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(54) Seperating device, seperation unit for such a seperating device, and seperating method.

(57) A device for separating particles from a fluid comprises a number of separation units. Each separation unit comprises a number of elongate cyclones (7) which are arranged parallel to and next to one another. Each cyclone is provided with a feed (14e), an overflow discharge (40) and an underflow discharge (41). Each separation unit furthermore comprises a first chamber (21), into which the overflow discharges of the cyclones open out, a second chamber (20), in which the cyclones are arranged, which second chamber contains the feeds of the cyclones, and a third chamber (22), into which the underflow discharges of the cyclones open out. The chambers are substantially cylindrical and are stacked as seen in the longitudinal direction of the cyclones. The separation units are also stacked as seen in the longitudinal direction of the cyclones.

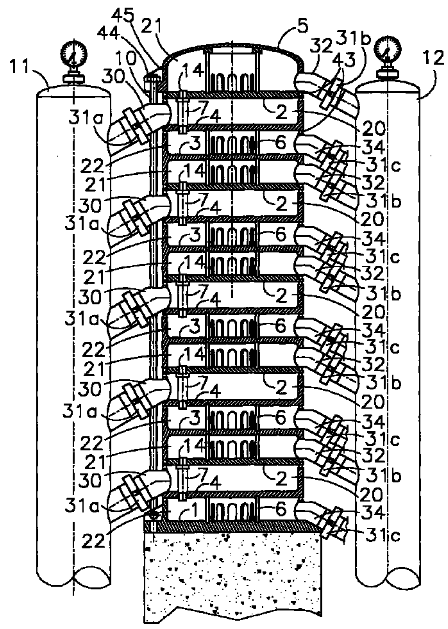

Fig 1

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Description

[0001] The invention relates to a separating device for separating particles from a fluid containing the particles, such as a liquid or a gas, the density of the particles being greater than that of the fluid. The invention also relates to a separation unit for use in such a separating device. The invention furthermore relates to a method for separating particles from a fluid containing the particles, in which the separating device according to the invention is utilized.

[0002] Separating devices of this nature, which are used, for example, for removing small fibres and dissolved proteins from starch suspensions, are generally known in the form of cyclones. The cyclones have a feed for feeding the fluid which contains the particles to be separated in a defined concentration, an underflow discharge for discharging fluid containing a (considerably) higher concentration of particles, and an overflow discharge for discharging fluid containing a (considerably) lower concentration of particles. This action of the cyclone is achieved without moving parts through the flow effects of the fluid in the cyclone brought about by its specific internal shape.

[0003] To increase the capacity of the said separating devices, cyclones are often connected in parallel to form a so-called multicyclone, in which the cyclones are usually accommodated in the form of one or more sets in a common housing.

[0004] To further increase the capacity, it is necessary to use more housings, which can be connected to one another by means of pipes for feeding and discharging the various flows of fluid.

[0005] This constitutes a drawback, since a solution of this nature is relatively expensive and inflexible. To at least partially overcome this drawback, cyclone housings have been developed in which sets containing cyclones extending in the radial direction are stacked on top of one another and are accommodated in a common housing. In this way, it is possible for a large number of cyclones to be placed in a single housing, and the desired capacity can be achieved by selecting a suitable number of sets and adapting the dimensions of the housing accordingly.

[0006] However, this construction has the drawback that, owing to the radial positioning of the cyclones, the accessibility of the components thereof during assembly, maintenance and cleaning is poor, in particular since overflow parts ("vortex finders"), which comprise the overflow discharges, have to be secured one by one in the cyclones (during assembly) or removed one by one from the cyclones (during dismantling).

[0007] The feed and discharge of flows of fluid to the individual cyclones or sets run via internal distribution ducts which are provided in the housing, making the housing relatively large. Moreover, the distribution ducts are difficult to clean.

[0008] Another drawback of the known multicyclones is their limited pressure resistance (maximum 6-10 bar) owing to the internal design, with the result that the capacity and/or the separating efficiency, which depend on the pressure, are also limited.

[0009] The object of the invention is to eliminate the drawbacks of the prior art or at least to considerably reduce these drawbacks and to provide a separating device which is easy to assemble, dismantle and maintain, can be operated at high pressure, is of limited dimensions and the capacity of which can be selected according to requirements without having to reconfigure internal distribution ducts.

[0010] To achieve these and other objects, the invention firstly provides a separation unit for separating particles from a fluid containing the particles, which separation unit comprises: a number of elongate cyclones which are arranged parallel to and next to one another and are each provided with a feed, an overflow discharge and an underflow discharge; a first chamber, into which the overflow discharges of the cyclones open out; a second chamber, in which the cyclones are arranged, which second chamber contains the feeds of the cyclones; and a third chamber, into which the underflow discharges of the cyclones open out, the first, second and third chambers being stacked as seen in the longitudinal direction of the cyclones. A separating device comprises a number of separation units of this nature, the separation units preferably being stacked as seen in the longitudinal direction of the cyclones. The stacking of the first, second and third chambers in each separation unit and the stacking of the separation units in the separating device may be in the vertical or horizontal direction or in another direction.

[0011] By designing the separating device in modular form with stacked separation units, it is possible to achieve a desired capacity of the separating device simply and expediently, by stacking a suitable number of separation units. The feeds, overflow discharges and underflow discharges of the various separation units are connected to one another outside the separating device by means of a feed connection duct, overflow discharge connection duct and underflow discharge connection duct, respectively, the feeds, overflow discharges and underflow discharges of the various separation units preferably being arranged substantially in a line in order to achieve a connection duct which is as short as possible.

[0012] The stacking of the separation units in general, and of the chambers of the separation units in particular, leads to a very efficient utilization of the material of the construction. It is thus possible, within a separation unit, for a wall of the first chamber also to serve as a wall of the adjoining second chamber, and an opposite wall of the second chamber can also serve as a wall of the third chamber. Between different separation units, it is possible for a wall of a first chamber of a first separation unit also to serve as a wall of an adjoining third chamber of an adjoining second separation unit.

[0013] To enable a specific separation unit to be cleaned while the other separation units remain in operation, in a preferred embodiment of the separating device according to the invention a valve is incorporated between the feed, the overflow discharge or the underflow discharge of each separation unit, on the one hand, and the feed connection duct, the overflow discharge connection duct or the underflow discharge connection duct, respectively, on the other hand. By closing the valves of one or more separation units, it is possible for these units to be cleaned/flushed by means of a cleaning agent which can be guided through the separation unit via separate cleaning feeds and discharges. The other separation units remain connected as normal to the various connection ducts and may therefore remain in operation as normal, while the closed valves ensure that there is no risk of cleaning agent entering the fluid which is to be or has been treated. Making use of this cleaning principle, it is possible to incorporate a certain excess capacity in the separating device by including at least one more separation unit than is absolutely necessary, and this excess capacity can be used for CIP ("Cleaning In Place") of the separating device by successively cleaning the various separation units of the separating device.

[0014] If the separation units are stacked in the vertical direction, the capacity of the separating device can easily be increased by placing new separation units on top of or beneath the existing units. In principle, this does not take up any extra floor space.

[0015] The separation units and their chambers are preferably of cylindrical design, resulting in a particularly pressure-resistant construction.

[0016] Although the above text has always referred to one feed, one overflow discharge and one underflow discharge per separation unit, a separation unit may also comprise more than one feed, overflow discharge or underflow discharge, for example in order to achieve optimum distribution of the fluid in the chambers which are connected to the feeds and discharges. Each feed, overflow discharge and underflow discharge may be provided with a valve, as explained above.

[0017] The invention and other advantages thereof are explained in more detail below with reference to the drawing, in which:

Fig. 1 shows a side view, partially in cross section, of a device according to the invention;

Fig. 2 shows a plan view of the device shown in Fig. 1, in the direction of arrow II;

Fig. 3 shows a diagrammatic cross section, on an enlarged scale, through a cyclone and the flows of liquid inside it;

Fig. 4 shows a plan view, on an enlarged scale, of a wall between a feed chamber and an overflow chamber;

Fig. 5 shows a cross section on line V-V through the wall shown in Fig. 4;

Fig. 6 shows part of a cross section, on an enlarged scale, through a variant of the separating device according to the invention;

Fig. 7 shows a partially diagrammatic cross section, on a smaller scale, through a variant of the separating device according to the invention, for the purpose of illustrating hydraulic retaining of the separation units;

Fig. 8 shows a plan view of a cascade circuit of separating devices according to the invention;

Fig. 9 shows a front view of the cascade circuit shown in Fig. 8; and

Fig. 10 shows a side view, in the direction of arrow X, of the cascade circuit shown in Fig. 8.

[0018] In the figures, identical reference numerals denote identical components or components with an identical function.

[0019] Figs. 1, 2 and 3 show a separating device with dish-shaped cyclone supports 4, which each support a large number (set) of cyclones 7, only one of which is shown in Fig. 1, for the sake of simplicity. Each cyclone 7 has a vortex finder 14, which is mounted on a plate 2. The cyclones 7 are thus situated substantially in a second chamber 20, of which the cyclone support 4 and the plate 2 form part, and in which a feed of each cyclone 7 is located. An overflow 40 of each cyclone 7 opens out, via the vortex finder 14, into a first chamber 21. An underflow 41 of each cyclone 7 opens out into a third chamber 22. Where a first chamber 21 adjoins a third chamber 22, these chambers 21, 22 are substantially formed by a chamber element 3. The second chamber 20 is provided with a feed pipe 30, which is connected to a common feed connection duct 11, through which a fluid containing particles which are to be separated therefrom can be fed. The first chamber 21 is provided with an overflow discharge pipe 32, which is connected to a common overflow discharge connection duct 12 through which cleaned fluid can be discharged. The third chamber 22 is provided with an underflow discharge pipe 34, which is connected to a common underflow discharge connection duct 13, through which substantially separated particles can be discharged.

[0020] In the separating device, there is a stack of (as seen from the top to the bottom in Fig. 1) five separation units, which each comprise a first chamber 21, a second chamber 20 and a third chamber 22. The cyclones 7 are positioned with their longitudinal directions parallel to the longitudinal axis of the device. The fluids which enter the first chambers 21 and third chambers 22 are immediately discharged laterally to the respective common connection ducts 12 and 13.

[0021] The various chambers are formed by substantially annular or partially cylindrical elements which are stacked on top of one another with seals 43, in the form of O-rings, between them. The number of elements which can be stacked is virtually unlimited, since each chamber has its own connection lines and there is no common housing constituting a limitation.

[0022] In order for the forces of pressure differences between the chambers to be absorbed, pressure rings 6 are positioned in the first and third chambers 21 and 22. The elements which are situated between a base element 1 and a cover element 5 are clamped together by means of clamping bolts 10. At their bottom ends, the clamping bolts 10 are connected to the base element 1 in such a manner that they can pivot in the radial direction. The top ends of the clamping bolts 10 are secured, by means of nuts 44, in open slots formed by lugs 45 of the cover element.

[0023] When the separating device is dismantled, the nuts 44 are unscrewed, after which the clamping bolts 10 can be pivoted outwards in the radial direction, out of the slots. Then, the cover element 5, the plates 2 located beneath it, the cyclone supports 4 and the chamber elements 3 can be removed.

[0024] During dismantling, the vortex finders 14 are removed as a single unit together with the plate 2, so that all the associated cyclones 7 are accessible for inspection purposes. Cleaning is also easy, since each chamber 21, 22 can be emptied completely due to the absence of dead spaces. Considerably more (axially positioned) cyclones can be incorporated in the chambers 20 per unit volume than with the known radial positioning of cyclones. The stacked, in particular cylindrical construction is able to withstand higher feed pressures (for example 20 bar) than designs which have been customary hitherto, which is of benefit to operation for some products: the separating device has a higher capacity and/or an improved separating efficiency for the same dimensions.

[0025] As a result of valves or shut-off members being positioned in the feed pipes 30 and discharge pipes 32, 34 (for example diagrammatically depicted shut-off valves 31a in the feed pipes 30, shut-off valves 31b in the discharge pipes 32, and shut-off valves 31c in the discharge pipes 34), it is possible for the first chamber 21, the second chamber 20, the third chamber 22 and the set of cyclones 7 of each separation unit to be cleaned separately, with the result that it is no longer necessary for the entire separating device to be shut down for cleaning purposes.

[0026] The vertical arrangement of the various chambers 20, 21 and 22 which is described above and shown in the drawing is not essential; an inclined or horizontal arrangement is also possible. Also, a first chamber 21 of a first separation unit does not have to adjoin a third chamber 22 of another separation unit, but rather the stacking of chambers may also be selected in such a manner that a first chamber 21 or a third chamber 22 of a separation unit adjoins a first chamber 21 or third chamber 22, respectively, of another separation unit.

[0027] Figs. 4 and 5 show the plate 2 in more detail. The plate 2 is provided with a central hole for the attachment of a lifting eyelet or the like, around which a pattern of 287 holes 48 is arranged, into which the same number of cyclones are placed. A slot 49 centres the associated pressure ring 6.

[0028] Fig. 6 shows details of a second chamber 20, cyclones 7a and a feed pipe 30a. The cyclones 7a comprise a vortex finder 14a and a cyclone body 14b. At one end, the cyclone body 14b is provided with an annular rim 14c, in which a complementary part of the vortex finder 14a is held. The cyclone body 14b substantially tapers and is also provided with a collar 14d. Fluid containing particles to be separated can be pressed out of the chamber 20 into the cyclones 7a via a feed opening 14e. The cyclones 7a are enclosed between the plate 2 and the cyclone support 4 using seals 50. Fluid containing particles to be separated is fed to the chamber 20 from the feed pipe 30a. At the end remote from the chamber 20, the feed pipe is circular, and at the end facing towards the chamber 20 this pipe is substantially oval or elliptical, the longitudinal axis of the oval or ellipse extending in the circumferential direction of the chamber 20.

[0029] Fig. 7 shows a separating device according to the invention with cyclones 7a, plates 2, cyclone supports 4, a chamber element 3, a cover element 5 with lugs 45, a base element 1, pressure rings 6, feed pipes 30 and overflow discharge pipes 32 and underflow discharge pipes 34, which in some instances are not shown.

[0030] The separation units formed by the above-mentioned components are clamped together by a preferably double-acting piston-cylinder unit 60 which, by means of a hand pump 61 or a generator unit, can move a plate 62 in the directions of double arrow 63, in order to vary the distance between the locations indicated by an "x". Pull rods 65, which can pivot about pins 64, are attached to the plate 62. At their ends which are remote from the plate 62, the pull rods 65 are each provided with a plug 66 which is supported on the lugs 45 of the cover element 5.

[0031] Fig. 7 shows two different solutions for opening and closing the separating device in a controlled manner by pivoting the pull rods 65 radially outwards about the pins 64.

[0032] On the right-hand side of the figure, the pull rod 65 is guided through a radial slot in a collar of the base element 1 and the pull rod 65 is driven in the radial direction towards the separating device by a compression spring 67 arranged in the slot. On the pull rod 65 there is a bevelled projection 68a, while opposite this projection, on the side wall of the base element 1, there is a complementary bevelled projection 68b. As a result of the piston-cylinder unit 60 being retracted, the plate 62 moves towards the base element 1 and the projections 68a and 68b come into contact with one another, the pull rod 65 being pivoted radially outwards counter to the force exerted by the compression spring 67; the separating device can be opened. When the plate 62 is moved in the opposite direction with respect to the base element 1, the compression spring 67 pushes the pull rod 65 radially back inwards - as far as the projections 68a and 68b permit - until the plug 66 comes into contact with the cover element 5; the separating device is closed. Thus, a mechanical control of the movement of the pull rod is provided.

[0033] On the left-hand side of Fig. 7, the pull rod 65 is provided with a projection 69 having a pin 70 which is situated in a slot 71 in a guide block 72. As a result of the piston-cylinder unit 60 being retracted, the plate 62 moves towards the base element 1 and the pin 70 moves upwards in the slot 71. Since the slot 71 is directed away from the separating device at an angle, the pull rod 65 is pivoted away outwards during this movement in the radial direction; the separating device can be opened. When the plate 62 is moved in the opposite direction with respect to the base element 1, the fact that the pin 70 is guided in the slot 71 ensures that the pull rod 65 is moved radially inwards until the plug 66 comes into contact with the cover element 5; the separating device is closed. This provides an alternative means of mechanically controlling the movement of the pull rod.

[0034] Figs. 8, 9, and 10 show a cascade circuit of separating devices 81, 82, 83 and 84 according to the invention, which each comprise a feed connection duct 81a, 82a, 83a and 84a, an underflow discharge connection duct 81b, 82b, 83b and 84b, respectively, an overflow discharge connection duct 81c, 82c, 83c and 84c, respectively, and a pump unit 81d, 82d, 83d and 84d, respectively. The cascade circuit of separating devices may also, for example at the location where the separating device 83 is located, comprise a plurality of separating devices of the same type which are connected to one another in a cascade arrangement in a similar manner.

[0035] From a tank (not shown in more detail), a pipe 97 feeds contaminated fluid to the pump unit 81d. The feed connection duct 81a is connected to the pump unit 81d by way of a pipe 85. The underflow discharge connection duct 81b is connected to the pump unit 82d by way of a pipe 86. The overflow discharge connection duct 81c discharges overflow fluid containing a low concentration of particles. The feed connection duct 82a is connected to the pump unit 82d via a pipe 87. The underflow discharge connection duct 82b is connected to the pump unit 83d via a pipe 88. The overflow discharge connection duct 82c is connected to the pump unit 81d via a pipe 98 or feeds overflow fluid to the pipe 97 via a tank (not shown in more detail). The feed connection duct 83a is connected to the pump unit 83d via a pipe 89. The underflow discharge connection duct 83b is connected to the pump unit 84d via a pipe 90. The overflow discharge connection duct 83c is connected to the pump unit 82d via a pipe 91. The feed connection duct 84a is connected to the pump unit 84d via a pipe 92. The overflow discharge connection duct 84c is connected to the pump unit 83d via a pipe 93. Furthermore a pipe for feeding washing water is connected to the pump unit 84d. The separating devices 81-84 are supported by a frame 95, which is only diagrammatically depicted.

[0036] The cascade circuit of separating devices 81-84 operates as follows. A fluid containing particles is fed to the separating device 81 by the pump unit 81d via the pipe 85 leading to the feed connection duct 81a. From the separating device 81, underflow fluid with a high concentration of particles is fed to the pump unit 82d via the underflow discharge connection duct 81b and the pipe 86. Overflow fluid with a low concentration of particles is also fed to the pump unit 82d from the separating device 83 via the overflow discharge connection duct 83c and the pipe 91. The mixture of the underflow fluid from the separating device 81 and the overflow fluid from the separating device 83 is fed to the separating device 82 by the pump unit 82d via the pipe 87 and the feed connection duct 82a. In a similar way, the pump unit 83d receives both underflow fluid from the separating device 82 via the underflow discharge connection duct 82b and the pipe 88 and overflow fluid from the separating device 84 via the overflow discharge connection duct 84c and the pipe 93. The pump unit 83d feeds the two fluids to the separating device 83 via the pipe 89 and the feed connection duct 83a. The pump unit 84d receives both underflow fluid from the separating device 83 via the underflow discharge connection duct 83b and the pipe 90 and washing water via the pipe 94, which flows are fed to the separating device 84 by the pump unit 84d via the pipe 92 and the feed connection duct 84a. Finally, underflow fluid which has passed through all stages of the cascade circuit and in which there is therefore a very high concentration of particles comes out of the underflow discharge connection duct 84b.

Claims

1. Separation unit for separating particles from a fluid containing the particles, which separation unit comprises:

   a number of elongate cyclones (7) with are arranged parallel to and next to one another and are each provided with a feed (14e), an overflow discharge (40) and an underflow discharge (41);
   a first chamber (21), into which the overflow discharges (40) of the cyclones (7) open out;
   a second chamber (20), in which the cyclones (7) are arranged, which second chamber contains the feeds (14e) of the cyclones; and
   a third chamber (22), into which the underflow discharges (41) of the cyclones (7) open out,
   the first, second and third chambers (21, 20, 22) being stacked as seen in the longitudinal direction of the cyclones (7).

2. Separation unit according to claim 1, in which the first, second and third chambers (21, 20, 22) are substantially cylindrical.

3. Separation unit according to claim 1 or 2, in which the stacking is in the vertical direction.

4. Separation unit according to any of the preceding claims, in which the first chamber (21) is provided with at least one overflow chamber discharge (32) outside the area where the first chamber adjoins another chamber.

5. Separation unit according to any of the preceding claims, in which the second chamber (20) is provided with at least one cyclone chamber feed (30) outside the area where the second chamber adjoins another chamber.

6. Separation unit according to any of the preceding claims, in which the third chamber (22) is provided with at least one underflow chamber discharge (34) outside the area where the third chamber adjoins another chamber.

7. Separating device for separating particles from a fluid containing the particles, comprising a number of separation units according to any of the preceding claims.

8. Separating device according to claim 7, in which the separation units are stacked as seen in the longitudinal direction of the cyclones (7).

9. Separating device according to claim 8, in which the stacking of the separation units is in the vertical direction.

10. Separating device according to claim 7 or 8, in which the first chambers (21) of the separation units are each provided with at least one overflow chamber discharge (32), the second chambers (20) of the separation units are each provided with at least one cyclone chamber feed (30), and the third chambers (22) of the separation units are each provided with at least one underflow chamber discharge (34), the cyclone chamber feeds, overflow chamber feeds and underflow chamber feeds of the various separation units being connected to one another by means of a feed connection duct (11), an overflow discharge connection duct (12) and an underflow discharge connection duct (13), respectively.

11. Separating device according to claim 10, in which each of the series of cyclone chamber feeds (30), overflow chamber discharges (32) and underflow chambers discharges (34) of the various separation units are arranged substantially in a line.

12. Separating device according to claim 10 or 11, in which a valve (31a, 31b, 31c) is incorporated between the cyclone chamber feed (30), the overflow chamber discharge (32) and the underflow chamber discharge (34) of each separation unit, on the one hand, and the feed connection duct (11), the overflow discharge connection duct (12) and the underflow discharge connection duct (13), respectively, on the other hand.

13. Separating device according to any of claims 8-12, in which the stacked separation units are pressed together by means of pull rods (10; 65).

14. Separating device according to claim 13, in which the pull rods (10; 65) are arranged outside the chambers (20, 21, 22).

15. Separating device according to claim 14, in which the pull rods (10, 65) can be pivoted away from the separating device when it is dismantled.

16. Method for separating particles from a fluid containing the particles, using a number of separating devices according to claim 10, the fluid from an underflow discharge connection duct (81b, 82b, 83b) of a first separating device (81, 82, 83) being fed to the feed connection duct (82a, 83a, 84a) of a second separating device (82, 83, 84), and the fluid from an overflow discharge connection duct (82c, 83c, 84c) of the second separating device (82, 83, 84) being fed to the feed connection duct (81a, 82a, 83a) of the first separating device (81, 82, 83).

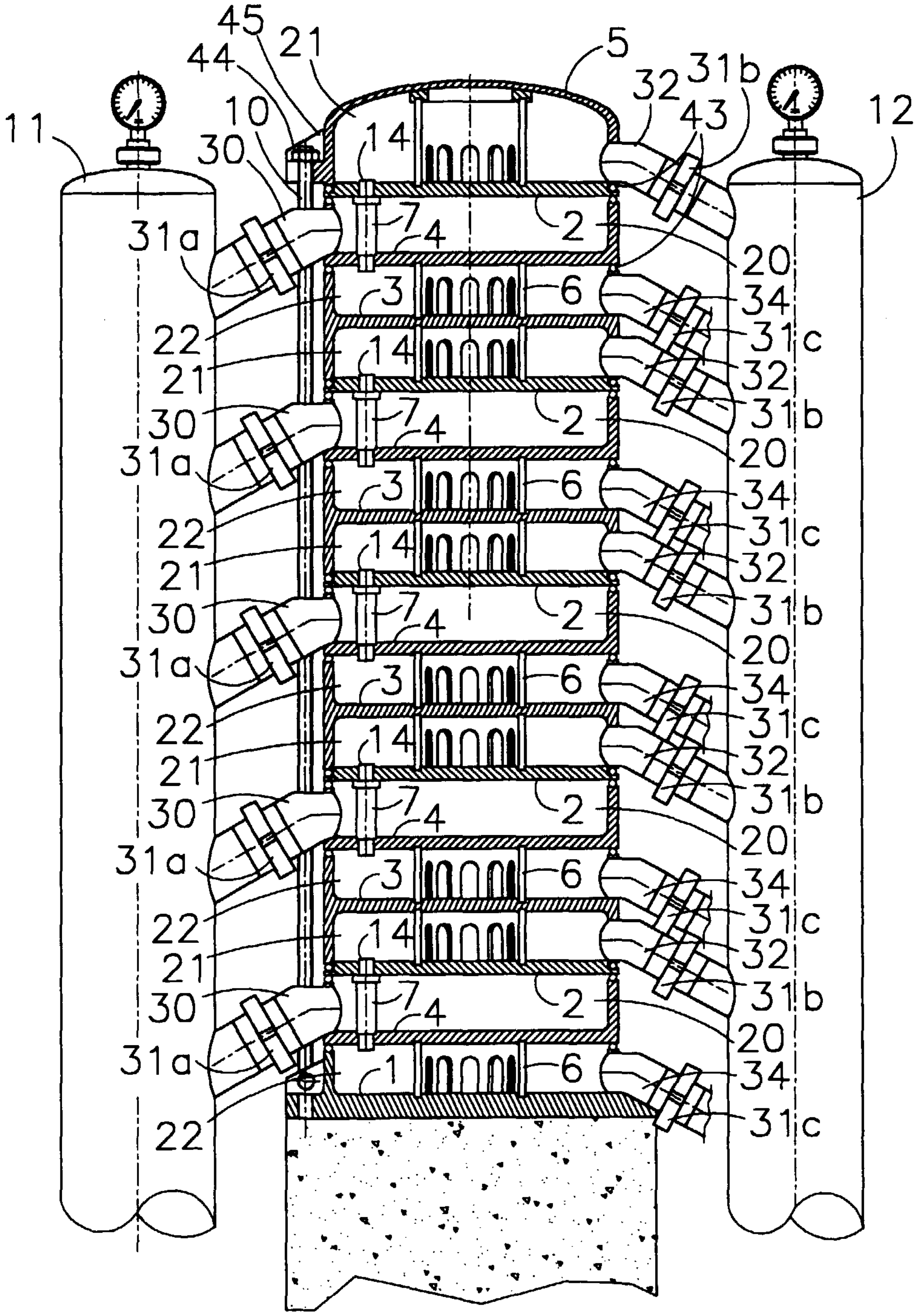
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Fig 1

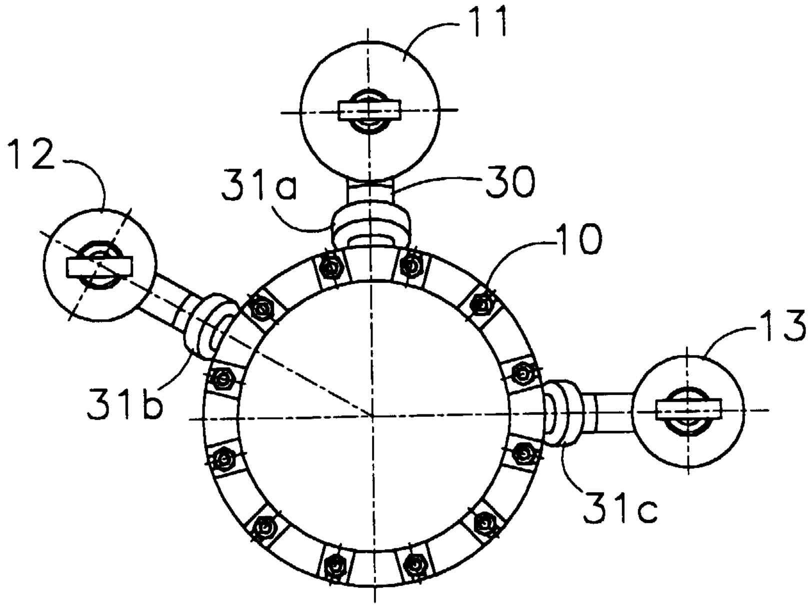


Fig 2

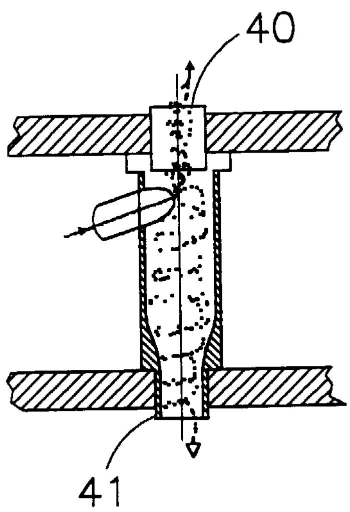


Fig 3

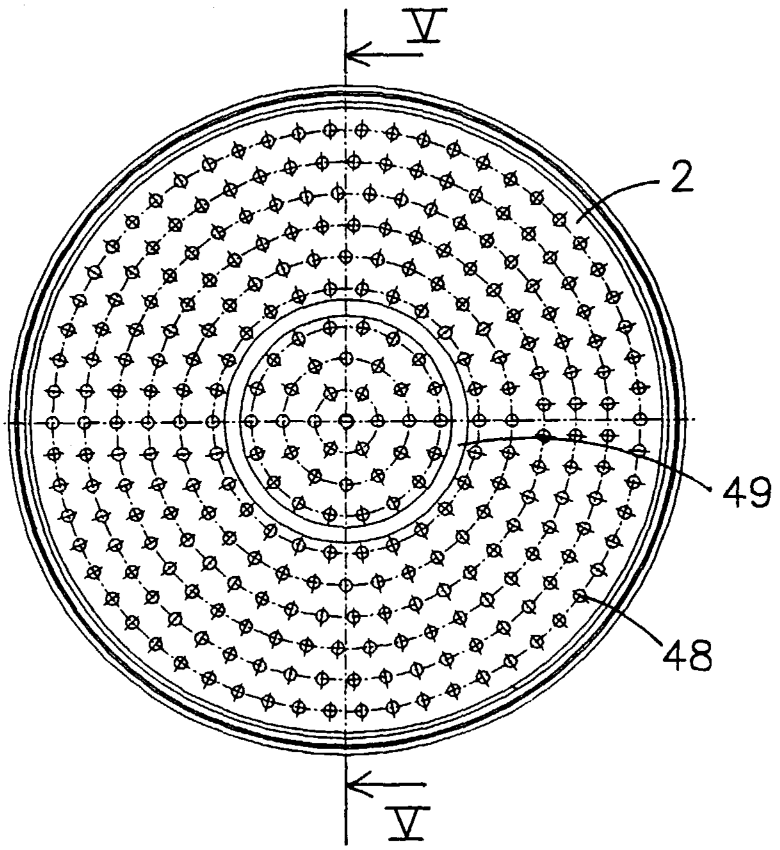
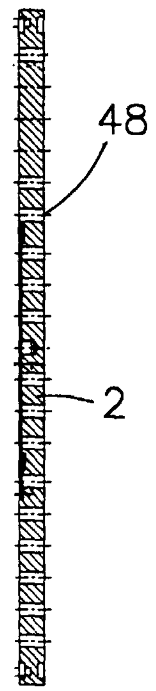


Fig 4



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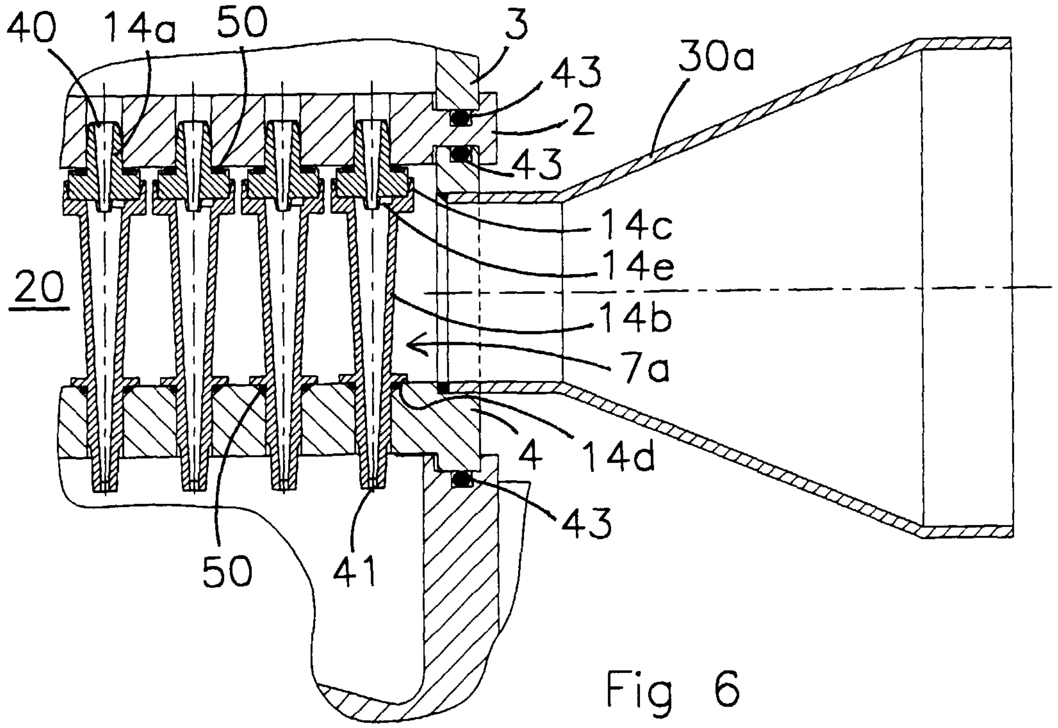

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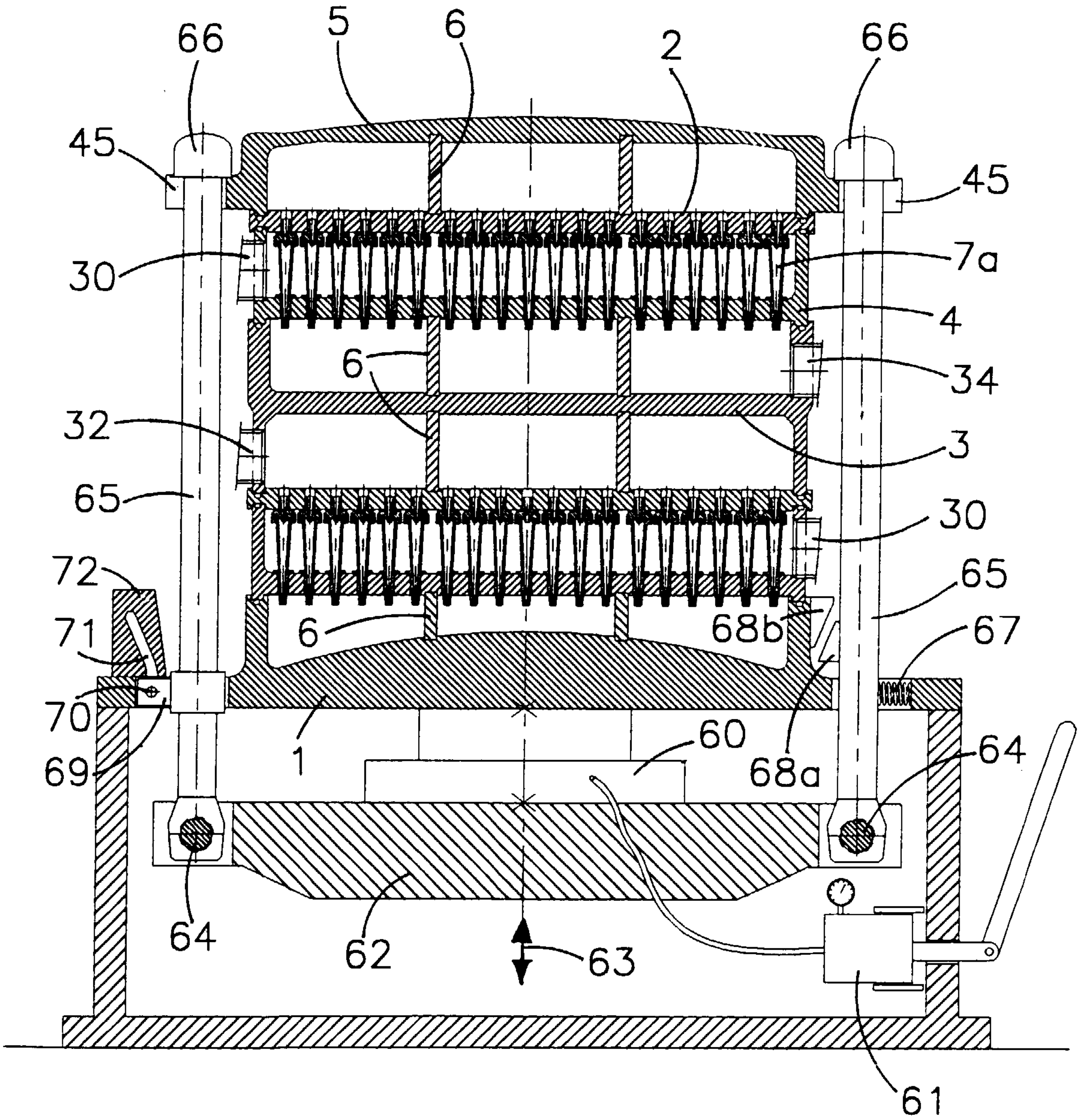
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Fig 7

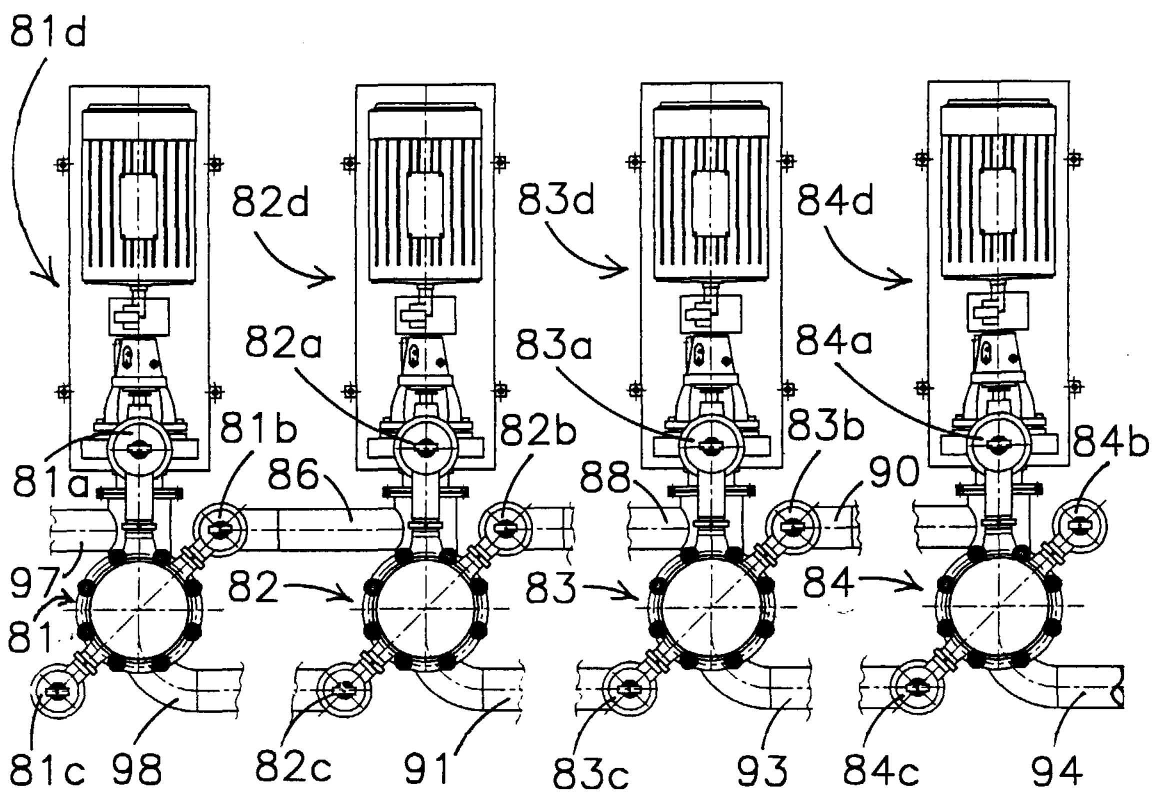
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Fig 8

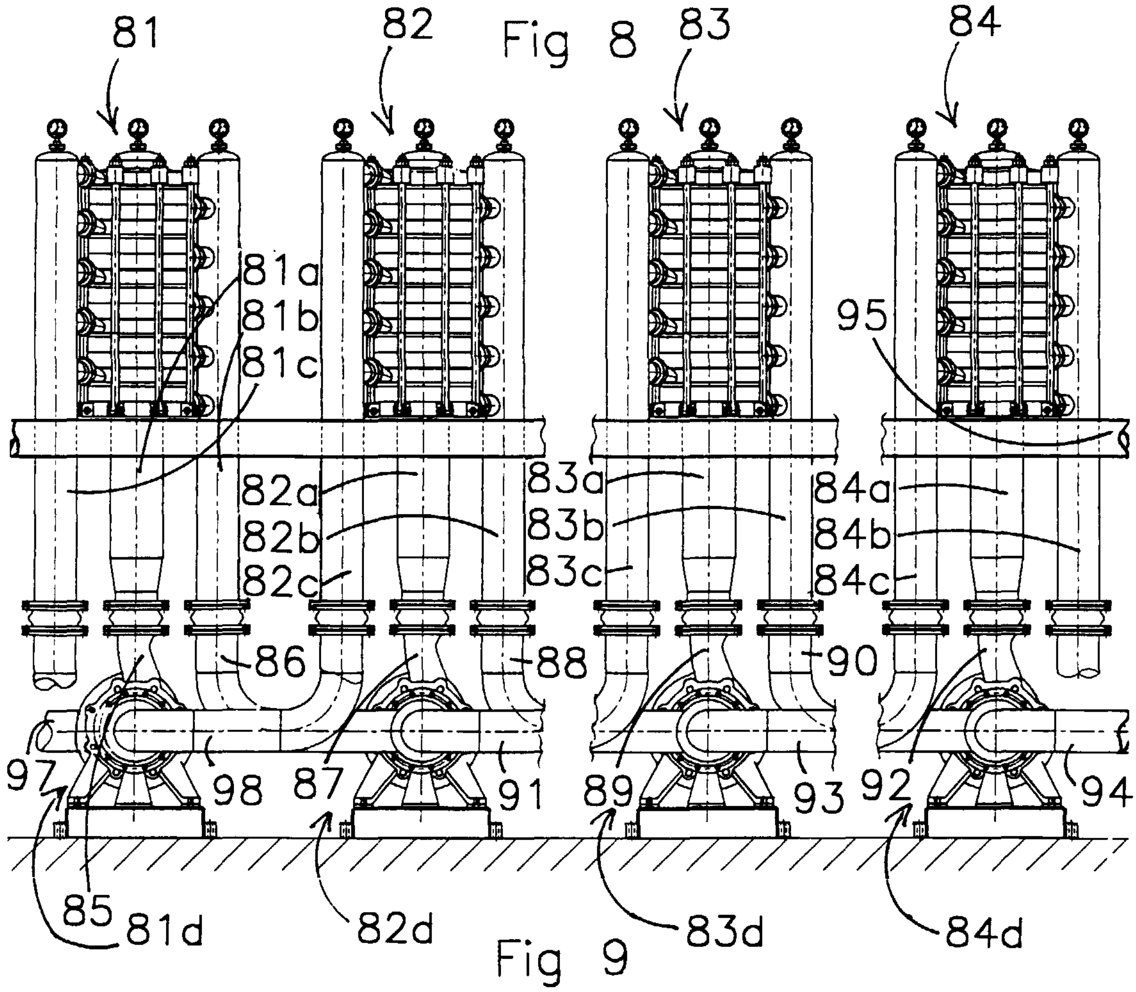
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Fig 9

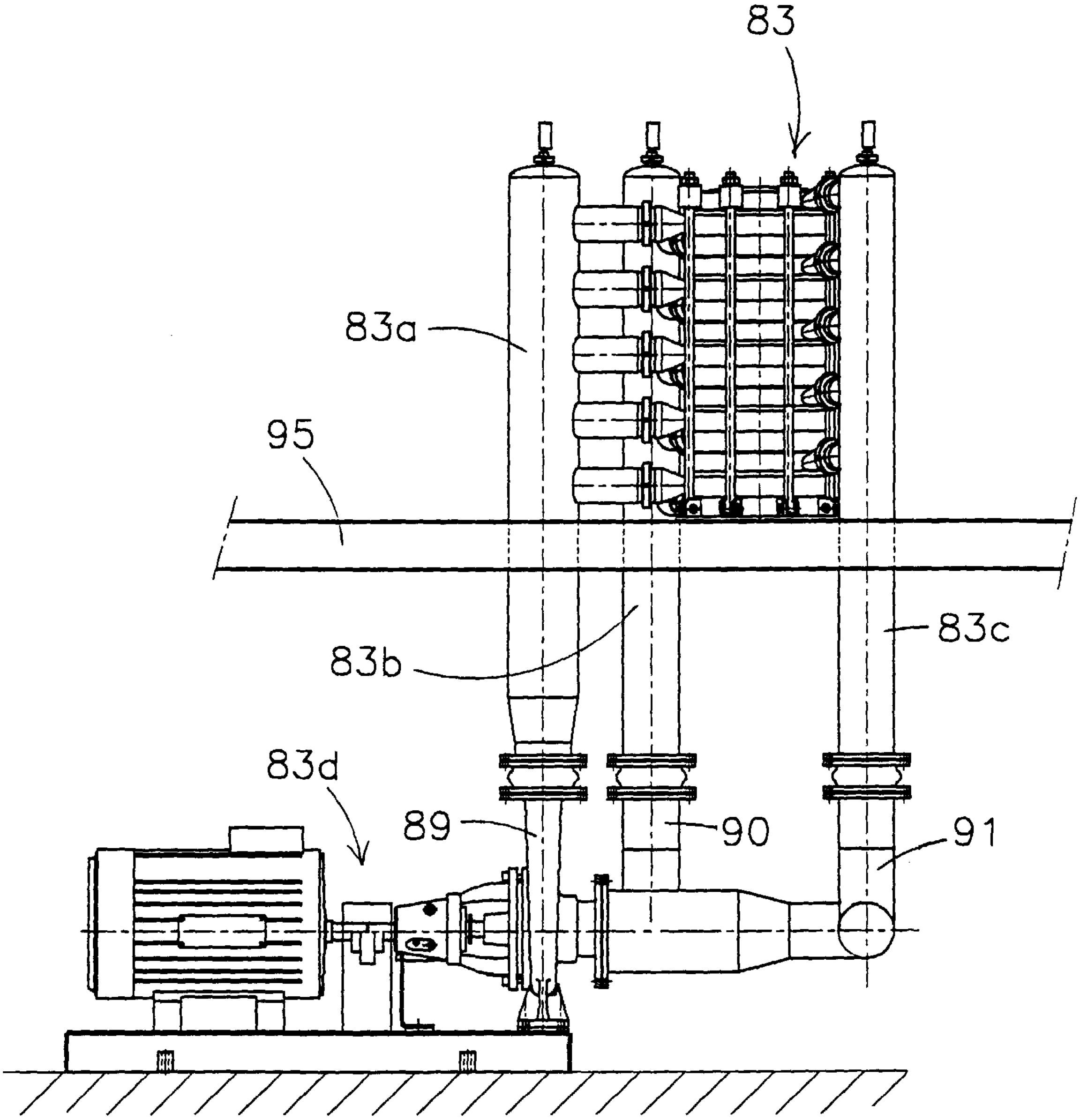

Fig 10