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We, GILBARCO INC, of 7300 West Friendly Avenue, Greensboro, North Carolina 27420, USA, being the applicant in respect of Application No. 10322/95 state the following:-

The Person nominated for the grant of the patent has entitlement from the actual inventors by assignment.

The person nominated for the grant of the patent has entitlement from the applicants of the application listed in the declaration under Article 8 of the PCT by assignment.

The basic application listed in the declaration made under Article 8 of the PCT is the first application made in a Convention country in respect of the invention.

By our Patent Attorneys,  
WATERMARK PATENT & TRADEMARK ATTORNEYS

  
.....  
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Registered Patent Attorney

3rd February, 1997  
.....



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(54) Title  
METHOD AND APPARATUS FOR REDUCING HYDROCARBON EMISSIONS FROM A FUEL STORAGE TANK

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(56) Prior Art Documents  
US 4994094  
WO 9322031

(57) Claim

1. Apparatus for reducing hydrocarbon emissions from a fuel storage tank, the apparatus including a chamber having:

an inlet for receiving gases and vapours from the tank;

a first outlet;

a filter element including a membrane having the property of permitting hydrocarbon vapours to permeate therethrough; and

a second outlet, partitioned from the inlet and first outlet by the membrane, for receiving vapours permeated through the membrane.

13. A method for reducing hydrocarbon emissions from a fuel storage tank, the method including passing gases from the tank to an inlet of a chamber, the chamber having:

a first outlet;

a filter element including a membrane having the property of encouraging hydrocarbon vapours to permeate through the membrane; and

a second outlet, partitioned from the inlet and first outlet by the membrane, such that hydrocarbons transmitted through the membrane are received by the second outlet.



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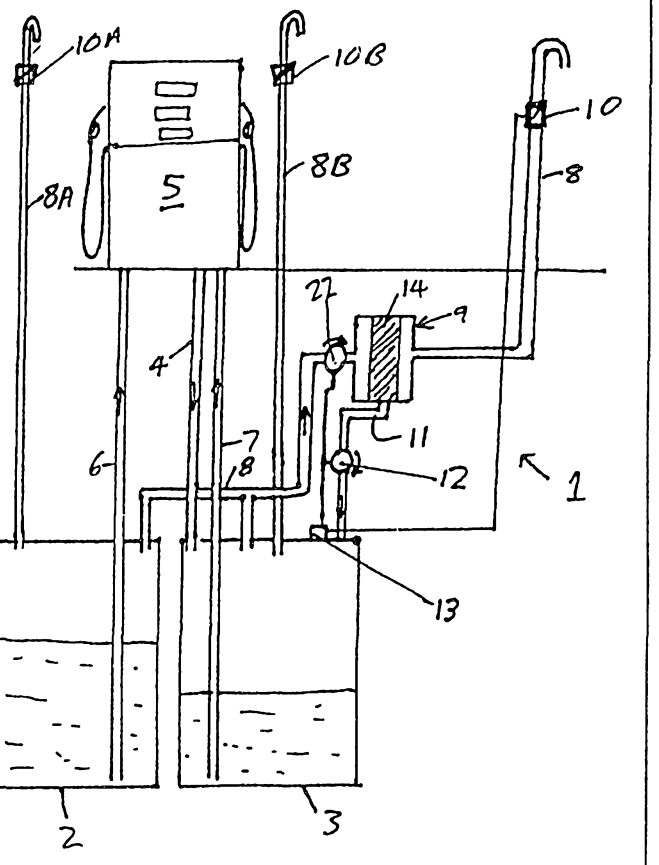
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(54) Title: METHOD AND APPARATUS FOR REDUCING HYDROCARBON EMISSIONS FROM A FUEL STORAGE TANK

(57) Abstract

Hydrocarbon emissions from a storage tank are reduced by passing the vapours through a fractionating membrane (17) which permits fuel vapours to pass through the membrane and be subsequently returned to the storage tank (3) but which is less permeable to air which instead is vented to atmosphere.



METHOD AND APPARATUS FOR REDUCING HYDROCARBON EMISSIONS FROM A FUEL STORAGE TANK.

The present invention relates to apparatus and a method for reducing the discharge of hydrocarbon pollutants from fuel storage tanks and, in particular, to a fuel storage tank pressure control system.

5 When fuel is added to a fuel reservoir, such as the petroleum tank of an automobile from a conventional gas dispenser apparatus such as the dispensing nozzle of a petroleum dispenser, petroleum vapour is displaced from the petroleum tank. If the vapour is not collected in some way, it will be released into the atmosphere. Due to the large number of automobile refuellings, such releases of fuel vapour constitute a significant hazard to the  
10 environment, particularly in heavily populated areas. Releases of these vapours, which are composed of volatile organic compounds (VOC's) such as hydrocarbons, are presently the subject of significant and increasing regulation.

In an effort to guard against the release of volatile organic compounds to the environment,  
15 several systems have been designed to collect the vapours displaced from automobile fuel tanks during refuelling. One such system called the "balance" system provides a rubber boot which surrounds the dispenser nozzle and forms a seal around an automobile fuel tank filler pipe. This system relies on the volumetric displacement of the vapour by the fluid transferred through the nozzle to the petroleum tank to force the vapour through the boot,  
20 through a connecting conduit, and back into a fuel storage tank. A bulky and cumbersome nozzle is required to effect the necessary seal at the filler pipe. If a perfect seal is not made, then vapour can leak to the atmosphere instead of being returned to the storage tank.

To mitigate the need for a cumbersome dispenser nozzle design and to increase the collection efficiency of the dispenser, systems have been designed wherein vapour collection at the nozzle is assisted by a vacuum pump. An example of such a system is disclosed in US Patent 5,040,577 to Pope, the disclosure of which is hereby incorporated  
5 by reference. A problem that can arise with a pump assisted system is that the pump can have a tendency to pressurize the fuel storage tank and associated piping. If the volume of vapour collected at the nozzle and conveyed into the fuel storage tank by the vapour pump is more than the volume of liquid fuel dispensed from the nozzle, the pressure in the fuel storage tank will be increased. In the current art of vapour pump assisted vapour  
10 recovery systems that use bootless nozzles, a ratio of vapour recovered versus product delivered greater than 1:1 is required to achieve desired recovery efficiency at the filler pipe.

Both pressurization and depressurization of the fuel storage tank can have detrimental  
15 effects. When a fuel storage tank has an internal pressure which is greater than the ambient pressure, there is an increased tendency for fuel and/or vapour to leak from gaps in the piping or the tank. Because many tanks are located underground, it is difficult both to detect leaks and to repair leaks. If the fuel storage tank becomes highly over-pressurized, there is a danger that the structural integrity of the tank may be threatened and even a  
20 danger of catastrophic breach of fuel containment. Additionally, over-pressurization of the fuel storage tank lessens the efficiency of the vacuum assist pump by creating a greater pressure differential between the nozzle and the fuel storage tank.

In order to solve the foregoing problems of over-pressurization, several devices and

methods have been developed to vent fuel storage tanks. It will be understood that a large portion of gas vented from the fuel storage tank will consist of volatile organic compounds. Regulations exist and will likely be made more stringent which limit the amount of VOC's that may be expelled into the atmosphere by such vents. Several techniques have been developed to meet these regulations. One such technique is disclosed in US Patent No. 4,118,170 to Hirt. The invention of Hirt involves burning the vapour vented. The danger of this technique is obvious, and the technique is presently not allowed in many areas. An alternate technique is to cool the vapour and return the condensed vapour to the tank as liquid. This technique is relatively expensive as it requires a refrigeration device.

10

International patent application, publication number WO 9322031 discloses an alternative system which attempts to solve the above problems. Here a gas separation diaphragm is positioned in the vapour recovery line of a dispenser, whereby an enriched mixture of volatile organic compounds is obtained on the permeate side of the diaphragm, which enriched mixture is returned to a storage tank, whilst depleted retentate is fed to a vent pipe of the tank. A similar system is also disclosed in German patent application, publication number DE 3806107.

15

The present invention is directed to an apparatus and method for maintaining a desired pressure within a fuel storage tank or tanks while minimizing or eliminating the amount or mass of pollutants discharged from the fuel storage tank or tanks.

20

According to a first aspect of the present invention there is provided a fuel dispensing system comprising: a fuel storage tank from which fuel is dispensed to a vessel and



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vapour recovery means for returning to the fuel storage tank vapours displaced from the vessel by the dispensed fuel, characterised in further comprising apparatus for reducing hydrocarbon emissions from the fuel storage tank, the apparatus comprising a chamber having: an inlet for receiving gases from the tank; a first outlet; a filter element comprising  
5 a membrane having the property of permitting hydrocarbon vapours to permeate therethrough; and a second outlet, partitioned from the inlet and first outlet by the membrane, for receiving vapours permeated through the membrane.

Employing the present invention reduces the quantity of pollutants emitted to the  
10 atmosphere by extracting through the membrane, preferably a fractionating membrane, a large proportion of the vapours that would otherwise be emitted to the atmosphere. However, because the membrane is located in the vent pipe from the tank it is both relatively simple to retrofit such a system to an existing installation, and also only a small proportion of vapour has to be filtered relative to that recovered by the vapour recovery  
15 system, and indeed it may only be necessary to occasionally vent the tank to atmosphere to release any cumulative imbalance between the quantity of fuel dispensed and quantity of air/vapour recovered.

Preferably the vent is provided with a controllable relief valve such as a solenoid valve to  
20 atmosphere. This is advantageously controlled in dependence on the pressure in the storage tank such that the valve is opened if the pressure exceeds a predetermined value. In this manner, minor variations in pressure in the tank can be tolerated without any requirement to vent to atmosphere, but if any larger increase in pressure occurs then this can be released by the valve.



Advantageously a pump is also provided to induce the vapour components to encounter the membrane within the above mentioned range. This encourages vapours to be absorbed through the membrane.

5 Advantageously the pump is located between the outlet and the tank and is controlled by a switch sensitive to the pressure in the tank, which switch turns the pump on when the pressure in the tank reaches a predetermined threshold, advantageously at or below the threshold at which the control valve opens.

10 In accordance with a second aspect of the invention there is provided a method for a method for reducing hydrocarbon emissions from a fuel storage tank, the method comprising dispensing fuel to a vessel, retrieving vapours displaced from the vessel and returning them to the tank, the method being characterised in further comprising passing  
15 gases from the tank to an inlet of a chamber, the chamber having: a first outlet; a filter element comprising a membrane having the property of encouraging hydrocarbon vapours to permeate through the membrane; and a second outlet, partitioned from the inlet and first outlet by the membrane, such that hydrocarbons transmitted through the membrane are received by the second outlet.

20 One embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of a vent filter system in accordance with the present invention:



Figure 2A is an enlarged cross-sectional view of the chamber and the filter of Figure 1; and

Figure 2B is a cross-section along line I-I of Figure 2A.

5 Referring now to the drawings, in which like numerals are used throughout, the fuel storage tank vent system 1 is shown in conjunction with two conventional underground fuel storage tanks 2, 3 containing high and low octane fuel respectively. It will be understood that vent system 1 may be used with any number of storage tanks above or below ground.

10 Fuel tank 3 has a vapour return line 4 for receiving vapour recovered by a fuel dispenser 5 having means for collecting fuel vapours (not shown). The fuel tanks 2, 3 further include fuel delivery lines 6, 7 for conveying fuel to the dispenser 5. Vent line 8 is provided at the top of tanks 2, 3 and equalizes the pressure between them, permitting the return of all vapours to one tank 3 via return line 4. Additional return lines to additional tanks can be  
15 provided but are generally not needed.

Vent line 8 extends to atmosphere, via chamber 9 and control valve 10. A return line 11 connects the lower portion of chamber 9 and tank 3 via pump 12, the pump 12 and control valve 10 being controlled by tank pressure sensor 13.

20

In addition to vent line 8, each tank is also vented to atmosphere via vent lines 8A and 8B each having a respective pressure/vacuum release valve 10A and 10B which ensure no pressure or vacuum exists within the tank outside a predetermined range. Gases will in normal operation be vented through vent line 8 in preference to vent lines 8A or 8B, but



any vacuum will be replenished by air being drawn in through lines 8A or 8B.

Referring now to Figures 2A and 2B, chamber 9 houses filter element 14 positioned such that it separates chamber 9 into two plenums 9A and 9B. Vapour and gases entering the  
5 chamber, from the storage tanks 2 and 3 along vent line 8, flow through the filter element 14 to valve 10, as indicated by arrows 15 in Figure 2B.

The filter 14 comprises a cylindrical core 16. Membrane 17 is configured as an outer cylinder coaxial with the core cylinder comprising a plurality of stacked and bound thin  
10 sheets, each adjacent pair sheets forming an envelope 18. Each envelope 18, formed between the membrane 17 and core 16, is connected to the space within the core 16 by holes 19 in the cylindrical core 16.

The filter element 14 is inserted through aperture 20 in the chamber 9, and is retained in  
15 place by threaded member 21, which member both seals the cavity and holds the cylindrical core 16 in contact with sealing ring 21, such that core 16 seals with return line 11.

Membrane 17 can be a fractionating membrane developed by GKSS-Forschungszentrum  
20 Gesthacht GmbH of Germany and described in "Operating Experiences with Membrane Systems in Gasoline Tank Farms", presented by K. Ohlbrugge at the 1991 9th Annual Membrane Technology/Planning Conference in Newton, Massachusetts, October 4-6, 1991 or "Volatile Organic Compound Control Technology by Means of Membranes", presented by K. Ohlbrugge at the 1993 11th Annual Membrane Technology/Separation Planning



Conference in Newton, Massachusetts October 11-13, 1993, the disclosures of which are hereby incorporated by reference. A property of membrane 17 is that it is permeable to selected pollutants including hydrocarbons such as petroleum vapour while it is relatively impermeable to air.

5

In operation, vent system 1 functions as follows. As fuel is dispensed via fuel dispenser 5, a given volume of liquid,  $V_L$ , is drained from either tank 2 or 3. Concurrently with the draining of liquid fuel, a given volume of fuel vapour,  $V_v$ , is forced into tank 3 through vapour return line 4 by a vapour pump (not shown). Typically, the ratio of  $V_v$  to  $V_L$  will be greater than 1:1, thus, the pressure within the tanks will have a tendency to become greater than the ambient atmospheric pressure. It is also possible that the ratio of  $V_v$  to  $V_L$  will be less than 1:1. This would result in tank pressures less than atmospheric.

Normally, valve 10 will remain closed. However, when the pressure in tanks 2, 3 reaches a given pressure, pressure transducer 13 causes pump 12 to operate. The actuation of pump 12 creates a vapour flow from tank 3, through vent line 8, through chamber 9, and return line 11 to tank 3. As the vapour flows through chamber 9, it encounters membrane 17. As the fuel vapour encounters membrane 17, vapours are encouraged to permeate through the membrane by the pressure gradient across the membrane, leaving "clean" air within plenum 9B. Shortly after operation of the pump commences, valve 10 opens releasing this "clean" air to atmosphere. The increased concentration of the returned vapours may encourage the vapour to condense within tank 3 until equilibrium is reached.

If the tank pressure drops below atmospheric pressure, then air is drawn in via pressure



vacuum release valves 10A and 10B.

In certain applications it may be advantageous to incorporate a pump 22, also controlled by pressure sensor 13, to assist in drawing gases away from the tank.

5

Certain modifications and improvements will occur to those skilled in the art upon a reading of the foregoing description. It should be understood that all such modifications and improvements are properly within the scope of the following claims.



## THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Apparatus for reducing hydrocarbon emissions from a fuel storage tank, the apparatus including a chamber having:
  - an inlet for receiving gases and vapours from the tank;
  - a first outlet;
  - a filter element including a membrane having the property of permitting hydrocarbon vapours to permeate therethrough; and
  - a second outlet, partitioned from the inlet and first outlet by the membrane, for receiving vapours permeated through the membrane.
2. Apparatus as claimed in claim 1 wherein the membrane is arranged in the filter element such that gases flowing through the filter element flow across the surface of the membrane.
3. Apparatus as claimed in claim 1 or 2 wherein the filter element extends across a flow path between the inlet and first outlet.
4. Apparatus as claimed in claim 3 wherein the filter element extends across the chamber such that gases flowing from the inlet to the first outlet flow through the filter element.
5. Apparatus as claimed in any preceding claim wherein the first outlet is vented towards atmosphere.
6. Apparatus as claimed in claim 5 further including a controllable valve connected between the first outlet and atmosphere.
7. Apparatus as claimed in claim 6 further including a sensor for determining the pressure in the tank and opening the controllable valve if the pressure exceeds a predetermined threshold.



8. Apparatus as claimed in any preceding claim wherein the second outlet is connected to the tank such that vapours permeating through the membrane are returned to the tank.

9. Apparatus as claimed in claim 8 further including a pump located between the second outlet and the tank, which pump in operation causes the pressure at the second outlet to decrease relative to the pressure at the inlet inducing hydrocarbon vapours to encounter and permeate through the membrane.

10. Apparatus as claimed in claim 9 further including a sensor for detecting the pressure in the storage tank and causing the pump to be actuated if the pressure exceeds a predetermined value.

11. Apparatus as claimed in any preceding claim wherein the membrane comprises a number of portions which absorb and transmit various components of hydrocarbon vapours.

12. A fuel dispensing system incorporating apparatus as claimed in any preceding claim wherein vapours from a tank being filled are returned to the storage tank.

13. A method for reducing hydrocarbon emissions from a fuel storage tank, the method including passing gases from the tank to an inlet of a chamber, the chamber having:

a first outlet;

a filter element including a membrane having the property of encouraging hydrocarbon vapours to permeate through the membrane; and

a second outlet, partitioned from the inlet and first outlet by the membrane, such that hydrocarbons transmitted through the membrane are received by the second outlet.



14. A method as claimed in claim 13 further including pumping hydrocarbons from the second outlet back to the tank such as to induce vapour to permeate through the membrane.

DATED this 3rd day of February, 1997.

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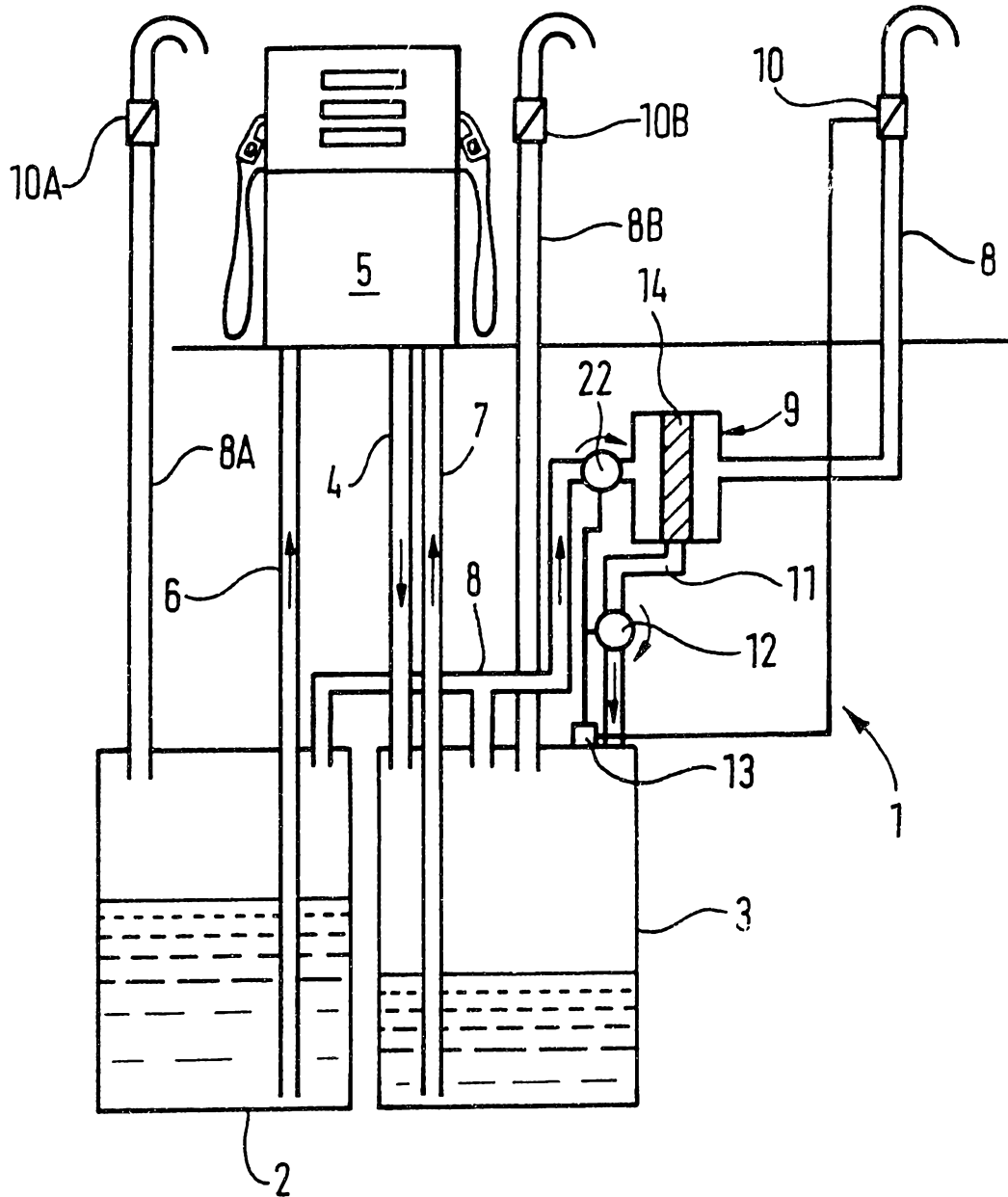
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FIG. 1



2 / 2

FIG. 2A

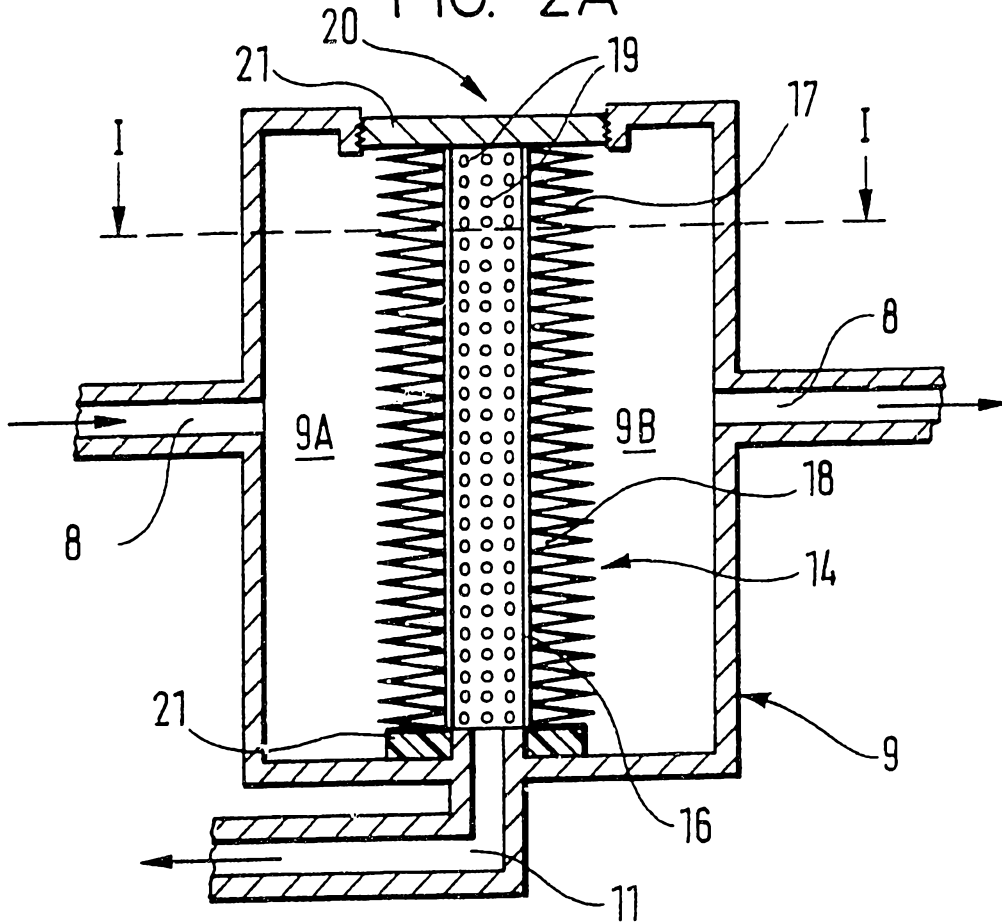
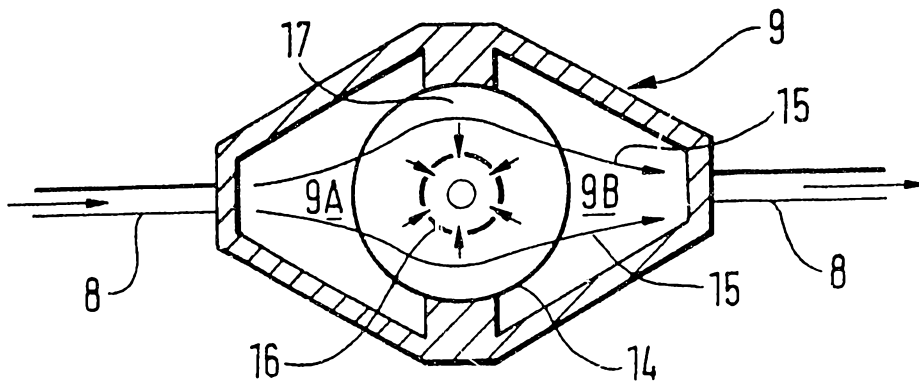


FIG. 2B



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1/24/67

## INTERNATIONAL SEARCH REPORT

International Application No  
PC/GB 94/02529

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 B67D5/378 B01D53/22

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 6 B67D B01D

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

Electronic data base consulted during the international search (name of data base and, where practical, 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.
Y	WO,A,93 22031 (OHLROGGE ET AL.) 11 November 1993 see page 7, paragraph 6 - page 9, paragraph 2; figure 1 ---	1-14
Y	DE,A,38 06 107 (BEHLING ET AL.) 31 August 1989 see page 4, line 1 - line 39; figures 1,2 ---	1-14
A	DE,U,92 05 552 (OSCAR GOSSLER KG) 26 August 1993 ---	
A	DE,A,38 24 400 (DAHLHOFF ET AL) 25 January 1990 ---	
A	DE,U,87 02 074 (SCHWEFER) 30 April 1987 ---	
	-/--	

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

## \* Special categories of cited documents :

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- \*E\* earlier document but published on or after the international filing date
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Date of the actual completion of the international search

15 February 1995

Date of mailing of the international search report

27.02.95

Name and mailing address of the ISA

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INTERNATIONAL SEARCH REPORT

International Application No

PC 1/GB 94/02529

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, X	DE, A, 42 25 170 (PREUSSAG ANLAGENBAU) 3 February 1994 see the whole document -----	1-9, 12-14

## INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 94/02529

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A-9322031	11-11-93	DE-A- 4214551 EP-A- 0637987	28-10-93 15-02-95
DE-A-3806107	31-08-89	AT-T- 106267 DE-D- 58907723 EP-A- 0329962 ES-T- 2056964 JP-A- 2021920 US-A- 4994094	15-06-94 07-07-94 30-08-89 16-10-94 24-01-90 19-02-91
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DE-A-3824400	25-01-90	NONE	
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DE-A-4225170	03-02-94	NONE	