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(54) Title: MULTIRATE TUBING FLOW RESTRICTOR

(57) Abstract: A flow control valve for medical liquid is disclosed. The valve has a housing including an inlet, an outlet, and a flow path therebetween. A plurality of flow restrictors are located in the flow path to define a plurality of flow streams of differing flow rates. A flow control member is disposed in the flow path, and has a plurality of discrete apertures in a first region or plane and at least one aperture in a second region or plane spaced apart from the first plane. The flow control member is rotationally movable and defines an annular gap and radial groove which provide fluid communication between the different planes and the outlet regardless of the orientation of the flow control member. The flow control member may be rotated between a first position in which one of the plurality of apertures in the first plane is in communication with one of the flow streams to define a first flow rate through the valve, and a second position in which one of the at least one aperture in the second plane is in communication with a different one of the flow streams to define a second flow rate through the valve different from the first flow rate.

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MULTIRATE TUBING FLOW RESTRICTOR

FIELD OF THE INVENTION

[0001] The present invention generally relates to a flow control valve for medical liquid, and more particularly to a multi-rate flow control device for dispensing a medical fluid at a selected one of a plurality of discrete flow rates.

BACKGROUND OF THE INVENTION

[0002] In the delivery of medical liquids, such as medication, drugs, chemotherapeutic agents, intravenous solutions or the like, it is known to use a flow control valve that permits the user to select a particular flow rate from a range of discrete flow rates. One such flow control valve, which uses glass capillary structures to control the flow rate, is described in U.S. Patent No. 6,273,133 entitled "Fluid Flow Rate Switching Device." The device shown there has two internal passageways, each with a glass capillary structure that limits flow through the passageway. A valve member directs fluid flow through either or both of the passageways to provide several different flow rates through the flow control device. While this device works satisfactorily, the use of glass capillary structures can add to the cost and there is a desire to have flow control devices with a greater selection of available flow rates. Although this is but one example, there continues to be a need for medical fluid flow control valves that address one or more of the drawbacks found in prior valves.

SUMMARY OF THE INVENTION

[0003] The present invention is embodied in a novel flow control device or valve that is relatively easily and inexpensively manufactured and provides a variety of flow rates for doctor or user selection. In one aspect of the present invention, a flow control valve for dispensing medical liquid is provided. The flow control valve includes a housing comprising an inlet, an outlet, and a flow path therebetween. A plurality of flow restrictors in the flow path define a plurality of flow streams of differing flow rates. A flow control member is disposed in the flow path and has at least one aperture disposed in a first plane and at least one aperture disposed in a second plane which is spaced apart from the first plane. The flow control member is movable relative to the housing between a first position and at least one second position. In the first position, one of the at least one apertures in the first plane is in communication with at least one of the flow streams to define a first flow rate through the valve. In the second position, one of the at least one apertures in the second plane is in communication with a different one of the flow streams to define a second flow rate through the valve different from the first flow rate.

[0004] In a second aspect of the present invention, a flow control valve for dispensing medical liquid is also provided. The flow control valve includes a housing comprising an inlet, an outlet, and a flow path therebetween. A plurality of flow regulators disposed in the flow path define a plurality of differing flow rates. A first of the plurality of flow regulators is defined by a tube of a first selected size. A second of the plurality of flow regulators is defined by a tube of a second selected size which is different from the size of the first flow regulator. A flow control member disposed in the

flow path has at least one discrete aperture at each of a first and second spaced apart locations. The flow control member is movable relative to the housing between a first position and a second position and defines an annular gap which is in communication with the outlet. In the first position, one aperture in the first location is in communication with one of the flow regulators to define a first flow rate through the valve. In the second position, one aperture in the second location is in communication with a different one of the flow regulators to define a second flow rate through the valve which is different from the first flow rate.

[0005] The flow control member of the valve in this aspect of the invention is rotatable between at least a first and second position. In the first position, one of the plurality of apertures in the first plane is in communication with the first opening in the annular wall to define a first flow rate through the valve. In the second position, one of the plurality of apertures in the second plane is in communication with the second opening in the annular wall to define a second flow rate through the valve that is different from the first flow rate.

[0006] In a fourth aspect of the invention, a flow control valve for dispensing medical liquid is provided. The flow control valve includes a housing comprising an inlet, an outlet, and a flow path therebetween. The housing includes an annular wall defining an interior bore and first and second axially spaced-apart openings extending through the annular wall. Within the interior bore, a flow control member is rotatably disposed and has a plurality of discrete apertures in each of a first and second plane.

[0007] The flow control member in this fourth aspect of the invention also defines a portion of a passageway that extends in a direction generally normal to at least one of

the first and second planes and communicates with the discrete apertures and one of the inlet and outlet regardless of the position of the flow control member.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0008] Figure 1 is a perspective view of one embodiment of a flow control device employing the present invention;
- [0009] Figure 2 an exploded perspective view of the view of the flow control device of Figure 1.
- [0010] Figure 3 is an end view of the flow control device of Figure 1.
- [0011] Figure 4 is a cross-sectional view of the flow control device of Figure 1 taken through line 4-4 of Figure 3.
- [0012] Figure 4A is a broken away, perspective of a portion of Figure 1, showing the inlet diverging into three separate flow restrictors or tubes.
- [0013] Figure 5 is a cross-sectional end view of the flow control device of Figure 4 taken through line 5-5.
- [0014] Figure 6 is a top view of the base of the flow control device of Figure 2.
- [0015] Figure 7 is a side view of the base of the flow control device illustrated in Figure 6.
- [0016] Figure 8 is a cross-sectional view of the base of the flow control device of Figure 6, taken through line 8-8.
- [0017] Figure 9 is a cross-sectional, end view of the base of the flow control device of Figure 6, taken through line 9-9.
- [0018] Figure 10 is a side view of the flow control member of Figure 1.
- [0019] Figure 11 is a top view of the flow control member of Figure 10.
- [0020] Figure 12 is a bottom, plan view of the flow control member of Figure 10.

[00021] Figure 13 is a cross-sectional view of the flow control member of Figure 11 taken along line 13-13.

[00022] Figure 14 is a cross-sectional view of the flow control member of Figure 13 taken along line 14-14.

[00023] Figure 15 is a cross-sectional view of the flow control member of Figure 13 taken along line 15-15.

[00024] Figure 16 is a cross-sectional view of the flow control member of Figure 13 taken along line 16-16.

[00025] Figure 17 is a cross-sectional view of the flow control member of Figure 13 taken along line 17-17.

[00026] Figure 18 is a top view of portion of the housing of the flow control device of Figure 1.

[00027] Figure 19 is an interior view of the inlet end of the flow control device of Figure 8, taken along line 19-19, with the tubes removed.

[00028] Figure 20 is a cross-sectional view of Figure 19 taken through line 20-20.

[00029] Figure 21 is a top view of a tool used to adjust the intended position of the flow control member of the flow control device of Figure 1.

[00030] Figure 22 is a side, cross-sectional view of the tool of Figure 21 taken along line 22-22.

[00031] Figure 23 is a cross-sectional, end view of the tool of Figure 22 taken along line 23-23.

[00032] Figure 24A is a diagram which pictorially illustrates an expanded view of a generally cylindrical side wall of the flow control member identifying the component flow

streams that are in communication with the outlet at different positions of the flow control member in the flow control device of Figure 1.

[00033] Figure 24B is a top view of the flow control member with superimposed indicator lines showing each of the different rotational positions which the flow control member in the flow control device of Figure 1, corresponding to the arrangement of the apertures for the flow streams shown in Figure 24A.

WRITTEN DESCRIPTION

[00034] Referring to Figure 1, the present invention is generally embodied in a flow control device, generally at 30. The flow control device 30 includes a housing 32 having an inlet 34 and an outlet 36, and a flow path defined between the inlet and outlet. The embodiment shown in the drawings is for purpose of illustration only, and it should be understood that the form and features of the flow control device of the present invention may vary according to the desired application or intended function. The scope of this invention is as defined in the claims now or hereafter submitted and, except to the extent included in such claims, is not limited to any specific form, feature or function described herein.

[00035] As shown in Figure 2, in exploded view, the illustrated flow control device 30 includes a base or bottom portion 38, a top and side portion 40 and an end portion 42. The housing is preferably made of rigid molded plastic, although other suitable materials may also be used.

[00036] The flow control device of the present invention preferably includes a movable flow control member associated with the housing to control flow therethrough. In the illustrated embodiment, the base 38 has an upstanding, generally cylindrical or annular wall 44, which forms a generally cylindrical interior bore 46 for receiving a rotating flow control member or valve element 48 that serves, in part, to control the flow rate of fluid through the housing. As best seen in Figures 2, 4 and 5, a plurality of axially spaced-apart apertures or ports 50a, 50b and 50c extend through the annular wall 44. Outlet 36 also includes an aperture or port 52 extending through wall 44.

[00037] A length of plastic tubing 54a, 54b, 54c of selected size extends between each aperture 50a, 50b and 50c and the inlet 34. Each tube is of a different size, diameter and/or length, to act as a flow restrictor or a flow setter to create a fluid flow stream having a selected flow rate different than the flow rate in the other tubes. For example, under the normal pressure exhibited by an elastomeric pump in the flow administration of IV solution to a patient, tube 54a is sized to provide a flow stream with a flow rate of 1.0 ml/hr between the inlet port and aperture 50a, tube 54b is sized to provide a flow stream with a flow rate of 2.0 ml/hr between the inlet port and aperture 50b, and tube 54c is sized to provide a flow stream with a flow rate of 4.0 ml/hr between the inlet port and aperture 50c. In a preferred embodiment the 1.0ml/hr tubing has an ID of .0021 inches and a length of 3.67 inches, the 2.0 ml/hr tubing has an ID of 0.0031 inches and a length of 3.65 inches and the 4.0 ml/hr tubing has an ID of 0.0036 inches and a length of 3.20 inches. It should be understood that tubings having different ID's and lengths may be employed to get the illustrated flow rates or other desired flow rates. It is apparent that use of a tubing having a smaller diameter and/or longer length would yield a tubing which provides a flow stream of 0.5 ml/hr.

[00038] Although illustrated with three different tubes, additional or fewer tubes may also be used. Also, structures other than tubing may be employed to function as flow restrictors or flow setters, including orifices, molded passageways, and the like. Tubing, however, is relatively easy to extrude and bond to the respective ports or apertures, and thus serves to minimize manufacturing cost.

[00039] In accordance with the present invention, a plurality of selected discrete flow rates may be provided through the flow control device by selectively allowing flow

from one or more of the flow restrictor tubings to pass through the housing. In the illustrated device, this flow control is provided by the flow control or valve member 48, which is best seen in Figures 10-17, in cooperation with the features described above.

[00040] As shown in Figures 10 and 13, the flow control member is generally hollow and cylindrical, and made of molded plastic or other suitable material. The flow control member has an exterior surface of generally uniform diameter except for an enlarged annular collar 56 at one end and an annular groove or channel 58 at the other end. "Uniform diameter" is intended to include a surface having a slight taper, such as a molding draft angle or taper, on either or both of the control member 48 and inner surface of bore 46. The illustrated flow control member has one or more apertures in each of a plurality of axially spaced apart regions or planes. In the illustrated valve member, there are four such regions or planes, generally shown in Figures 14-17, although the number can vary. At least one of the planes, however, includes a plurality of apertures.

[00041] More specifically, Figure 14 is a cross-sectional view taken along line 14-14 of Figure 13, which is generally perpendicular to the axis 60 of the flow control member 48. For purposes of this description this will be referred to as region or plane 14-14. As evident from Figures 13 and 14, plane 14-14 extends through the annular groove 58, and has a single aperture 62. As will be described in more detail later, when assembled in the housing, annular groove 58 is in registration (fluid communication) with outlet port aperture 52 regardless of the orientation of the flow control member 48.

[00042] Using the same terminology, plane 15-15 is located at the other end of the flow control member 48. As seen in Figure 15, this region or plane contains four

apertures 64, circumferentially spaced apart 90°, and are oriented (in a clockwise direction from the 9 o'clock position) at the 45°, 135°, 225° and 315° positions. As best seen in Figure 16, plane or region 16-16 of Figure 13 also includes four apertures 66, which are oriented (in a clockwise direction from the 9 o'clock position), at the 45°, 90°, 225° and 270° positions. Plane 17-17 of Figure 13 is located between planes 14-14 and 16-16. As shown in Figure 17, this plane or region includes four apertures 68, which are oriented (in a clockwise direction from the 9 o'clock position) at the 0°, 225°, 270° and 315° positions.

[00043] As noted earlier, and as best seen in Figure 4, the flow control member 48 is rotatably received within the bore 46 defined in the base portion 38 of the housing 32. The flow control member 48 is sized so that it is in relatively liquid tight interference fit with the inner surface of bore 46. More specifically, the fit between the outside surface of the flow control member 48 and inner surface of bore 46 should preferably be sufficiently liquid tight so that there is no substantial fluid flow or leakage between the surfaces, either between apertures 50a – 50c or between apertures 50a – 50c and the outlet aperture 62. The fit however cannot be so tight that the flow control member 48 may not be rotated with the typical force which may be applied to the member. Thus a leakage tight fit is provided without the use of O-rings or other typical rotational seals which would increase the complexity of manufacture and cost.

[00044] When fully inserted into the bore, the annular groove 58 of the flow control member is aligned with outlet port aperture 52, and planes 15-15, 16-16 and 17-17 are each aligned, respectively, with one of the apertures 50a, 50b and 50c through the cylindrical wall 44. By rotating flow control member, one or more of the apertures

64, 66 and 68 in each plane or region can be brought into registration or alignment (flow communication) with any of the respective apertures 50a, 50b, 50c, through which the flow stream passes from one of the flow restrictor tubings 54a, 54b and 54c.

[00045] To stabilize the flow control member and aid assembly, the housing base 38 includes a center cylindrical support member 70 within bore 46. When assembled, the support member extends through the center of the flow control member 48. The upper end of the support member 70 is tapered at 72 to engage a matching internal taper 74 in the flow control member to assist in assembly and centering alignment.

[00046] The outside diameter of the support member 70 is smaller than the inside diameter of flow control member 48 and, as a result, an annular flow path 76 in the form of an annular region or gap is defined between them. In the illustrated orientation, this flow path 76 extends axially or vertically between the support member 70 and flow control member 48 through each of the horizontal regions or planes 14-14 through 17-17. Thus, fluid flowing through any of the apertures in planes 15-15 through 17-17 is combined in and conducted through the flow path 76 defined between support member and flow control member and directed to aperture 62 (in plane 14-14).

[00047] The outer diameter of the support member 70 and inside diameter of the control member 48 are preferably sized to provide several desired benefits. One such benefit is to define a flow path which does not provide an appreciable resistance to flow but also define a volume which is low to minimize priming and residual volume. Because of the typical low flow rates, the larger the volume the longer the time to prime, and the larger the volume of fluid that is not dispensed to the patient. A second benefit is that the thickness of the tubular walls of the control member 48 may be controlled

such that it may be molded with tight tolerances to provide the fluid tight interference fit with the bore 46 as described above. It has been found that if the thickness is too great, it is harder to maintain the tolerance of the outer diameter of the control member 48 to provide the desired interference fit.

[00048] Another benefit of the flow control member 48 is the placement of an aperture 62 that communicates in all rotational positions, via annular groove 58, with outlet port aperture 52. Thus in a preferred embodiment regardless of the orientation of the flow control member 48 to provide a desired communication with none, one or more of the apertures 50, the outlet port aperture 52 is always in communication with the annular flow path 76.

[00049] As best seen in Figures 2 and 4, when assembled, the upper annular collar 56 of the flow control member is captured between an internal shoulder 78 of bore 46 and the top wall of the housing. To rotate the flow control member to selected flow positions, the upper end of the flow control member is accessible through an opening 80 in the upper wall of the housing (see Fig. 2). The upper end of the flow control member defines a recess 82 of selected shape, such as square, triangular or other cross-sectional to interfit with a complementary – shaped end 84 of tool 86 to allow the clinician or health care worker to rotate the flow control member. Preferably the recess 82 is located recessed or below the upper wall of the housing to prevent inadvertent or unauthorized turning of the flow control member by one who does not possess the tool 86.

[00050] Referring in particular to Figs 4 and 10, the flow device 30 (Fig. 1) includes means for imparting a tactile sensation to the setting of the desired flow rate. In

particular the upper annular collar 56 includes a series of detents 57 radially spaced about the upper surface of the collar. These detents 57 register with a downwardly projecting bump 59 on the top portion 40 to preferably impart a tactile and audible indication that the flow control member 48 is properly oriented to provide the desired flow rate. The flow rates may also be depicted on the top portion 40 as is illustrated in Fig. 2.

[00051] By way or example when the flow rates provided by the flow restrictor tubing 54a is 0.5 ml/hr; by flow restrictor tubing 54b is 1.0 ml/hr and by flow restrictor tubing 54c is 2.0 ml/hr and as depicted in Figures 24A and 24B, the illustrated flow control device provides seven specific discrete flow rates, in addition to an "off" position. Figure 24B shows eight different rotational positions of the flow control member, each designated by a letter A – H. The graph or chart in Figure 24A diagrammatically shows which apertures in the flow control member are in communication with which of the flow restrictor tubing in each of the rotational positions. With these example provided restrictor flow tubing, in position A, one of the apertures 64 in plane 15-15 communicates with aperture 50a and the flow restrictor tubing 54a, thereby providing a flow rate of 0.5 ml/hr. No aperture in planes 16-16 or 17-17 communicates with the other flow restrictor tubing. The resultant flow rate through the valve is therefore 0.5 ml/hr.

[00052] In position B of Figure 24B, one of the apertures in plane or region 16-16 is in alignment or registration with aperture 50b, which is connected to the flow restrictor tubing 54b, thereby providing a flow rate of 1.0 ml/hr. The apertures 64 and 68 in

planes 15-15 and 17-17 are out of registration or alignment with ports 50a and 50c, so that no fluid flows through them, and the total flow rate through the valve is 1.0 ml/hr.

[00053] In position C, one of apertures 64 and one of apertures 66 in planes 15-15 and 16-16 are in alignment or registration with ports 50a and 50b, respectively, which are connected to restrictor tubing 54a and 54b. None of the apertures 68 in plane 17-17 is in communication with port 50c. Thus, the flow rate through the valve is the combined flow of 0.5 ml/hr and 1.0 ml/hr through ports 50a and 50b for a total flow rate of 1.5 ml/hr.

[00054] The chart in Figure 24A may be followed in similar fashion to see that at position D, flow is only allowed through one of apertures 68 in plane 17-17, at 2.0 ml/hr. In position E, flow is allowed through apertures 64 and 68 in planes 15-15 and 17-17 (0.5 ml/hr and 2.0 ml/hr) for a combined flow rate through the valve of 2.5 ml/hr. In position F, flow is allowed through apertures 66 and 68 in planes 16-16 and 17-17 (1.0 ml/hr and 2.0 ml/hr) for a combined flow rate of 3.0 ml/hr. In position G, flow is permitted through one of the apertures 64, 66 and 68 in each of planes 15-15, 16-16 and 17-17 (0.5 ml/hr, 1.0 ml/hr and 2.0 ml/hr) for a total flow through the device of 3.5 ml/hr.

[00055] At position H and between each of the other positions, no aperture in planes 15-15, 16-16 or 17-17 is in communication with its respective port or flow restrictor tubing and there is essentially no flow through the flow control device.

[00056] Although the flow control device is illustrated in its preferred form, many variations are possible without departing from the present invention. For example, additional flow restrictors and flow streams could be provided to offer different flow

rates. Also, while in the illustrated embodiment of the present invention, a fluid stream is described as entering the flow control valve through the inlet 34 and exiting through the outlet 36, it should be understood that the illustrated flow control valve is equally suitable in situations where a fluid stream enters the valve through the outlet 36 and exits the valve through the inlet 34. Therefore, as used herein, "inlet" and "outlet" are interchangeable and are used only as a naming convention. Thus, the scope of the present invention as described and claimed herein and hereafter is intended to encompass all such operable flow control valves or devices regardless of the name of the part or passage through which fluid enters or leaves the flow control valve.

What is claimed is:

1. A flow control valve for medical liquid comprising:
 - a housing including an inlet, an outlet, and a flow path therebetween;
 - a plurality of flow restrictors in the flow path to define a plurality of flow streams of differing flow rates;
 - a flow control member disposed in the flow path, the flow control member having a plurality of discrete apertures in a first plane and at least one aperture in a second plane spaced apart from the first plane, the flow control member and housing being relatively movable between a first position in which one of the plurality of apertures in the first plane is in communication with one of the flow streams to define a first flow rate through the valve, and a second position in which one of the at least one aperture in the second plane is in communication with a different one of the flow streams to define a second flow rate through the valve different from the first flow rate.
2. A flow control valve in accordance with claim 1 wherein the flow control member is rotationally received within the housing.
3. A flow control valve in accordance with claim 1 wherein the flow control member includes a plurality of apertures in the second plane.

4. A flow control valve in accordance with claim 3 wherein the flow control member is movable to a position in which of the plurality of apertures in the first plane is in communication with one of the flow streams and one of the plurality of apertures in the second plane is in communication with a different one of the flow streams such that the flow rate through the valve is the sum of the flow rates of one and other fluid streams.
5. A flow control valve in accordance with claim 1 wherein the flow control member has an engagement region of selected shape for engagement with a complimentary shaped tool to change the flow rate of liquid through the valve.
6. A flow control valve in accordance with claim 5 wherein the engagement region of the flow control member is disposed to restrict tampering with the position of the flow control member.
7. A flow control valve in accordance with claim 3 wherein there are a plurality of discrete apertures in each of the first and second planes, each aperture being circumferentially spaced apart within each of their respective planes to provide a plurality of flow rates through the valve.
8. A flow control valve for medical liquid comprising:
a housing including an inlet, an outlet, and a flow path therebetween;

a plurality of flow regulators disposed in the flow path to define a plurality of differing flow rates wherein a first flow regulator is defined by a tube of a first selected size and a second flow regulator is defined by a tube of a second selected size which is different from the size of the first flow regulator;

a flow control member disposed in the flow path, the flow control member having at least one discrete aperture at each of a first and second spaced apart locations, the flow control member and housing being relatively movable between a first position in which one aperture in the first location is in communication with one of the flow regulators to define a first flow rate through the valve, and a second position in which one aperture in the second location is in communication with a different one of the flow regulators to define a second flow rate through the valve different from the first flow rate.

9. A flow control valve in accordance with claim 8 wherein the tube defining the first flow regulator has at least one of a different inside diameter and different length of the tube defining the second flow regulator.

10. A flow control valve in accordance with claim 8 wherein the tube defining the first flow regulator has a different length than the tube defining the second flow regulator.

11. A flow control valve in accordance with claim 8 wherein at least one of the tubes defining the flow regulators are fully enclosed with the housing.

12. A flow control valve in accordance with claim 8 wherein the housing comprises a first chamber in which the tubes are located and a second chamber containing the flow control member.

13. A flow control valve for medical liquid comprising:

a housing including an inlet, an outlet, and a flow path therebetween;

the housing including an annular wall defining an interior bore and first and second axially spaced-apart openings extending through the annular wall;

a flow control member rotatably disposed within the interior bore and having a plurality of discrete apertures in a first plane and a plurality of discrete apertures in a second plane;

a plurality of tubes, the tubes comprising a first tube having a first size and communicating at one end with one of the inlet or outlet and at the other end with the first opening in the annular wall and a second tube having a size different from the first tube and communicating at one end with the one of the inlet or outlet and at the other end with the second opening in said annular wall;

the flow control member being rotatable between at least a first position and a second position, in said first position one of the plurality of apertures in the first plane being in communication with the first opening in said annular wall to define

a first flow rate through the valve and in said second position one of the plurality of apertures in the second plane being in communication with the second opening in said annular wall to define a second flow rate through the valve different from the first flow rate.

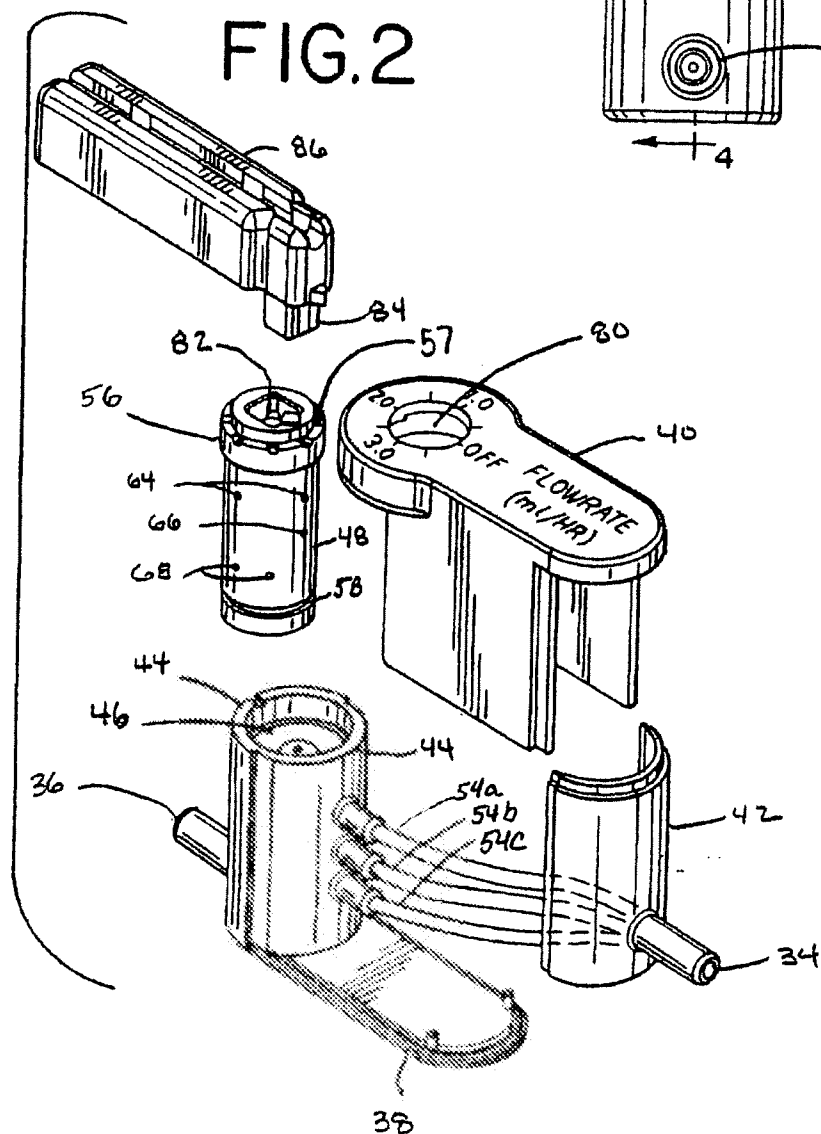
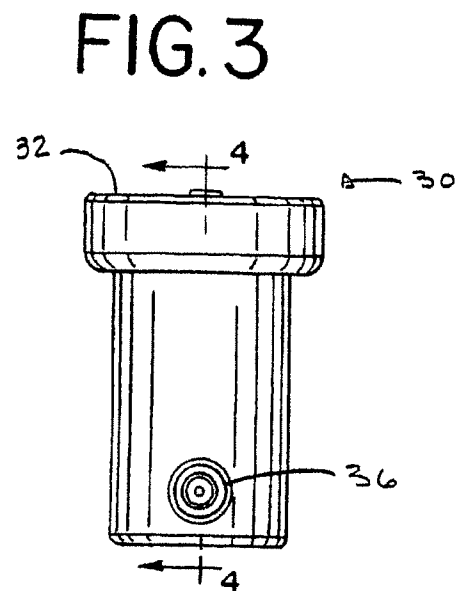
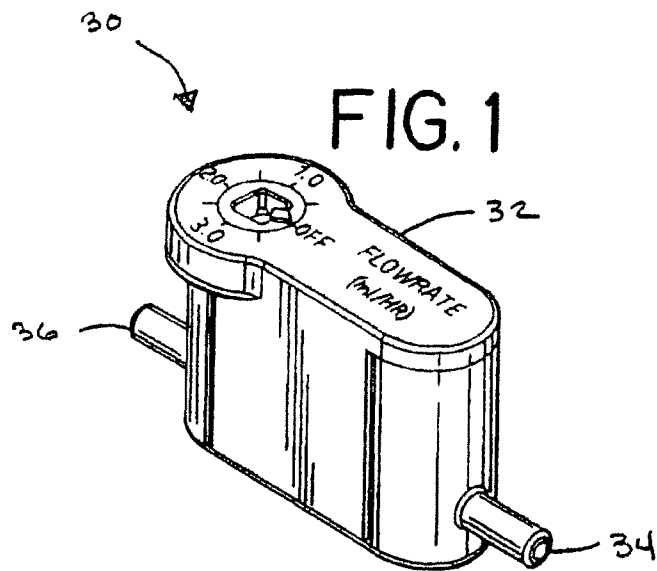
14. A flow control valve in accordance with claim 13 wherein one of the apertures on in the second plane is in communication with the second opening when the flow control member is in the first position.

15. A flow control valve in accordance with claim 13 wherein none of the apertures in the second plane is in communication with the second opening when the flow control member is in the first position.

16. A flow control valve in accordance with claim 13 wherein any fluid flow through the apertures in the first and second openings is combined before flowing through the other of the inlet or outlet.

17. A flow control valve in accordance with claim 1 wherein the flow control member defines at least one aperture in a third plane spaced apart from the first plane and the second plane.

18. A flow control valve in accordance with claim 13 wherein the flow control member defines at least one aperture in a third plane spaced apart from the first plane and the second plane.



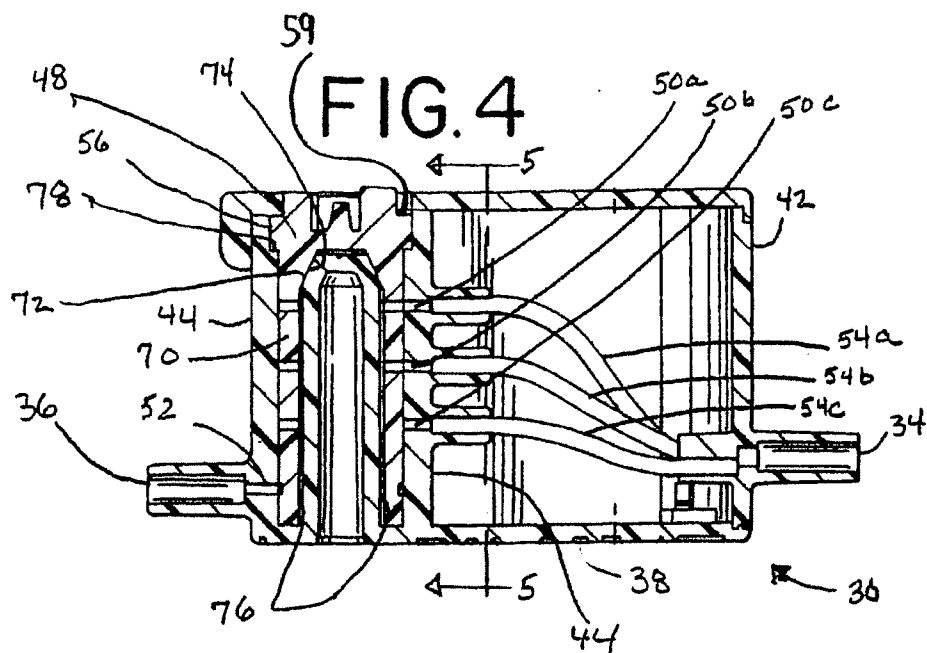


FIG. 4A

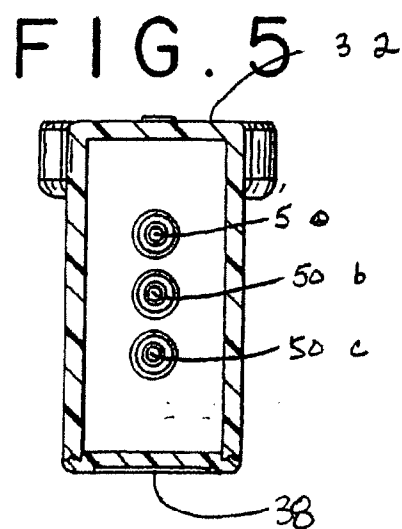
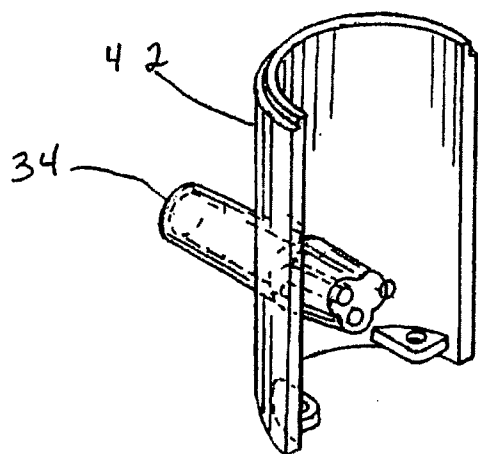


FIG. 6

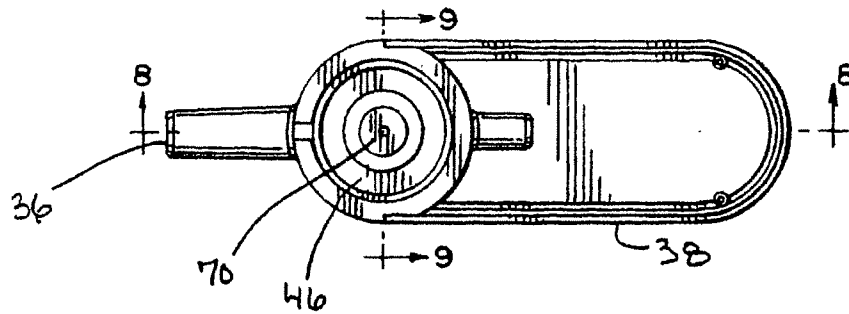


FIG. 7

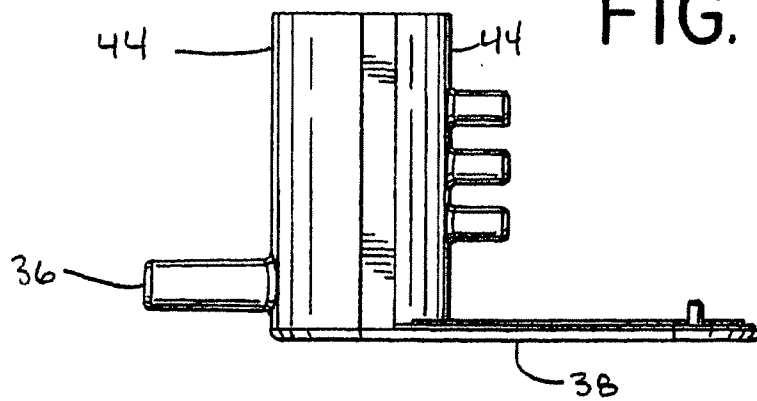


FIG. 8

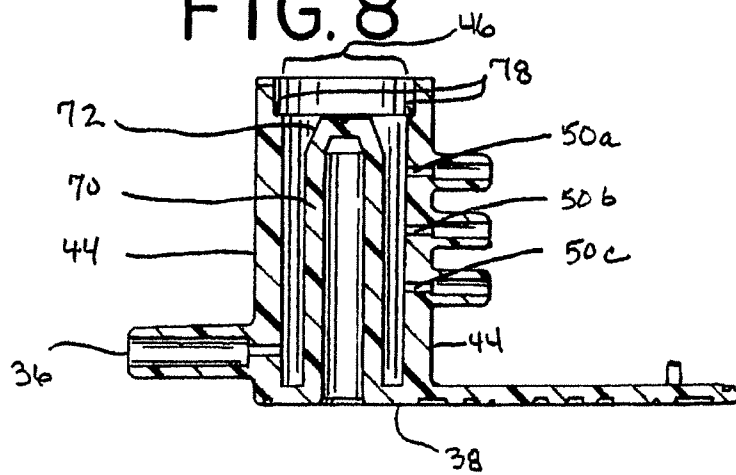
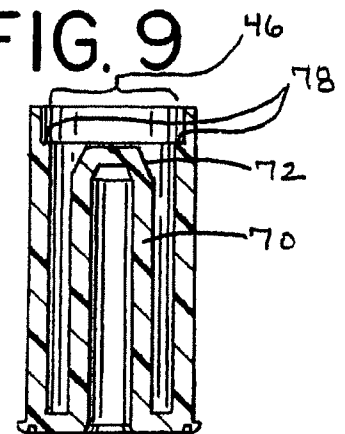
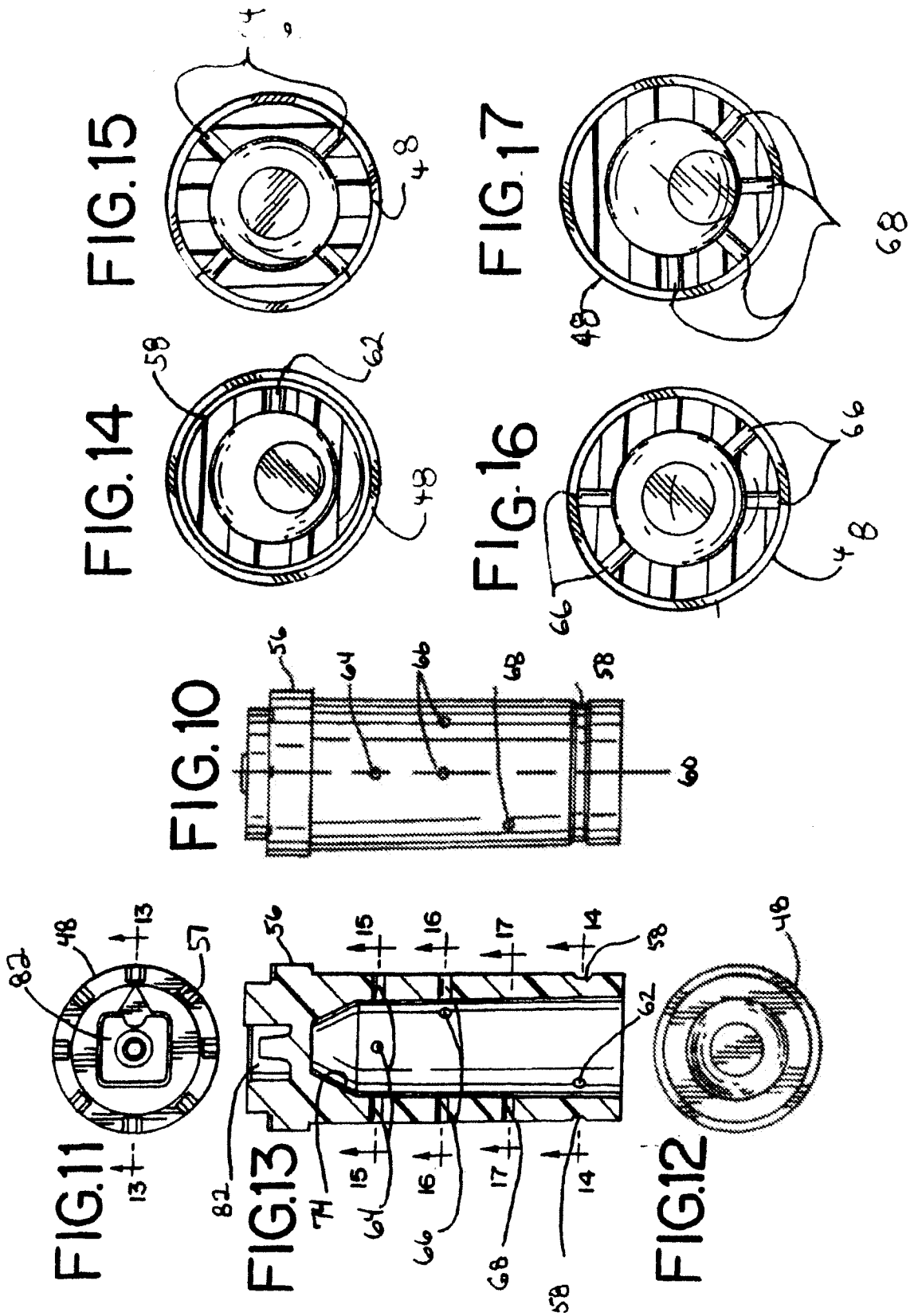


FIG. 9





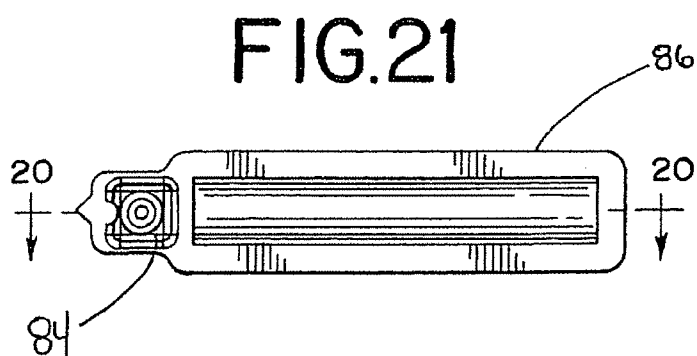
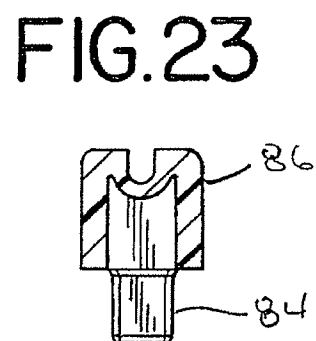
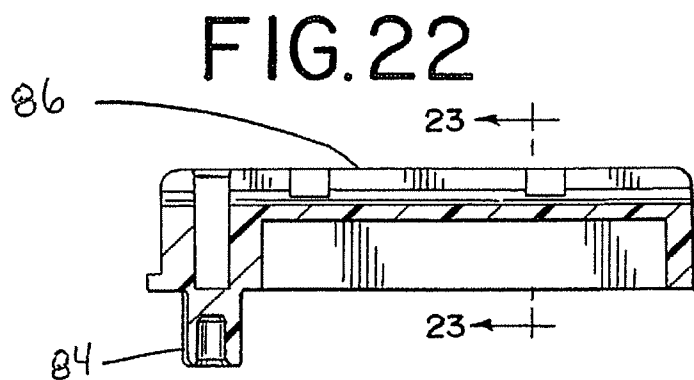
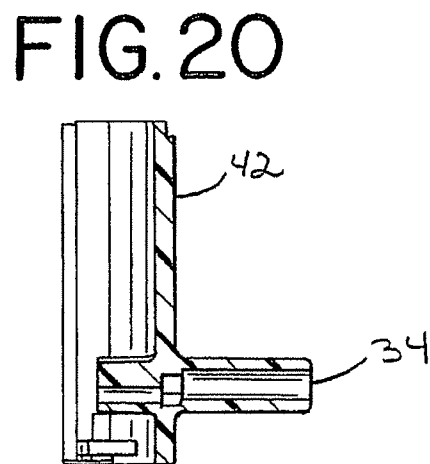
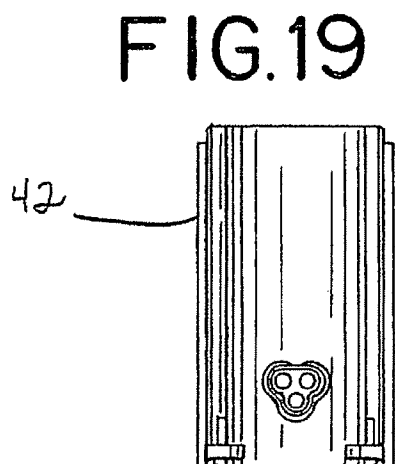
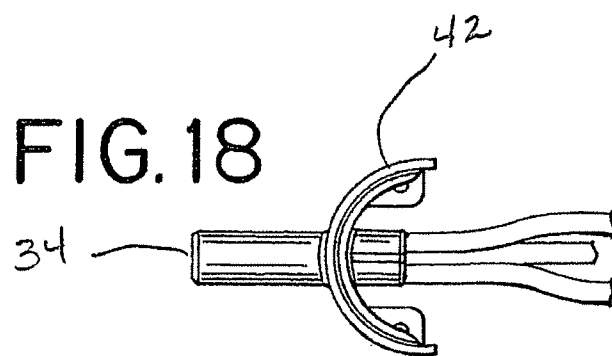


FIG. 24A

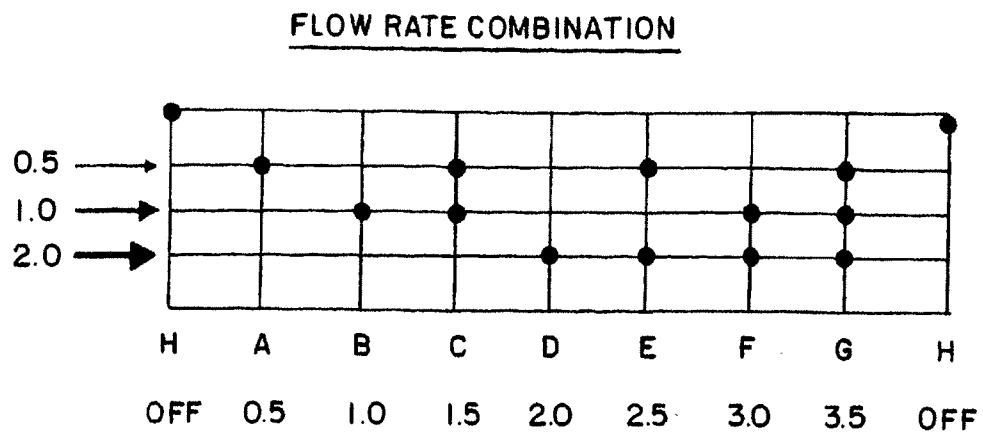


FIG. 24B

