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(54) **Method and apparatus for mixing slurry**

(57) A method of mixing slurry within a slurry tank comprising the steps of calculating the gauge pressure at the bottom of the slurry tank as a function of the slurry density and/or slurry consistency and the tank dimensions, locating a plurality of nozzles in the bottom of the tank and passing air from an air supply through said nozzles at a pressure and/or flow rate determined as a function of the calculated slurry gauge pressure and an apparatus for mixing slurry in a slurry tank (1), said apparatus comprising a kit of parts comprising a plurality of air supply pipes, a plurality of connection members for joining said air supply pipes, a plurality of outlet nozzles (10) connectable to said air supply pipes for passing air into slurry contained within the slurry tank, an air supply for supplying air to the assembled air supply pipes, connection members and outlet nozzles, and a computer program for calculating the pressure and/or flow rate of the air to be supplied to the assembled air supply pipes, connection members and outlet nozzles located within the bottom of the slurry tank by the air supply as a function of the slurry density and/or slurry consistency and the tank dimensions, and a control device for controlling the air supply to achieve said calculated air pressure and/or flow rate.

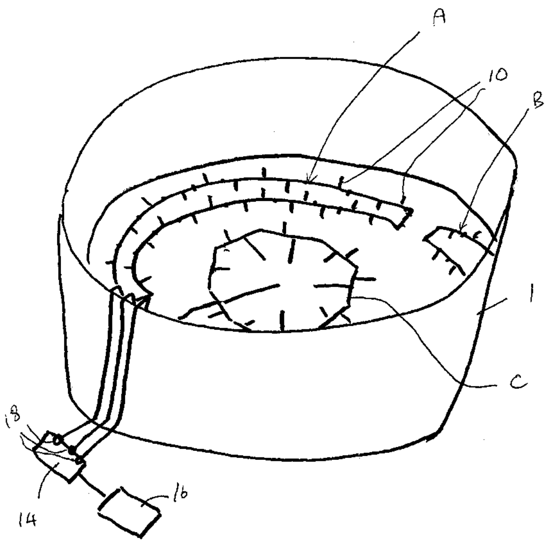

Figure 1

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Description

[0001] This invention relates to a method and apparatus for mixing slurry to prevent the formation of a crust on the slurry and to enhance the nutrient content of the slurry.

[0002] Slurry from cattle and other animals is a good source of nitrates and thus it is desirable to spread the slurry on land as a fertilizer. However, environmental legislation is placing increasing limits on when and how slurry can be spread, requiring the storage of increasing volumes of slurry in slurry tanks for increasing lengths of time. Also the trend to increased herd size in dairy farming has resulted in greater slurry storage requirements.

[0003] Environmental concerns have resulted in the placing of greater restrictions on the spreading of slurry to avoid spreading at wet times of the year to reduce pollution in rivers, lakes and other waterways and to reduce nutrient losses. In Northern Ireland, The Nitrates Directive Action Programme Regulations require livestock farms to have a minimum of 22 weeks slurry storage capacity. Pig and poultry farms require 26 weeks storage capacity. Many farms are making significant investment to meet this requirement.

[0004] Slurry is typically stored in large tanks, either above or below ground. Over time the slurry tends to settle out, forming a crust of solid material on the surface and leading to anaerobic conditions within the slurry. Anaerobic conditions inhibit bacteria required for digestion and lead to poor nutrient content of the slurry. The crust can lead to the trapping of methane and also leads to difficulties in extracting the slurry from the tank.

[0005] Attempts have been made to provide mechanical stirring devices within the tank to alleviate this problem. However, such mechanical devices frequently encounter reliability problems, particularly due to the corrosive nature of the slurry and require difficult and costly maintenance.

[0006] A more reliable and relatively maintenance free method of mixing and aerating the slurry is to place pipes having outlet apertures in the bottom of the tank and to supply compressed air to the pipes whereby air is bubbled through the slurry to mix and aerate the slurry. An example of this is shown in GB 1 568 813. While this method has been found to be effective, considerable trial and error is required with regard to the number and position of the pipes in the tank and the pressure and flow rate of the air passed into the slurry in order to ensure optimum mixing without excessive disturbance of the slurry. The required air flow through the slurry for optimum mixing has been found to vary, depending upon the consistency and content of the slurry and the dimensions of the tank.

[0007] An object of the present invention is to overcome the disadvantages of the prior art by providing a reliable, repeatable and easy to use method and apparatus for mixing and aerating slurry in a slurry tank, for all types of slurry and sizes of tank.

[0008] According to a first aspect of the present invention there is provided a method of mixing slurry within a slurry tank comprising the steps of calculating the gauge pressure at the bottom of the slurry tank as a function of the slurry density and/or slurry consistency and the tank dimensions, locating a plurality of nozzles in the bottom of the tank and passing air from an air supply through said nozzles at a pressure and/or flow rate determined as a function of the calculated slurry gauge pressure.

[0009] Preferably the method further comprises the step of selecting the number of nozzles to be located in the bottom of the tank as a function of the area of the bottom of the tank. Preferably the number of nozzles is selected to achieve a predetermined nozzle density. Groups of said plurality of nozzles may be connected to separate air supply circuits, the number of circuits being selected to achieve a predetermined number of nozzles per circuit. Preferably said method comprises the step of specifying an optimum assembly of a plurality of pipe sections, pipe connections and outlet nozzles to achieve the predetermined nozzle density. while minimising pressure losses. Preferably the method comprises the further step of assembly said plurality of pipe sections, pipe connections and outlet nozzles and locating said assembly within the bottom of the tank in accordance with the determined specification.

[0010] Preferably the method comprises connecting the outlet nozzles to an air supply. Where the nozzles are arranged in more than one air supply circuit, preferably the method comprises connecting the circuits to the air supply via change over valves whereby the circuits can be sequentially placed in communication with the air supply. Preferably the change over valves are associated with an air manifold connected to the air supply.

[0011] The air supply may comprise a blower, such as a roots type blower, or any other suitable source of compressed air.

[0012] Preferably the method comprises determining the air flow rate and/or supply pressure of the air supply as a function of the calculated slurry gauge pressure. Preferably the method of determining said air flow rate and/or supply pressure of the air supply further comprises determining said air flow rate and/or supply pressure as a function of pressure losses though the air nozzles and circuits. Preferably said pressure losses are determined as a function of one or more of the distance from the air supply to the furthest aeration circuit, the internal dimensions of the air circuits, the number and type of pipe fittings within the air circuits, and the number of circuits open simultaneously.

[0013] According to a further aspect of the present invention there is provided an apparatus for mixing slurry in a slurry tank, said apparatus comprising a kit of parts comprising a plurality of air supply pipes, a plurality of connection members for joining said air supply pipes, a plurality of outlet nozzles connectable to said air supply pipes for passing air into slurry contained within the slurry tank, an air supply for supplying air to the assembled air supply pipes, connection members and outlet nozzles, and a computer program for calculating the pressure and/or flow rate of the air to be supplied to the assembled air supply pipes, connection members and outlet nozzles located within the bottom of the slurry tank by the air supply as a function of the slurry density and/or slurry consistency and the tank dimensions, and a control device for controlling the air supply to achieve said calculated air pressure and/or flow rate.

[0014] Preferably the control device comprises a programmable digital controller.

[0015] Preferably the computer program determines the optimum arrangement of the air supply pipes, connection members and outlet nozzles within the slurry tank to achieve a predetermined nozzle density as a function of the slurry tank dimensions.

[0016] Preferably said computer program calculates the gauge pressure at the bottom of the slurry tank as a function of the slurry density and/or slurry consistency and the tank dimensions, and calculates the air pressure and/or flow rate of the air to be supplied to the nozzles by the air supply as a function of the calculated slurry gauge pressure. Preferably said air flow rate and/or supply pressure of the air supply is calculated as a function of pressure losses though the air supply pipes, connection members and outlet nozzles.

[0017] Preferably said air supply pipes, connection members and outlet nozzles are arranged to be assembled in a plurality of separate circuits, valve means being provided for enabling air to be supplied to the separate circuits independently and/or sequentially. Preferably said plurality of circuits are connectable to the air supply via a manifold, said valve means being associated with or provided within the manifold. Preferably the valve means comprises a plurality of solenoid valves.

[0018] Preferably the computer program calculates the number of air supply circuits to be assembled based upon the total number of nozzles required and the number of nozzles to be provided in each circuit and/or to minimise pressure losses.

[0019] An 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 perspective view of an aeration system according to an embodiment of the present invention located within a circular slurry tank;

Figure 2 is a plan view of an aeration system according to a further embodiment of the present invention located within a rectangular slurry tank; and

Figure 3 is a detailed view of an air outlet nozzle of the aeration system of either Figure 1 or Figure 2.

[0020] A slurry mixing and aeration system according to an embodiment of the present invention comprises a plurality of air outlet nozzles 10 located on the bottom of the slurry tank 1, the outlet nozzles 10 being connected to an air supply by a number of air supply circuits, each circuit comprising approximately eighteen outlet nozzles 10 connected in series via a plurality of pipe sections and connectors. The pipe section may comprise UPVC or galvanised steel pipes having a diameter of at least 50mm. To achieve an optimum nozzle density within the bottom of the tank of approximately 1 nozzle per 2.375 m^2 each circuit of 18 nozzles can cover an area of approximately 45 m^2, allowing for a 1 metre void around the edge of the tank. Therefore the number of circuits required will depend upon the size of the slurry tank.

[0021] In the embodiment shown in Figure 1, three circuits A,B,C are used, two semicircular circuits A,B arranged around the periphery of the tank and a single central circuit C. In the embodiment shown in Figure 2, two circuits D,E are required.

[0022] A non-return valve 12 (Figure 2) is located at the inlet end of each circuit A,B,C,D,E to prevent the backflow of slurry into the air supply circuits.

[0023] Each circuit is connected to an air supply manifold 14, into which air is supplied from an air blower 16. A solenoid valve 18 is associated with each circuit for controlling the supply of air from the manifold 16 into the respective circuit, the solenoid valves 18 being controlled by a controller, as will be described below, so that air can be supplied to each circuit sequentially.

[0024] Each air outlet nozzle 10 comprises a flattened neoprene sleeve 20 having an open end 22, as illustrated in Figure 3. The nozzle 10 comprises a UPVC socket 24 adapted to receive the end of an air supply pipe, a UPVC bushing 26 is mounted in one end of the socket 24, the bushing 26 threaded to receive a UPVC hose adaptor 28 to which is fitted the neoprene sleeve 20. The sleeve 20 is secured onto the hose adaptor by means of a cable tie 30.

[0025] The apparatus is supplied as a kit of parts, comprising a plurality of pipe sections, a plurality of connectors and a plurality of outlet nozzles, at least one suitable manifold provided with sufficient outlets for the maximum number of circuits likely to be required, each outlet having a solenoid valve for controlling the supply of air to the respective outlet, a suitable air blower for supplying air to the manifold at the required pressure, and a programmable digital controller for controlling the operation of the system.

[0026] Part of the invention comprises the provision of software, capable of running on any Windows based PC, for determining the installation and operation of the system for a given slurry tank based upon the dimensions of the tank and the composition/solids content of the slurry to be mixed. For example, for a slurry containing 6% dry matter and 69 kg/m^3 total solids, the density of the slurry will be 944 kg/m^3 and the gauge pressure at the base of the tank can be calculated based upon the slurry density and the height of the tank.

[0027] The software is programmed to determine the layout of the nozzles, supply pipes and connections to achieve the optimum circuit layout that meets the nozzle density requirement while minimising pressure losses by minimising the distance of the further nozzle from the manifold. This is determined primarily as a function of the tank dimensions.

[0028] The software is also programmed to calculate the required air pressure and air flow rate from the air blower required to achieve the desired air flow from the nozzles. The aim is to achieve between 0.75 and 1m3 of air flow per square metre of tank base area per aeration cycle (typically a twelve hour period). This ensured thorough turbulation of the slurry and avoids crust formation, while optimising the nutrient content of the slurry by encouraging aerobic digestion.

[0029] A first step is the calculation of the gauge pressure in the base of the tank as a function of the tank dimensions, slurry volume and slurry consistency.

[0030] A typical calculation for the gauge pressure, GP is:-

$$GP = TH((STS \times DM)+(WD \times WC))$$

[0031] Where:-

GP = Gauge Pressure (kg/m2)
SD = Slurry Density (kg/m3)
STS = Slurry Total Solids (kg/m3)
DM = Dry Matter %
WD = Water Density (kg/m3)
WC = Water Content %
TH = Tank Height (m)

[0032] The software calculates the gauge pressure at the floor of the tank based on the following variables:-

1. The slurry consistency (total solids and dry matter);
2. The dimensions of the tank (or part thereof).

[0033] The software calculates the number of nozzles and circuits required to aerate the tank. This based on the nozzle density on the floor of the tank and the optimum number of nozzles per circuit.

[0034] The software then adds to the gauge pressure the pressure loss in the pipe work of the system based on:

1. The distance from the blower unit to the furthest aeration circuit;
2. The pipe internal dimensions;
3. The number and type of pipe fittings;
4. The number of circuits open simultaneously; and
5. The air flow required;

to determine the required air pressure to be supplied by the blower.

[0035] The software checks that the blower unit is capable of working at this pressure. If not, a warning is provided indicating that the system will not work. There is an option to reduce the air flow from the nozzles at this stage.

[0036] If the system pressure is within the capacity of the blower, the software:-

1. Specifies the blower size required to produce the required air flow based on the blower manufacturers data;
2. Specifies the quantity of pipe, nozzles, fittings, manifolds etc for the complete system.

[0037] The latter is calculated as a function of:-

a. the number of circuits and nozzles required;
b. the position that the pipe work enters the tank (for rectangular tanks);
c. the distance from the blower unit position to the tank entry point; and

d. the number of manifolds required.

[0038] The blower may be a roots type blower. However, the use of other sources of compressed air is envisaged.

[0039] Based upon the output of the software, the air supply pipes, connectors and nozzles are assembled in the specified arrangement and number of circuits and located within the slurry tank. The pipes may be fixed to the base of the slurry tank by suitable plastic clips, preferably located at 1 metre intervals along the pipes, the clips being secured to the floor of the tank by stainless steel screws inserted into plugged apertures. The pipes may be secured to the walls of the tank by similar fastening means. A check valve is located at the entry of each circuit to into the slurry tank to prevent the back flow of slurry into the pipes and the circuits are connected to respective outlets of the air manifold, which is connected to the air blower. The blower may be located within an acoustically isolated enclosure to reduce noise from the blower.

[0040] The programmable digital controller is programmed from the output of the software to operate the air supply to provide the calculated optimum air flow to the nozzles to achieve the desired air flow for optimised mixing and aeration of the slurry.

[0041] The invention is not limited to the embodiment(s) described herein but can be amended or modified without departing from the scope of the present invention.

Claims

1. A method of mixing slurry within a slurry tank comprising the steps of calculating the gauge pressure at the bottom of the slurry tank as a function of the slurry density and/or slurry consistency and the tank dimensions, locating a plurality of nozzles in the bottom of the tank and passing air from an air supply through said nozzles at a pressure and/or flow rate determined as a function of the calculated slurry gauge pressure.

2. A method as claimed in claim 1, wherein the method further comprises the step of selecting the number of nozzles to be located in the bottom of the tank as a function of the area of the bottom of the tank.

3. A method as claimed in any preceding claim, wherein groups of said plurality of nozzles are connected to separate air supply circuits, the number of circuits being selected to achieve a predetermined number of nozzles per circuit.

4. A method as claimed in claim 3, wherein the method comprises connecting said plurality of air supply circuits to the an air supply via change over valves whereby the circuits can be sequentially placed in communication with the air supply.

5. A method as claimed in claim 4, wherein the change over valves are associated with an air manifold connected to the air supply.

6. A method as claimed in any preceding claim, wherein the method of determining said air flow rate and/or supply pressure of the air supply further comprises determining said air flow rate and/or supply pressure as a function of pressure losses though the air nozzles and circuits.

7. A method as claimed in claim 6, wherein said pressure losses are determined as a function of one or more of the distance from the air supply to the furthest aeration circuit, the internal dimensions of the air circuits, the number and type of pipe fittings within the air circuits, and the number of circuits open simultaneously.

8. An apparatus for mixing slurry in a slurry tank, said apparatus comprising a kit of parts comprising a plurality of air supply pipes, a plurality of connection members for joining said air supply pipes, a plurality of outlet nozzles connectable to said air supply pipes for passing air into slurry contained within the slurry tank, an air supply for supplying air to the assembled air supply pipes, connection members and outlet nozzles, and a computer program for calculating the pressure and/or flow rate of the air to be supplied to the assembled air supply pipes, connection members and outlet nozzles located within the bottom of the slurry tank by the air supply as a function of the slurry density and/or slurry consistency and the tank dimensions, and a control device for controlling the air supply to achieve said calculated air pressure and/or flow rate.

9. An apparatus as claimed in claim 8, wherein the control device comprises a programmable digital controller.

10. An apparatus as claimed in claim 8 or claim 9, wherein the computer program determines the optimum arrangement of the air supply pipes, connection members and outlet nozzles within the slurry tank to achieve a predetermined nozzle density as a function of the slurry tank dimensions.

11. An apparatus as claimed in any of claims 8 to 10, wherein said computer program calculates the gauge pressure at the bottom of the slurry tank as a function of the slurry density and/or slurry consistency and the tank dimensions, and calculates the air pressure and/or flow rate of the air to be supplied to the nozzles by the air supply as a function of the calculated slurry gauge pressure.

12. An apparatus as claimed in claim 11, wherein said air flow rate and/or supply pressure of the air supply is calculated as a function of pressure losses though the air supply pipes, connection members and outlet nozzles.

13. An apparatus as claimed in any of claims 8 to 12, wherein said air supply pipes, connection members and outlet nozzles are arranged to be assembled in a plurality of separate circuits, valve means being provided for enabling air to be supplied to the separate circuits independently and/or sequentially.

14. An apparatus as claimed 13, wherein said plurality of circuits are connectable to the air supply via a manifold, said valve means being associated with or provided within the manifold, said valve means preferably comprising a plurality of solenoid valves.

15. An apparatus as claimed in any of claims 8 to 14, wherein the computer program calculates the number of air supply circuits to be assembled based upon the total number of nozzles required and the number of nozzles to be provided in each circuit and/or to minimise pressure losses.

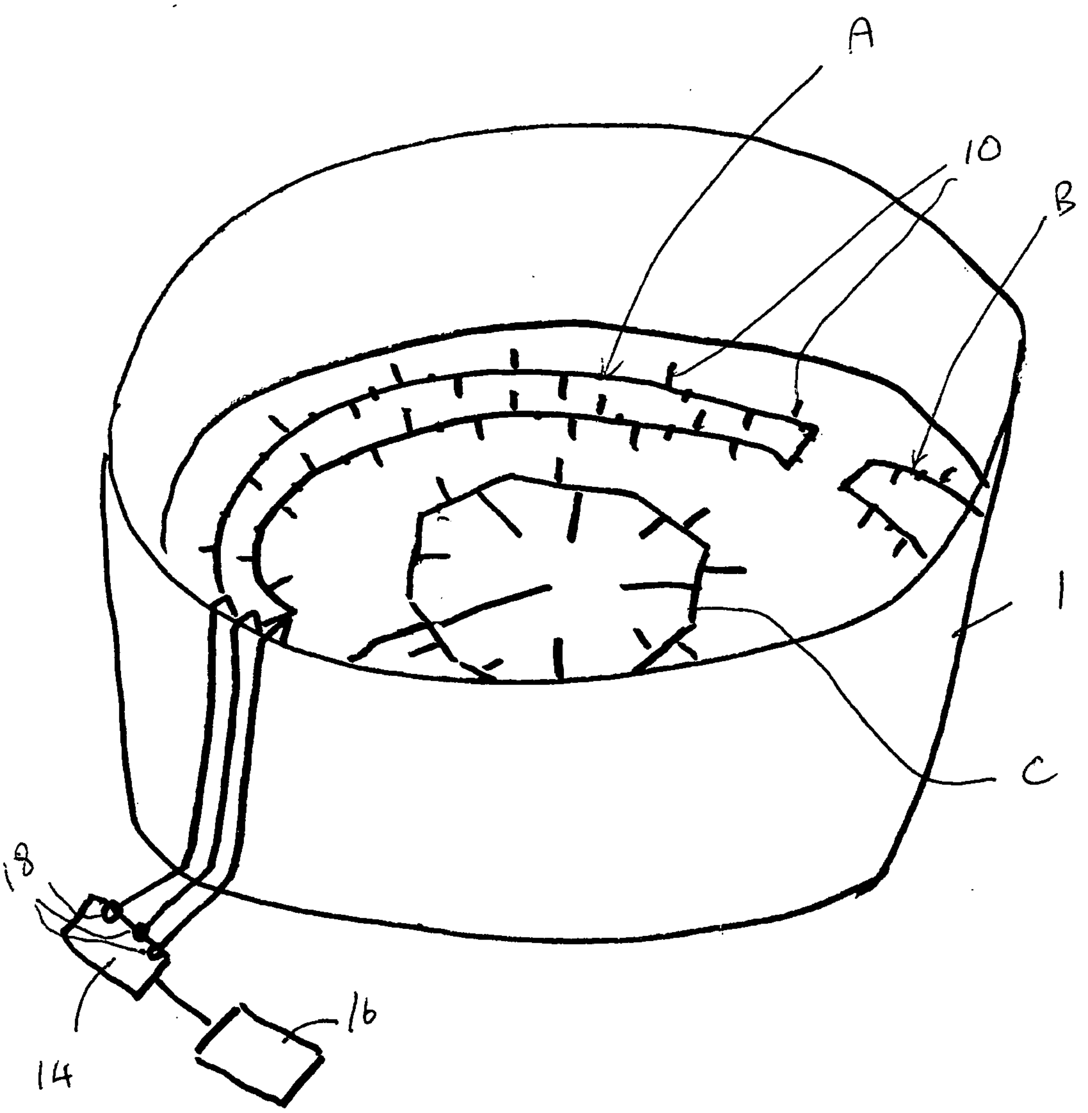

Figure 1

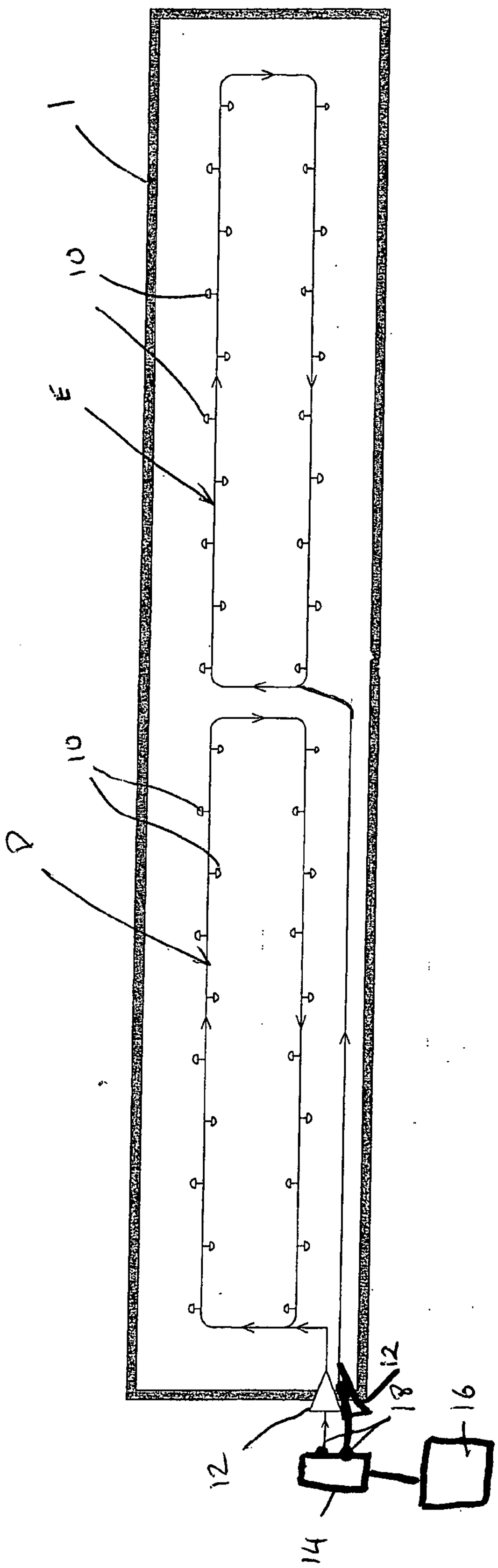

Figure 2

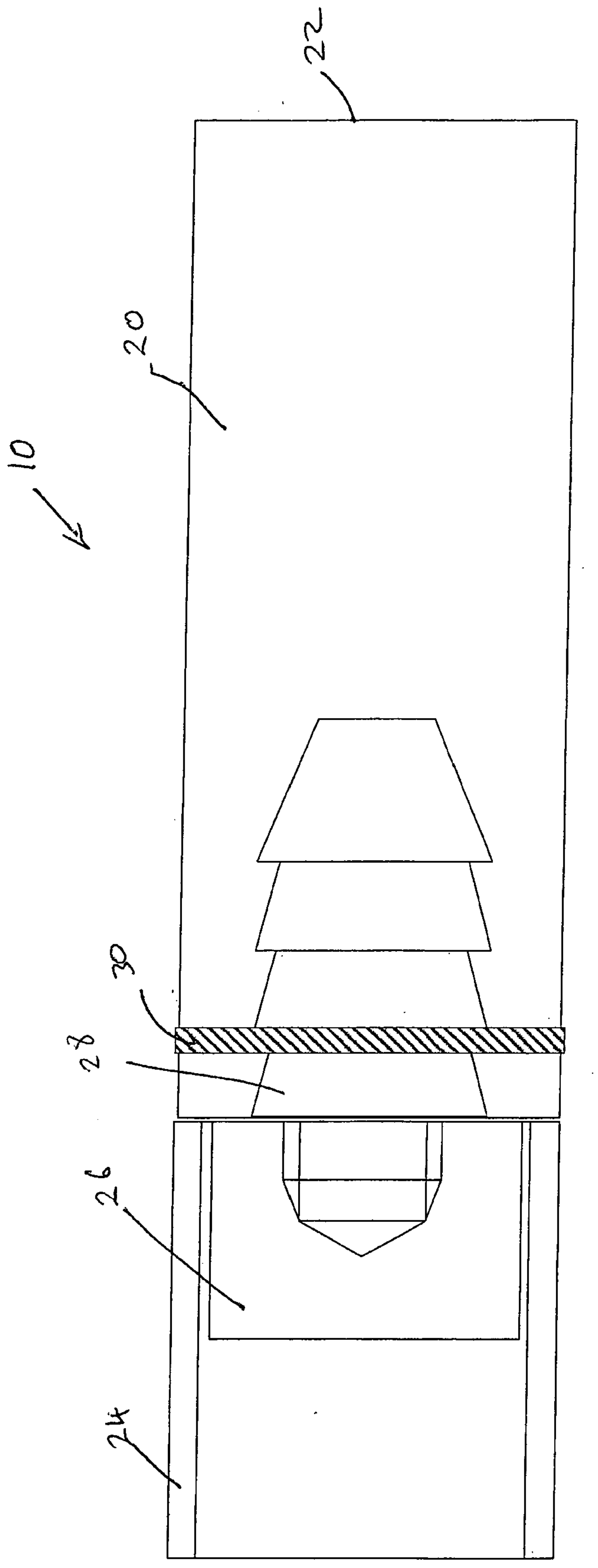

Figure 3

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EUROPEAN SEARCH REPORT

Application Number
EP 09 01 5822

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 6 475 395 B1 (SCHMIT FRANK L [US] ET AL) 5 November 2002 (2002-11-05) * column 16, line 13 - column 17, line 32 * * column 23, lines 29-67 * * column 31, lines 15-50 * * column 48, lines 25-38 * * abstract; figures 1-6,19 * -----	1-15	INV. B01F3/04 B01F13/02 B01F15/00
A	US 2 860 600 A (CHENEY WILLIAM O) 18 November 1958 (1958-11-18) * column 2, lines 29-51 * * column 3, lines 3-17,44-69 * * figures 1-3 * -----	1-15	
A	CH 161 777 A (WYSS PAUL [CH]) 31 May 1933 (1933-05-31) * figures 1-3 * -----	1-15	
A	JP 56 073531 A (HITACHI PLANT ENG & CONSTR CO) 18 June 1981 (1981-06-18) * abstract; figures 1,2 * -----	1-15	TECHNICAL FIELDS SEARCHED (IPC) B01F
A	JP 54 131171 A (BABCOCK HITACHI KK) 12 October 1979 (1979-10-12) * abstract; figures 1-3 * -----	1-15	
A	WO 2004/091764 A1 (PARKS RICHARD E [US]) 28 October 2004 (2004-10-28) * abstract; figures 1,2a,2b,3 * -----	1-15	
A	US 2001/006261 A1 (KELLY JEFFREY T [US]) 5 July 2001 (2001-07-05) * abstract; figures 1,2 * -----	1-15	

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	15 April 2010	Brunold, Axel

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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O : non-written disclosure
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The members are as contained in the European Patent Office EDP file on
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15-04-2010

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 6475395	B1	05-11-2002	NONE			
US 2860600	A	18-11-1958	NONE			
CH 161777	A	31-05-1933	NONE			
JP 56073531	A	18-06-1981	NONE			
JP 54131171	A	12-10-1979	JP	62008205	B	21-02-1987
WO 2004091764	A1	28-10-2004	AU	2004229516	A1	28-10-2004
			NZ	537239	A	31-08-2006
US 2001006261	A1	05-07-2001	NONE			

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- GB 1568813 A **[0006]**