A novel infusion control device for selectively controlling the rate of administration of fluids parenterally to a patient. The control device provides attachment fittings which allow it to be placed at any point along a supply tube between a reservoir and the patient. A rotatable metering plate defines a capillary flow path between the input and output ports of the control device. The metering plate is axially rotatable with respect to the input and output ports to vary the effective length of the flow path so as to regulate the flow rate essentially uniformly between full flow and zero flow conditions.

2 Claims, 9 Drawing Figures
VARIABLE INFUSION CONTROL DEVICE

BACKGROUND

1. Field of the Invention
The present invention relates to fluid control apparatus and more particularly to parenteral infusion control devices having particular application when low flow rates are desired.

2. The Prior Art
The administration of parenteral fluids has long been known in the art. The conventional parenteral administration system normally comprises a container of liquid, an elongated flexible tube and a cannula or catheter which is inserted usually into the cardiovascular system of the patient. The liquid may be whole blood, plasma, any one of a variety of nutritional substances, isotonic saline and the like.

Historically, the flow of parenteral fluids to a patient has been controlled by selectively collapsing a portion of the delivery tube. The rate of flow was determined by the rate at which drops of fluid were observed falling through a conventional drip chamber. This technique has proved satisfactory in most cases where the desired flow rates are comparatively fast and where the accuracy is not particularly critical.

Recent developments in parenteral infusion have caused flow rates to assume critical importance. First, it has now become common practice to administer medication to a patient by first injecting the medication in the infusion liquid and then administering the infusion liquid over an extended period of time at an essentially constant rate. Secondly, the constant administration of parenteral fluids at very low flow rates has been used to keep intravenous cannulas and catheters from becoming clogged with clotting blood. Thirdly, in the case of patients suffering from renal disorders, it is frequently necessary to control fluid intake with substantial precision. Accordingly, when medication and fluids are administered to patients suffering from renal disorders, very low flow rates must be used and careful control of the flow rates is critically important.

Flow control devices for regulating the flow of parenteral fluids are known in the art. One well-known type includes a valve forming part of the drip chamber of the intravenous fluid delivery system. Representative of this type is U.S. Pat. No. 3,323,774. Control valves which are usable at any suitable location along the length of the I.V. tubing have heretofore included a plurality of individually adjustable control elements and have been substantially complex in construction and difficult to use. Representative of this type is U.S. Pat. No. 3,298,367.

Until this present invention, there has been no infusion control device which combines the advantages of accurate fluid regulation over a continuous scale from full on to off, which can be located at any desirable location along the length of the infusion tubing and which maintains with accuracy extremely low flow rates.

BRIEF SUMMARY AND OBJECTS OF THE INVENTION

The present invention comprises a novel continuously variable infusion control device. The invention provides precise and continuously variable control over the flow of parenteral fluid and may be placed at any point in a supply line between a reservoir and the patient. The control valve achieves the precise regulation through the use of a metering capillary having a variable effective length interposed between two fluid communication ports.

It is, therefore, a primary object of the present invention to provide a novel continuously variable infusion control device.

Another object of the present invention is to regulate the flow of parenteral fluids by selectively varying the effective length of a capillary resistor.

These and other objects and features of the present invention will become more fully apparent from the following description and appended claims taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded perspective illustration of a presently preferred embodiment of the infusion control device, portions being broken away to reveal inner parts.

FIG. 2 is a fragmentary perspective illustration of the capillary metering plate.

FIG. 3 is a cross-sectional view of the infusion control device of FIG. 1 taken along lines 3–3.

FIGS. 4 and 5 are perspective view of other presently preferred infusion control device embodiments particularly illustrating structure for controlling displacement of the metering plate.

FIG. 6 is a schematic plan view of another presently preferred metering plate embodiment.

FIG. 7 is a cross-sectional view of still another infusion control device embodiment.

FIG. 8 is a plan view of the metering plate of the device of FIG. 7.

FIG. 9 is a plan view of still another presently preferred metering plate embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Attention is now directed to the figures wherein like parts are designated with like numerals throughout.

The Embodiment of FIGS. 1–3

Referring particularly to FIG. 1, the infusion control device generally designated 10 is illustrated. The control device has a delivery member 12 which is formed of a cylindrical body 14 which presents an outwardly projecting male coupling 16. The male coupling is sized to mate in fluid-tight relationship with conventional fluid delivery tubing. It should be observed that the male coupling 16 is eccentrically located adjacent the periphery of the cylindrical body 14.

The body 14 circumscribes an annular disc 18 which is recessed away from the leading edge 20 of the body. The disc is provided with a through-bore 23 which is disposed in alignment with the male coupling 16 and is in open communication therewith.

A bearing shaft 22 is formed integrally with the annular disc 18 and is centered with respect to the disc 18 and the body 14. The bearing shaft 22 has a longitudinal keyway 24 extending the entire length of the shaft 22 and opening at the leading end 26 thereof. The purpose for the keyway 24 will be described more fully hereafter. A diametrically reduced alignment shaft 28 is concentric with and extends axially from the bearing shaft 22. The alignment shaft 28 defines a space 30 which, for purposes of this illustration, is shown open. It should be appreciated that the space 30 may be filled with any suitable material or may be completely open.
depending upon weight, balance and structural strength requirements.

An annular gasket 32 has a central opening 34 which is large enough to allow the gasket 32 to fit snugly over the bearing shaft 22. Preferably, when the gasket 32 is superimposed over the bearing shaft 22, the periphery 36 of the gasket 32 will fit snugly against the inside surface of the body 14. The transverse dimension of the gasket is selected so that the exposed face of the gasket 32 will project slightly beyond the face 20 of the body 14. The gasket 32 has a through-bore 38 which is similar in size to the through-bore 23 in the disc 18. Alignment of the bores 38 and 23 is maintained by a key 40 projecting inwardly from the annular gasket 32. When the key 40 is situated within the keyway 24, alignment of the through-bores 38 and 23 is assured.

A metering sleeve generally designated 44 has a hub 46 which is cylindrical in configuration and has a smooth, hollow interior surface 48. A metering plate 50 is integrally formed on the interior surface 48 of the hub 46 and interiorly defines a diametrically reduced aperture 52. The metering sleeve 44 is shown in greater detail in FIG. 2. The metering plate 50 presents an open capillary 60 which is concentric with the plate 50 and is the configuration of an open circle. The capillary 60, in the illustrated embodiment, is in the form of an open groove. Any suitable liquid-conducting passageway could be used. The term capillary, as used herein, means an elongated passageway which affects the flow rate of fluid along its length.

Another capillary 62 precisely complements the capillary 60 and is disposed on the face of the metering plate 50 opposite the face defining capillary 60. Capillary 60 and capillary 62 are joined at one end by a through-bore 64. Between the through-bore 64 and the terminal end 67 of the capillaries, the metering plate 50 presents a smooth portion 66.

The exterior of the hub 46 defines an annularly enlarged, radially projecting flange 54 at the leading end of the metering sleeve 44. Indicia 53 representing flow rates or other desirable information are desirably placed on the flange 54. Raised elements 56 may be formed on the exterior periphery of the hub 46 to facilitate controlled gripping of the metering sleeve 44. Also, if desired, at least one of the raised elements 56 may be used to identify the location of the through-bore 64.

As pointed out above, the metering plate 50 is spaced rearward of the flange 54 so as to be recessed within the hub 46. The aperture 52 defined by the plate 50 is adapted to be superimposed upon the bearing shaft 22 of the delivery member 14 (FIG. 1). It is observed that there is no key projecting into the opening 52 and, accordingly, the metering sleeve 44, even when superimposed upon the bearing shaft 22, is rotatable thereto as will be subsequently more fully described.

A second gasket 70 which may be substantially identical to the gasket 32 is nested within the recess forward of the metering plate 50 and behind the flange 54. The gasket 70 has a through-bore 72 and defines a central aperture 74 adapted to be superimposed upon the bearing shaft 22. A key 76 projecting into the aperture 74 will maintain alignment of the through-bore 72 with the corresponding bores 38 and 23.

In the mentioned assembled relationship, as shown also in FIG. 3, the gaskets 32 and 70 serve to form a fluid-seal with the capillaries 62 and 60, respectively. It is apparent that the capillaries may be located other than on the metering plate 50, for example on the corresponding faces 18 and 84 of the members 12 and 80, respectively. Also, any suitable number of capillaries could be used to improve control of low flow rates.

A fluid receiving member generally designated 80 is generally cylindrical in configuration and is adapted to nest within the hub 46 at the flange 54. The receiving member 80 has an elongated cylindrical body 82 which is preferably long enough in axial dimension to allow the body 82 to be grasped easily with the fingers. As shown in the broken away portion, the body 82 has a diametrically reduced annular shoulder 84 which is sized so as to receive the gasket 70. Preferably, the gasket 70 will project slightly beyond the trailing end 86 of the body 82 so that a fluid-tight seal will be formed between the receiving member 80 and the metering plate 50. An intermediate sleeve 88 is continuous with the shoulder 84 and sized so as to be superimposed upon the bearing shaft 22. A key 90 (shown best in FIG. 3) mates with the keyway 24 in the bearing shaft 22 so that the delivery member 12 and the receiving member 80 are non-rotatably connected one with the other.

The intermediate sleeve is continuous with a diametrically reduced opening 91 which is adapted to snugly receive the alignment shaft 28 in press-fit relation. When the alignment shaft 28 is press-fit into the opening 91, adequate compressive force can be maintained on the gaskets 32 and 70 to assure a fluid seal in the entire fluid control device 10.

The receiving member 80 also defines a female coupling 92 which will receive in mating relationship any suitable conventional conduit such as that commonly used in intravenous delivery systems. The female coupling 92 terminates in a diametrically reduced bore 94 which opens at the face 84 of the receiving member 80. The bore 94 is disposed in alignment with the corresponding bores 72, 38 and 23 and is maintained in that alignment because of the locking relationship of the key 90 in the keyway 24 (see FIG. 3). At least one peripheral raised element 95 facilitates gripping the member 80 and may be used also as an indicator directed toward the indicia 53.

In the use of the illustrated embodiment of the invention, the control valve is situated at any desirable location along an intravenous fluid delivery tube. One portion of the tube is press-fit into the female coupling 92 and another portion press-fit onto the male coupling 16. When the metering sleeve 44 is situated in the position illustrated in FIG. 3, the through-bore 64 (FIG. 1) is in direct alignment with the through-bores 23, 38, 72 and 94. Accordingly, fluid will flow directly through the aligned bores from the receiving member to the delivery member and resistance to flow will be generated only because of the reduced diameter of the bores.

However, as previously described, while the receiving member 80 and delivery member 12 are fixed in position one with respect to the other, the metering sleeve, interposed therebetween, is easily rotatable relative thereto. Accordingly, the metering sleeve may be rotated about the axis of the bearing shaft 22 so as to displace the through-bore 64 out of alignment with the bores 23, 38, 72 and 94. If the metering sleeve 44 (shown best in FIG. 2) is rotated into the plane of the paper, the flow path must necessarily be through the ports 94 and 72 to the capillary 60. Liquid will then flow along a portion of the capillary 60, through the
port 64, along a corresponding portion of the length of the capillary 62 and thence through the ports 38 and 23. The greater the degree of rotation of the metering sleeve 44, the greater the effective length of the capillaries 60 and 62 that the fluid must traverse after leaving the port 72 and before entering the port 38. When the smooth portion 66 of the metering plate 50 is positioned between the ports 72 and 38, fluid flow will be completely stopped.

The flow rate of fluid from the receiving member 80 to the delivering member 12 has been found to be a direct function of the length of the capillary 60 and 62 through which the liquid must pass because of the resistance to flow which increases as a function of capillary length. It has been found to be a significant advantage to have dual capillaries, one on each side of the metering plate 50, because an incremental rotation of the metering sleeve 44 has the effect of doubling the capillary length through which liquid must pass. This effect is highly advantageous where accurate control of extremely low flow rates is desired.

Accurate flow rates can be more precisely delivered by the control valve 10 if the source of fluid at the receiving member 80 is under constant pressure. This could be accomplished by maintaining an essentially constant pressure in the intravenous fluid container.

According to the illustrated embodiment of the invention, it has also been found highly advantageous to provide a metering sleeve 44 which adjusts the flow of fluid between the receiving member 80 and the delivering member 12 without at the same time effecting a twisting or rotation of either the inlet tube 97 or the outlet tube 99 (see FIG. 3). Tubes 97 and 99 are held by the corresponding receiving member 80 and delivering member 12 in a relatively fixed position. The metering sleeve 44 rotates in planetary fashion about the axis of the bearing shaft 22.

The Embodiments of FIGS. 4 and 5

FIG. 4 illustrates an assembled fluid control device similar to the FIG. 1 embodiment and including a delivery member 112, a receiving member 80 and a metering sleeve 144. The FIG. 4 embodiment differs from the FIG. 1 embodiment in that the metering sleeve 144 has a forwardly projecting detent 145. The detent 145 is adapted to abut a rigid stop 147 mounted on the periphery of the delivery member 112.

Preferably, the detent 145 and stop 147 are positioned so that when the metering sleeve is rotated clockwise (as shown in FIG. 4) until the detent 145 abuts the stop 147, the through-bore (not shown in FIG. 4) of the metering sleeve 144 will be in alignment with the corresponding through-bore in the delivery member 112 and the receiving member 80. Accordingly, rapid fluid delivery will exist in this position. As the metering sleeve 144 is rotated counterclockwise to the position illustrated in FIG. 4, fluid flow from the receiving member 80 to the delivery member 112 will be completely stopped. Continued counterclockwise rotation will cause the fluid to flow through the control device at progressively increasing flow rates until the detent engages the back side of the stop 147. In that position, the flow rate will be rapid, although short of the full flow position previously described.

One advantage of the described flow characteristics is to provide a way of rapidly flushing the flow control valve and its attached I.V. system. Moreover, while the detent 145 and stop 147 provide for quick, facile full-

flow setting, at the same time inadvertent movement of the metering sleeve 144 to the full-flow position is substantially reduced. Thus, the safety and flow predictability of the control device is improved.

The FIG. 5 embodiment is substantially the same as the FIG. 4 embodiment except that the metering sleeve 244 in the FIG. 5 embodiment is provided with a forwardly projecting resilient finger 245. The finger 245 engages a peripheral flange 247 which is integral with the delivery 212. The flange 247 is scalloped so as to bias the position of the metering sleeve 244 through engagement with the finger 245. Accordingly, positioning of the metering sleeve 244 can be more easily maintained and inadvertent rotation avoided.

Clearly, there are a variety of suitable techniques that could be used to provide the advantageous results described in connection with FIG. 4 and 5. The embodiment of FIGS. 4 and 5 is described as illustrative only, it being understood that any suitable structure accommodating selective control of the position of the metering sleeves 144 or 244 could be used.

The Embodiment of FIG. 6

FIG. 6 is the plan view of a metering sleeve 344 which may be substantially the same construction as metering sleeves disclosed in FIGS. 1, 4 and 5. Metering sleeve 344 has a metering plate 350 which differs from the metering plate 50 (FIG. 2) principally in that a plurality of radially spaced through-bores 364–367 are formed in the metering plate 350. Each of the through-bores 364–367 is intersected by corresponding capillaries 370–373. As with capillary 60 in FIG. 2, a substantially identical capillary (not shown in FIG. 6) is formed in the opposite side of the plate 350.

It is observed that in the FIG. 6 embodiment the capillary 370 is larger in size than the capillary 371 and the capillaries 372 and 373 are serially reduced in size. Accordingly, the metering plate 350 provides for a plurality of ranges of flow, each of which is variable along the length of the corresponding capillary. Any suitable number of ranges could be used that can be structurally fit on the face of the metering plate 350.

The Embodiment of FIGS. 7 and 8

The embodiment of FIGS. 7 and 8 differs from the foregoing embodiments principally in that dual capillaries both exist on the same side of a metering plate as will now be more fully described. The control device generally designated 400 comprises a body 402 preferably formed of plastic or the like. The body 402 defines an annular recess 404 and an integral centrally disposed boss 406. The body has a male coupling 408 and a female coupling 410, preferably situated in side-by-side relation along a line projecting radially from the center of the body. Both the male coupling 408 and the female coupling 410 are provided with corresponding hollow bores 409 and 411, respectively.

A metering plate 412 is nested within the opening 404 and preferably has a transverse dimension slightly greater than the depth of the opening 404 so as to tend to project slightly beyond the body 402. The metering plate is preferably formed of a resilient rubber material and is provided with at least two concentric capillaries 414 and 416. The capillaries 414 and 416 are best illustrated in FIG. 8 and are shown to be in the form of an incomplete circle, the ends of the circle terminating in a flat area 420. The end of each of the capillaries 414 and 416 intersects apertures 422 and 424, respectively. As shown in FIG. 7, the apertures 422 and 424 are in
alignment with the female and male couplings 410 and 408, respectively.
The metering plate 412 has a centrally disposed aperture 430 adapted to closely circumscribe the boss 406. In the illustrated embodiment, the capillaries 414 and 416 of the metering plate 412 are closed by a control cap 432. Control cap 432 has a flat undersurface which functions to close the otherwise exposed capillaries 414 and 416. The interior surface of the control cap 432 has an elongated radially projecting slot 434 which is long enough to bridge the capillaries 414 and 416. Accordingly, the slot 434 provides a channel or passage-way which selectively connects the capillaries 414 and 416 as shown in FIG. 7.

An annular bearing 436 is superimposed upon the control cap 432, the bearing 436 having a central aperture through which a threaded screw 440 passes. The screw 440 threadedly engages the hollow interior 438 of the boss 406.

In operation, the control cap 432 is arcuateley displaced around the axis of the boss 406 and screw 440. As the cap 432 is rotated, the channel 434 is arcuateley displaced about the axis of the boss 406. When channel 434 is positioned over the smooth portion 420, all flow will stop. When the channel 434 is situated across the apertures 422 and 424, essentially full flow will exist between the couplings 410 and 408. The velocity of the flow between the couplings 410 and 408 is thus determined by the length of the capillary through which the fluid must travel which is, in turn, controlled by the position of the channel 434 upon the plate 412.

The Embodiment of FIG. 9

Referring now to FIG. 9, a metering plate 444 is shown in plan view. The metering plate is similar to the metering plates heretofore described except in the configuration of capillary 448. Capillary 448 is formed in the face 446 of the metering plate 444 and communicates with through-bore 450. Preferably, the capillary 448 has a transverse diameter which is larger than the capillaries described above so as to reduce the resistance to flow of fluid therethrough.

A plurality of restrictions 452, 453 and 454 project into the capillary 448, each restriction developing a predetermined resistance to fluid flow. The restrictions can have any suitable configuration. As shown in the illustrated embodiment, the restriction 452 has an orifice of greater dimension than the orifice of restriction 453 which is, in turn, greater than the orifice of restriction 454. The capillary 448 may or may not be formed on the opposite face (not shown) of the plate 444.

The operation of this embodiment differs from previously described embodiments principally in that fluid flow volumes are controlled almost entirely at the orifices of the restrictions 452-454. Thus, when fluid enters the capillary 448 at any location between the restriction 452 and the bore 450, essentially full flow will result. When fluid enters the capillary 448 at essentially any location between the restrictions 452 and 453 the flow rate will be reduced by the restriction 452 to a predetermined level. Correspondingly, the flow rate of fluid entering the capillary between restrictions 453 and 454 will be affected by the combined effect of restrictions 453 and 454.

Accordingly, it can be understood that accurately predictable flow rates can be achieved by positioning the metering plate with respect to the site of incoming fluid. While orifice size progressively decreases in the embodiment of FIG. 9, clearly all could be uniformly sized and any desirable number could be used. The capillary embodiment of FIG. 9 could be used in place of the capillaries in corresponding metering plates of FIGS. 2, 6 and 8.

The invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiment is to be considered in all respects only as illustrative and not restrictive and the scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

What is claimed and desired to be secured by United States Letters Patent is:

1. A variable infusion device for administering liquids parenterally to a patient comprising:
a fluid receiving means;
a fluid delivering means nonrotatably joined to the fluid receiving means; and
metering means interposed between the fluid receiving means and the fluid delivering means and comprising a single metering plate the periphery of which is exposed and hand rotatable about an axis, a capillary formed in at least one face of the metering plate, the capillary comprising:
at least two grooves of uniform cross-sectional area;
each groove being formed along an arc of constant radius, the arc traversing less than 360° about the axis; and
means providing fluid communication between the grooves; rotation of the metering plates altering the effective length of the capillary by a distance greater than the arcuate displacement of the metering plate.

2. A variable infusion device for administering fluids parenterally to a patient comprising:
a fluid receiving means;
a fluid delivering means nonrotatably joined to the fluid receiving means;
at least first and second capillaries formed as coplanar grooves, such having a uniform cross-sectional area and lying in a plane transverse to the axis of the fluid receiving means and the fluid delivering means, the first capillary having a first constant radius about an axis and defining an arc, the first capillary being in fluid communication with the fluid receiving means, the second capillary having a second constant radius about the axis and defining an arc, the second capillary being in fluid communication with the fluid delivering means, and a fluid metering means comprising a channel transversely bridging the first and second capillaries to provide fluid communication therebetween, the channel being arcuatley displaceable along the arc of the capillaries.

* * * * *