made of stainless steel of invar type, while the cover member CM may be formed of stainless steel of such composition that it has about the same coefficient of expansion as copper. If desired, negative or inverse compensation can be secured by selecting a cover member of greater proportional expansion than the liquid fill. Also the sizes of the spaces at 13 may be controlled by the expanse of the cover member, such as reducing its width as shown in Figure 9.

Having described certain specific embodiments of my invention together with the operation thereof, I desire it to be understood that these forms are selected merely for the purpose of facilitating disclosure of the invention rather than for the purpose of limiting the number of forms which it may assume. It is to be further understood that various modifications, adaptations and alterations may be applied to the specific forms disclosed to meet the requirements of practice without in any manner departing from the spirit and scope of the present invention except as set forth in the claims appended hereto.

I claim as my invention and desire to secure by Letters Patent of the United States:

1. In a fabricated compensated capillary element, a cylindrical wire core having a groove longitudinally therein of predetermined cross sectional area, said groove being uniform throughout its length, and an enclosure for said wire, said enclosure comprising a sheet of material having a higher coefficient of expansion than said wire core and extending around said wire core, the side edges of said sheet of material being welded together with the sheet in tight engagement with the surface of said wire core, the coefficient of expansion of the sheet being so related to the coefficient of expansion of the core that the growth of the volume of the space therebetween per degree of increase in temperature is substantially the same as the growth of the same shaped volume of the fluid for which the capillary element is intended.

2. In a fabricated compensated capillary element, a core having a groove longitudinally therein, and a sheet of material having a higher coefficient of expansion than said core extending at least partially around the core and constituting a closure for said groove, the side edges

of said sheet of material being sealed relative to said core on opposite sides of said groove, the coefficient of expansion of the sheet being so related to the coefficient of expansion of the core that the growth of the volume of the space therebetween per degree of increase in temperature is substantially the same as the growth of the same shaped volume of the fluid for which the capillary element is intended.

3. In a fabricated capillary element, an elongated core having a surface irregularity extending from end to end thereof, said irregularity being uniform in cross section throughout its length, an enclosure for said irregularity comprising a sheet of material wrapped at least partially around said core, and means for sealing the side edges of said sheet to said core on opposite sides of said irregularity so as to leave a longitudinally extending space of substantially capillary size between the core and the enclosure.

4. A fabricated capillary element comprising a core having a groove longitudinally therein of predetermined cross sectional area and a cover for said groove comprising a sheet of material, said sheet being wrapped about and tightly contacting the surface of said core adjacent the sides of and spanning said groove with the side edges of the sheet located at spaced points on opposite sides thereof, and means for sealing the side edges of said sheet relative to said core.

5. A fabricated compensated capillary element comprising a core having a surface irregularity extending uniformly from end to end thereof, a sheet of material spanning the surface irregularity of the core and sealed to the core on opposite sides of the surface irregularity so as to leave a longitudinally extending space of substantially capillary size therebetween adjacent the surface irregularity, the coefficient of expansion of the sheet being so related to the coefficient of expansion of the core that the growth of the volume in the space therebetween per degree of increase in temperature is substantially the same as the growth of the same shaped volume of the fluid for which the capillary element is intended.

6. A fabricated compensated capillary element comprising a core, a sheet of material wrapped at least partially about the core and having its side edges sealed to the core, the walls of said core and said sheet being of different configuration so as to leave a space therebetween, the coefficient of expansion of the sheet being so related to the coefficient of expansion of the core that the growth of the volume of the space therebetween per degree of increase in temperature is substantially the same as the growth of the same shaped volume of the fluid for which the capillary element is intended.

LAWRENCE M. PERSONS.