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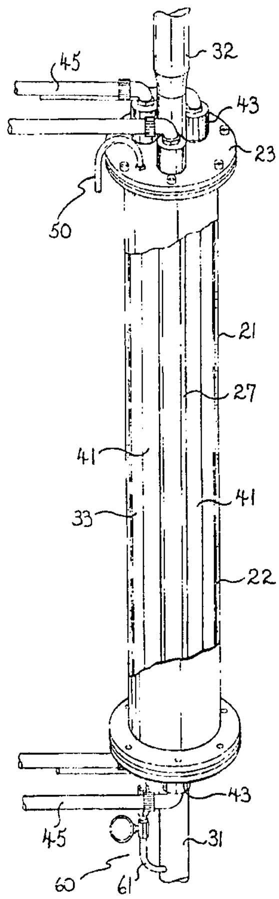
(54) Title: TREATMENT OF FLUIDS

(57) Abstract

Apparatus for treating a fluid comprising a tube (27) defining a fluid flow passage (28) and a chamber (33) surrounding the fluid flow passage. An ultraviolet radiation source (40) is provided for transmitting ultraviolet radiation into the interior of the chamber (33). The ultraviolet radiation source (40) is disposed within the interior of the chamber, and means (50) are provided for conducting a gas through the chamber whereby the gas can be exposed to ultraviolet radiation within the chamber. The tube (27) may be transparent to ultraviolet radiation so that fluid flowing therealong is also exposed to ultraviolet radiation.



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TITLE

"Treatment of Fluids"

TECHNICAL FIELD

THIS INVENTION relates to the treatment of fluids, and more particularly to an apparatus and a process for treatment of fluids.

The treatment of fluids may take any suitable form such as cleaning to remove unwanted contaminants, sterilisation, oxygenation and/or ozonation.

The invention is suitable for treating fluids in various forms such as: gases including gases containing liquid and/or solid substances; liquids including liquids containing gases, solids and/or liquid substances, such as slurries and effluent. Indeed, the treatment may be applicable to any material or mixture of materials which is capable of flow.

BACKGROUND OF THE INVENTION

While the invention may have various applications, one particular application is in the sterilisation of contaminated liquid such as water.

It is known to sterilise or otherwise treat contaminated liquids, and in particular water, using ultraviolet radiation at wavelengths of 254 nanometres and 185 nanometres. The two wavelengths can be generated simultaneously by the same source.

Radiation at the 185 nanometre wavelength is known to produce oxidising effects including the formation of ozone from gas containing oxygen. When the ozonated gas is introduced into the liquid, the ozone destroys or at least degrades organic substances through oxidisation.

The radiation at a wavelength of 254 manometers is known as a germicidal wave length which destroys organisms contained in the liquid.

There have been various proposals to utilise the effects of ultraviolet radiation at the two wavelengths. Such proposals are exemplified by disclosures in US Patent Nos. 4,189,363 (Beitzel), 4,273,660 (Beitzel), 4,179,616 (Coviello), 4,141,830 (Last) and 4,230,571 (Dadd).

Typically, the prior art proposals comprise a ultraviolet light source surrounded by an inner chamber. An outer chamber surrounds the inner chamber and is separated therefrom by a wall which is transparent to ultraviolet radiation so that emissions from the ultraviolet source can pass through the inner chamber and into the outer chamber. A stream of air or other gas containing oxygen is passed through the inner chamber so as to allow the radiation to convert oxygen into ozone. The ozone-enriched gas is then introduced into a stream of water which is passed through the outer chamber where it is exposed to radiation within that chamber. The stream of water receives the benefit of both the ozone and the radiation from the ultraviolet source as it passes through the outer chamber.

There is a disadvantage with the configuration of such prior art proposals whereby the ultraviolet source is surrounded by the inner chamber which is in turn surrounded by the outer chamber. With such an arrangement, the ultraviolet source is not in close proximity to the outer chamber through which the contaminated liquid is passed.

Accordingly, the effectiveness of the ultraviolet radiation acting on the liquid in the outer chamber may be diminished.

In an endeavour to maintain adequate proximity between the ultraviolet source and the outer chamber so as not to result in the ultraviolet radiation in the second chamber being so diminished as to be ineffective, it is necessary to restrict the radial dimension of the inner chamber. Such a restriction can, however, be disadvantageous as it limits the opportunity for exposure of the air or other gas containing oxygen to ultraviolet radiation for generation of ozone. This may result in insufficient contact time between gas and ultraviolet radiation in the inner chamber for a sufficient quantity of the oxygen to be converted to ozone.

DISCLOSURE OF INVENTION

The present invention seeks to provide a novel and useful apparatus and process for treatment of fluids.

The present invention may also provide an apparatus and process for treating fluids in which contact between ultraviolet radiation and a gas exposed thereto is enhanced.

Some embodiments of the present invention also seek to overcome, or at least reduce the effect of, at least some of the deficiencies outlined in relation to the prior art referred to above.

According to one aspect of the invention there is provided apparatus for treating a fluid comprising means defining a fluid flow passage, means for conducting a fluid along the fluid flow passage, means defining a chamber surrounding the fluid flow passage, an ultraviolet radiation source for transmitting ultraviolet radiation into the interior of the chamber, the ultraviolet radiation source being disposed within the interior of the chamber, and means for conducting a gas through the chamber.

In one arrangement, the fluid to be treated may comprise a fluid passing along the fluid flow passage.

In another arrangement, the fluid to be treated may comprise a fluid passing through the chamber.

Preferably, the means defining a fluid flow passage allows ultraviolet radiation to enter the passage. Such means may comprise a tube transparent to ultraviolet radiation.

The ultraviolet radiation source may generate ultraviolet radiation for germicidal activity or ultraviolet radiation for dissociation of oxygen. However, the ultraviolet radiation source preferably generates ultraviolet radiation for both dissociation of oxygen and germicidal activity. Conveniently, the ultraviolet radiation source generates radiation at a wavelength of 185 nanometres and at a further wavelength of 254 nanometres.

The gas conducted through the chamber may be a gas containing molecular oxygen whereby ozone and atomic oxygen are produced upon exposure of the gas to the ultraviolet radiation.

The apparatus may further comprise means for introducing the gas after exposure thereof to ultraviolet radiation into a fluid flow. Such means preferably introduces the gas into a fluid flow passing along the fluid flow passage. In one arrangement, the gas introduced into the fluid passes along the fluid flow passage with the fluid for exposure to ultraviolet radiation within the passage.

In addition to providing germicidal activity, the wavelength of 254 nanometres has the effect of disassociating ozone to produce atomic oxygen which in turn can produce oxygen. Thus the fluid on exposure to ultraviolet radiation in the fluid flow passage has the benefit of treatment by exposure to ultraviolet radiation and the benefit of the treatment by contact with ozone and atomic oxygen for sterilisation purposes. Further, the dissociation of ozone into atomic oxygen in the fluid results in the production of oxygen which may be beneficial in many applications.

While the gas containing oxygen may be of any suitable form including air, it is conveniently oxygen gas so as to provide sufficient molecular oxygen for the production of ample ozone and atomic oxygen for the purposes of the treatment process.

Preferably, the gas introduced into the chamber is under pressure while in the chamber. This has the benefit of increasing the concentration of oxygen in the chamber thereby enhancing the amount of ozone and atomic oxygen generated in the chamber.

The chamber may be hermetically sealed to facilitate pressurisation of the gas introduced into it.

Preferably, an inlet control means such as a valve or regulator is provided for regulating the gas introduced into the chamber. Preferably, an outlet control means such as a valve or regulator is provided for regulating the gas leaving the chamber and being introduced into the fluid flow passage.

The ultraviolet radiation source may comprise an ultraviolet lamp. Conveniently, the ultraviolet source comprises a plurality of such lamps which are positioned within the chamber. Conveniently, the ultraviolet lamps are positioned in close proximity to the fluid flow passage.

The plurality of ultraviolet lamps are preferably so positioned in relation to each other to provide a close-coupling effect which enhances the combined output of the lamps.

The interior surface of the chamber may have a ultraviolet reflective surface to reflect ultraviolet radiation incident thereon inwardly.

The means for introducing the gas after exposure thereof to ultraviolet radiation into the fluid flow passage may take any suitable form such as a nozzle or other form of gas injector, a bubbler or a gas shear reactor.

The arrangement whereby the gas flows through the chamber provides a cooling effect for the ultraviolet lamps. The fluid passing through the flow passage also provides a cooling effect. This cooling action is enhanced by reflection of heat from the reflective surface towards the flow passage thereby limiting the amount of heat passing to the exterior of the chamber.

The means defining a fluid flow passage is preferably transparent to ultraviolet radiation and may comprise a quartz tube.

There may be a plurality of fluid flow passages surrounded by the chamber. In such a case, the fluid flow passages are preferably connected serially for maximising the exposure of fluid flowing therethrough to ultraviolet radiation. The fluid flow passages are conveniently arranged in parallel relation within the chamber, the passages being coupled together for fluid flow therebetween.

The means defining the chamber may comprise a housing having a side wall and a pair of opposed end walls between which the or each fluid flow passage, and the ultraviolet source, are supported. Conveniently, the side wall is of a cylindrical configuration.

The casing is preferably elongated and oriented vertically whereby the gas is passed downwardly through the chamber and whereby fluid to be treated is passed upwardly through at least one fluid flow passage within the chamber, the gas after exposure to the ultraviolet radiation in the chamber being introduced into said at least fluid flow passage at the lower end thereof.

In one application of the apparatus according to the invention, fluid may be recirculated through the fluid flow passage and a gas undergoing treatment passed through the chamber. In this way the fluid passing through the fluid flow passage can be employed as a cooling agent.

In another application of the apparatus according to the invention, the gas may be recirculated through the chamber and the fluid undergoing treatment passed along the flow passage. In this way, the gas can be employed as a cooling agent.

According to a second aspect of the invention there is provided apparatus for treating a fluid comprising means defining a fluid flow passage and allowing ultraviolet radiation to enter the passage, means defining a chamber surrounding the fluid flow passage, an ultraviolet radiation source for transmitting ultraviolet radiation into the fluid flow passage and into the interior of the chamber, the ultraviolet radiation source being adapted to simultaneously generate ultraviolet radiation for dissociation of oxygen and for germicidal activity, the ultraviolet radiation source being disposed within the interior of the chamber, means for conducting a gas containing molecular oxygen through the chamber for exposure to the ultraviolet radiation to produce ozone and atomic oxygen in the gas, means for introducing the gas after exposure thereof to ultraviolet radiation into the fluid flow passage to flow through the passage with the liquid for exposure to ultraviolet radiation within the passage.

According to a third aspect of the present invention there is provided a process for treating a fluid comprising the steps of: passing a gas containing molecular oxygen through a chamber accommodating a source of ultraviolet radiation; passing the fluid through a fluid flow passage which is surrounded by the chamber and which is transparent to ultraviolet radiation; and introducing the gas after exposure thereof to ultraviolet radiation within the chamber into the fluid flowing through the passage.

The gas may be introduced into the fluid to flow through the passage with the fluid for exposure to ultraviolet radiation within the passage.

The source may generate ultraviolet radiation for dissociation of oxygen and the gas introduced into the chamber may be a gas containing molecular oxygen. The source may also generate ultraviolet radiation for germicidal activity.

Preferably the gas introduced into the chamber is maintained under pressure while in the chamber.

Conveniently the gas is passed downwardly through the chamber and the fluid to be treated is passed upwardly through at least one fluid flow passage within the chamber, the gas after exposure to the ultraviolet radiation in the chamber being introduced into said at least fluid flow passage at the lower end thereof.

According to a fourth aspect of the invention there is provided a process for treating a fluid comprising the steps of: passing a gas containing molecular oxygen through a chamber accommodating a source generating ultraviolet radiation for dissociation of oxygen and for germicidal activity whereby the gas is exposed to the ultraviolet radiation to produce ozone and atomic oxygen in the gas; passing the fluid through a fluid flow passage which is surrounded by the chamber and which is transparent to ultraviolet radiation; and introducing the gas after exposure thereof to ultraviolet radiation within the chamber into the fluid flow passage whereby the gas flows through the passage with the liquid for exposure to ultraviolet radiation within the passage.

BRIEF DESCRIPTION OF DRAWINGS

The invention will be better understood by reference to the following description of several specific embodiments thereof as shown in the accompanying drawings in which:

Fig. 1 is a schematic view of a water treatment system incorporating apparatus according to a first embodiment;

Fig. 2 is perspective view of the apparatus according to the first embodiment with part of the apparatus cut-away;

Fig. 3 is a sectional elevational view of the apparatus;

Fig. 4 is a fragmentary perspective view of the apparatus, partly shown in section;

Fig. 5 is a cross-sectional view of the apparatus;

Fig. 6 is a perspective view of apparatus according to a second embodiment, with part of the apparatus being cut-away;

Fig. 7 is a sectional elevational view of the apparatus according to the second embodiment;

Fig. 8 is a fragmentary perspective view of the apparatus according to the second embodiment, with part of the apparatus being shown in section;

Fig. 9 is a cross-sectional view of the apparatus according to the second embodiment;

Fig. 10 is a schematic view partly in section showing apparatus according to a third embodiment;

Fig. 11 is a schematic view partly in section showing apparatus according to a fourth embodiment; and

Fig. 12 is a schematic view partly in section showing apparatus according to a fifth embodiment.

BEST MODES OF CARRYING OUT THE INVENTION

Referring to Fig. 1 of the drawings there is shown a system for treating contaminated water. The treatment system sterilises the water by the use of ozone, atomic oxygen and ultraviolet light which in combination oxidises organic contaminants and destroys microbiological contamination. The system also oxygenates the water.

The treatment system 10 comprises apparatus 11 according to the first embodiment to which water is delivered for treatment purposes by delivery line 13 and from which the water is conveyed after treatment by way of return line 17. A delivery pump 15 is incorporated in the delivery line 13. A filtering system (not shown) may be incorporated in the delivery line 13 for removing relatively large solid contaminants from the water prior to treatment in apparatus 11.

The apparatus 11 comprises a housing 21 having a cylindrical side wall 22 and a pair of end walls 23. The housing 21 is oriented such that the central longitudinal axis of the cylindrical side wall 22 is substantially vertical. The end walls 23 are removably mounted onto the end sections of the side wall 22 in any suitable fashion which in this embodiment comprises mounting flanges 25 provided on the cylindrical side wall 22 to which the end walls 23 are releasably bolted.

A tube 27 formed of quartz (or other material transparent to ultraviolet radiation) is centrally located within the interior of the housing 21 and is supported between the end walls 23. The tube 27 defines a flow path 28 through which water for treatment is conveyed from an inlet 31 on the lower end wall 23 to an outlet 32 on the upper end wall 23. The delivery line 13 communicates with the inlet 31 and the return line 17 communicates with the outlet 32. Coupling systems (not shown) are provided for releasable connection of the inlet 31 and outlet 32 to the delivery and return lines 13 and 17 respectively.

An annular chamber 33 is defined within the housing 21 between the tube 27 and the cylindrical side wall 22. The chamber 33 is hermetically sealed. The tube 27 and housing 21 are dimensioned such that the cross-sectional area of the annular chamber 33 is considerably larger than the cross-sectional area of the passage 28 defined within the tube 27.

The inner surface 35 of the cylindrical side wall 22 is lined with a material which is highly reflective to ultraviolet radiation. The highly reflective surface provides a boundary for the annular chamber 33.

An ultraviolet radiation source 40 is provided for transmitting ultraviolet radiation into the annular chamber 31 and the flow passage 28 within the tube 27. The ultraviolet radiation source 40 is accommodated within the annular chamber 33 and its emissions penetrate the tube 27 to enter the passage 28 by virtue of the tube being transparent to ultraviolet radiation.

The ultraviolet radiation source 40 comprises a plurality of ultraviolet lamps 41, there being three such lamps in this embodiment. The ultraviolet lamps 41 are of a type which simultaneously generate ultraviolet radiation at wavelengths of 185 and 254 nanometres.

The lamps 41 are each of elongated form and supported between the end walls 23 of the housing 21. The lamps 41 are circumferentially spaced around the tube 27 and are located in close proximity to the tube, as best seen in Fig. 5 of the drawings. Terminal connections 43 are provided on the end walls 23 of the casing for provision of an electrical supply to the lamps. The electrical supply is provided by way of an electrical supply circuit which incorporates electrical cabling 45 and a control and monitoring station 47. The station 47 incorporates switches for individually energising the lamps 41 and an alarm system for providing a warning in the event that any one of the lamps 41 fails while in operation.

A means 50 is provided for delivery a gas containing oxygen to the upper end of the annular chamber 33. In this embodiment the gas is oxygen gas but it can be air or any other gas containing molecular oxygen. The advantage of using oxygen gas is that it provides ample molecular oxygen for conversion to ozone and atomic oxygen as will be explained later. The gas delivery means 50 includes a gas delivery line 51 one end of which communicates with a port 53 formed in the end wall 23 at the upper end of the casing 21. The other end of the delivery line 51 is coupled to an oxygen supply 55 which in this form is a gas bottle. A flow meter 57 is incorporated into the delivery line 51 so that the flow rate of the gas can be monitored. An inlet valve 59 is also provided in the delivery line 51 for regulating the rate of delivery of the gas to the chamber.

A means 60 is provided for removing gas from the lower end of the chamber 31 and introducing it into water flowing towards the fluid flow passage 27. The means 60 comprises a gas flow line 61 one end of which communicates with the annular chamber 31 by way of an outlet port (not shown) which is provided on the lower end wall 23 and which opens into the annular chamber. The other end of the gas flow line 61 communicates with an injection system (not shown) adapted to inject the gas into water flowing into the tube 27. The injection system can be of any form such as a nozzle, a bubbler or simply one or more ports opening onto the inlet 31. An outlet control valve 65 is provided for regulating the rate at which the gas leaves the annular chamber and is introduced into the inlet 31.

While not shown in the drawings, means may be provided for subjecting the water to the influence of a magnetic field before, during and/or after injection of the gas into the water. The magnetic field may have various influences including removal of magnetic particles from the water.

The magnetic field may be generated by a series of magnets circumferentially arranged about the fluid flow. Indeed there may be two magnetic fields in spaced apart relation with respect to the direction of fluid flow. The relationship between the two fields may be such that there is resonance therebetween. Preferably, the magnetic arrangement is such that the polarity of the field can be charged for optimal performance.

The magnetic influence may also be arranged to act on the gas before and/or during injection thereof into the water.

In operation of the treatment system 10, gas is delivered under pressure to the annular chamber 33 from the supply 55. The gas enters the annular chamber 33 and flows downwardly through the chamber towards the outlet port. As the gas moves downwardly it is exposed to ultraviolet radiation generated by the lamps 41. The radiation of a wavelength of 185 nanometres dissociates molecular oxygen within the gas to form ozone and atomic oxygen. The radiation of wavelength 254 sterilisers the gas to destroy any microbiological matter which may be present. Because the gas is under pressure in the chamber 33, the concentration of molecular oxygen in the chamber is enhanced so as to provide an opportunity for ample levels of ozone and atomic oxygen to be generated. The comparatively large size of the annular chamber ensures that there is sufficient contact time between the molecular oxygen and the ultraviolet radiation for generation of the necessary amount of ozone and atomic oxygen.

The gas flows under pressure from the annular chamber 33 through outlet port along the gas line 61 and is injected at inlet 31 into water being delivered to the tube 27 along the delivery line 13. The gas mixes with the water and is conveyed through the passage 27 with the water where it is again exposed to ultraviolet radiation along with the water. The radiation at wavelength of 254 nanometres has a sterilising effect on the water. The radiation also dissociates ozone within the water to form atomic oxygen which leads to the production of oxygen gas. Oxygen gas in the water is also dissociated by the radiation of wavelength 185 nanometres. Thus, in the liquid flowing along the passage 28 there is a continual interchange between ozone and oxygen, molecules of each gas being dissociated to form atomic oxygen. The presence of the ozone and atomic oxygen has an oxidising effect on contaminants within the water and so provides a cleaning operation within the water. The presence of oxygen also increases the amount of dissolved oxygen within the water, a feature which can be particularly advantageous in many circumstances.

The configuration of the apparatus 11 provides for proper treatment of the water. Because the ultraviolet lamps 41 are accommodated within the chamber 33 there is good contact between the gas passing through the chamber and ultraviolet radiation generated by the lamps. Similarly, because the lamps 41 are located in close proximity to the tube 27, there is good contact between the water passing along flow passage 28 and ultraviolet radiation generated by the lamps. Additionally, because the source of ultraviolet radiation 40 comprises a plurality of lamps 41 at spaced locations within the annular chamber 33, there is good dissemination of the ultraviolet radiation within both the annular chamber 33 and the flow passage 28.

The feature whereby the lamps 41 are accommodated within the flow passage 27 is also beneficial for the reason that it provides cooling for the lamps thereby ensuring that excessive heat is not generated within the apparatus. The reflective surface on the inner surface 35 of the housing 21 not only enhances concentration of ultraviolet radiation within the housing, and in particular towards the tube 27, but also reduces the amount of heat for dissipation through the housing with the result that the exterior of the housing does not become excessively hot..

As the water is only in contact with the quartz tube 27 when exposed to ultraviolet radiation in the housing 21, there is little likelihood of deposits forming on the interior wall of the tube to diminish the effectiveness of the radiation. In any event, if a deposit did form on the tube, it would in all probability soon be removed by the action of the ozone present in the water.

In the apparatus according to the first embodiment, there is a single pass of water through the housing 21 for exposure to ultraviolet radiation. The exposure of the water to ultraviolet radiation can, however be enhanced if there are multiple passes of the water through the housing 21. The apparatus according to the second embodiment provides such an arrangement.

Referring now to Figs. 6 to 9, the apparatus according to the second embodiment is similar to the apparatus according to the first embodiment with the exception that there are a plurality of tubes 27 provided within the casing housing 21. The tubes 27 are each supported between the end walls 23 of the housing and are connected serially for fluid flow therebetween. The connections are provided by piping 70 mounted exteriorly on the end walls 23 of the housing for providing fluid flow from one tube 27 to another tube 27.

In the embodiment, there are three tubes 27 such that the water enters the apparatus 11 from one end of the housing and leaves the apparatus from the other end of the housing after making multiple passes through the housing for exposure to ultraviolet radiation.

As with the first embodiment, the source of ultraviolet radiation 40 again comprises a plurality of ultraviolet lamps 41. There are, however, four such lamps 41 in this embodiment positioned around the three flow passages 28. As best seen in Fig. 9 of the drawings, one of the lamps 41 is positioned centrally between the three flow passages and the other lamps are each positioned radially outwardly between neighbouring flow passages. This arrangement provides for good dissemination of ultraviolet light generated by the lamps 41 within both the chamber 33 and the passages 28 within the tubes 27.

The apparatus according to the first and second embodiments can be operated by passing water or other fluid along the flow passage 28 within tube 27 in the opposite direction to that desired. This would provide treatment to the liquid by exposure to ultraviolet radiation within the passage 28 followed by injection of the gas containing ozone and atomic oxygen. The mixture of the liquid and injected gas would then flow from the apparatus rather than being exposed to the ultraviolet radiation.

There may be circumstances where it is only necessary to inject oxygen and/or ozone into water or some other fluid without having to treat the water or other fluid by exposure to ultraviolet radiation. This can be accomplished with apparatus which is similar to the first and second embodiments but with the modification that the or each tube 27 is not transparent to ultraviolet radiation. The tube 27 may, for instance, be made of a suitable grade of stainless steel.

In circumstances where it is desired to treat a liquid or other fluid by exposure to ultraviolet radiation without injection of ozone and atomic oxygen, the apparatus according to each of the first and second embodiments can be operated without the introduction of gas into the chamber 33. In such an arrangement, the liquid or other fluid flowing the passage 28 would be exposed to ultraviolet radiation transmitted through the or each tube 27.

The apparatus according to the second embodiment is more appropriate for such an application as it can be operated with only the central lamp 41 operating if so desired, thereby reducing the likelihood of overheating within the chamber.

There may be situations in which it is desirable to enhance the transmission of ultraviolet radiation from the source 40 to the tube 27. This may be accomplished by introducing an inert gas into the chamber. The gas would not pass through the chamber but rather would be retained therein. As it is inert, the gas would not react to the ultraviolet radiation but would serve to enhance transmission of ultraviolet radiation to the or each tube 27.

There may be situations where the only requirement is to subject a fluid to ultraviolet radiation. This may be accomplished by apparatus according to a third embodiment as shown in Figure 10.

The apparatus according to the third embodiment is similar in many respects to the apparatus according to the first and second embodiments and similar reference numerals are employed to designate similar parts.

In this embodiment a recirculation system 80 is associated with the chamber 33 whereby a gas can be recirculated through the chamber for the purpose of cooling the lamps 41 accommodated therein. The lamps 41 generate ultraviolet radiation for the purpose of treating a flow flowing through the tube 28. The gas is not, however, introduced into the fluid; it is simply recirculated.

The recirculation system 80 includes a recirculation line 81 connected between the upper and lower ends of the chamber 33. A heat exchanger 83 incorporated in the recirculation line 81. A recirculation pump (not shown) may also be incorporated in the recirculation line 81, although thermosiphonic action may suffice for causing the circulation.

In the third embodiment the fluid undergoing treatment is passed through the fluid flow passage 28 defined within tube 27 and a cooling fluid for the lamps 41 is passed through the chamber 33. It is, however, also possible to provide an arrangement in which a gaseous fluid undergoing treatment is passed through the chamber 33 and a cooling fluid is passed through the fluid flow passage 28. Apparatus according to a fourth embodiment, which is shown in Fig. 11, provides such an arrangement. In this embodiment, the tube 27 defining the fluid flow passage 28 is incorporated in a recirculation line 87 as is a heat exchanger 89. With this arrangement, the lamps 41 generate ultraviolet radiation to which the gaseous fluid undergoing treatment is exposed as it passes through the chamber 33. A cooling fluid passing through the tube 27 serves to carry away heat generated by the lamps 41. As the tube 27 only conducts a cooling fluid, there is no necessity for it to be transparent to ultraviolet radiation.

Apparatus according to the fourth embodiment is particularly suitable for use as an ozone generator.

There may be situations where it is desirable to enhance exposure of a gaseous fluid undergoing treatment to ultraviolet radiation, such as in cases where a large concentration of ozone is required. Apparatus according to the fifth embodiment, which is shown in Fig. 12, is provided for such a purpose. In this embodiment the gaseous fluid undergoing treatment is passed through both the chamber 33 and the passage 27 for exposure to ultraviolet radiation generated by the lamps.

The inlet 31 of the tube 27 defining passage 28 is closed at 91 so as to only receive gas introduced into it by way of the gas flow line 61. The gas thus passes downwardly through the chamber 33 and is exposed to ultraviolet radiation. From the chamber 33 the gas flows via line 61 into the inlet 31 to flow upwardly through the passage 28 where it is exposed to further radiation. This double exposure enhances the treatment which the gas receives. In circumstances where the gas is oxygen, it may optimise the production of ozone.

The apparatus according to the third, fourth and fifth embodiments have been described and illustrated with a tube 27 providing a single pass arrangement. It should be understood that the embodiments may have tubes arranged as a multiple pass arrangement, somewhat similar to the second embodiment.

Where a multiple pass arrangement is used, means may be provided for subjecting fluid flowing along the passages to magnetic influences at the region where the fluid passes from one passage into another.

From the foregoing, it is evident that the apparatus according to each embodiment provides a simple yet effective system for treating contaminated liquids and other fluids. The apparatus can be used to sterilise the fluids or simply to provide a cleaning operation on the fluids to remove unwanted and/or harmful contaminant materials. The apparatus can also be used to oxygenate the fluids. The feature of oxygenation can be advantageous as it can be used to provide water with a very high concentration of dissolved oxygen for subsequent use such as delivery to water bodies which are in an oxygen-depleted state. The delivery of water containing high levels of dissolved oxygen can be used to increase the oxygen content of the depleted water.

While the invention has been described with reference to several specific embodiments, it should be appreciated that it is not limited thereto and that various alterations and modifications may be made without departing from the scope of the invention.

CLAIMS

1. Apparatus for treating a fluid comprising means defining a fluid flow passage means for conducting a fluid along the fluid flow passage, means defining a chamber surrounding the fluid flow passage, an ultraviolet radiation source for transmitting ultraviolet radiation into the interior of the chamber, the ultraviolet radiation source being disposed within the interior of the chamber, and means for conducting a gas through the chamber.

2. Apparatus according to claim 1 wherein the fluid to be treated comprises a fluid passing along the fluid flow passage.

3. Apparatus according to claim 1 wherein the fluid to be treated comprises a fluid passing through the chamber.

4. Apparatus according to claim 1, 2 or 3 wherein the means defining a fluid flow passage allows ultraviolet radiation to enter the passage.

5. Apparatus according to claim 4 wherein the means defining a fluid flow passage comprises a tube transparent to ultraviolet radiation.

6. Apparatus according to any one of claims 1 to 5 wherein the ultraviolet radiation source generates ultraviolet radiation for germicidal activity.

7. Apparatus according to any one of claims 1 to 5 wherein the ultraviolet radiation source generates ultraviolet radiation for dissociation of oxygen.

8. Apparatus according to any one of the preceding claims wherein the ultraviolet radiation source generates ultraviolet radiation for both dissociation of oxygen and germicidal activity.

9. Apparatus according to claim 8 wherein the ultraviolet radiation source generates radiation at a wavelength of 185 nanometres and at a further wavelength of 254 nanometres.

10. Apparatus according to claim 7, 8 or 9 wherein the gas conducted through the chamber is a gas containing molecular oxygen whereby ozone and atomic oxygen are produced upon exposure of the gas to the ultraviolet radiation.

11. Apparatus according to claim 10 further comprising means for introducing the gas after exposure thereof to ultraviolet radiation into a fluid flow.

12. Apparatus according to claim 11 wherein said means introduces the gas into a fluid flow passing along the fluid flow passage.

13. Apparatus according to claim 12 wherein the gas introduced into the fluid passes along the fluid flow passage with the fluid for exposure to ultraviolet radiation within the passage.

14. Apparatus according to any one of claims 1 to 10 further comprising means for introducing the gas after exposure thereof to ultraviolet radiation into the fluid flow passage for movement therealong.

15. Apparatus according to any one of the preceding claims wherein the gas introduced into the chamber is under pressure while in the chamber.

16. Apparatus according to claim 15 wherein the chamber is hermetically sealed.

17. Apparatus according to any one of the preceding claims wherein an inlet control means is provided for regulating the gas introduced into the chamber.

18. Apparatus according to any one of the preceding claims wherein an outlet control means is provided for regulating the gas leaving the chamber and being introduced into the fluid flow passage.

19. Apparatus according to any one of the preceding claims wherein the ultraviolet radiation source comprises an ultraviolet lamp.

20. Apparatus according to claim 19 wherein the ultraviolet source comprises a plurality of ultraviolet lamps.

21. Apparatus according to claim 19 or 20 wherein the or each lamp is positioned in close proximity to the fluid flow passage.

22. Apparatus according to claim 20 or 21 wherein the plurality of ultraviolet lamps are so positioned in relation to each other to provide a close-coupling effect.

23. Apparatus according to any one of the preceding claims wherein the interior surface of the chamber is provided with an ultraviolet reflective surface to deflect ultraviolet radiation incident thereon inwardly.

24. Apparatus according to any one of the preceding claims wherein there are a plurality of fluid flow passages surrounded by the chamber.

25. Apparatus according to claim 24 wherein the fluid flow passages are connected serially.

26. Apparatus according to claim 24 or 25 wherein the fluid flow passages are arranged in parallel relation within the chamber, the passages being coupled together for fluid flow therebetween.

27. Apparatus according to any one of the preceding claims wherein the means defining the chamber comprises a housing having a side wall and a pair of opposed end walls, the or each fluid flow passage and the ultraviolet source being supported between the opposed end walls.

28. Apparatus according to claim 27 wherein the casing is elongated and oriented vertically whereby the gas is passed downwardly through the chamber and whereby fluid to be treated is passed upwardly through at least one fluid flow passage within the chamber, the gas after exposure to the ultraviolet radiation in the chamber being introduced into said at least fluid flow passage at the lower end thereof.

29. Apparatus according to any one of the preceding claims wherein the flow area of the chamber transverse to the direction of gas flow is larger than the flow area of the or each fluid flow passage transverse to the direction of fluid flow.

30. Apparatus according to any one of the preceding claims wherein the gas is recirculated through the chamber.

31. Apparatus according to any one of claims 1 to 29 wherein the fluid passing through the fluid flow passage is recirculated.

32. Apparatus for treating a fluid comprising means defining a fluid flow passage and allowing ultraviolet radiation to enter the passage, means defining a chamber surrounding the fluid flow passage, an ultraviolet radiation source for transmitting ultraviolet radiation into the fluid flow passage and into the interior of the chamber, the ultraviolet radiation source being adapted to simultaneously generate ultraviolet radiation for dissociation of oxygen and for germicidal activity, the ultraviolet radiation source being disposed within the interior of the chamber, means for conducting a gas containing molecular oxygen through the chamber for exposure to the ultraviolet radiation to produce ozone and atomic oxygen in the gas, means for introducing the gas after exposure thereof to ultraviolet radiation into the fluid flow passage to flow through the passage with the liquid for exposure to ultraviolet radiation within the passage.

33. A process for treating a fluid comprising the steps of: passing a gas containing molecular oxygen through a chamber accommodating a source of ultraviolet radiation; passing the fluid through a fluid flow passage which is surrounded by the chamber and which is transparent to ultraviolet radiation; and introducing the gas after exposure thereof to ultraviolet radiation within the chamber into the fluid flowing through the passage.

34. A process according to claim 33 wherein the gas is introduced into the fluid to flow through the passage with the fluid for exposure to ultraviolet radiation within the passage.

35. A process according to claim 34 wherein the source generates ultraviolet radiation for dissociation of oxygen

and wherein the gas introduced into the chamber is a gas containing molecular oxygen.

36. A process according to any one of claims 33 to 35 wherein the source generates ultraviolet radiation for germicidal activity.

37. A process according to any one of claims 33 to 36 wherein the gas introduced into the chamber is maintained under pressure while in the chamber.

38. A process according to claim 36 or 37 wherein the gas is passed downwardly through the chamber and the fluid to be treated is passed upwardly through at least one fluid flow passage within the chamber, the gas after exposure to the ultraviolet radiation in the chamber being introduced into said at least fluid flow passage at the lower end thereof.

39. A process for treating a fluid comprising the steps of: passing a gas containing molecular oxygen through a chamber accommodating a source generating ultraviolet radiation for dissociation of oxygen and for germicidal activity whereby the gas is exposed to the ultraviolet radiation to produce ozone and atomic oxygen in the gas; passing the fluid through a fluid flow passage which is surrounded by the chamber and which is transparent to ultraviolet radiation; and introducing the gas after exposure thereof to ultraviolet radiation within the chamber into the fluid flow passage whereby the gas flows through the passage with the liquid for exposure to ultraviolet radiation within the passage.

40. Apparatus substantially as herein described with reference to the accompanying drawings.

41. A process substantially as herein described.

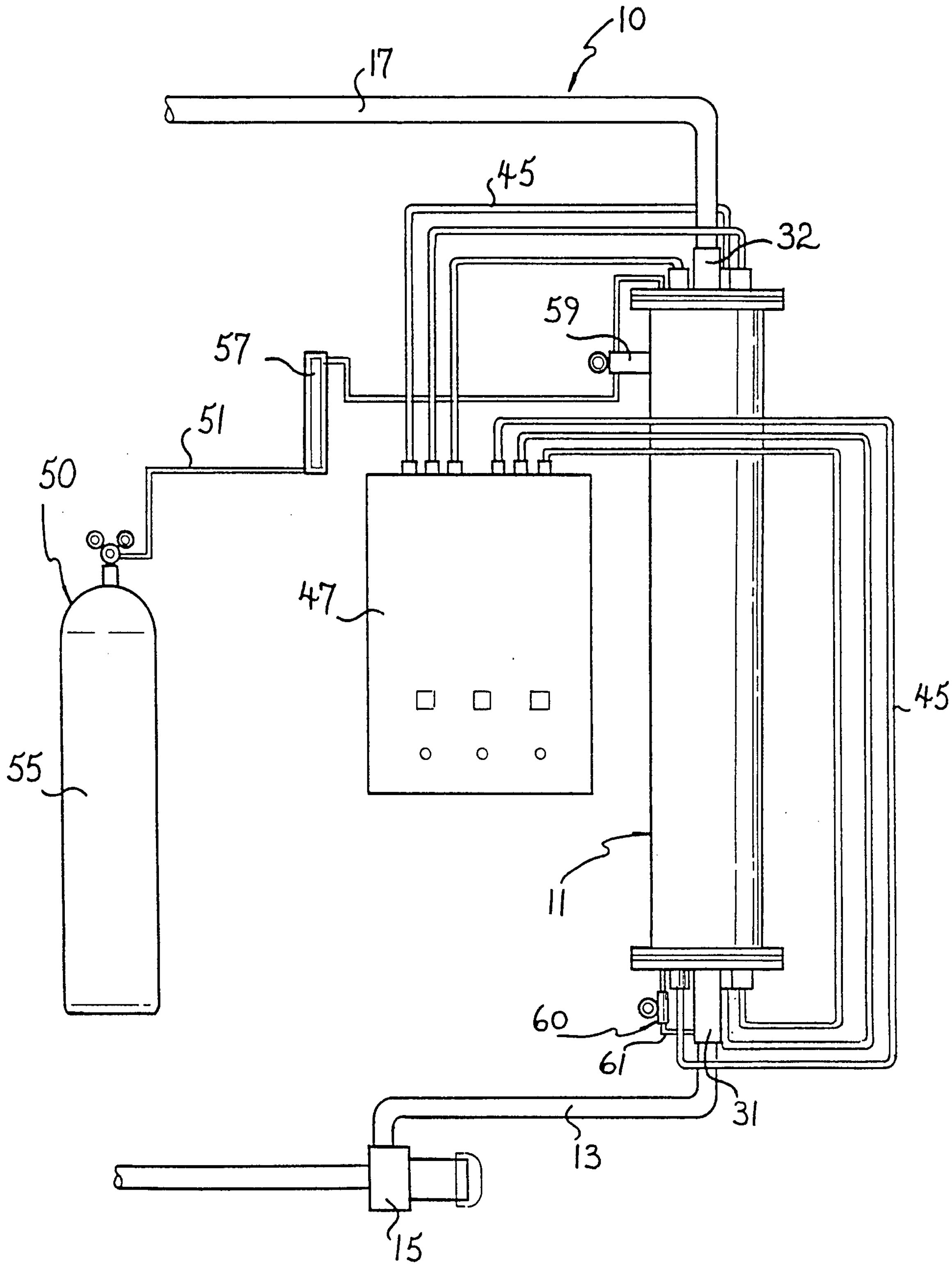

Fig 1

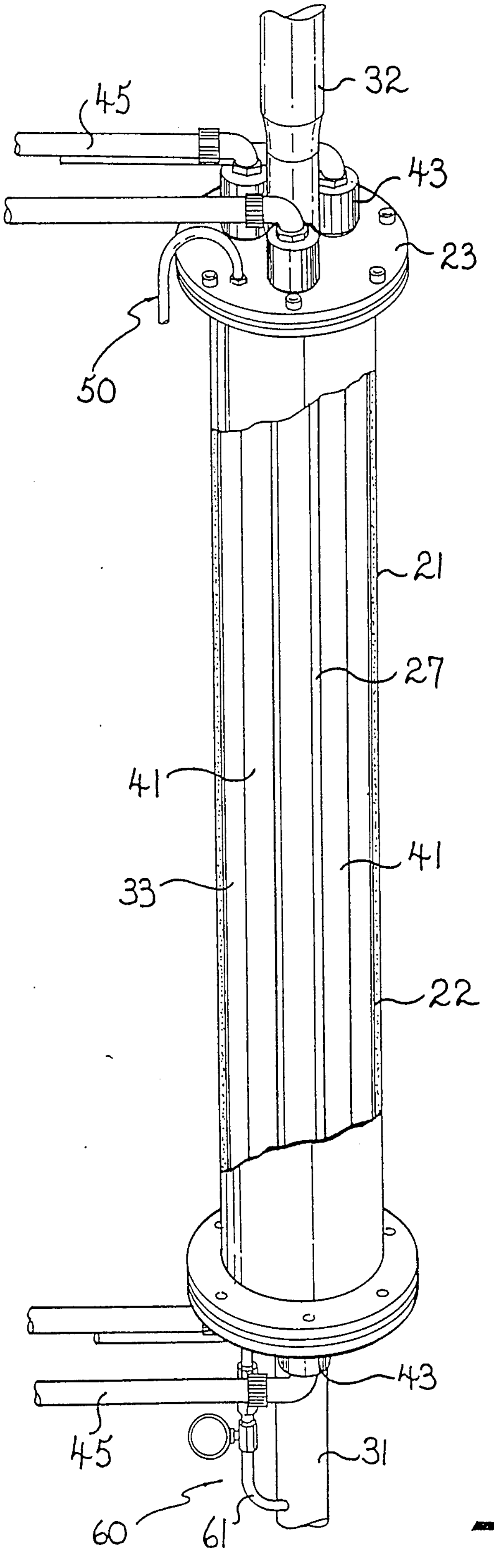

Fig 2.

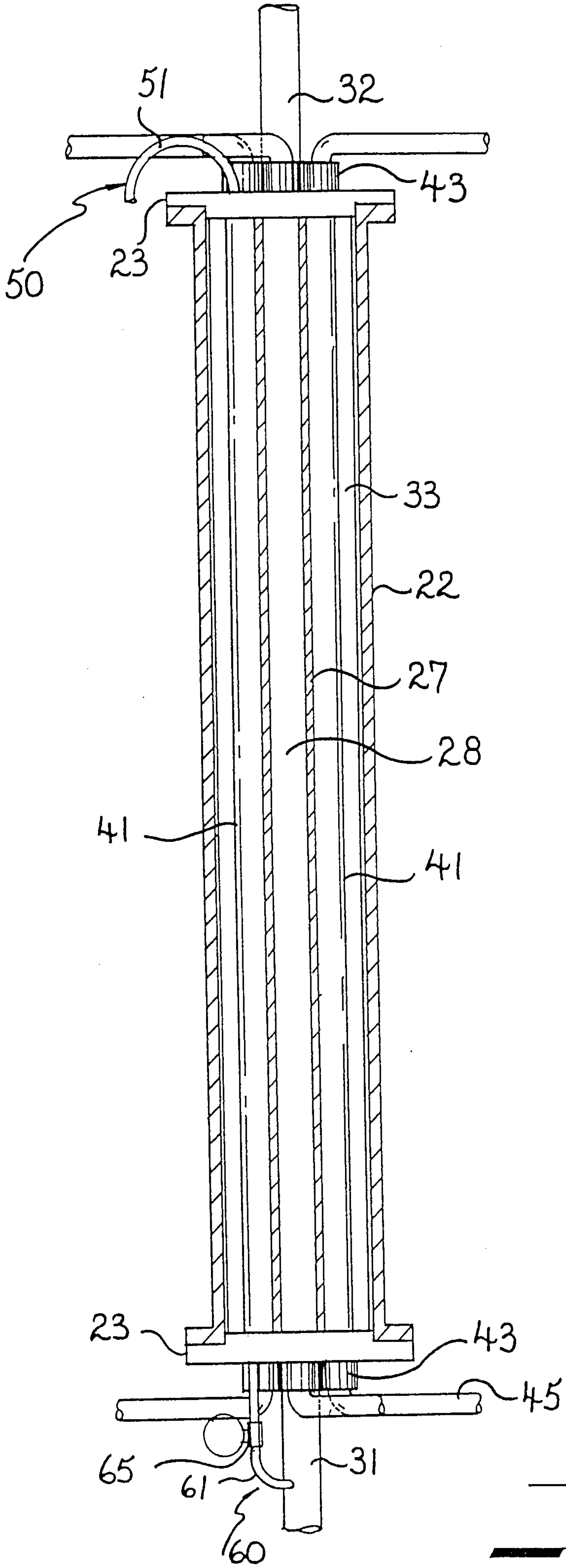

Fig.3

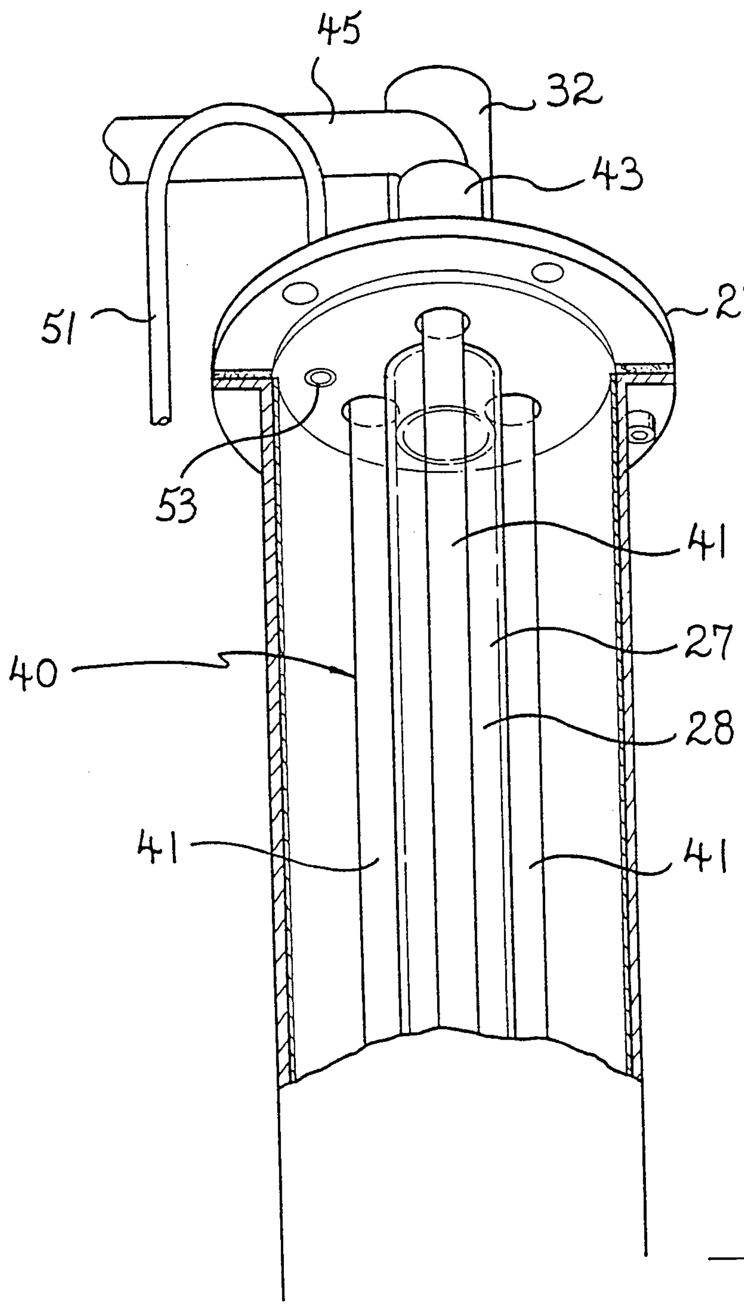

Fig 4

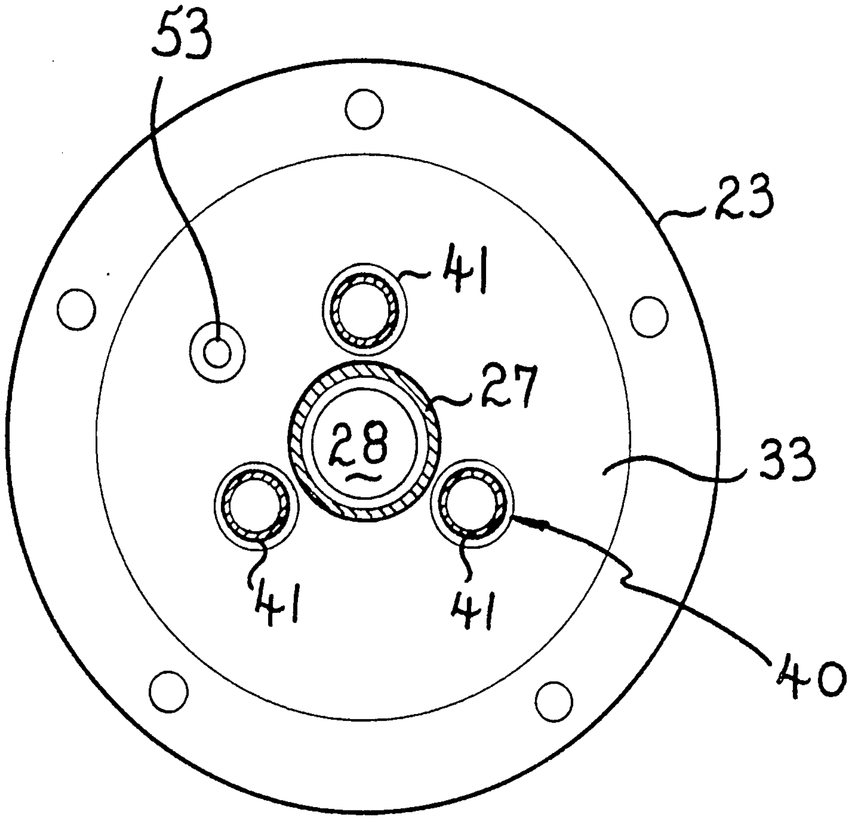

Fig 5

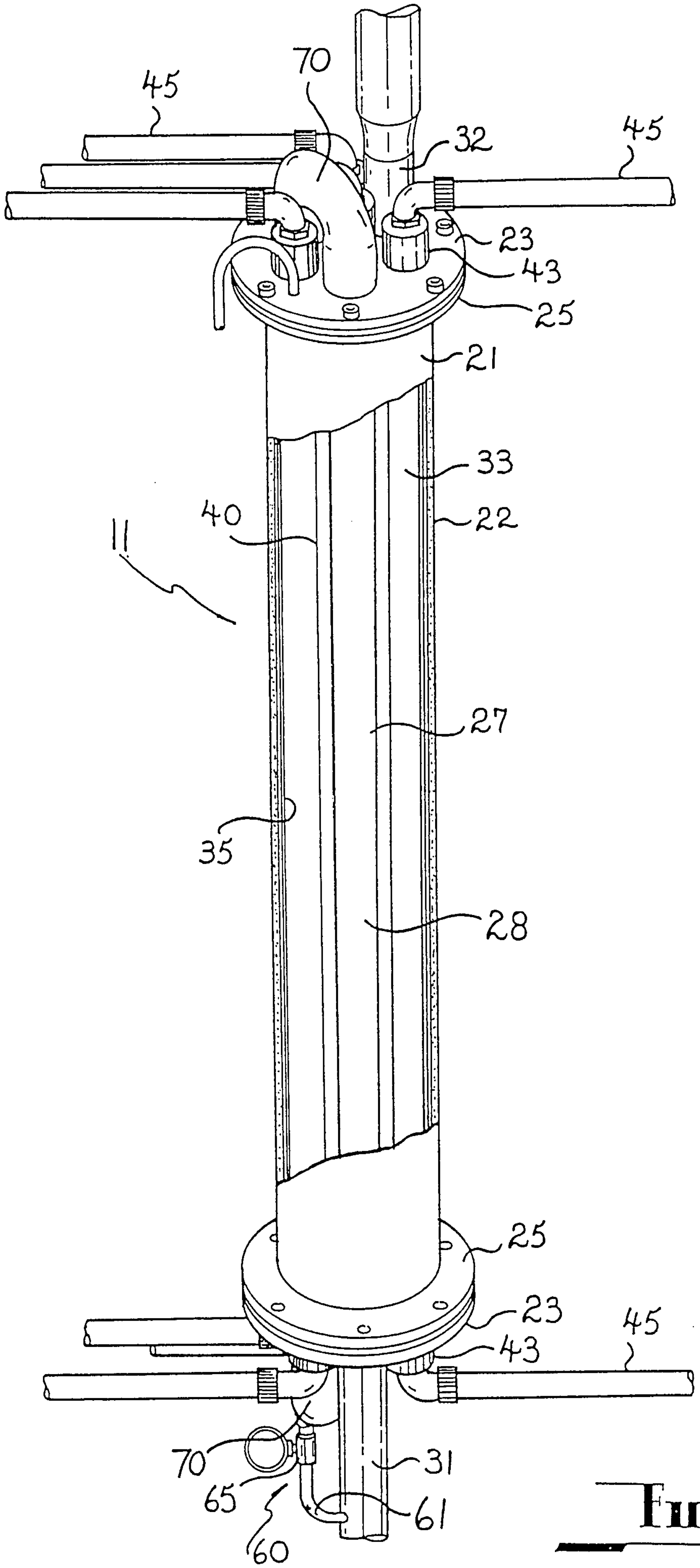

Fig. 6

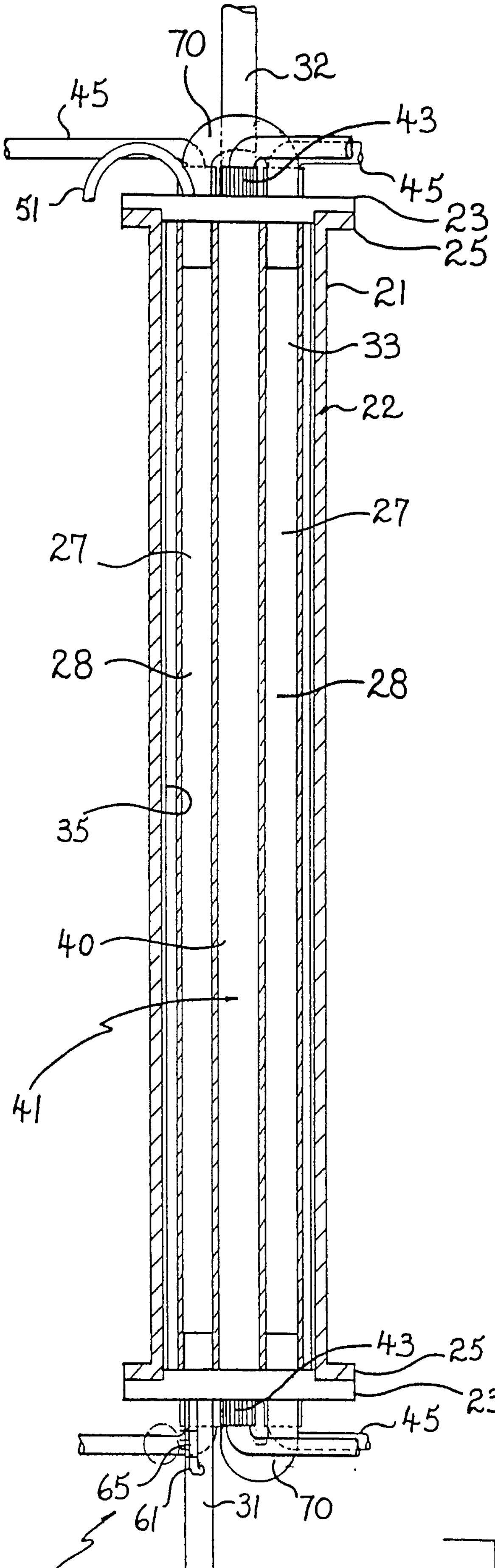
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Fig 7.

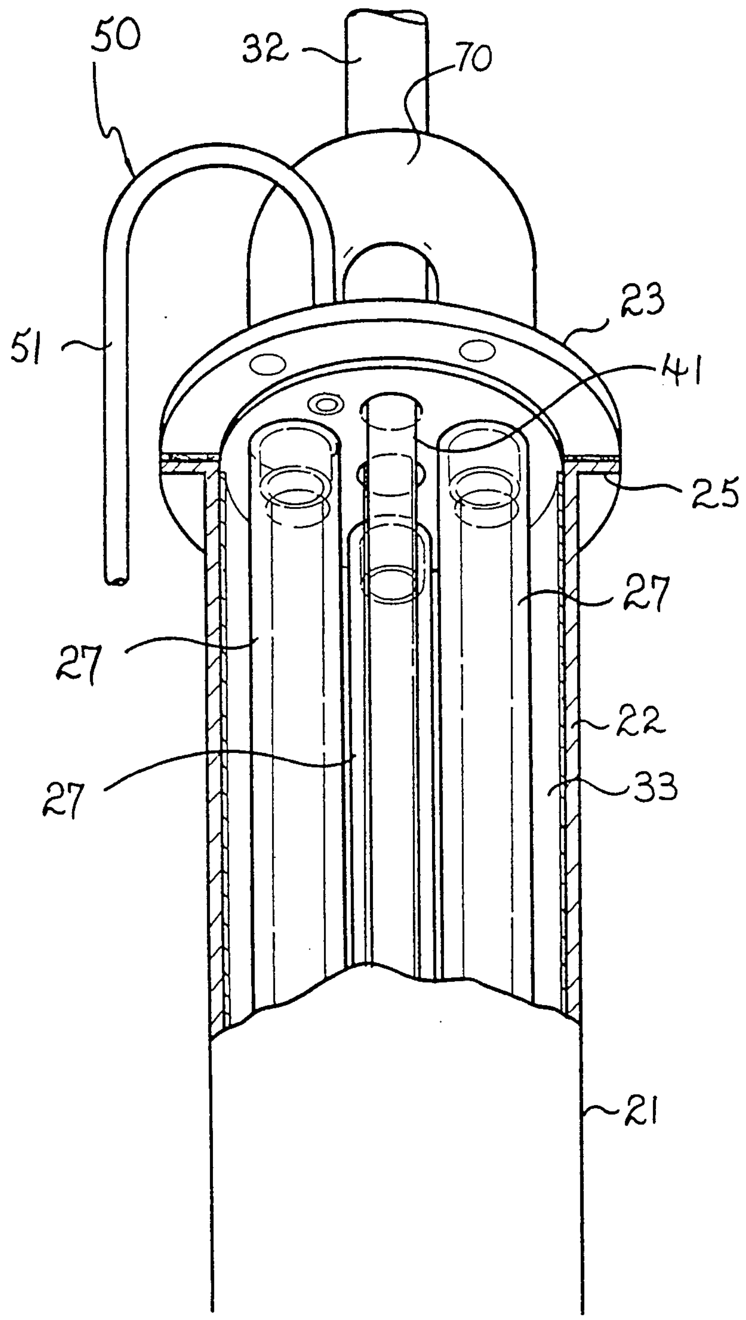

Fig 8

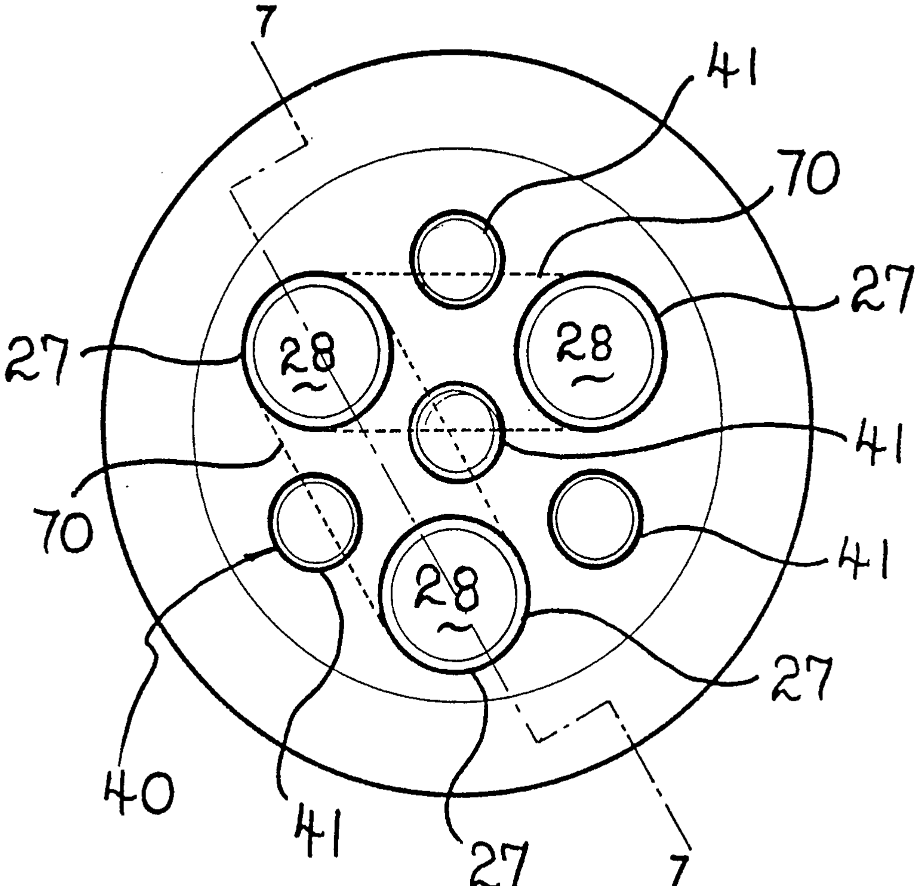

Fig. 9.

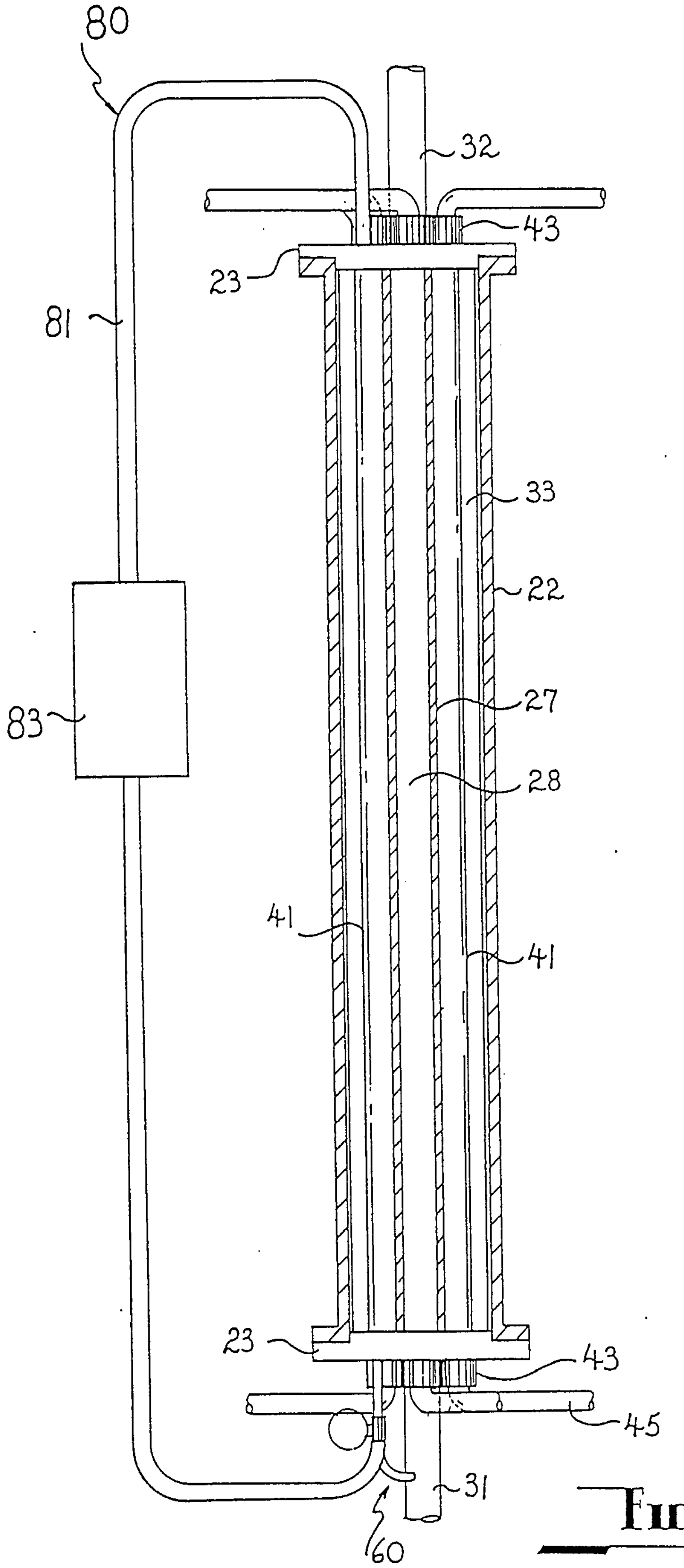

Fig 10

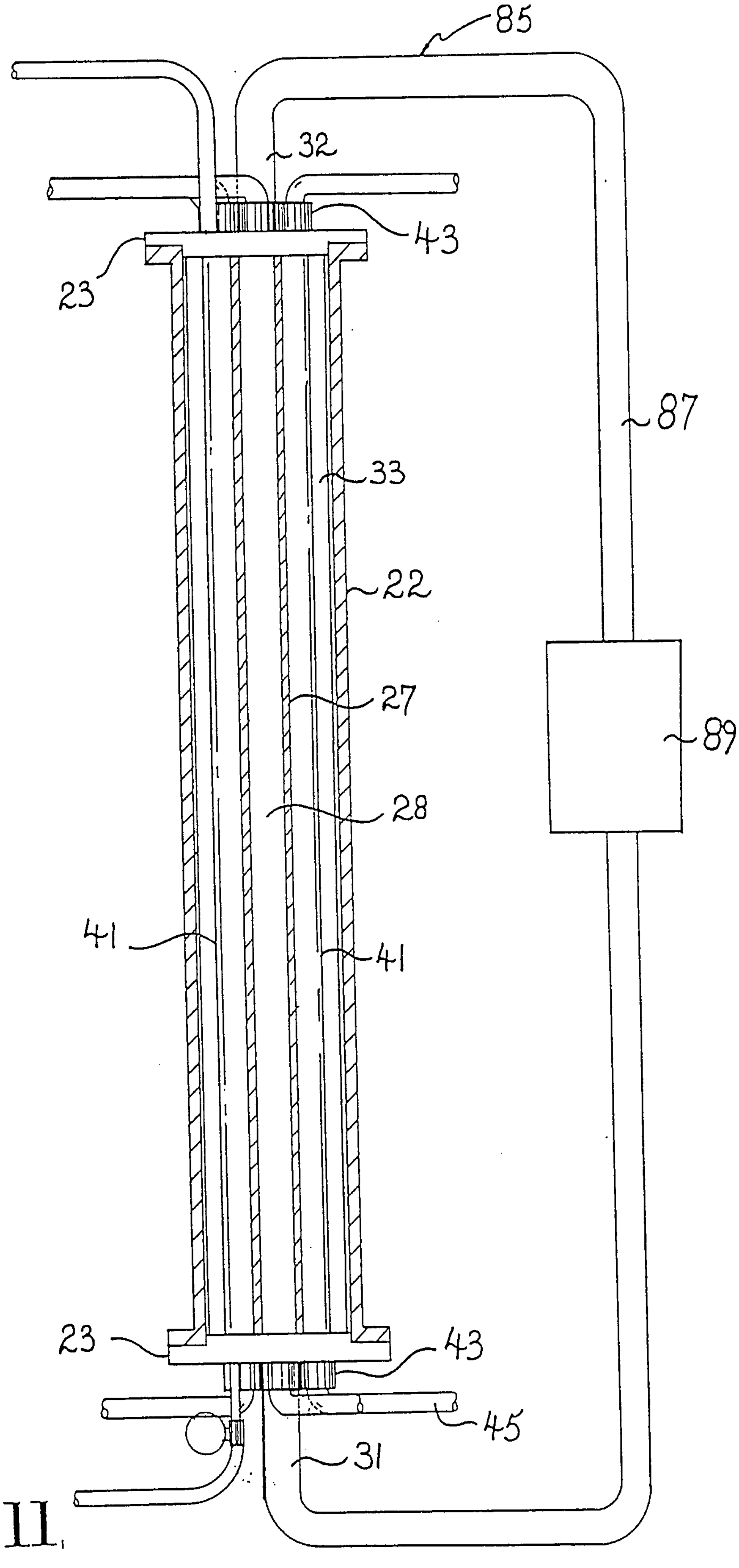

Fig 11

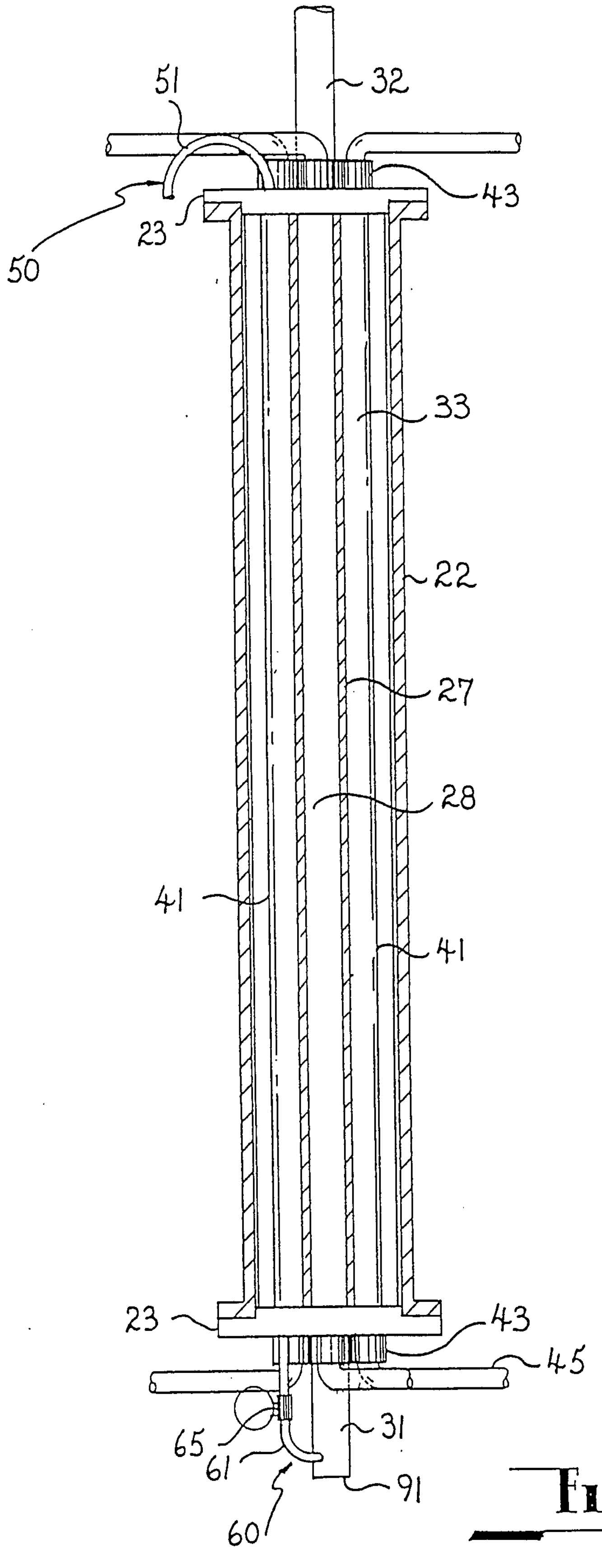

Fig. 12

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.[6] C02F 1/32 1/78

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)
IPC : C02F 1/32, 1/78; C02B 3/08, 1/38, 3/02, 1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU : Co2F 1/32, 1/78

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	AU,A, 43993/93 (THETFORD CORPORATION) 30 August 1979 (30.08.79)	1, 3-8, 10-11, 16, 17, 19, 27
X	AU,B, 26737/77 (508837) (THE COMMONWEALTH INDUSTRIAL GASES LIMITED) 3 March 1980 (03.03.80)	1-8, 10, 11, 16, 19, 21, 27, 30, 31
X	US,A, 4323810 (HORSTMANN) 6 April 1982 (06.04.82)	1-3, 7-10
X	US,A, 4274970 (BEITZEL) 23 June 1981 (23.06.81)	1, 2, 4-14, 18, 19, 24, 25, 29, 32-36, 39

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 October 1994 (13.10.94)	18 Oct 1994 (18.10.94)

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
X	US,A, 3550782 (VELOZ) 29 December 1970 (29.12.70)	1, 2, 4-11, 19-21, 24
X	DE,A, 4138916 (FRICKE) 11 June 1992 (11.06.92) Col. 2 line 13 to Col. 4 line 20. Fig. 1	1-13, 19, 21

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
AU	43993/79	BR	7900905	CA	1081913	EP	3879
		JP	54123288	US	4179616		
AU	26737/77	GB	1583394				
US	4323810	AT	3982/79	BE	876755	CA	1147011
		CH	648155	DE	2825018	DK	2338/79
		FR	2428323	GB	2027265	JP	55025992
		NL	7904412	NO	791869	SE	7904810

END OF ANNEX