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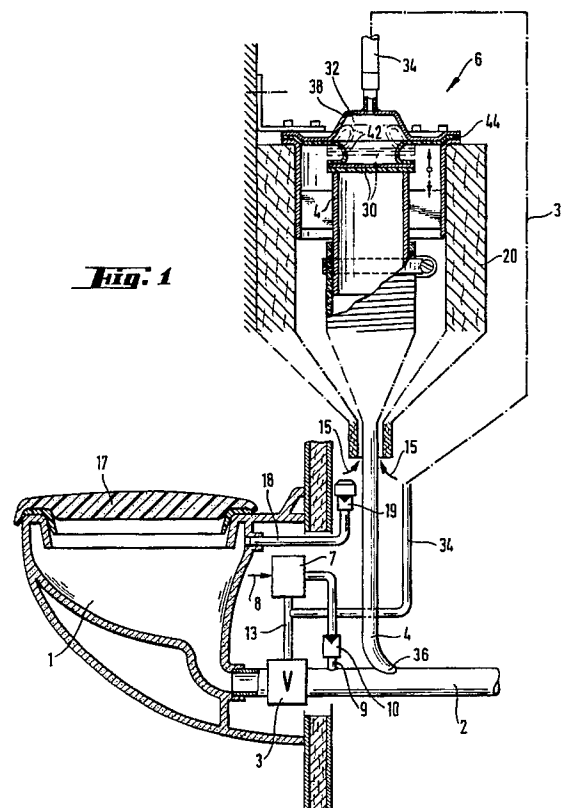
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(54) **Vacuum sewer arrangement.**

(57) A vacuum sewer arrangement comprises a bowl (1) connected to a sewer pipe (2) provided with means for establishing, in the sewer pipe (2), a vacuum sufficient for obtaining efficient sewage transport. There is a normally-closed sewer valve (3) connecting the bowl (1) to the sewer pipe (2) and a control device (7) for controlling operation of the sewer valve (3) to allow discharge of sewage from the bowl (1) to the sewer pipe (2). There is also an air inlet duct (4) for letting air into the sewer pipe (2) separately from the bowl (1). For controlling flow of air through the air inlet duct (4) into the sewer pipe (2), when the sewer pipe (2) is under proper vacuum for effective sewage transport, there is an air inlet valve (6) with means operating it in response to pressure variations in the sewer pipe (2). Such pressure variations occur when the sewage discharged from the bowl (1) has passed the point (36) where the air inlet duct (4) is connected to the sewer pipe (2). This ensures that the air inlet valve (6) operates accurately and securely.



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VACUUM SEWER ARRANGEMENT

The invention relates to a vacuum sewer arrangement for use with a waste-receiving bowl.

In a vacuum sewer arrangement, a waste-receiving toilet or WC bowl is connected to a sewer pipe by means of a sewer valve, and a vacuum is maintained in the sewer pipe. In order to carry out a flushing operation, the sewer valve is opened and waste in the bowl is inducted into the sewer pipe.

The waste forms a movable plug in the sewer pipe, and the pressure difference across the plug propels the plug through the sewer pipe to a waste-receiving tank. In a conventional vacuum sewer arrangement, air for transportation of the waste plug enters the sewer by way of the sewer valve. When the sewer valve closes, the plug stops moving almost immediately.

Two main factors determine how long the sewer valve remains open. Firstly, the sewer valve must remain open for long enough to ensure, with a reasonable degree of certainty, that the waste in the bowl has entered the sewer pipe. Although normally the waste is pressed into the sewer almost instantaneously, it is usual to allow about two seconds for the waste to leave the bowl. Secondly, it is important for proper operation of a vacuum sewer arrangement that the chance of one waste plug merging with a preceding or succeeding plug in the sewer pipe be very small, and therefore the plug must travel a substantial distance along the sewer pipe, for example at least 10 m, before stopping. In vacuum sewer arrangements that are currently in use, the waste plug typically travels at a maximum speed of around 5 to 10 m/s. Therefore, in a typical vacuum sewer arrangement, the sewer valve remains open for about four seconds on each flush.

The waste will enter the sewer pipe immediately the sewer valve opens, followed by a large quantity of air. This causes considerable pressure variations in the bowl, in particular during the opening and closing phase of the sewer valve when material (waste or air) is inducted through a relatively small opening. Due to this, a high noise level is usually generated. The noise level is dependent on the pressure difference between the interior of the bowl and the sewer pipe - the greater the difference, the greater the noise tends to be.

The Patent Publication GB-A-2203461 discloses a vacuum sewer arrangement with a noise-reducing air inlet device connected to the sewer immediately downstream of the sewer valve.

One object of the present invention is to provide a simplified and more reliable version of the arrangement disclosed in GB-A-2203461.

A disadvantage of the vacuum sewer arrange-

ment described with reference to Figure 1 in GB-A-2203461 is that a vacuum accumulator may be required in order to provide a sufficiently large volume under vacuum for proper functioning of the sewer valve and the air inlet valve. Also, since the air inlet valve opens after the sewer valve, and a single control device is used to control both the sewer valve and the air inlet valve, a throttle is required in order to delay operation of the air inlet valve relative to the sewer valve. Further, the proper location of the outlet of the air inlet duct depends on several factors, and it is not possible to be certain that these factors will remain constant or will be the same from installation to installation.

According to the invention a much simpler and more reliable system is obtained by applying means for operating the air inlet valve in response to the pressure in the vacuum sewer close to the sewer valve, as stated in claim 1.

The air inlet duct can be sound insulated to the point where air flowing through the air inlet duct will not cause a disturbing level of noise. The noise level of a vacuum toilet sewer arrangement according to the invention can be further reduced by providing, as known per se, the bowl with a lid forming a substantially airtight and sound-proof closure at the top of the bowl. In this case, it is favourable that the lid be of relatively thick sound-insulating material. Various plastics materials, and in particular sandwich structures, are well suited for this purpose. If the lid provides a seal, the volume of air contained in the bowl may be too small for proper discharge of the sewage from the bowl, in which case additional air can be provided through a separate tube. This tube may have its inlet end connected to the air inlet duct upstream of the air inlet valve, but it may also be a completely separate tube. The lowest noise level is achieved if the tube is provided with a muffler, is sound insulated and has its inlet end outside the toilet compartment. The tube is preferably provided with a non-return valve in order to prevent escape of odours from the toilet bowl into the surroundings.

The connection of the air inlet duct to the sewer is desirably sufficiently close to the sewer valve that in normal operation of the vacuum sewer arrangement, the sewer plug formed when the waste enters the sewer through the sewer valve, will pass the outlet of the air inlet duct less than one second after the sewer valve reaches its fully open condition, and preferably less than 0.5 seconds after the sewer valve reaches its fully open condition. Conveniently the air inlet valve opens less than 2.5 seconds after the sewer valve opens, preferably between 1 and 2 seconds after the sew-

er valve opens, and most preferably about 1.5 seconds after the sewer valve opens. However, the time at which the air inlet valve opens should be selected relative to the distance between the sewer valve and the outlet of the air inlet duct and the expected speed of travel of the sewage plug so that the air inlet valve will not open before the sewage plug has passed the air inlet duct, since otherwise proper transportation of the plug might not be achieved. The air inlet valve will typically stay open for about 5 seconds or less. This introduces slightly more transport air into the sewer than is usual in conventional vacuum sewer systems. The increased amount of air provides a greater travel distance for a sewage plug discharged from the bowl.

Conventionally, the sewer valve of a vacuum sewer arrangement is operated by using the vacuum present in the vacuum sewer. In an arrangement according to the invention the same vacuum can be used also for operating the air inlet valve. This gives a simple and reliable structure.

A check valve should be arranged between the sewer valve control device and the sewer, so that a pressure rise in the sewer is unable to have any influence on the pressure in the valve control device.

In the descriptive portion of this specification and in the claims the term "vacuum" should be taken to mean a sub-atmospheric pressure of a magnitude suitable for use in a vacuum sewer system. Conventionally, the pressure in such a system is about 38 cm Hg. The term "atmospheric" as used herein means ambient pressure and thus, in the case of an aircraft in flight can mean the cabin pressure.

The invention will now be described in greater detail, by way of example, with reference to the accompanying drawings, in which:

Figure 1 schematically shows, partly at an enlarged scale, one embodiment of the invention, and

Figure 2 shows schematically an arrangement according to the invention having multiple waste-receiving bowls.

Figure 1 illustrates a waste-receiving bowl 1 and a sewer pipe 2 connected to the bowl 1 by a sewer valve assembly 3. The interior space of the sewer pipe 2 is maintained under vacuum, which may be provided as known per se, by a vacuum pump (not shown). Such a pump is usually connected to the downstream end of the sewer pipe 2, or may be connected to a sewage collecting tank (not shown) into which the pipe discharges. The sewer valve assembly 3 includes a sewer valve proper and a sewer valve operating device which opens the sewer valve (e.g. by using the vacuum). Various valve assemblies of this type are described

in US-A-3,482,267, 3,807,431, 3,984,080 and 4,376,444.

An air inlet duct 4 opens into the sewer pipe 2 through an outlet 36. An air inlet valve assembly 6 is connected to the air inlet duct 4.

A control device 7, which controls the valve assembly 3, is activated by a function impulse 8. Such an impulse may originate from a push button operated by the user of the toilet and may be transmitted, for instance mechanically, in the form of a pressure impulse, or electrically in the form of a signal pulse, to the control device 7. The function impulse 8 may be dependent on, for instance the closing of a lid 17 of the toilet bowl or on other factors which are relevant to controlling the flushing of the toilet. Since these factors also are well known in the art, neither the creating of a function impulse nor the manner of operation of the control device 7 will be explained here.

A general principle behind the operation of a vacuum sewer arrangement is that the sewer valve should open only when there is sufficient vacuum in the sewer pipe for effective transport of sewage. In order to achieve this, the vacuum required to open the sewer valve is taken from the sewer pipe 2 or from another point of the vacuum system. If the available vacuum is too weak for effective transport of sewage, the sewer valve will not open. In the embodiment of Figure 1 the vacuum required for the operation of the sewer valve is communicated from the sewer pipe 2 to the control device 7 through a tube 9 and a check valve 10. Upon receiving a function impulse 8, the control device 7 transmits vacuum received from the sewer pipe 2 via a tube 13 to the operating device of the sewer valve assembly, which then opens the sewer valve. At the same time the control device 7 transmits vacuum through a tube 34 towards the air inlet valve assembly 6.

The distance of the outlet 36 of the air inlet duct 4 from the sewer valve assembly 3 and the delay between opening of the sewer valve and opening of the air inlet valve are selected so that, in normal operation, the air inlet duct 4 supplies air to the sewer practically immediately after the plug of sewage from the bowl 1 has passed the outlet 36. Since air for transporting the plug is then provided through the air inlet duct, the sewer valve need not be held open any longer than is necessary to ensure that the plug has passed the outlet 36. When the sewer valve closes, air is no longer inducted through the toilet bowl and the noise level therein is reduced. Moreover, when both the sewer valve and the air inlet valve are open, air is inducted through the sewer valve at a lower rate and the noise level is also reduced.

The basic structure of an arrangement according to the invention requires that air is led through

the air inlet duct 4 to the vacuum sewer pipe 2 when the sewage-providing unit 1 is emptied. This substantially reduces the noise level, but nevertheless, the noise level might be unpleasantly high. Hence, letting in air by way of an air inlet duct is not always sufficient to reduce the noise level to an acceptable value. Additional measures might be necessary for improving the technical effect of the basic embodiment of the invention. A suitable additional measure is to provide the bowl 1 or a corresponding sewage-providing unit with an airtight lid 17. Such a lid desirably should be made relatively sound-proof. Opening of the sewer valve can, as known *per se*, easily be made dependent on the closing of the lid 17, so that the valve opens only when the lid is closed.

Using an airtight lid in a vacuum toilet may result in the amount of air present in the bowl 1 being too small for efficient flushing of the bowl, flushing being effected by discharging a volume of water into the bowl to assist in removing the waste plug from the bowl. The water supply are not shown in either of Figures 1 or 2. If too little air is available in the bowl with the lid 17 closed, the problem can be overcome by connecting an air tube 18 to the bowl 1. Air is led into the bowl through the tube 18 and a check valve 19 without any substantial noise. The air supply for the tube 18 can be taken from any place, for instance, from outside the toilet compartment and can, for example, be passed through an air silencer or the like incorporated in the valve 19.

In the embodiment shown in Figure 1, the air inlet valve 6 and the air inlet duct 4 are surrounded by a tube 20 of sound insulating material. This tube forms a noise damping air entrance duct coaxially disposed around the duct 4 to leave an annular air passage between the tube 20 and the duct 4. Ambient air flows into this passage via an entrance at the lower end of the tube 20 as is shown by arrows 15. The air inlet valve 6 comprises a diaphragm 30 (e.g. a rubber pad) that is deflectable towards and away from the upper end of the duct 4, depending on the difference in pressure between the duct 4 and a control chamber 32, which is connected to the narrow-bore tube 34 leading back to the tube 13. The control chamber 32 is bounded partially by the diaphragm 30 and partially by a rigid wall 38, to which the diaphragm 30 is connected through a flexible rubber skirt 42 and a flange 44. The flexible rubber skirt 42 biases the diaphragm 30 towards the upper end of the duct 4.

Normally, the pressure in tube 13 is substantially that existing in the toilet compartment (e.g. normal atmospheric pressure or cabin-pressure in an aircraft) while there is a lower pressure in the duct 4 because it is directly connected to the sewer pipe 2, which is under vacuum. As a result,

the diaphragm 30 is held in firm sealing contact with the upper end of the duct 4. On receiving a function impulse 8, the control unit 7 communicates vacuum from the sewer pipe 2 to the tube 13. This opens the sewer valve, and waste in the bowl 1 is drawn rapidly into the sewer pipe 2.

The vacuum in the tube 13 is communicated through the tube 34 to the control chamber 32 and the pressures on the two sides of the diaphragm then move towards equality. However, owing to the bias provided by the resilient skirt 42, and the difference between the area of the diaphragm exposed to pressure in the duct 4 and the area of the diaphragm and skirt effectively exposed to pressure in the chamber 32, the diaphragm 30 remains in contact with the duct 4 and therefore the air inlet valve remains closed. When the waste passes the outlet 36 of the duct 4, and is followed by air from the bowl 1, the pressure in the sewer pipe 2 and consequently also in the duct 4 rises, but the check valve 10 prevents a corresponding rise in pressure in the tube 34. Then, the diaphragm 30 can become unseated from the upper end of the duct 4, and air can enter the sewer pipe 2 through the duct 4. At about the same time as the air inlet valve opens, the control unit 7 starts to communicate atmospheric pressure to the tube 13, causing the sewer valve to close. Atmospheric pressure is then also communicated to the control chamber 32, with a slight delay due to the length of the tube 34, and the air inlet valve 6 closes.

The toilet lid 17 is in sealing relationship with the rim of the bowl 1, and the function impulse 8 can only be generated when the lid 17 is closed. When the sewer valve opens and waste is drawn into the sewer pipe 2, air for transporting the waste is inducted into the bowl 1 through the tube 18 and the check valve 19 and the pressure in the sewer pipe 2 behind the waste remains close to atmospheric.

The outlet 36 of duct 4 is sufficiently close to the sewer valve assembly 3 that the operation of the sewer valve directly induces operation of the air inlet valve 6. Thus, when the sewer valve opens, it is the rise in pressure in the sewer pipe when the waste plug from the toilet bowl has passed the outlet 36 that causes the air inlet valve to open, and when the sewer valve closes in response to control unit 7, the fall in pressure (increased vacuum) in the sewer pipe causes the air inlet valve 6 to close. Since the air inlet valve cannot open until the plug of waste has passed the outlet 36, there is no possibility of the air inlet valve opening too soon and interfering with reliable transportation of waste from the bowl 1 into the sewer pipe 2.

Figure 2 illustrates schematically an arrangement in which the sewer pipe 2 has several branches 48 connected to respective waste-receiv-

ing bowls 1 through respective sewer valves 3. An air inlet valve 50 and a control unit 7 are associated with each toilet bowl 1 and sewer valve 3. The arrangement of each bowl 1, sewer valve, control unit and air inlet valve may be as shown in Figure 1.

The air inlet valves 50 operate independently of one another, so that, for example, application of a function impulse to the control unit 7 associated with one of the air inlet valves has no effect on the other air inlet valve(s).

It will be appreciated that the invention is not restricted to the particular embodiments that have been described, and that variations may be made therein without departing from the scope of the invention as defined in the following claims.

Claims

1. A vacuum sewer arrangement comprising a sewage-providing unit (1), a sewer pipe (2) defining an interior space, means for establishing, in the interior space of the sewer pipe, a vacuum sufficient for obtaining efficient sewage transport in the sewer pipe, a normally-closed sewer valve (3) connecting the sewage-providing unit (1) to the sewer pipe (2), a control device (7) for controlling operation of the sewer valve (3) to allow discharge of sewage from the sewage-providing unit (1) to the sewer pipe (2), an air inlet duct (4) for letting air into the sewer pipe (2) separately from the sewage-providing unit (1), characterised in that for controlling the flow of air through the air inlet duct (4) into the sewer pipe (2) when the sewer pipe is under proper vacuum for effective sewage transport, there is an air inlet valve (6) with means operating it in response to pressure variations in the sewer pipe (2).
2. An arrangement according to claim 1, characterised in that the air inlet duct (4) is connected to the sewer pipe (2) at a point (36) close to and downstream of the sewer valve (3).
3. An arrangement according to claim 1 or claim 2, characterised in that the air inlet valve (6) comprises an annular seat portion defining an opening that is in open communication with the air inlet duct (4), a sealing member (30) separating the opening from the influence of ambient air, the sealing member (30) being displaceable between a position in which it engages the seat portion and a position in which it is spaced from the seat portion, and means (32, 34) for controlling the position of the seal-

ing member (30).

4. An arrangement according to claim 3, characterised in that the means for controlling the position of the sealing member (30) comprise flexible wall means (42) defining a control chamber (32) bounded by the sealing member (30), and means (34) for controlling the pressure in the control chamber (32).
5. An arrangement according to claim 4, characterised in that the control device (7) comprises means (13) for communicating vacuum to both the sewer valve operating device and the control chamber (32) of the air inlet valve (6).
6. An arrangement according to any preceding claim, characterised in that the sewage-providing unit (1) is a wc-bowl having a lid (17) that provides a substantially airtight closure thereto.
7. An arrangement according to claim 6, characterised in that the bowl 1 is provided with a tube (18) for delivering air to the interior of the bowl when the lid (17) of the bowl is closed.
8. An arrangement according to claim 7, characterised in that the tube (18) for delivering air to the bowl (1) is provided with a check valve (19).
9. A vacuum sewer arrangement according to any preceding claim, characterised in that it comprises a plurality of sewer branches (48) each defining an interior space in open communication with the interior space of the sewer pipe (2), a plurality of normally-closed sewer valves (3) connected between respective sewage-providing units (1) and respective sewer branches (48), control means (7) for controlling operation of the sewer valves (3), a plurality of air inlet ducts (4) for letting air into the sewer branches (48) respectively, separately from the sewage-providing units (1), the air inlet ducts (4) being connected to the respective sewer branches (48) close to the respective sewer valves (3), and a plurality of air inlet valves (50) one associated with each sewer valve (3) respectively, for controlling separately the flow of air through any of the air inlet ducts (4) into the associated sewer branch (48) in response to the function of the associated sewer valve (3).
10. A method of operating a vacuum sewer arrangement that comprises a sewage-providing unit (1), a sewer pipe (2) defining an interior space, a normally-closed sewer valve (3) connecting the sewage-providing unit (1) to the

sewer pipe (2), and an air inlet duct (4) for letting air into the sewer pipe (2) separately from the sewage-providing unit (1), the air inlet duct (4) being connected to the sewer pipe (2) at a point (36) close to the sewer valve (3), the method being characterised by the combination of the following steps: establishing, in the interior space of the sewer pipe (2), a vacuum sufficient for obtaining effective sewage transport in the sewer pipe, thereafter opening the sewer valve (3), whereby sewage in the sewage-providing unit (1) is inducted into the sewer pipe (2) to form a movable plug therein, immediately after the sewage plug has passed the point (36) where the air inlet duct (4) is connected to the sewer pipe (2) introducing air into the sewer pipe (2) by way of the air inlet duct (4), closing the sewer valve (3), and discontinuing introduction of air into the sewer pipe (2) by way of the air inlet duct (4) when the sewage plug has travelled the full length of the sewer pipe or a distance of at least 10 m from the sewer valve (3).

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Fig. 1

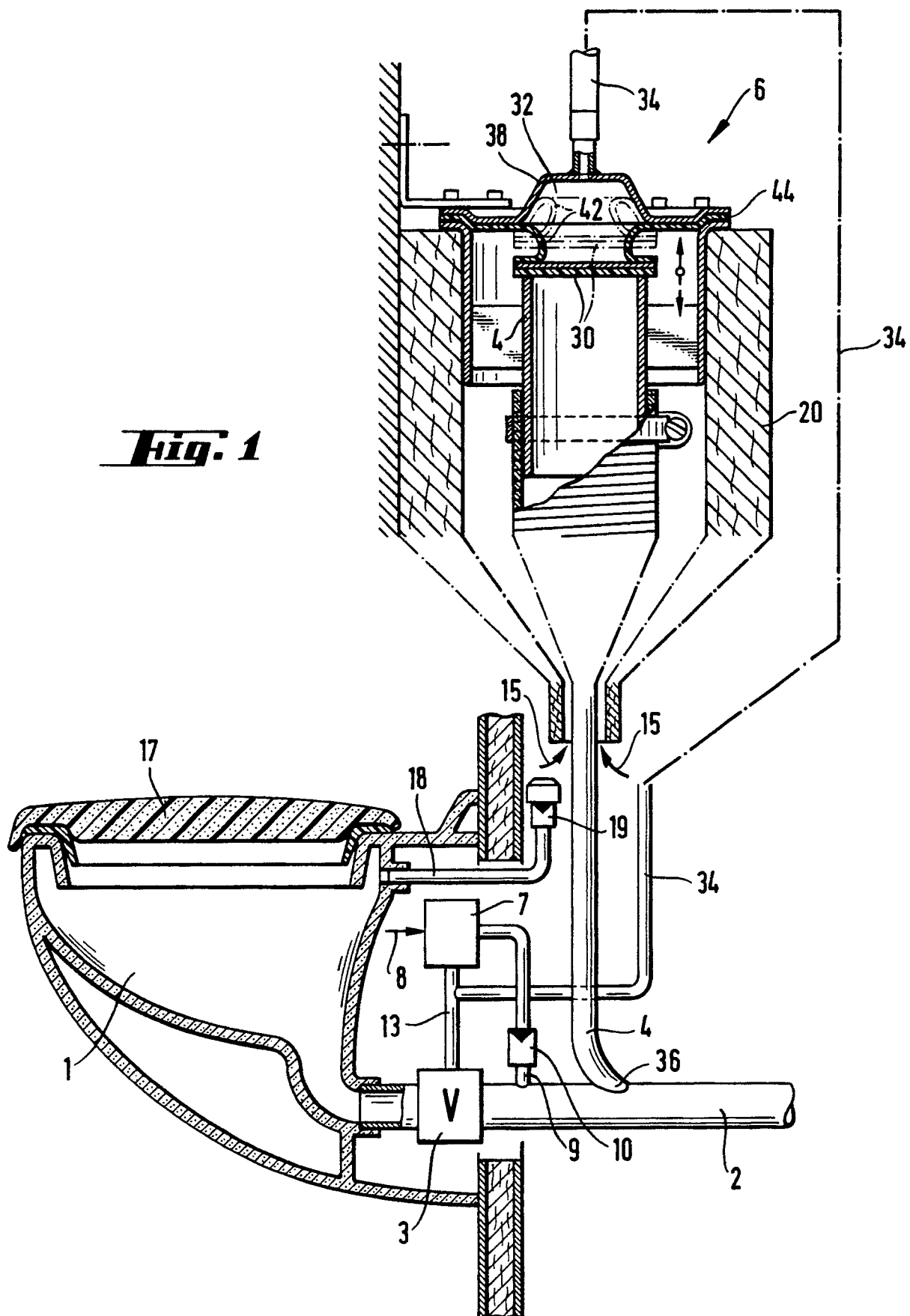
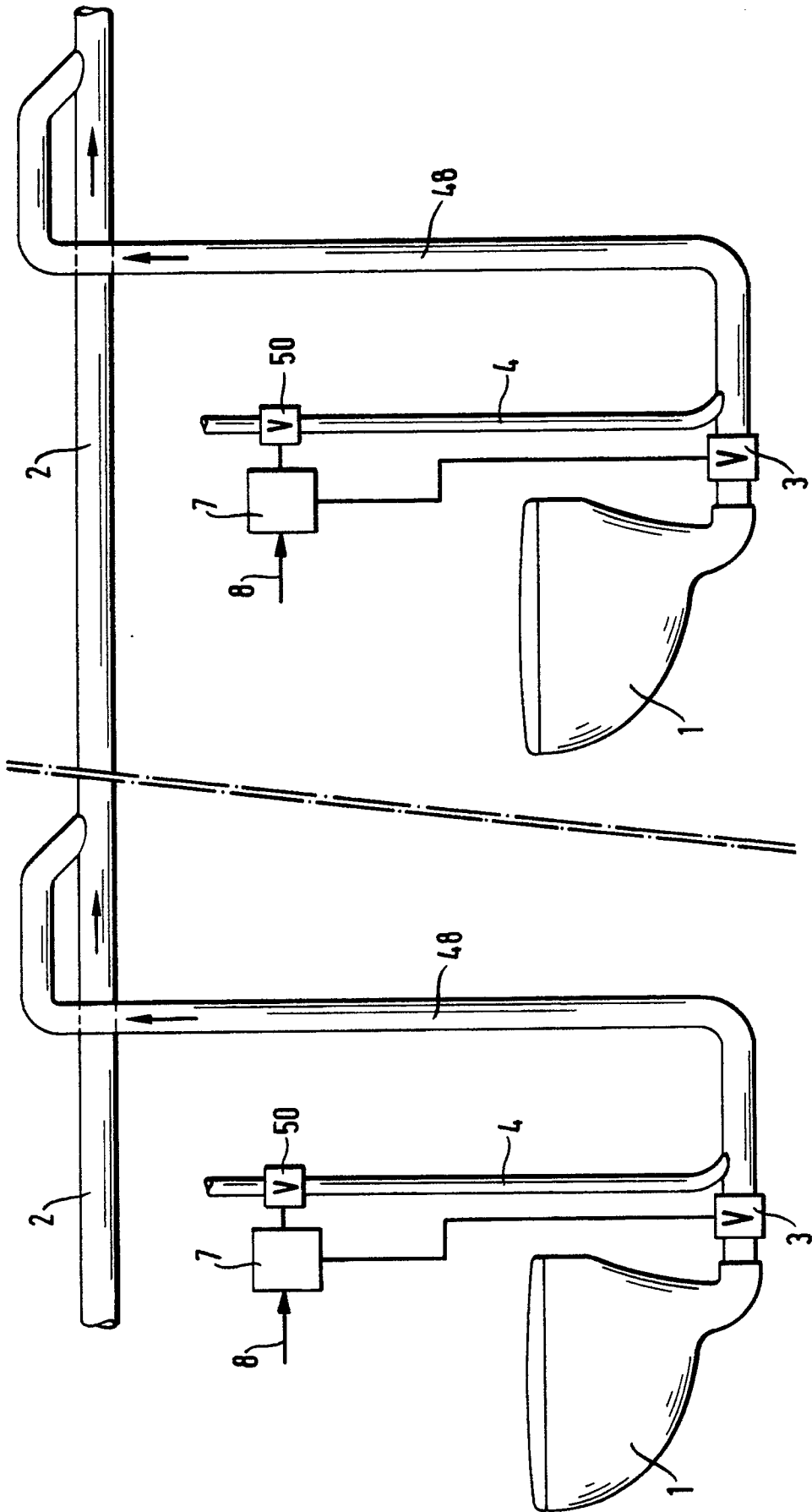


Fig. 2





European
Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 31 3991

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,X,D,Y- ,D,	GB-A-2 203 461 (O. WARTSILA AB) * page 4, line 33 - page 5, line 27 ** page 7, line 4 - line 30; claims 1,2; figure 1 * - - -	1,2,6,7,8, 10,3,5,9	E 03 F 1/00
Y,A	US-A-3 623 504 (J. DAVIS) * column 1, line 70 - column 3, line 16; figures 2,3 * - - -	3,4	
A	DE-U-8 524 288 (H. MICHAEL) * page 4, paragraph 4 - page 5; figure * - - -	3,4	
A	US-A-4 184 506 (M. VARIS) * column 2, line 25 - line 63 ** column 3, line 14 - line 27; figures 1,2 * - - - - -	1,9	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.5) E 03 F F 16 K
Place of search The Hague		Date of completion of search 08 April 91	Examiner KRIEKOUKIS S.
CATEGORY OF CITED DOCUMENTS X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention		E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons &: member of the same patent family, corresponding document	