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Yamanouchi et al.

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[54] **LIQUID TRANSFUSION PIPE FOR A VERY SMALL QUANTITY**

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[52] **U.S. Cl.** **138/40;** 138/111

[51] **Int. Cl.** **F15d 1/02**

[58] **Field of Search** ..... 138/40, 41, 42, 46, 111, 138/115, 116; 73/205 L, 211, 392; 62/511, 527, 528; 128/214 R, 214 C, 348

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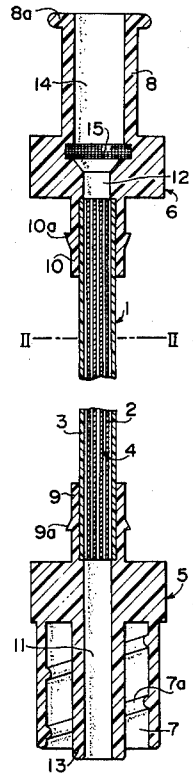
Primary Examiner—Charles A. Ruehl

[57] **ABSTRACT**

The invention relates to a liquid transfusion pipe which comprises an elongate tubular member having an axially extending capillary passage and terminating in connectors one of which is a socket and the other a plug adapted for mating engagement with a plug and socket respectively of connecting lines.

8 Claims, 5 Drawing Figures



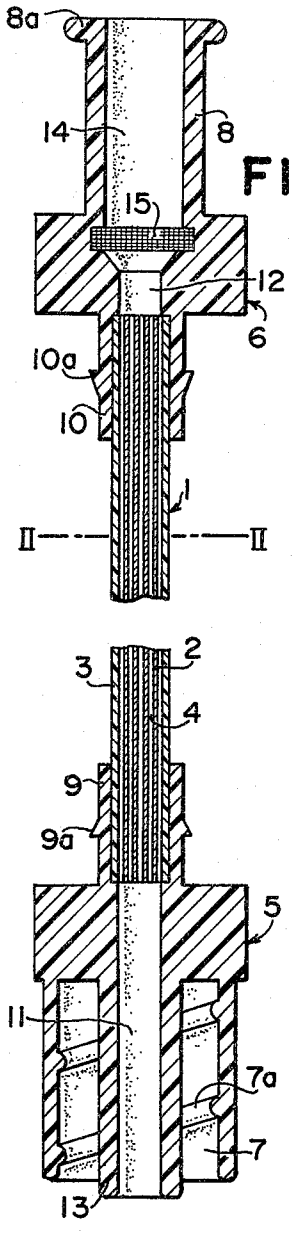


FIG. 1

FIG. 2

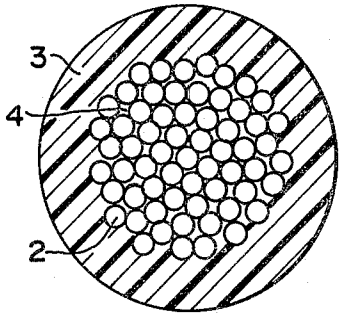
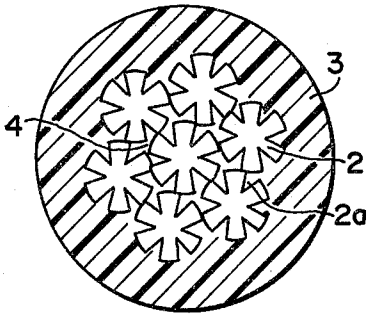


FIG. 3



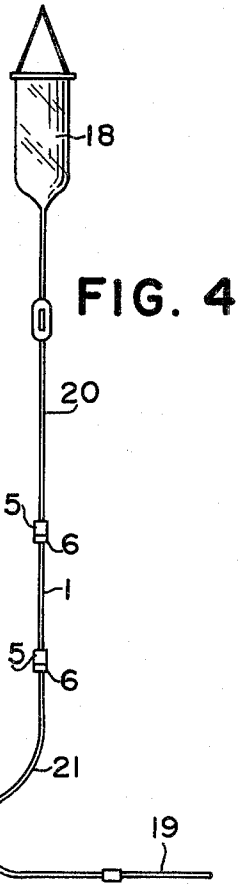


FIG. 4

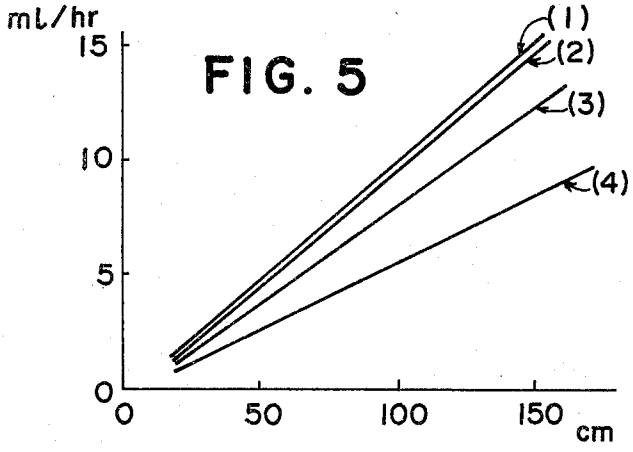


FIG. 5

LIQUID TRANSFUSION PIPE FOR A VERY SMALL QUANTITY

The invention relates to a liquid transfusion pipe for transfusing a small quantity of liquid, and more particularly to a pipe of the kind terminating in connectors and having a capillary passage for controlling the flow rate through a liquid transfusion system adapted to inject Ringer's solution or other liquids into the human body.

For transfusing very small quantities of liquid, it is known to adjustably squeese a rubber tube with a pinch cock for obtaining flow rate, down to 120 ml per day or 5 ml per hour. It is, however, difficult with this procedure to control the flow rate when below 5 ml per hour. This is true because at flow rates of less than 5 ml per hour, precision adjustment of the pinch cock is extremely difficult, and moreover the flow loses its steady state nature. There is frequent need for transfusion at a rate less than 5 ml per hour particularly when treating a newly born baby.

Therefore, it is an object of the invention to provide a liquid transfusion pipe for transfusing a very small quantity of liquid, which pipe includes a capillary passage for maintaining a steady state flow.

It is another object of the invention to provide a liquid transfusion pipe having connectors which permit ready connection with and removal from a liquid transfusion system.

In accordance with the invention, there is provided a liquid transfusion pipe for a very small quantity having a capillary passage the cross-sectional area and the length of which can be varied. Thus, when the liquid transfusion pipe according to the invention is connected in a liquid transfusion system, the flow rate of the liquid to be transfused can be controlled to a desired value so that only an extremely small quantity is injected.

The above and other objects and features of the invention will become apparent from the following detailed description of the embodiments thereof illustrated in the drawings, in which:

FIG. 1 is a longitudinal section of the liquid transfusion pipe according to the invention,

FIG. 2 is a cross section, to an enlarged scale, taken along the line II—II shown in FIG. 1,

FIG. 3 is a similar cross section of another embodiment,

FIG. 4 is an elevational view of a liquid transfusion system incorporating the pipe according to the invention, and

FIG. 5 is a graph illustrating several examples of the relationship between the available head of the liquid transfusion system of FIG. 4 and the liquid transfusion rate.

Referring to the drawings the liquid transfusion pipe according to the invention is shown as comprising a tubular member generally denoted by **1**, which includes a number of axially assembled filaments **2** surrounded by a sleeve **3**. The tubular member **1** includes a number of capillary passages **4** defined between adjacent filaments **2**. As will clearly be noted from FIG. **2** which shows one example of the tubular member **1**, the sleeve **3** is moulded from resin so as to firmly encase a number of filaments **2** surrounded thereby. The filaments **2**, which when assembled form capillary passages **4** as mentioned previously, may be formed of synthetic resin such as nylon or polypropylene or of fibre glass. FIG. **3** shows another embodiment of the tubular member having filaments of a shape different from that of the filaments shown in FIG. **2**. Each filament of FIG. **3** has axially extending grooves **2***a* formed therein, which serve as the capillary passages **4**. When the filaments are formed of synthetic resin, it is known that any desired cross-sectional shape may be achieved for the filaments in their spinning process, and therefore it should be understood that the profile of the filaments is not limited to those illustrated in FIGS. **2** and **3**. Where grooved filaments are used, their apparent diameter is generally greater than the diameter of other shapped filaments. However, it is the total cross-sectional area of capillary passages **4** which is controlling. The cross-sectional area depends on the thickness of the filaments, the size of any groove formed therein, the number as well disposition of the filaments, and the degree to which the filaments are compressed when they are encased in the sleeve **3**.

The procedure for moulding resin around a bundle of filaments **2** to form the sleeve **3** is not part of the invention. A bundle of filaments **2** may, for example, be coated with moulded resin as they are drawn out of thin nozzles.

The tubular member **1** may have a length of 10 cm. and is provided with a pair of connectors **5** and **6** on its opposite ends to permit connection of the tubular member **1** in a liquid transfusion system. One of the connectors comprises a socket **7** while the other connector comprises a plug **8** which is adapted to be inserted into a socket similar to socket **7** of another tubular member permitting thereby connection of a series of tubular members in tandem. The socket **7** is formed with a helical ridge **7***a* on its inner wall, and the plug **8** is formed on its outer end with a flange **8***a* which is adapted to engage threadably with the helical ridge **7***a* of another tubular member. The tubular member **1** and each of the connectors **5** and **6** are assembled by fitting the opposite ends of the tubular member **1** into hollow cylindrical portions **9** and **10** respectively part of connectors **5** and **6**, respectively. Each of the connectors **5** and **6** has a path **11** or **12** which communicates with the capillary passages formed in the tubular member **1**. One of the paths, **11**, is formed in and extends through an axially extending guide member **13** which is integrally formed with the socket **5** and centrally located therein. The other path **12** communicates with an axially extending guide bore **14** centrally formed within the plug **8**. The guide member **13** and the guide bore **14** are dimensioned to permit interfitting therebetween. In the FIG. **1** embodiment, a filter **15** is positioned in the connector **6** between path **12** and guide bore **14**, and advantageously prevents clogging of capillary passages **4**.

FIG. **4** is a diagrammatic illustration of a liquid transfusion system. As will be noted, the liquid transfusion pipe or the tubular pipe **1** constructed in accordance with the invention is connected between an irrigator **18** and a cannula **19** by way of a pair of rubber tubes **20** and **21**. The interconnection takes place by separately preparing connectors similar to those shown at **5** and **6** and inserting their hollow cylindrical portions similar to those shown at **9** and **10** into the respective tubes **20** and **21**. To ensure against inadvertent separation of these cylindrical portions **9** and **10** from tubes **20**, **21**, the cylindrical portions are formed with wedge-shaped tabs **9***a* and **10***a* thereabout.

With the liquid transfusion pipe of the invention, the flow rate therethrough is determined principally by the length of the tubular member **1**, the cross-sectional area of its capillary passages, the pressure of the irrigator **18**, or the distance between the irrigator and the cannula **19**, and the viscosity of the liquid to be transfused.

FIG. **5** graphically shows the experimental results in terms of the relationship between the flow rate and the distance between the irrigator and cannula. For rectilinear curves **1** to **3**, the tubular members **1** had a length of **10** cm and substantially similar cross-sectional area of the capillary passages **4**. The curve **4** represents the result obtained with a pair of the transfusion pipes used in plotting the curves **1** to **3**, the pair of pipes being connected in parallel. In plotting curves **1** and **4** distilled water was used, for curve **2** ringer lactate and for curve **3** 10 percent glucose. As far as the data shown in FIG. **5** are concerned, it is considered that the flow rate through the liquid transfusion pipe of the invention obeys the Poiseuille-Hagen's formula:

$$V = \frac{P\pi R^4}{8 L \eta}$$

As will be readily understood from the foregoing description, a varying flow rate can be obtained using a liquid transfusion pipe having a fixed cross-sectional area for the capillary passages **4**, by varying the length of the tube **1** or by varying the height of the irrigator **18**. The use of a liquid transfusion pipe having different cross-sectional areas for the capillary passages **4** permits even greater control of the flow rate. It will be apparent from the foregoing that the use of a liquid transfusion pipe according to the invention assures a steady state flow rate and maintains liquid pressure transfused in the cannula **19** constant, thereby avoiding possibility of coagulation which may occur due to reverse flow through the cannula.

What is claimed is:

1. A liquid transfusion pipe for transfusing a small quantity of liquid and comprising an elongate tubular member having an axially extending capillary passage therein, and a pair of connectors, one at one end of the tubular member and the other at the opposite end of the tubular member, said one of said pair of connectors comprising a socket having a helical ridge on its inner wall and said other of said pair of connectors comprising a plug having a flange, said helical ridge and said flange being adapted for respective engagement with a flange and a helical ridge of a like plug and a like socket provided on separate connecting lines.

2. A liquid transfusion pipe according to claim **1** in which the tubular member contains a plurality of filaments between which are defined a plurality of capillary passages, an elongate sleeve encasing the filaments.

3. A liquid transfusion pipe according to claim **2** in which the filaments are substantially circular in cross section.

4. A liquid transfusion pipe according to claim **2** in which the filaments have axially extending grooves formed in their outer periphery, said capillary passages being defined between said filaments in spaces provided by the grooves.

5. A liquid transfusion pipe according to claim **2** in which the sleeve comprises resin moulded around the assembled filaments.

6. A liquid transfusion pipe according to claim **2** in which the filaments are formed of synthetic resin.

7. A liquid transfusion pipe according to claim **2** in which the filaments are formed of fibre glass.

8. A liquid transfusion pipe according to claim **2** in which each of the connectors has a space which communicates with the capillary passages of the tubular member.

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