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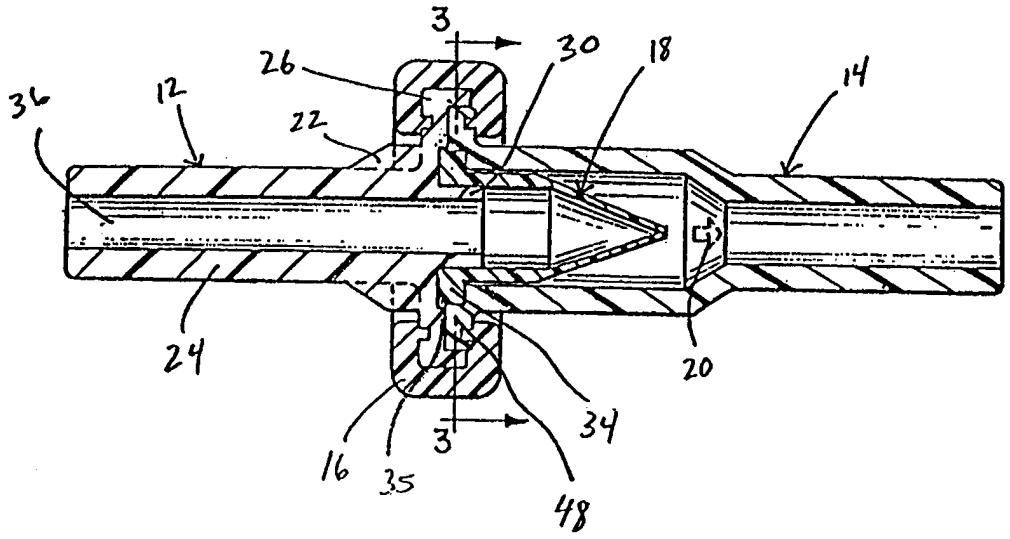

(57) Abstract

A valve (18) includes an inlet (12) and outlet (14) housing, a flexible one-way valve (18), and a collar (30). The flexible valve (18) is locked between the housings (12, 14). The collar (30) is attached to the inlet housing (12) and extends into the flexible valve (18). As fluid flows through the valve (18), the collar (30) supports the flexible valve (18) and prevents collapse due to back flow pressure.

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VALVE APPARATUS AND METHOD

FIELD OF THE INVENTION

The present invention relates to an improved check valve and process of manufacturing the same. More specifically, the invention relates to a check valve having a collar portion to support and prevent collapse of a flexible valve during usage.

BACKGROUND OF THE INVENTION

Check valves are well known in a variety of industries, including the medical industry. The purpose of such units is to allow blood or other fluids, including gases and liquids, to flow in only one direction. Under normal operating conditions the flow is prevented from reversing itself. Under certain conditions, however, back pressure may build up to a level which may cause the check valve to collapse and fail.

In the medical field, for example, check valves are used in kidney dialysis machines which filter a patient's blood of waste products and excess water, and return the blood to the body. Normally, patients would check into the hospital three times a week to have their blood artificially cleaned. Check valves used in existing in-hospital dialysis machines are normally replaced after each use. Recent development in dialysis products now allow a patient to use a home dialysis system. This enables the patient to use the dialysis machine on a daily basis to help the patient's overall health and quality of life. In some dialysis machines, the components may be sanitized in place with steam. This requires the check valve components to withstand temperatures of 85°C. Many existing check valves would degrade under these high temperatures.

Check valves commonly include an inlet and outlet housing made of molded plastic and a flexible one-way or duckbill valve made of rubber or silicone. The flexible valve is aligned and secured between the housings. As fluid is passed through the check valve, a variety of conditions may cause back pressure to build up, causing the flow to attempt to reverse its direction. Existing check valves may fail due to collapse of the flexible duckbill valve, which may actually invert itself and allow the back flow of fluid to pass through the inlet. The flexible valve may also pull away from its original secured position between the housings. Accordingly, it would be desirable to have a check valve design that would withstand high back pressure spikes which commonly occur during usage.

SUMMARY OF THE INVENTION

One aspect of the invention provides a valve apparatus including an inlet housing member including an opening and a support portion, an outlet housing member including an opening and a support portion, and a collar extending from the support portion and including an opening in communication with the inlet housing member. The collar is configured to allow a flexible valve to be positioned over the collar portion. The apparatus may further include a flexible valve, preferably a duckbill valve, positioned over the collar portion. Preferably, the base portion of the duckbill valve is secured between the inlet housing and outlet housing, and the housings are sealed with an overmold band. The collar may extend into the duckbill valve at least about one sixth of the length of the duckbill valve. Preferably, the collar extends into the duckbill valve a distance sufficient to prevent collapse of the duckbill valve under pressure spikes of at least about four times normal back pressures, which for hemodialysis check valves may reach 30psi. Preferably, the housing is made of a high density thermoplastic resin capable of withstanding temperatures in the range of 85°C, which is required for steam sanitation.

Another aspect of the invention provides for a method of operating the valve apparatus. A housing having an opening formed therein and a collar portion inside the housing and aligned with the opening is provided. A flexible valve fitted over the collar portion is also provided. A fluid is flowed through the opening and through the flexible valve. The valve is subjected to back pressure. The collar supports the flexible valve to prevent the back pressure from collapsing the valve.

Another aspect of the invention provides a valve apparatus including an inlet housing, an outlet housing, a flexible one-way valve, and a collar. The inlet housing includes a cylindrical shaft portion, a circular support portion, and an opening formed in the inlet housing. The outlet housing includes a cylindrical end portion, a valve housing portion, a base portion and an opening formed in the outlet housing. The base portion is in contact with the support portion and the openings are aligned. The flexible one-way valve includes a flange portion, a tapered portion, and an opening formed in the valve. The flange portion is locked between the base portion of the outlet housing and the support portion of the inlet housing. The collar is attached to the support portion of the inlet housing and extending into the valve opening. The apparatus may further include an overmold band formed over the support portion of the inlet housing and base portion of the outlet housing. The valve apparatus may also include a recessed area formed in the support portion for receiving the flange portion of the flexible valve. Preferably, the collar and inlet housing are formed as a monolithic member. The housings and collar may preferably be made of a high density polypropylene resin. The flange portion of the flexible valve may preferably be compressed between the base portion of the outlet housing and the support portion of the inlet housing in an axial direction. The flange portion of the flexible valve may also preferably be compressed between the collar and the base portion of the outlet housing in a radial direction. The valve apparatus may further include an arrow inscribed on an outer surface of the outlet housing to indicate the direction of fluid flow during normal operation. Preferably, the housings are made of a

clear material which allows a user to view fluid flow. A plurality of ribs extending axially from the support portion and radially from the shaft portion of the inlet housing may stabilize the support portion and reduce bending during usage of the check valve. Preferably, the collar extends into the flexible valve opening at least about one sixth of the length of the flexible valve. The desired length of the collar will vary based on flow conditions, back pressure conditions, material costs, and other factors determined by the check valve size, configuration and use.

Additional features and advantages are described in, and will be apparent from, the detailed description of the presently preferred embodiments and from the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of an embodiment of the check valve of the present invention;

FIG. 2 is a sectional view of the embodiment of **FIG. 1**;

FIG. 3 is a sectional view taken along lines 3-3 of **FIG. 2**;

FIG. 4 is an exploded sectional view of the embodiment of **FIG. 1**, shown without the overmold band;

FIG. 5 is an end view of the inlet housing of **FIG. 4**; and

FIG. 6 is an end view of the outlet housing of **FIG. 4.**

DETAILED DESCRIPTION OF THE DRAWINGS AND PRESENTLY PREFERRED EMBODIMENTS OF THE INVENTION

Referring to **FIGS. 1** and **2**, a preferred check valve **10** of the present invention includes an inlet housing **12**, an outlet housing **14**, a duckbill valve **18** and an overmold band **16**. As shown in **FIGS. 2-4**, the inlet and outlet housings **12**, **14** are aligned with each other and the duckbill valve **18**. The inlet and outlet housings **12**, **14** are made of a rigid material, preferably a clear material which will allow the user to observe fluid flowing through the housing members. Preferably, the housings are made of a thermoplastic which will withstand repeated exposure to temperatures of 85°C and allow for

in-place steam sanitation without significant deterioration. One example of such a thermoplastic is a high density polypropylene resin. The inlet housing **12** includes a cylindrical shaft portion **24**, circular support portion **26**, and collar portion **30**. The outlet housing **14** includes an end portion **15**, a valve housing portion **17** and a base portion **48**.

In one embodiment, for example, the inlet housing **12** has a length **X** of 1.145 inches, measured from the inlet to the edge of the support portion **26**, with the shaft portion **24** having an outer diameter **Y** of 0.315 inch, and the support portion **26** having an outer diameter **Z** of 0.789 inch. In this embodiment, the inlet orifice **36** has a diameter **Q** of 0.175 inch. The support portion includes a recessed region **28** with a diameter **R** to receive the base portion **48** of the outlet housing **14**. A second recessed area **52** in the support portion **26** is designed to receive the rim **35** of the duckbill valve. The collar **30** has a length **A**, for the embodiment shown of 1/4 inch measured from the recessed area **52**. The collar **30** has an outer diameter **B**, of 0.255 inch and is received in the valve opening **38**. The length of the collar **30** may vary depending on the intended use of the check valve. The 1/4 inch collar, described above, supports the duckbill valve **18** and prevents collapse under back pressures, which may spike, for example, to 30psi during the hemodialysis process. The collar **30** is preferably formed as a portion of the inlet housing **12**, but may alternatively be formed as a separate member.

For this embodiment, the outlet housing **14** has a length **M** of 1.620 inches, with the end portion **15** having an outer diameter of 0.315 inch, the valve housing portion **17** having an outer diameter of 0.465 inch, and the base portion **48** having an outer diameter **N** of 0.684 inch. The outlet housing base portion **48** is received in the recessed area **52** of the support portion **26**. The duckbill valve **18** is a standard one-way valve having a tapered portion **40**, a cylindrical portion **42** and a flange portion **37**. The flange portion **37** includes base portion **34** and a rim portion **35**. As shown in **FIG. 6**, the duckbill valve has a slit **54** and a flat tapered area **56** which forms the duckbill. The remainder of the tapered portion **40** has a tapered and curved surface, and the cylindrical body portion **42** is cylindrical. Preferably, the

duckbill valve **18** is made of a soft rubber or silicone and, for the embodiment shown, has a length of about 5/8 inch. For example, Vernay Laboratories of Yellow Springs, Ohio supplies duckbill valves suitable for use in this embodiment of the check valve.

As shown in **FIGS. 2** and **3**, as assembled, the cylindrical body portion **42** of the duckbill valve fits within the inner chamber **60** of the valve housing portion **17**. The base and rim portions **34**, **35** of the duckbill valve **18** are received within the recessed regions **52** and **58** and between the base portion **48** and support portion **26**. The collar portion **30** extends into the valve opening **38**. Preferably, the collar **30** extends at least above one sixth of the length of the flexible valve **18**. Alternatively, the collar may extend further into the cylindrical portion **42** of the flexible valve **18**. With some flexible valves, the collar may extend only far enough so that the outlet housing **14** may radially compress the flexible valve **18** against the collar **30**. Once assembled, overmold material, which is a compatible thermoplastic material, is injected around the support portion **26** and base portion **48** and flows into the support and base grooves **44**, **45**. The overmold band **16** locks and hermetically seals the housings and secures the flexible valve base and rim portions **34**, **35** in a compressed state.

As shown in **FIG. 5**, rib members **22** extend radially from the shaft **24** and axially from the support portion **26**. The ribs **22** add structural support to the inlet housing **12** and reduce bending under pressure, which might otherwise act to release the rim and base portions **34**, **35** of the duckbill valve, causing the valve to collapse.

In operation, fluid is passed through the inlet orifice **36**, through the flexible valve (shown in its open position by dashed lines **19** in **FIG. 4**) and through the outlet orifice **50**, as indicated by arrow **20**. The duckbill valve **18** remains in place even with extreme pressure spikes, which, for example, may reach 30psi under same condition during hemodialysis. As secured by the overmold band **16**, the base portion **48** of the outlet housing **14** compresses the base **34** and rim **35** of the flexible valve **18** axially against the support portion **26** of the inlet housing **12** and radially against the collar **30**. The ribs

22 further stabilize the support portion **26** and reduce bending during high back pressure conditions, and help prevent the flexible valve **18** from pulling away from its secured position between the housings.

It should be appreciated that the apparatus and methods of the present invention are capable of being incorporated in the form of a variety of embodiments, only one of which has been illustrated and described above. The invention may be embodied in other forms without departing from its spirit or essential characteristics. The described embodiments are 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.

I CLAIM:

1. A valve apparatus comprising:

a) an inlet housing member including an opening formed therein and a support portion;

b) an outlet housing member including an opening formed therein and a base portion seated against the support portion; and

c) a collar extending from the support portion and including an opening formed therein in communication with the inlet housing member opening, the collar being configured to allow a flexible valve to be positioned over the collar portion.

2. The valve apparatus of Claim 1 further comprising a flexible valve positioned over the collar portion.

3. The valve apparatus of Claim 2 wherein the flexible valve comprises a duckbill valve.

4. The valve apparatus of Claim 3 wherein a flange portion of the duckbill valve is secured between the inlet housing and outlet housing and the housings are sealed with an overmold.

5. The valve apparatus of Claim 3 wherein the collar extends at least about one sixth of the length of the duckbill valve positioned over the collar.

6. The valve apparatus of Claim 1 wherein the collar extends a distance sufficient to prevent collapse of a duckbill valve under pressure spikes of at least about 30psi.

7. The apparatus of Claim 1 wherein the inlet housing member and outlet housing member are sealed together with an overmold.

8. The apparatus of Claim 1 wherein the housings are made of high density thermoplastic capable of withstanding temperatures in the range of 85°C.

9. A method of operating a valve apparatus comprising:

a) providing a housing having an opening formed therein and a collar portion inside the housing and aligned with the opening, and a flexible valve fitted over the collar portion;

b) flowing a fluid through the opening and through the flexible valve;

c) subjecting the valve to back pressure; and

d) supporting the flexible valve with the collar to prevent the back pressure from collapsing the valve.

10. A valve apparatus comprising:

a) an inlet housing including a cylindrical shaft portion, a circular support portion, and an opening formed in the inlet housing;

b) an outlet housing including a cylindrical end portion, a valve housing portion, a base portion, and an opening formed in the outlet housing, the base portion being in contact with the support portion of the inlet housing, and the openings being aligned with one another;

c) a flexible one-way valve including a flange portion, a tapered portion, and an opening formed in the valve, the flange portion locked between the base portion of the outlet housing and the support portion of the inlet housing; and

d) a collar attached to the support portion of the inlet housing and the collar extending into the valve opening.

11. The valve apparatus of Claim 10 further comprising an overmold band formed over the support portion of the inlet housing and the base portion of the outlet housing.

12. The valve apparatus of Claim 10 further comprising a recessed area formed in the support portion for receiving the base portion of the flexible valve.

13. The valve apparatus of Claim 10 wherein the collar and inlet housing are formed as a monolithic member.

14. The valve apparatus of Claim 13 wherein the housings and collar are made of a high density polypropylene resin.

15. The valve apparatus of Claim 10 wherein the flange portion of the flexible valve is compressed between the base portion of the outlet housing and the support portion of the inlet housing in an axial direction.

16. The valve apparatus of Claim 15 wherein the flange portion of the flexible valve is compressed between the collar and the base portion of the outlet housing in a radial direction.

17. The valve apparatus of Claim 10 further comprising an arrow inscribed on an outer surface of the outlet housing to indicate the direction of fluid flow under normal operation.

18. The valve apparatus of Claim 10 wherein the housings are made of a clear material which allows a user to view fluid flowing through the apparatus.

19. The apparatus of Claim 10 further comprising a plurality of ribs extending axially from the support portion and radially from the shaft portion of the inlet housing.

20. The apparatus of Claim 10 wherein the collar extends into the flexible valve opening at least about one sixth of the length of the flexible valve.

FIG. 1

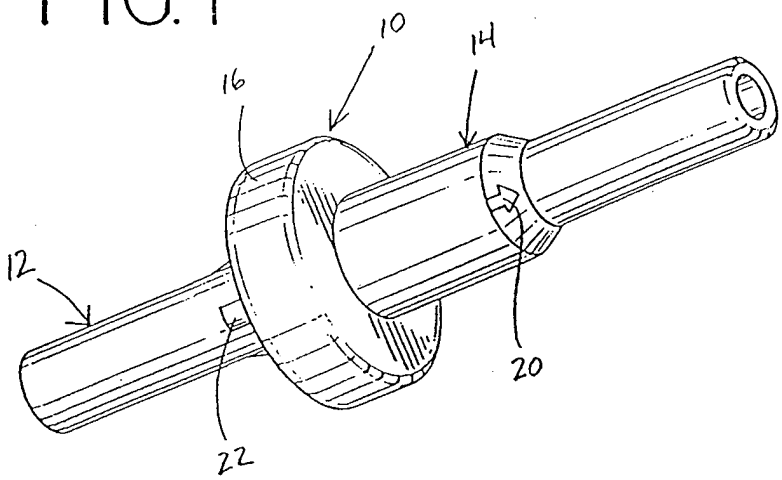


FIG. 2

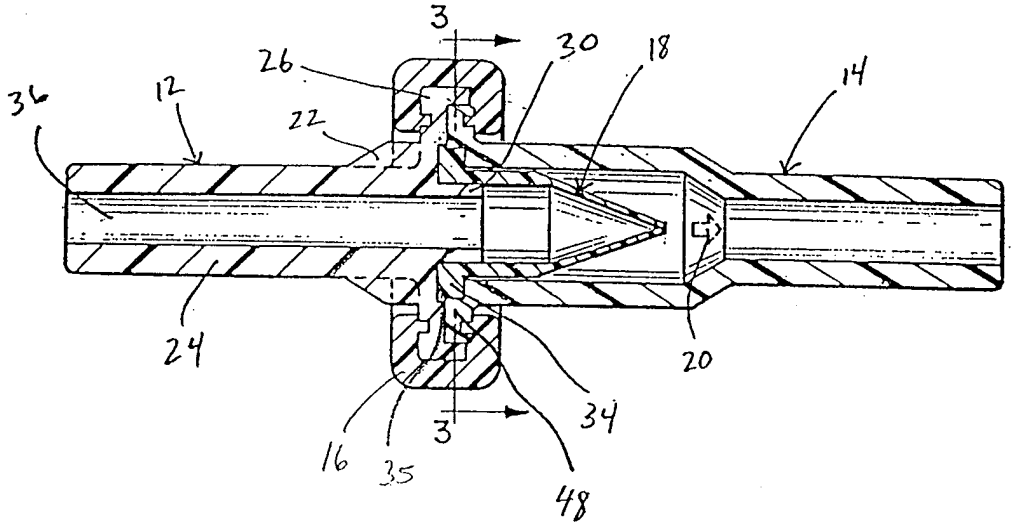
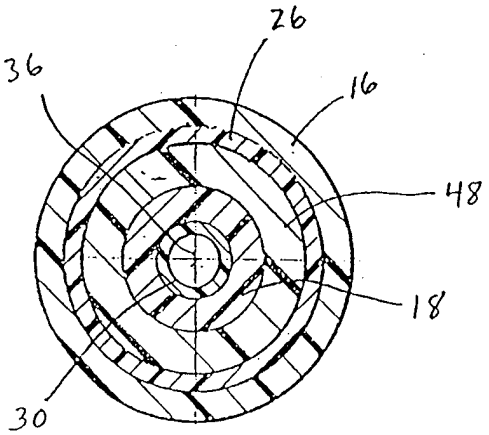


FIG. 3



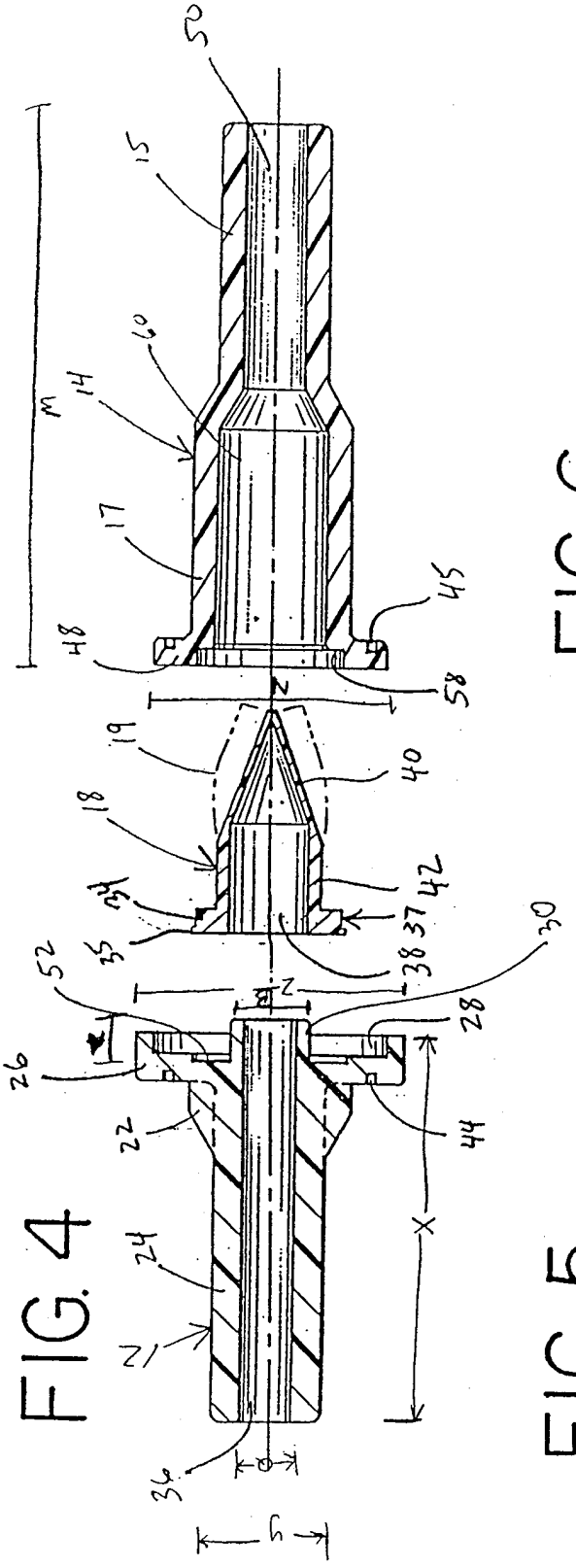


FIG. 4

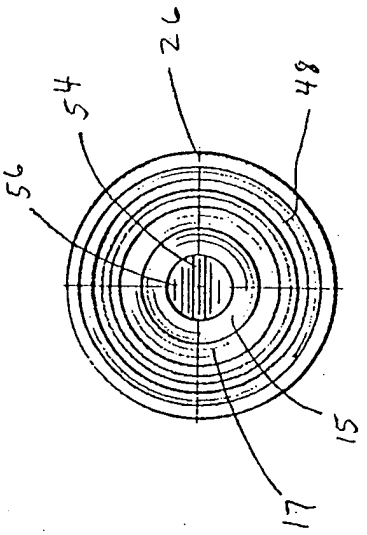


FIG. 6

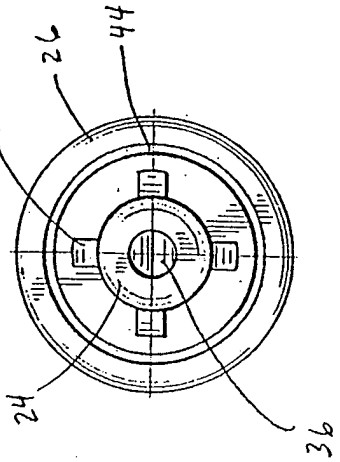


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/03984

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :F16K 15/14
US CL : 137/846; 604/247
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 137/846; 604/247

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 4,725,266 A (SIPOSS) 16 February 1988, see Figure 2.	1-9 --- 4,7,10-13, 15,16
X	US 4,535,819 A (ATKINSON et al) 20 August 1985, see Figure 3.	1 - 3 , 6 , 8 - 1 0 , 13,15,16, 18
X	US 4,612,960 A (EDWARDS et al) 23 September 1986, see Figure 5.	1-3,5,6, 8 - 1 0 , 1 2 , 1 3 , 15,16,19, 20

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/03984

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 4,535,818 A (DUNCAN et al) 20 August 1985, see Figures. 11,13.	1-3,5,6, 8-10,12,13, 15,16, 18-2 0 ---------- 10-13,15, 16
Y	US 3,710,942 A (ROSENBERG) 16 January 1973, see col.2, line 66.	14
Y	US 4,295,412 A (HACHIRO) 20 October 1981, see Figure 4.	17