Nov. 8, 1966 W. J. DAVIS 3,283,787

FLUID TRANSMISSION

Filed Aug. 24, 1964 2 Sheets-Sheet 1

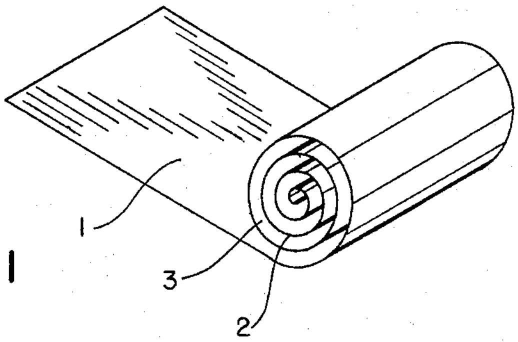


FIG. 1

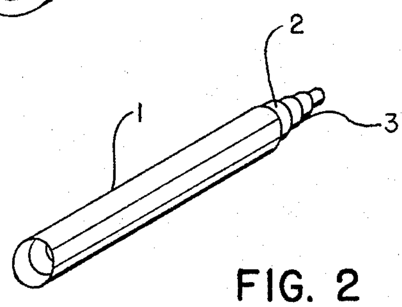


FIG. 2

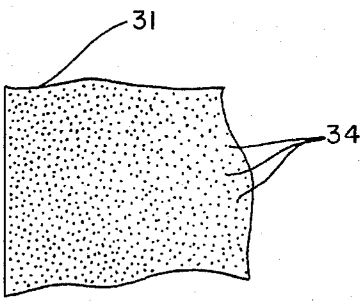
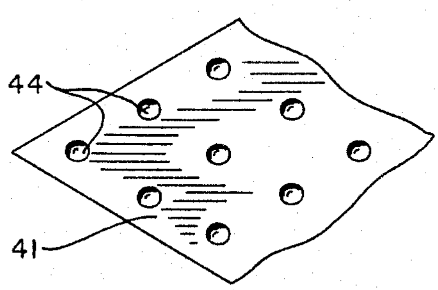


FIG. 3

FIG. 4



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FLUID TRANSMISSION

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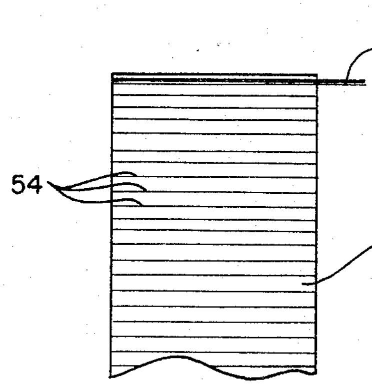

FIG. 5

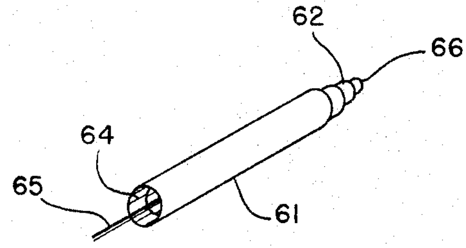

FIG. 6

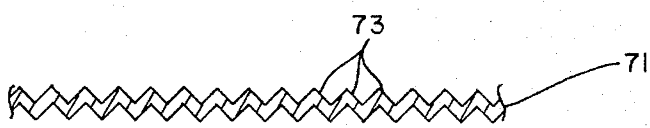

FIG. 7

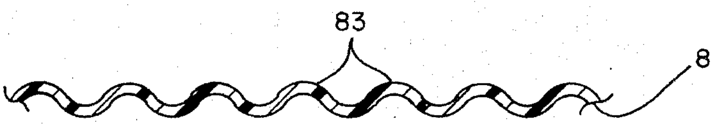

FIG. 8

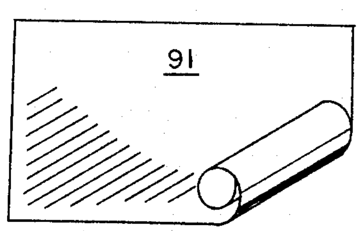

FIG. 9

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FLUID TRANSMISSION

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10 Claims. (Cl. 138—148)

This invention relates to methods and means for the transmission of fluids, and, more particularly, relates to capillary devices.

Man-made capillary devices for the transmission of liquids, such as fuels, lubricants, and writing fluids, are of ancient origin, and conventionally utilize wicks that are comprised either of woven or non-woven bundles of fibers.

Although these capillary devices have been known and used for centuries, many inherent deficiencies that limit their utility have never been overcome. For example, fiber wicks generally have poor, if any, structural strength; they do not wear well; they are limp and without stiffness or rigidity; and no convenient means is available to control and alter the flow of fluids through them.

Accordingly, it is an object of this invention to provide improved capillary devices.

A further object of this invention is to provide capillary devices having a simplified construction.

Another object of this invention is to provide capillary means for the transmission of fluids that are comparatively stiff, strong, and resistant to wear.

A still further object of this invention is to provide capillary devices in which the flow of fluids therethrough can controllably be altered.

Briefly, the objects of this invention are achieved by convolving a thin sheet of material about itself while maintaining capillary spaces between adjacent convolutions, thereby providing suitable capillaries for the transmission of fluids. Depending upon the means selected, the spacing between adjacent convolutions may be fixed or movable. Also, the sheet may be axially displaced as it is being convolved to provide a compound spiral in which a helix is developed in both radial and axial directions.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic and perspective view of a capillary device being formed in accordance with this invention.

FIG. 2 is a perspective view of the fully formed capillary device of FIG. 1.

FIG. 3 illustrates a portion of a sheet of material adapted to form a capillary device.

FIG. 4 shows a portion of a sheet of material adapted to form a capillary device.

FIG. 5 shows a portion of a sheet of material adapted to form a capillary device.

FIG. 6 shows a capillary device constructed in accordance with this invention having flow adjusting means associated therewith.

FIG. 7 shows a sheet in section adapted to form a capillary device.

FIG. 8 shows a sheet in section adapted to form a capillary device.

FIG. 9 schematically illustrates another method for the formation of a capillary device.

In FIG. 1 there is generally illustrated in schematic form a method of forming capillary devices for the transmission of fluids in accordance with this invention. A sheet of material **1** is shown partially rolled with convolutions shown as at **2** and capillary spaces between the convolutions as at **3**.

FIG. 2 shows the same capillary device, except in this instance the sheet **1** has been completely spiraled about

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itself. Note that the spiral of FIG. 2 is compound in that it is developed in both radial and axial directions.

In FIG. 3 a sheet **31** of material suitable for forming a spiraled capillary device is shown in which small, substantially spherical, particles, **34** are adhered to the surface of the sheet by any convenient means such as with glue or solvents. These particles act as standoffs or spacers between the various convolutions **2**. By selecting an appropriate diameter of the particles **34**, the desired size of the open capillary spaces **3** may be obtained with facility.

In FIG. 4 another means for achieving a uniform spacing between the various convolutions is shown. Here, instead of adhering granules to the sheet **41**, indentations or dimples **44** are calendered onto the sheet. As these indentations raise corresponding high spots on the opposite side of the sheet, standoffs are provided to maintain the desired capillary spacing between adjacent convolutions. It may be desirable in this construction to provide for a somewhat random distribution of the various indentations to reduce the possibility of the alignment of indentations and high spots of adjacent convolutions.

In FIG. 5 yet another means for achieving spacing between the convolutions is shown. Here the sheet of material **51** is covered with a series of fibers **54** that have a diameter equal to the desired spacing between the convolutions. Note that the fibers are positioned generally parallel to each other and are oriented with respect to the sheet **51** so that axial passages for the transmission of fluids will result when the sheet **51** is convolved.

As shown in the figure, a slightly longer group of fibers **55** is positioned at one end of the sheet **51**. As is best illustrated in FIG. 6, the sheet **61** is wound so that the fiber bundle **65** (corresponding to fibers **55** in FIG. 5) will be attached to the centermost convolutions of the spiral. This provides a convenient element that enables both radial and axial adjustment of the spiral in order that the tip **66** and the flow of fluids therethrough may be controlled. This adjustment is achieved either by rotating the bundle **65** about its elongated axis and/or by movement of the bundle **65** along the axis of the capillary device. For example, if the bundle **65** is rotated to twist the spiral tighter while it is simultaneously advanced toward the tip **66**, the diameter of the tip will be reduced and the point will become sharper. The converse also applies when the bundle **65** is rotated to relax the spiral while it is simultaneously moved away from the tip **66**.

While only one means for adjusting the spiral in axial and radial directions is illustrated, it can be appreciated that any suitable gripping element, such as a rod, strip, or tube, can be substituted for the bundle **55** of FIG. 5. Also, if desired, the gripping element may be an extension of the sheet of material itself, in which case the sheet would be fashioned with a contiguous extension roughly equivalent to the bundle of fibers **55** shown in FIG. 5. One particular advantage of this type of construction lies in the fact that the gripping element will not occupy space within the capillary device that would otherwise be available for the transmission of fluids.

While the means for controlling these capillary devices has been discussed in respect to the modification shown in FIG. 5, it is to be understood that these means are equally applicable with respect to other modifications such as described, for example, in relationship to FIGS. 3 and 4. In any case, it must be understood that if the sheets of FIGS. 3, 4 and 5 are tightly wound against the spacing elements **34, 44** and **54** respectively, the gripping element may be axially moved, but it will not be possible to tighten the spiral. For this reason, in the constriction of a capillary device of this sort, it may be desirable to relax or unwind the spiral away from the standoff members before the capillary device is placed in service in order to allow clearance for adjusting the spiral by tightening it.

In FIG. 7 a metal sheet **71** suitable for rolling a capillary tube in accordance with this invention is shown in section. The sheet **71** has been calendered to impart a saw toothed pattern **73** onto its surface. Similarly, in FIG. 8 a sheet of plastic has been calendered to impart sine waves **81** onto its surface. The object of providing sheets with these configurations is two-fold. First, it provides for capillary spaces between adjacent convolutions when the sheet is convolved, and second, by twisting the spiral to tighten or loosen it, the peaks and valleys of adjacent convolutions can be brought into and out of phase with each other and the open areas of the capillaries so controlled. When the peaks and valleys are completely out of phase the open area will be at a maximum, and when they are in phase or registry the open area of the capillaries will be at a minimum.

FIG. 9 illustrates another method for convolving a capillary device in accordance with this invention. As here illustrated, the sheet is rolled diagonally from one corner to the other. By this means, the length of the spiral edges of the device are increased since all four edges of the sheet become part of the spiral rather than only two edges when the sheet is convolved as in FIG. 1. It may be important to maximize this length of spiral edge per given sheet in some applications, such as, for example, in the aspiration or volatilization of a liquid into a moving gas stream.

The sheet from which the capillaries of this invention are formed may be comprised of many suitable materials, both metallic and non-metallic. They should be selected with regard to the intended condition of use so that they will be available in a suitable thickness, be chemically resistant to the fluids being transmitted, have proper mechanical properties to provide structural strength and flexibility, and be resistant to wear.

As an example of suitable materials that may be used as sheet material may be mentioned synthetic resinous materials which are readily available in the form of thin films. Nylon, for example, is particularly useful due to its mechanical strengths, wearability, resistance to most chemicals, and its low coefficient of friction. Its resistance to wear and abrasion make it particularly useful when the discharge tip of the capillary device is brought into considerable sliding contact with a surface. Also, polyethylene and polytetrafluoroethylene should be mentioned as particularly suitable where low coefficients of friction are required. If high temperatures or severe corrosive problems are encountered, polytetrafluoroethylene and polysiloxanes may prove useful.

In addition to synthetic resinous materials, metal foils are also particularly useful. These have the advantage of providing higher strengths and stiffness. It may also be useful to combine the advantages of metals and plastics by coating a thin layer of plastic over the metal foil.

The granules used to control the size of the capillary spaces as shown in FIG. 3 and the fibers of FIG. 5 may be of any material that conveniently may be bonded or otherwise attached to the film. Also, these fibers or granules should be inert to the fluid passing through the capillary and, particularly, not be soluble therein. As an example of a suitable composite construction, there may be mentioned, for example, a nylon film upon which small nylon granules are adhered by use of a solvent, such as resorcinol. Similarly, nylon fibers may be attached to a nylon film.

What is claimed is:

1. A capillary device for the transmission of liquids comprised of a sheet of material convolved about itself with capillary spaces provided between adjacent convolutions.

2. A capillary device in accordance with claim **1** in which standoff means are provided to obtain the capillary spaces between adjacent convolutions.

3. A capillary device in accordance with claim **2** in which said standoff means are granules attached to one surface of said sheet.

4. A capillary device in accordance with claim **2** in which said standoff means are fibers attached to one surface of said sheet.

5. A capillary device in accordance with claim **2** in which said standoff means are calendered onto said sheet.

6. A capillary device in accordance with claim **5** in which standoff means are calendered in the form of continuous curves.

7. A capillary device in accordance with claim **6** in which said continuous curves are calendered on both surfaces of said sheet.

8. A capillary device in accordance with claim **7** in which said continuous curves on adjacent convolutions may be brought into or out of contact with each other.

9. A capillary device in accordance with claim **1** in which means are provided to adjust the convolutions in an axial direction with respect to the convolved sheet.

10. A capillary device in accordance with claim **1** in which means are provided to radially displace the convolutions.

No references cited.

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E. S. BECK, *Examiner.*