Description

1. Field of the Invention

The present invention relates to a sequence valve for use with the administration of intravenous (IV) fluid, in particular the administration of multiple IV solutions or medications at predetermined intervals to a patient.

2. Description of the Prior Art

It is quite common in IV therapy to give a patient a primary solution and one or more secondary solutions or medications. The secondary (or piggyback") medication is usually given several times a day. An example is when a patient is on antibiotics. It is desirable to have an IV pump and a sequencing valve that administers the primary and secondary solutions sequentially.

In the past, there have been IV pump systems which allow two fluids to be administered. In these systems, the secondary medication is pumped until the secondary container goes empty, and then the pump switches to the primary fluid. An example of this type of system is shown in U.S. Patent 4,451,255. This proves to be a substantial burden to hospital personnel, particularly where the secondary medication is required several times a day. With the prior art systems, the medical personnel must change secondary medication bags several times each day.

A prior art that is of particular interest is that disclosed in US-A-3 895 649. In this prior art first and second parallel flexible tubes pass through a channel extending transversely through a housing. Within the housing is a coiled spring wound about a shaft, the axis of the shaft being parallel to longitudinal direction of said flexible tubes where they pass through said channel. The coiled spring has one end connected to said shaft and a free end that extends between the two flexible tubes in said channel, the free end projecting out of said housing. The shaft is rotatable to a setting in which the spring is wound up to such an extent that its free end compresses a first one of the flexible tubes to such an extent that the tube becomes occluded. The shaft is then locked in this position. Thus, the spring acts as a biasing means that causes its free end to normally maintain said first one of the tubes in an occluded state. A solenoid or any other suitable electromechanical device having a linkage coupled to the free end of the spring where it projects out of the housing, is also provided, the arrangement being such that when the solenoid or said electromechanical device is energized the free end of the spring is moved against its biasing force to a setting in which it compresses the second of the two flexible tubes to such an extent that the second tube is occluded and the first of the two flexible tubes is no longer occluded.

Summary of the Invention

The sequence valve of the present invention is as defined in the accompanying claims. Claim 1 has been divided into a two-part form with those features of Claim 1 that are already known from US-A-3 985 649 appearing in the pre-characterizing part.

The sequence valve of the present invention operates on two tubes which are connected between the inlet of an IV control device (e.g. a pump or controller) and a pair of sources of IV fluids. The sequence valve is set to a first state in which the first tube is pinched off and the second is open.

In response to a valve control signal, the sequence valve changes to a second state in which the second tube is pinched off and the first tube is open.

The sequence valve preferably includes a base, a crank pivotally connected to the base, bias means for applying a bias force to the crank, occluder means connected to the crank, and releasable latch means for latching the crank in a first crank position. When the crank is in the first crank position, the occluder means occludes the first tube, and when when the crank is in the second crank position, the occluder means occludes the second tube.

The bias force urges the crank toward the second crank position, but when the crank is in the first crank position it is held there by the releasable latch means. In response to a control signal, the releasable latch means releases the crank, thus allowing the crank to move to the second crank position and allowing the sequence valve to switch from the first state to the second state.

Brief Description of the Drawings

Figure 1 is a partially schematic diagram of a preferred embodiment of the IV administration system using the sequence valve of the present invention.

Figure 2 is a front view of the IV pump of Figure 1.

Figure 3 is an electrical block diagram of the system of Figure 1.

Figure 4 is a front view of a first preferred embodiment of the sequence valve.

Figure 5 is a front view of the sequence valve of Figure 4 with the front cover removed.

Figure 6 is a sectional view along section 6-6 of Figure 5.

Figure 7 is a top view of the valve of Figure 4.

Figure 8 is a front view of a second preferred embodiment of the sequence valve.

Figures 9 and 10 are partial left and right side views of the sequence valve of Figure 8.

Figure 11 is a top view of the sequence valve of Figure 8 with the tube retainer pivoted to its open position.

Figure 12 is an electrical schematic diagram of the sequence valve of Figure 8.

Detailed Description of the Preferred Embodiments

In the preferred embodiment shown in Figure 1, IV administration system 10 includes IV pump 12,

which pumps fluid from primary solution bag 14 or secondary (or piggyback) solution bag 16, to a patient (not shown). Sequence valve 18 is connected between bags 14 and 16 and pump 12 to select one of the bags 14 and 16 for connection to pump 12.

In the particular embodiment shown in Figure 1, pump 12 is an IV pump such as the AVI GUARDIAN 400. Pumps of this general type (which are described in U.S. Patent No. 4,236,880) use a disposable multiple rolling diaphragm pumping chamber 20 which is inserted into pump 12. Pumping chamber 20 has an inlet tubing 22 connected at its inlet end, and an outlet tubing 24 at its outlet end. A drive mechanism within pump 12 causes relative movement of two of the rolling diaphragms of pumping chamber 20 and the operation of two valves to cause fluid to be pumped from inlet tubing 22 through pumping chamber 20 and out through outlet tubing 24 to the patient.

In the embodiment shown in Figure 1, disposable multiple rolling diaphragm pumping chamber 20, inlet tubing 22 and outlet tubing 24 form a part of a disposable IV administration set which also includes primary spike 26, primary drip chamber 28, primary tubing 30, proximal Y connector 32, primary roller clamp 34, secondary spike 36, secondary drip chamber 38, secondary tubing 40, secondary roller clamp 42, distal Y connector 44, distal tubing 46, needle 48, and distal roller clamp 50.

Primary spike 26 is inserted into the lower end of primary bag 14, and is connected to the upper end of primary drip chamber 28. The lower end of primary drip chamber 28 is connected by primary tubing 30 to one leg of proximal Y connector 32.

Similarly, secondary spike 36 is inserted into the lower end of secondary bag 16 and is connected to the upper end of secondary drip chamber 38. The lower end of secondary drip chamber 38 is connected through secondary tubing 40 to the second leg of proximal Y connector 32. The third leg of Y connector 32 is connected to inlet tubing 22.

Primary tubing 30 and secondary tubing 40 pass through sequence valve 18, and at least one (preferably primary tubing 30) supports sequence valve 18. In the preferred embodiment of the present invention, sequence valve 18 is a lightweight, solenoid actuated device which initially pinches off primary tubing 30 to prevent flow from primary bag 14 while permitting flow from secondary bag 16 to pumping chamber 20. In response to a valve control signal received from pump 12 through multiconductor cable 52, sequence valve 18 switches so that secondary tubing 40 is pinched off and primary tubing 30 is unobstructed. When secondary tubing 40 is unobstructed and primary tubing 30 is pinched off, secondary (piggyback) bag 16 is connected to inlet tubing 22, and pump 12 pumps the secondary medication from piggyback bag 16 to the patient. Conversely, when secondary tubing 40 is pinched off and primary tubing 30 is unobstructed, the primary solution is pumped from primary bag 14 to the patient by IV pump 12.

At the outlet end, outlet tubing 24 is connected through distal Y connector 44 to distal tubing 46. At the end of distal tubing 46 is needle 48, which is inserted into a vein of the patient. Distal Y connector 44 has another leg which is normally closed, but which allows the insertion of a syringe needle to introduce medication directly into distal tubing 46 as fluid is being pumped to the patient.

Roller clamps 34, 42 and 50 are used by medical personnel during the installation of the IV administration set into pump 12, during initial set-up, and during removal of the IV administration set.

Figure 2 shows a front view of pump 12. Pump 12 includes a housing 54 which contains the electrical control circuitry and the mechanical portions of the pump which interact with disposable pumping chamber 20. Pump 12 is supported on an IV stand or pole (not shown) by pole clamp 56. Door 58 covers a receptacle into which disposable pumping chamber 20 is inserted. In the embodiment shown in Figure 2, the opening of door 58 requires operation of the three separate devices: load control handle 60, door lock 62, and door latch 64. During normal operation, when the IV administration set is installed with pumping chamber 20 within the receptacle of pump 12, door 58 is closed as shown in Figure 2.

In the lower left corner of the front of pump 12 is control panel 66, which includes a keyboard formed by numerical key pads ("0" through "9"), operate key pad (OPR) 68, standby key pad (STBY) 70, PRIMARY key pad 72, PIGGYBACK key pad 74, RATE key pad 76, volume limit (LIMIT) key pad 78, and volume infused clear (CLEAR) key pad 80. Control panel 66 also includes three digital displays: rate display 82, volume limit display 84, and volume infused display 86.

Pump 12 also includes indicator panel 88, (which provides visual indication of different error or alarm conditions), and audio alarm annunciator 90.

Figure 3 is an electrical block diagram of pump 12 and sequence valve 18, which are connected together by multiconductor cable 52 and connector 92 Sequence valve 18 receives a valve control signal from pump 12, and provides a valve state signal, which indicates which fluid line (primary tubing 30 or secondary tubing 40) is occluded.

The operation of pump 12 is controlled by pump control 94, which in preferred embodiments includes a microcomputer, together with associated memory, timing and clock circuitry and appropriate interface circuitry. Pump control 94 receives input signals from control panel 66, from sensors 96 (which sense various operating conditions or parameters such as output pressure, air bubbles in the IV administration set, empty bags and opening of door 58), and from sequence valve 18. Pump control 94 provides outputs to displays 82, 84 and 86 of control panel 66, indicator panel 88, audio annunciator 90 and to pump drive motor 98. In addition, when

sequence valve 18 is connected to pump 12 and a piggyback operation has been selected, pump control 94 provides the valve control signal to sequence valve 18.

Control panel 66 allows the medical personnel to "set up" an IV administration schedule so that predetermined volumes of the primary and secondary solutions are delivered at predetermined rates. Pump control 94 controls the operation of both sequence valve 18 and pump drive motor 98, so that it controls both the particular solution being pumped at any given time, and the rate at which the fluid is being pumped.

By depressing STBY key pad 70, the medical personnel places pump 12 in a standby mode. This allows changing or resetting of both rates and volume limits for both the primary and piggyback solutions. The primary solution rate is selected by depressing PRIMARY key pad 72 and then RATE key pad 76, followed by the keys representing the numerical value desired. The primary volume limits can then be set by pressing LIMIT key pad 78 and then using the numerical keys to enter the desired numerical limit for the primary solution.

For the piggyback or secondary solution, PIGGYBACK key pad 74 is pressed. RATE key pad 76 is then pressed, followed by appropriate numerical keys to enter the piggyback rate. LIMIT key pad 78 is then depressed, followed by selected numerical key pads to set the piggyback volume limit.

Pump control 94 stores the rates and volume limits entered for both the primary solution and the piggyback solution. These stored values are used, together with an accumulated volume infused value in controlling sequence valve 18 as well as pump drive motor 98.

Sequence valve 18 of the present invention is a spring loaded, solenoid actuated device which initially occludes primary tubing 30 so that the secondary solution is pumped first. Sequence valve 18 is placed in this initial condition by inserting primary tubing 30 into one slot of sequence valve 18 and then cocking lever 100 so that primary tubing 30 is occluded. Secondary tubing 40 is then inserted into an adjacent slot alongside primary tubing 30 in sequence valve 18 as shown in Figure 1.

Operation of pump 12 in the piggyback mode is initiated by depressing OPR key pad 18. Pump control 94 provides pump drive control signals to pump drive motor 98 which cause motor 98 to produce the pumping rate stored for the piggyback solution. As pump drive motor 98 is operated, pump control 94 maintains an accumulated value which represents the amount of secondary solution which has been pumped with sequence valve 18 in its initial setting. When that accumulated value reaches the piggyback volume limit stored by pump control 94, a valve control signal is produced which causes sequence valve 18 to change state. Sequence valve 18, in response to the valve control signal, occludes secondary tubing 40, and allows primary solution to flow through primary tubing 30, to inlet tubing 22. Upon receiving the signal from sequence valve 18 indicating that the change has been made, pump control 94 provides pump drive signals which cause pump drive motor 98 to operate at the pumping rate selected for the primary solution. Pump control 94 again maintains an accumulated value which represents the amount of primary solution which has been pumped. This value is displayed on volume infused display 86. When the accumulated value reaches the stored primary volume limit, pump control 94 halts operation of pump drive motor 98 and provides an indication through indicator panel 88 and audio annunciator 90 that both the piggyback and primary administration has been completed. At that point, the medical personnel responsible for the IV administration are required to intervene to set a new schedule of primary and piggyback rates and volume rates.

The present invention is advantageous because all of the medication for a single day or for several days can be stored in one large secondary bag 16, as opposed to much smaller secondary bags which run dry after each administration of that medication. For example, if a patient is to receive 50 milliliters of secondary medication four times a day, four bags would be required with the prior art systems, in which the switching from the secondary bag to the primary solution is determined by when the secondary bag is empty. With the system of the present invention, one 200 milliliter bag can be used for the entire day. Since a large or a small bag costs essentially the same, there is a cost saving just by virtue of the reduced number of bags. In addition, the system significantly reduces the amount of time which is required of medical personnel. It is not necessary to change the secondary bag 16 after each administration of medication, and in fact the present invention allows the secondary medication to be provided multiple times without a change in the secondary bag.

By use of pump control 94 within housing 54 of pump 12 to control operation of both pump 12 and sequence valve 18, the size, weight, complexity and cost of sequence valve 18 are significantly reduced. As a result, sequence valve 18 can be suspended from the tubing (e.g. primary tubing 30) rather than requiring separate clamping to a pole. This makes sequence valve 18 simpler and easier to use, and makes it portable so that sequence valve 18 can be moved wherever pump 12 is moved.

Figures 4 through 7 show a first preferred embodiment of sequence valve 18. Figure 4 shows valve 18 in its normal initial operating position for piggyback operation. As shown in Figure 4, tubes 30 and 40 pass side-by-side through valve 18. At the upper end, tubing 30 and tubing 40 are retained by retainer spring 102, which has a pair of retainer arms 102A and 102B. At the lower end, tubing 30 and tubing 40 are retained in side-by-side position by retaining fingers 104A and 104B of front cover 106.

As shown in Figure 4, lever 100 is in its

uppermost ("cocked") position, which causes occluder stud 108 to be in its leftmost position. As a result, primary tubing 30 is pinched off between occluder stud 108 and leaf spring 110. Also shown in phantom in Figure 4 is the position of lever 100 and the position of occluder stud 108 after sequence valve 18 has received a valve control signal from pump 12 which causes occluder stud 108 to move generally to the right to pinch off secondary tubing 40 between occluder stud 108 and wall 112. Thus sequence valve 18 has two stable positions, one in which primary tubing 30 is occluded and secondary tubing 40 is unoccluded; and the other in which secondary tubing 40 is occluded and primary tubing 30 is unoccluded.

Figure 5 shows sequence valve 18 with front cover 106 removed. The operating mechanisms of sequence valve 18 are supported by valve base 114. Both occluder stud 108 and lever 100 are attached to bell crank 116, which is pivotally mounted to valve base 114 by pivot pin 118.

As in Figure 4, two positions of occluder stud 108 and the other moving parts of sequence valve 18 are shown. Solid lines represent the initial position in which primary tubing 30 is occluded, and phantom lines to illustrate the second position in which secondary tubing 40 is occluded.

Bell crank 116 is biased in a clockwise direction by bias spring 120, which is connected at its upper end to stud 122 and thus to valve base 114, and which is connected at its lower end to stud 124 which projects rearwardly from the lower end of bell crank 118.

Latch 126 is pivotally mounted about pivot pin 128, and has a latch tooth 130 which engages lower leg 132 of bell crank 116 when lever 116 is its cocked upper position. Latch arm 134 is held in the initial position by solenoid plunger 136, which prevents rotation of latch 126 about the axis defined by pivot pin 128.

Valve 18 will remain in a stable initial position until a valve control signal actuates solenoid 138 (Figure 6). This causes solenoid plunger 136 to be pulled in a rearward direction out of contact with arm 134 of latch 126 This allows the bias force of spring 120 to rotate bell crank 116 and in turn latch 126 about their respective pivot pins 118 and 128 to the position shown in phantom in Figure 5. The second stable position of bell crank 116 is defined by stop 140, which engages leg 132 of bell crank 116 to prevent further rotation in the clockwise direction. In this second stable state, occluder stud 108 is at its rightmost position, so that secondary tubing 40 is pinched off between occluder stud 108 and wall 112.

Sequence valve 18 is reset to its initial position by moving lever 100 upwards to the initial cocked position shown in solid lines. Latch spring 142 urges latch 126 back to its initial position when sequence valve 18 is being reinitialized. As shown in Figure 6, rear surface 134A of arm 134 is bevelled to form a ramp which allows arm 134 to move past solenoid plunger 136 as lever 100 is being cocked.

Solenoid 138 includes a solenoid plunger stud 144 which extends out the rear end of solenoid cover 146. At the rear end of solenoid plunger stud 144 is solenoid button 148. This button allows the nurse or technician to pull solenoid plunger 136 out of the way of latch 126 in order to manually release lever 100, bell crank 116 and latch 126 from the cocked position. Button 148 can then be released and, due to the bias force of bias spring 150 solenoid plunger 136 returns to its normal position shown in Figure 6.

It is also preferable for sequence valve 18 to provide an electrical signal which indicates the current state of sequence valve 18. In the embodiment shown in Figure 5, a metal contact stud 152 is attached to bell crank 116. When valve 18 is in its initial state, contact stud 152 is in contact with contact wire 154. When the valve control signal has been received and bell crank 116 has rotated to the position shown in phantom, contact stud 152 has moved into engagement with contact wire 156. Depending upon which wire 154 or 156 is in contact with contact stud 152, a different electrical signal is supplied through cable 152 to pump 12. This provides a simple, yet very effective way of indicating the state of sequence valve 18 to pump 12.

As shown in Figure 7, upper retainer 102 is a single wire clip which mounts over stud 158 at the upper end of valve base 114. The resilient nature of retainer 102 allows the retainer arms 102A and 102B to be displaced outwardly while tubing 30 and 40 are inserted into sequence valve 18. Once released, arms 102A and 102B return to their normal position shown in Figure 7, thus securely holding tubing 30 and tubing 40 in place.

Sequence valve 18 shown in Figures 4-7 is particularly advantageous, since it is small, lightweight (so that it can be supported on tubing 30 and 40 without the need for a separate support stand) and uses a small, low-power solenoid. By using a pivoted latch 126 and a pivoted bell crank 116, both of which provide a substantial mechanical advantage (e.g. 4:0 each), a very small movement of solenoid plunger 136 provides the sufficient force to move occluder stud 108 to the right so as to pinch off tubing 40. The force required to move solenoid plunger 136 is, for example, only one-sixteenth of the force applied by occluder stud 108 to tubing 40.

Sequence valve 18 shown in Figures 4-7 also uses an extremely simple mechanism to pinch off alternately either tubing 30 or tubing 40. By the use of leaf spring 110 to urge tubing 30 toward occluder stud 108, sequence valve 18 does not require a precise alignment of both positions of occluder stud 108, and variations in the diameters of tubing 30 and 40 are accommodated. It is merely necessary to ensure that occluder stud 108 moves far enough to the right to pinch off tubing 40 against right wall 112 for the minimum expected diameter of tubing 40.

Figures 8-12 show a second embodiment of the sequence valve of the present invention. This second embodiment (which is designated valve

18') is generally similar to the embodiment of sequence valve 18 shown in Figures 4-7, and similar reference numerals are used to designate similar elements. The internal operation of the bell crank, latch and solenoid of sequence valve 18' of Figures 8-12 are identical to those shown in Figures 4-7 and will not be discussed again.

The main difference between sequence valve 18' of Figures 8-12 and sequence valve 18 of Figures 4-7 is in the retaining of tubing 30 and 40. In sequence valve 18', a tube retainer 200 is pivotally mounted at the upper end of valve 18' between top end plate 202 and the upper ends of front cover 106 and valve base 114. Tube retainer 200 has a right leg 20 which is pivotally mounted about pivot pin 206, a left leg 208, a front flange 210, and a tube hold-down flange 212. The closed position of tube retainer 200 is shown in Figures 8-10, and the open position is shown in Figure 11. Flange 210 forms a handle by which the nurse can pivot tube retainer 200 to the open position to allow insertion or removal of tubing 30 and 40 from sequence valve 18'.

Left leg 208 of tube retainer 200 contains a hole 214 which receives a spring loaded ball 216 mounted in top plate 202 when tube retainer 200 is in the closed position shown in Figures 8-10. Spring loaded ball 216 maintains tube retainer 200 in the closed position and prevents it from moving from the closed position if IV pump 12 or tubing 30 or 40 are moved or bumped inadvertently.

Sequence valve 18 also uses tube retainer 200 as a switch to indicate to pump 12 that sequence valve 18' is in a condition to operate. For this purpose, tube retainer 200 is an electrically conductive material, preferably metal. An electrically conductive washer 218, which is partially shown in Figure 11, is mounted on pivot pin 206 in contact with right leg 204 of tube retainer 200. Spring Contact 220 is positioned so that it will be engaged by left leg 208 when tube retainer 200 is in the closed position. Thus when tube retainer 200 is in the closed position, a closed electrical path is provided between conductive washer 218 and spring contact 220.

Figure 12 shows an electrical schematic diagram of sequence valve 18'. In this embodiment, cable 152 (which connects valve 18' to pump control 94) contains four wires 152A, 152B, 152C and 152D. Solenoid 138 is connected between wires 152A and 152B. Wire 152B is connected to ground. When pump control 94 causes a voltage to be present between wires 152A and 152B, solenoid 138 is actuated.

Wires 152C and 152D are used to indicate to pump control 94 the condition or state of sequence valve 18'. The switch formed by tube retainer 200, conductive washer 218 and spring contact 220 is connected in series with a switch formed by contact stud 152 and contact wires 154 and 156. Contact wire 154 is connected to wire 152D, and contact wire 156 is connected to wire 152C.

If tube retainer 200 is in its open position, both wires 152C and 152D will indicate an open circuit. When tube retainer 200 is closed, normally one of the two wires 152C and 152D will be an open circuit, while the other will be connected to ground. By monitoring wires 152C and 152D, therefore, pump control 94 can determine the operating state of sequence valve 18', as well as whether tube retainer 200 is in closed position.

Figures 8-11 also show retainer posts 222 and 224, which are positioned along the channel, and which maintain tubing 30 and 40 in position along the entire length of the channel.

At the upper end of valve 18' is hook 226, which is attached by screw 228 to top plate 202. Primary tubing 30 is threaded through hook 226 to maintain sequence valve 18' in a generally vertical position. This counteracts the tendency of the lower end of valve 18' to tip forward due to the greater weight of solenoid 138 within solenoid housing 146 (see Figure 6).

Also included in sequence valve 18' is a spring clip 230 and retainer pad 232 which are positioned along the left side of sequence valve 18'. Clip 230 allows sequence valve 18' to be clipped onto pump 12 when not in use. pad 232 prevents sequence valve 18' from slipping when it is clipped onto pump 12.

Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the scope of the invention as defined in the claims. For example although the present invention has been described in the context of a system in which a primary and only one secondary bag are used, it is also applicable to more complex systems in which multiple secondary bags are used in conjunction with a primary bag.

Similarly, although the present invention has been described the context of a specific type of IV pump sold by the applicant, the present invention is applicable to other IV pump and controller systems as well.

Claims

1. A sequence valve (18) having a first state in which a first flexible tube (30) is occluded and a second flexible tube (40) is not and a second state in which the second tube (40) is occluded and the first tube (30) is not, the sequence valve being settable to the first state and switching to the second state in response to a control signal, the sequence valve comprising:

(a) a pivotable tube pincher (108, 116) for pinching off the first tube (30) when the valve is in the first state and the tube pincher is in a first position and for pinching off the second flexible tube (40) when the valve is in the second state and the tube pincher is in a second position;

characterized by

(b) bias means (120) for applying a bias force to the tube pincher (108, 116) in a direction toward the second position;

18') is generally similar to the embodiment of sequence valve 18 shown in Figures 4-7, and similar reference numerals are used to designate similar elements. The internal operation of the bell crank, latch and solenoid of sequence valve 18' of Figures 8-12 are identical to those shown in Figures 4-7 and will not be discussed again.

The main difference between sequence valve 18' of Figures 8-12 and sequence valve 18 of Figures 4-7 is in the retaining of tubing 30 and 40. In sequence valve 18', a tube retainer 200 is pivotally mounted at the upper end of valve 18' between top end plate 202 and the upper ends of front cover 106 and valve base 114. Tube retainer 200 has a right leg 20 which is pivotally mounted about pivot pin 206, a left leg 208, a front flange 210, and a tube hold-down flange 212. The closed position of tube retainer 200 is shown in Figures 8-10, and the open position is shown in Figure 11. Flange 210 forms a handle by which the nurse can pivot tube retainer 200 to the open position to allow insertion or removal of tubing 30 and 40 from sequence valve 18'.

Left leg 208 of tube retainer 200 contains a hole 214 which receives a spring loaded ball 216 mounted in top plate 202 when tube retainer 200 is in the closed position shown in Figures 8-10. Spring loaded ball 216 maintains tube retainer 200 in the closed position and prevents it from moving from the closed position if IV pump 12 or tubing 30 or 40 are moved or bumped inadvertently.

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Figure 12 shows an electrical schematic diagram of sequence valve 18'. In this embodiment, cable 152 (which connects valve 18' to pump control 94) contains four wires 152A, 152B, 152C and 152D. Solenoid 138 is connected between wires 152A and 152B. Wire 152B is connected to ground. When pump control 94 causes a voltage to be present between wires 152A and 152B, solenoid 138 is actuated.

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Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the scope of the invention as defined in the claims. For example although the present invention has been described in the context of a system in which a primary and only one secondary bag are used, it is also applicable to more complex systems in which multiple secondary bags are used in conjunction with a primary bag.

Similarly, although the present invention has been described the context of a specific type of IV pump sold by the applicant, the present invention is applicable to other IV pump and controller systems as well.

Claims

1. A sequence valve (18) having a first state in which a first flexible tube (30) is occluded and a second flexible tube (40) is not and a second state in which the second tube (40) is occluded and the first tube (30) is not, the sequence valve being settable to the first state and switching to the second state in response to a control signal, the sequence valve comprising:

(a) a pivotable tube pincher (108, 116) for pinching off the first tube (30) when the valve is in the first state and the tube pincher is in a first position and for pinching off the second flexible tube (40) when the valve is in the second state and the tube pincher is in a second position;

characterized by

(b) bias means (120) for applying a bias force to the tube pincher (108, 116) in a direction toward the second position;

* C L M S *

(c) manually movable means (100) connected to the tube pincher (108, 116) for moving the tube pincher against the bias force to the first position in which the first tube (30) is pinched off;

(d) a pivotable latch (126) for engaging and holding the tube pincher in the first position in which the first tube (30) is pinched off; and

(e) a solenoid (138) which releases the latch (126) in response to the control signal to permit the latch to pivot out of engagement with the tube pincher and thereby allow the bias force to pivot the tube pincher (108, 116) to a position in which the second tube (40) is pinched off.

2. The sequence valve of Claim 1 wherein the latch (126) has a latch tooth (130) and an arm (134), the latch having a first latch position in which the latch tooth holds the tube pincher and having a second latch position in which the latch tooth is out of engagement with the tube pincher, and wherein the solenoid (138) has a plunger (136) for engaging the arm (134) of the latch in the first latch position to hold the latch and for moving out of engagement with the arm (134) of the latch in the first position to hold the latch and for moving out of engagement with the arm (134) in response to the control signal to release the latch.

3. The sequence valve of Claim 1 or Claim 2 and further comprising:

contact means (152) for contacting a first switch element (154) when the tube pincher is in the first position in which the first tube (30) is pinched off and for contacting a second switch element (156) when the tube pincher is in the second position in which the second tube (40) is pinched off to provide signals representative of the position of the tube pincher.

4. The sequence valve of any one of Claims 1 to 3 wherein the tube pincher (108, 116) comprises:

a pivotable crank (116); and

an occluder stud (108) conected to the crank (116) for pinching off one of the first and second tubes (30, 40) depending upon the position of the crank (116); and

wherein the bias means (120) comprises a bias spring for applying the bias force to the crank (116).

5. The sequence valve of Claim 4 and further comprising a channel in which the tubes (30, 40) are positioned in side-by-side relationship and wherein the occluder stud (108) extends into the channel between the first and second tubes and is movable in a generally transverse direction as the crank (116) moves.

6. The sequence valve of Claim 5 and further comprising tube retaining means (102; 200) positioned at a first end of the channel for holding the first and second tubes in position in the channel.

Patentansprüche

1. Folgeschaltventil (18) mit einem ersten Zustand, in dem ein erster Schlauch (30) abgesperrt ist und ein zweiter Schlauch (40) nicht abgesperrt ist, und mit einem zweiten Zustand, in dem der zweite Schlauch (40) abgesperrt und der erste Schlauch (30) nicht abgesperrt ist, wobei das Folgeschaltventil in den ersten Zustand setzbar ist und auf Grund eines Steuersignals in den zweiten Zustand schaltet, und wobei das Folgeschaltventil umfaßt:

(a) einen schwenkbaren Schlauchquetscher (108, 116) zum Abquetschen des ersten Schlauches (30), wenn sich das Ventil im ersten Zustand und der Schlauchquetscher in einer ersten Stellung befindet, und zum Abquetschen des zweiten Schlauches (40), wenn sich das Ventil im zweiten Zustand und der Schlauchquetscher in einer zweiten Stellung befindet;

gekennzeichnet durch

(b) Vorbelastungsmittel (120) zum Ausüben einer Vorbelastungskraft auf den Schlauchquetscher (108, 116) in einer Richtung zu der zweiten Stellung hin;

(c) eine mit dem Schlauchquetscher (108, 116) verbundene, handbewegbare Einrichtung (100) zum Bewegen des Schlauchquetschers gegen die Vorbelastungskraft in die erste Stellung, in der der erste Schlauch (30) abgequetscht ist,

(d) ein schwenkbares Sperrglied (126) zum Angreifen an dem Schlauchquetscher und zum Halten desselben in der ersten Stellung, in der der erste Schlauch (30) abgequetscht ist, und

(e) einen Elektromagneten (138) zur Freigabe des Sperrgliedes (126) auf Grund des Steuersignals für ein Verschwenken des Sperrgliedes von dem Schlauchquetscher weg, so daß die Vorbelastungskraft den Schlauchquetscher (108, 116) in eine Stellung verschwenken kann, in der der zweite Schlauch (40) abgequetscht ist.

2. Folgeschaltventil nach Anspruch 1, dadurch gekennzeichnet, daß das Sperrglied (126) einen Sperrzahn (130) und einen Arm (134) hat und eine erste Sperrgliedstellung besitzt, in der der Sperrzahn den Schlauchquetscher hält, und eine zweite Sperrgliedstellung, in der der Sperrzahn von dem Schlauchquetscher abgerückt ist, und daß der Elektromagnet (138) einen Tauchanker (136) zum Angriff an dem Arm (134) des in der ersten Sperrgliedstellung befindlichen Sperrgliedes zum Halten des Sperrgliedes und zum Abrücken von dem Arm (134) des in der ersten Stellung befindlichen Sperrgliedes zum Halten des Sperrgliedes und zum Abrücken von dem Arm (134) auf Grund des Steuersignals unter Freigabe des Sperrgliedes hat.

3. Folgeschaltventil nach Anspruch 1 oder 2, mit einer Kontakteinrichtung (152) zum Kontaktieren eines ersten Schaltelements (154), wenn sich der Schlauchquetscher in der ersten Stellung befindet, in der der erste Schlauch (30) abgequetscht ist, und zum Kontaktieren eines zweiten Schaltelements (156), wenn sich der Schlauchquetscher in der zweiten Stellung befindet, in der der zweite Schlauch (40) abgequetscht ist, so daß die Stellung des Schlauchquetschers anzeigende darstellende Signale erzeugt werden.

4. Folgeschaltventil nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß der Schlauchquetscher (108, 116)

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eine schwenkbare Kurbel (16) und einen mit der Kurbel (116) verbundenen Absperrbolzen (108) zum Abquetschen des ersten und des zweiten Schlauches (30, 40) in Abhängigkeit von der Stellung der Kurbel (116) umfaßt, und daß die Vorbelastungseinrichtung (120) eine Vorbelastungfeder zum Ausüben der Vorbelastungskraft auf die Kurbel (116) aufweist.

5. Folgeschaltventil nach Anspruch 4 mit einem Kanal, in dem die Schläuche (30, 40) nebeneinander angeordnet sind, wobei sich der Absperrbolzen (108) zwischen dem ersten und dem zweiten Schlauch in den Kanal erstreckt und bei einer Bewegung der Kurbel (116) allgemein in einer Querrichtung bewegbar ist.

6. Folgeschaltventil nach Anspruch 5, mit einem Schlauch an einem ersten Ende des Kanals angeordneten Schlauchhalter (102; 200) zum Festlegen des ersten und des zweiten Schlauches in dem Kanal.

Revendications

1. Vanne séquentielle (18) ayant un premier état dans lequel un premier tube souple (30) est fermé et un deuxième tube souple (40) ne l'est pas et un deuxième état dans lequel le deuxième tube (40) est fermé et le premier tube (30) ne l'est pas, la vanne séquentielle pouvant être mise au premier état et passant au deuxième état en réponse à un signal de commande, la vanne séquentielle comprenant:

(a) un élément pivotant de pincement de tube (108, 116) pour fermer par pinçage le premier tube (30) lorsque la vanne est dans le premier état et l'élément de pincement de tube est dans une première position, et pour fermer par pinçage le deuxième tube souple (40) lorsque la vanne est dans le deuxième état et l'élément de pincement de tube est dans une deuxième position; caractérisée en ce qu'elle comprend:

(b) des moyens de rappel (120) pour appliquer une force de rappel à l'élément de pincement de tube (108, 116), en direction de la deuxième position;

(c) des moyens déplaçables manuellement (100) reliés à l'élément de pincement de tube (108, 116) pour amener l'élément de pincement de tube, contre la force de rappel, à la première position dans laquelle le premier tube (30) est fermé par pinçage;

(d) un verrou pivotant (126) pour venir en prise et retenir l'élément de pincement de tube dans la première position, dans laquelle le premier tube (30) est fermé par pinçage; et

(e) un solénoïde (138) qui libère le verrou (126) en réponse au signal de commande, pour permettre au verrou de pivoter et de se dégager de l'élément de pincement de tube, ce qui permet à la force de rappel de faire pivoter l'élément de pincement de tube (108, 116) à une position dans laquelle le deuxième tube (40) est fermé par pinçage.

2. Vanne séquentielle suivant la revendication 1, dans laquelle le verrou (126) comporte une dent de verrouillage (130) et un bras (134), le verrou ayant une première position de verrou, dans laquelle la dent de verrouillage retient l'élément de pincement de tube, et ayant une deuxième position de verrou dans laquelle la dent de verrouillage est dégagée de l'élément de pincement de tube, et dans laquelle le solénoïde (138) comporte un plongeur (136) qui vient en prise avec le bras (134) du verrou dans la première position de verrou pour retenir le verrou, et qui se dégage du bras (134) du verrou en réponse au signal de commande, pour libérer le verrou.

3. Vanne séquentielle suivant la revendication 1 ou la revendication 2, comprenant en outre:

des moyens de contact (152) pour fermer un premier élément interrupteur (154) lorsque l'élément de pincement de tube est dans la première position, dans laquelle le premier tube (30) est pincé, et pour fermer un deuxième élément interrupteur (156) lorsque l'élément de pincement de tube est dans la deuxième position dans laquelle le deuxième tube (40) est pincé, de manière à fournir des signaux représentatifs de la position de l'élément de pincement de tube.

4. Vanne séquentielle suivant l'une quelconque des revendications 1 à 3, dans laquelle l'élément de pincement de tube (108, 116) comprend:

un levier pivotant (116) et

une barrette d'occlusion (108) reliée au levier (116) pour fermer par pinçage l'un des premier et deuxième tubes (30, 40) selon la position du levier (116); et

dans laquelle les moyens de rappel (120) comprennent un ressort de rappel pour appliquer la force de rappel au levier (116).

5. Vanne séquentielle suivant la revendication 4, comprenant en outre un canal dans lequel les tubes (30, 40) sont placés côte à côte, et dans laquelle la barrette d'occlusion (108) s'étend dans le canal entre les premier et deuxième tubes et est mobile dans une direction sensiblement transversale lorsque le levier (116) se déplace.

6. Vanne séquentielle suivant la revendication 5, comprenant en outre des moyens de retenue de tube (102; 200) situés à une première extrémité du canal pour retenir les premier et deuxième tubes en position dans le canal.

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