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(54) Combined complex plant of diaphragm pumps.

(57) A plant has a plurality of pumping units combined together, each of them being composed of a cylindrical housing, an expansible and constructible rubber diaphragm having a U-shaped longitudinal section to define a pressure chamber at one side and a pumping chamber at the other side, a liquid pressure source communicated with the pressure chamber, a liquid feed port communicated with the pumping chamber, a liquid discharge port communicated with the pumping chamber and used to send the liquid to a filter press, and an arm inserted into and slidingly movable in the housing and supporting the diaphragm at the free end thereof, and, particularly, a plant is provided with a plurality of housings (1) joined to a plant frame (7), and arms (5') inserted into and slidingly movable in these housings and supported pivotably on a single connecting bar (10) via pins, the arms (5') being moved forward and backward with a predetermined phase difference.

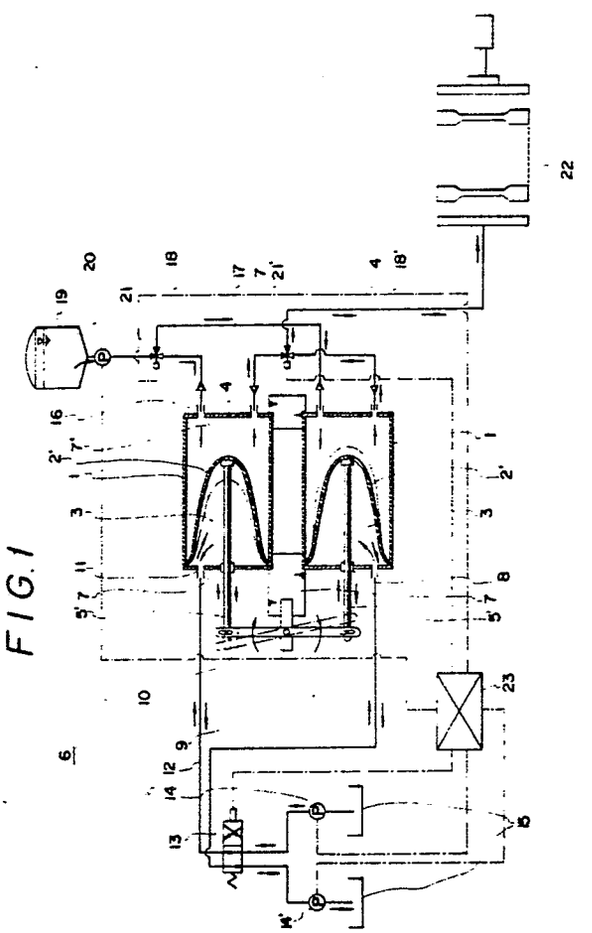

FIG. 1

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COMBINED COMPLEX PUMPING PLANT

Field of the Invention

The disclosed techniques belong to the technical field of the construction of a high-pressure pump type pumping plant used to send under pressure a slurry of industrial waste to a solid-liquid separator, such as a filter press.

Description of the Prior Art

As generally known, various types of liquid pumps have been developed and improved. The high-pressure pumps include in addition to a plunger type pump a so-called diaphragm type pump shown in Fig. 6 and used at present. As shown in Fig. 5, this type of pump is provided in a housing 1 with a diaphragm 2, which defines a pressure chamber 3 and a pumping chamber 4 in the interior of the housing 1, and used as a high-pressure pump in which the compressing force against the pumping chamber is increased by the pressure put into the pressure chamber.

However, in this diaphragm type pump, a stroke is small, so that the level of an output of the diaphragm 2 is limited. In view of these facts, a super-high-pressure pumping plant disclosed in the applicant's earlier-filed patent application and shown in Fig. 7 in the present application was developed. In this pumping plant, new techniques were developed and utilized, by which a flexible rubber diaphragm 2′ having a U-shaped longitudinal section is provided expansibly and contractibly in a housing 1 to thereby define a pressure pump 3 and a pumping chamber 4 in the interior thereof, and the diaphragm 2′ is supported on the base end of an arm 5 which is moved axially with the diaphragm kept in a sealed state, whereby a large output can be applied to a slurry by a small compressive force.

This super-high-pressure pumping plant is advantageous in that such a high output pressure that might cause an operating liquid consisting of an oil to leak from various portions, to which parts of the pumping plant are joined in a sealed state, of the housing can be obtained. However, this pumping plant, which is constructed on the basis of the newly-developed techniques, still has some points to be improved.

One of these points resides in the following. Since the capacity of the pumping chamber in the housing is large, the working stroke is large, and the operation cycle is long. Therefore, the operation efficiency becomes low. Apart from the smoothness of output in a batch treatment for a slurry, the smoothness of output in a flow treatment therefor cannot be obtained. In order to deal with this problem, it is possible to provide a plurality of pumping units, and operate them in staggered phases so that the smoothness of output can be obtained at the output side thereof. However, a controller of extremely complicated construction is required to maintain the phases of operations of these pumping units, and the maintenance and inspection of and the repairs on the pumping units becomes troublesome. This causes an increase in the manufacturing cost and maintenance charges.

Summary of the Invention

An object of the present invention is to give a solution to the technical problems included in a high-output pumping plant which is made on the basis of the above-described conventional techniques, and which has a flexible diaphragm having a U-shaped cross section, and provide an excellent combined complex pumping plant having a desired number of pumping units which are connected together mechanically so that they can be controlled easily, whereby an output per cycle of one pumping unit is smoothed to enable an easily-controllable, the smoothest possible high-output operation to be carried out; and contributing much to various industrial fields in which the pressure techniques are utilized.

Brief Description of the Drawings

Figs. 1-5 illustrate the embodiments of the present invention, wherein:

Fig. 1 is a general schematic construction diagram of an embodiment;

Fig. 2 is a schematic diagram of the arrangement of the pumping members in another embodiment;

Figs. 3, 4 and 5 illustrate still another embodiment, wherein:

Fig. 3 is a perspective view of a connecting bar;

Fig. 4 is a schematic side elevation of combined complex pumping unit; and

Fig. 5 is a plan view of the pumping unit of Fig. 4.

Fig. 6 is a schematic diagram of a conventional diaphragm pump; and

Fig. 7 is a sectional view of a conventional pumping plant.

Detailed Description of the Preferred Embodiment

An embodiment of the present invention will now be described with reference to Figs. 1-5.

The parts of this embodiment, the modes of which are the same as those of the parts of the plant of Figs. 6 and 7, are to be designated by the same reference numerals.

In the embodiment shown in Fig. 1, reference numeral 6 denotes a combined complex pumping plant in which the gist of this invention resides. The plant in this embodiment is a twin type plant, in which a pair of housings 1, 1 are fixed to frames 7, 7 so that the housings extend in parallel with each other. Each housing 1 has a basically identical mode a a conventional housing of this kind. The housing 1 is provided therein with a rubber diaphragm 2', which has U-shaped longitudinal section, in such a manner that the diaphragm 2' can be expanded and contracted mainly in the longitudinal direction and disassembled and replaced by another. The interior of the housing 1 is divided by this diaphragm 2' into a pressure chamber 3 and a pumping chamber 4 which is on the opposite side of the pressure chamber 3. The diaphragm 2' is fixed unitarily at the central portion thereof by a vulcanizing treatment to a base end of an arm 5' which is slidable through a seal bearing 8 provided in one of a pair of vertically arranged walls of the housing 1, in such a manner that the diaphragm 2' can be kept supported thereon even when it is in a contracted position. The arms 5' inserted into the housings 1, 1 are connected to both ends of a connecting bar 10 by pins via slits, which connecting bar 10 is support pivotably by a pin on a bracket 9 fixed to the frame 7. Accordingly, the cycles of the forward and backward movements of these two arms 5', 5' are staggered at a 180° phase. Consequently, the cycles of expansion and contraction of the diaphragm 2', 2' in the housings 1, 1 also have a 180° phase difference.

A feed-discharge port 11, through which an oil, a working liquid is fed into and discharged from the pressure chamber 3, provided in the above-mentioned vertical wall 7 of each housing 1 is communicated with an oil tank 15 via a feed-discharge line 12, an electromagnetic three-way valve 13, a feed pump 14 and a discharge pump 14' so as to supply and input the oil, a working liquid at a high predetermined pressure into the pressure chamber 3.

Regarding the pumping chamber 4 in the housing 1, a feed port 16 and a discharge port 17 for a liquid to be treated are provided in the other wall 7'. The feed port 16 is communicated with a high-pressure pump 20 for a slurry tank 19 via a line provided with a check valve 18 and branching at an electromagnetic three-way valve 21. Each of the discharge ports 17, 17 is connected to an electromagnetic three-way valve 21' via a check valve 18' which is connected to a filter press 22, a treatment apparatus in a subsequent stage.

Since the diaphragms 2' in the housings 1 are adapted to be operated with a 180° phase difference, the feeding of a slurry from the slurry tank 19 into the pumping chambers 4 and the discharging of the slurry therefrom are done by the three-way valves 21, 21' contrarily and selectively so that the feeding of the slurry from the slurry tank 19 and the discharging thereof into the filter press 22 are done alternately, whereby the pumping operations in the plant as a whole are smoothed.

Reference numeral 23 denotes a control unit which is adapted to operate the servo valve 13 and high-pressure pumps 14', 20 through lead wires and control the operations of the three-way valves 21, 21' automatically in accordance with a predetermined program.

(Operation of the Embodiments)

When the control unit 23 in the above-described combined complex pumping plant 6 is operated, the high-pressure pump 14 on the input side is operated. Since the electromagnetic valve 13 is at this time in an initial posture as shown in the drawing, the oil, a working liquid is in high-pressure condition and fed into the pressure chamber 3 in one (upper in the drawing) housing 1 via the liquid feed port 11.

The embodiment may also be designed so that the servo valve 13 is opened and closed by an electromagnetic valve provided in the feed-discharge line 12 and electrically connected to the control unit 23.

The oil thus put into the pressure chamber 3 in one housing causes the diaphragm 2' to expand, so that the arm 5' the base end of which is fixed to the diaphragm 2' advances to right in the drawing in the interior of the housing 1. Consequently, the connecting bar 10 supported on the bracket 9 fixed to the frame 7 is turned to right in the drawing. Therefore, the arm 5' in the other housing 1 is moved back to left, i.e., to the outer side of the housing 1, so that the diaphragm 2' in the other housing 1 assumes a contracted posture. Accordingly, the working oil in the pressure chamber 3 in this housing 1 is fed back from the feed-discharge port 11, 11 to the oil tank 15 via the feed-discharge line 12, servo valve 13 and liquid discharge pump 13'.

In the pumping chamber 4 in which the diaphragm 2′ is expanded, the slurry therein is fed under high pressure into the filter press 22 through the check valve 18′ and three-way valve 21′ which has been shifted to the side of the upper housing 1 by the control unit 23.

On the other hand, the slurry is fed from the slurry tank 19 into the pumping chamber 4 via the three-way valve 21 which is provided below the high-pressure pump 20, and which has been shifted to the side of the lower housing 1, and via the check valve 18 and feed port 16. During this time, the slurry in the same pumping chamber is prevented from flowing out from the discharge port 17 by the check valve 18′, and is not sent to the filter press 22.

Consequently, in the lower housing 1, the working oil returns to the oil tank 15 and the slurry is fed to the pumping chamber 4 by the diaphragm 2′ owing to a kind of push-pull effect of the suction vacuum generated by the liquid discharge pump 14′ and the pressure generated by the high-pressure pump 20 on the side of the slurry tank 19.

The arms 5′, 5′ fixed to the diaphragms 2′, 2′ in both of the housings 1, 1 are connected mechanically to the connecting bar 10, and moved forward and backward with the 180° phase difference. Accordingly, the compression-discharging of the slurry and the feeding thereof in the two pumping chambers 4, 4 in different housings are done at once, while the feed-pressurization of the working oil and the compression-discharging thereof in the pressure chambers 3 in different housings are done at once. Although these operations are contrary to each other, they can be carried out without deranging the phase difference thereof owing to the connecting bar 10 joined to the arms.

The feeding of the slurry into the filter press 22 by the compress on thereof owing to the feeding of the working oil in the upper housing 1 and the depressurization and discharging of the working oil and the feeding of the slurry in the other housing 1 are done in one full stroke. When these operations have reached the end of the stroke, it is detected by a predetermined microswitch, and a switching opera tion is carried out by the control unit 23, so that the servo valve 13 and electromagnetic valve 21 are switched. As a result, the expansion and contraction operations of the diaphragms 2′, 2′ in the upper and lower housings 1, 1 are reversed. Namely, the diaphragm 2′ in the upper housing 1 is switched to a contraction stroke, and the diaphragm 2′ in the lower housing 1 to an expansion stroke, so that operations contrary to the above-described operations are carried out with the slurry kept supplied to the filter press 22 continuously at a high pressure.

Therefore, the high-pressure-feeding of the slurry into the filter press 22 is necessarily carried out by a continuous flow process.

If such a process is carried out repeatedly, the feeding of high-pressure slurry into the filter press 22 is done continuously. Moreover, such continuous operation cycles are made by the connecting bar 10 without causing any phase difference to occur on the diaphragms 2′, 2′ in the housings 1,1.

Moreover, the slurry discharged under pressure in the repeated cycles has a substantially constant output pressure since the expansion and contraction of the diaphragms 2′, 2′ in the housings 1, 1 are done by the connecting bar 10. This ensures uniform and smooth operations of the plant with the output pressure not fluctuating in the repeated cycles.

The above-described embodiment is a twin type pumping plant. An embodiment shown in Fig. 2 is a combined quadruplex pumping plant which consists of a twin type pumping unit shown in the right half portion of the drawing and similar to the above-described twin type pumping plant, a similar pumping unit shown in the left half portion of the drawing and composed of a pair of pumping members in the same manner as the right-hand pumping unit, an integral arm 5″ inserted into the upper pumping members 1, 1, an integral arm 5″ inserted into the lower pumping members 1, 1, and a connecting bar 10 which connects these arms 5″, 5″ together. In this mode of pumping plant, the pumping of a slurry into the filter press 22 in each cycle can be done at a higher pressure, and the operations of the four combined pumping members can be carried out as a predetermined operational stroke is maintained reliably.

An embodiment shown in Figs. 3, 4 and 5 is a mode of a combined complex pumping plant in which a considerably large number of pumping members can theoretically be combined. A connecting bar 10′ consists of a crankshaft having one axis and provided thereon via journals with cranks 24, 24 .... which are formed with predetermined phase differences in planes extending at right angles to the mentioned axis. In this mode of embodiment, the arms 1, 1.... inserted into the housings are connected to the cranks 24 via joints 25 as shown in Fig. 4, and a plurality of pumping members can be arranged in planes with predetermined phase differences as shown in Fig. 5. Accordingly, the feeding and discharging of a slurry into and from the pumping members are done selectively in a staggered manner with designed phase differences maintained. Therefore, the supplying of a slurry to a filter press 22 is done by a flow system very constantly. Moreover, the pumping of the slur-

ry in each process is done at a high pressure in a sufficiently assuring manner owing to the high-pressure pumping effect of each pumping member .

In this mode of embodiment, the servo valves for the pumping members are designed so that they can be switched independently of one another via a control unit.

In this embodiment, it is effective to design the pumping plant so that all the pumping members connected to the cranks on the crankshaft 10' be arranged radially in the same plane as shown in Fig. 5.

The mode of embodiment of the present invention is not, of course, limited to those of the above-described embodiments. It is possible to employ various other modes, in which an electromagnetic clutch is inserted between the connecting bar and arm so as to control the servo valve by the arm via the limit switch; or a damper spring is provided so as to absorb a shock occurring between the connecting bar and arm at the end of a stroke.

The present invention is not limited to the slurry used in the above-described embodiments. The present invention can also be applied to the high-pressure pumping and packing of a liquid medicine and a liquid food, the high-pressure ejecting of water from a pump for a fire-extinguishing operation, and the high-pressure discharging of a liquid from a tool in operation in a cutting process using a liquid. Accordingly, the treatment apparatus used in a subsequent stage is not limited to a filter press. Namely, a nozzle may also be used, and the pumping plant itself can be used as a compressor.

According to the present invention, which is directed to a high-pressure pumping plant provided basically with a diaphragm having a U-shaped longitudinal section and placed expansibly and contractibly in a housing so as to define a pressure chamber and a pumping chamber therein, a continuous output can be obtained without any output-interrupted half-cycle period in each cycle as the basic effect in obtaining a very high pressure at the output side is guaranteed even when the pressure at the input side is rendered low. Moreover, the constancy of the high-pressure discharging of a slurry can be ensured by increasing the number of the pumping members.

In this pumping plant, the diaphragm in each housing can be kept in a predetermined posture even when the diaphragm is in a contracted position. In spite of the simple construction of this pumping plant in which the arms are joined to each other by a single connecting bar, a cyclic operation of the pumping plant with predetermined phase differences between a plurality of pumping members maintained throughout is guaranteed, and a present high continuous output can be obtained.

Since a plurality of pumping members are joined together by a single connecting bar, the construction of the pumping plant can be constructed simply, and the maintenance and inspection thereof can be carried out easily. Moreover, the running cost, not to speak of the initial cost, can be reduced.

In the pumping plant designed in a certain manner, the feeding and discharging of a working oil, such as an oil into and from the pressure chamber in each housing are done by a single servo valve, so that the construction of the pumping plant as a whole does not become unduly complicated.

The capability, which constitutes the advantage of the pumping plant, of obtaining a high output as compared with the small actual capacity of each housing can be made most of as it is when the pumping plant is put to practical use. When a plurality of housings are joined to a central element with slight phase differences, a very high constant output which has not ever been obtained in any kind of industries can be obtained.

Claims

1. A combined complex pumping plant having a plurality of housings, cross-sectionally U-shaped expansible and contractible diaphragms provided in the interior of said housings and dividing the same into a pressure chamber and a pumping chamber, and arms moving slidingly into and toward the outside of said housings and supporting at the free ends thereof said diaphragms, said pressure chambers being connected to liquid pressure sources, said pumping chambers being communicated with liquid feed ports and liquid discharge ports, characterized in that said arms (5') fitted movably in said housings are adapted to be operated in different phases via a connecting bar (10) joined to a frame (7).

2. A combined complex pumping plant according to Claim 1, wherein the number of said housings is two, said arms (5') being connected to the end portions of a single connecting bar (10) which is supported pivotably via a pin (9).

3. A combined complex pumping plant according to Claim 2, wherein said arms can be engaged with and disengaged from said connecting bar by electromagnetic clutches.

4. A combined complex pumping plant according to Claim 2, wherein said arms are connected to said connecting bar via cushion springs.

5. A combined complex pumping plant according to Claim 2, wherein both of said pressure chambers are controlled by a single servo valve (13).

6. A combined complex pumping plant according to Claim 1, wherein said arms in said housing pair are formed of a single arm, one more identical housing pair having an identical arm being disposed in parallel with the first-mentioned housing pair, said integral arms in said housing pairs being connected unitarily by a single connecting bar which is supported pivotably via a pin on said frame (fig. 2).

7. A combined complex pumping plant according to Claim 1, wherein said plural housings (1) are arranged circularly, said arms (5') fitted movably in said housings being supported on cranks (29) of different phases on a crankshaft which is supported pivotably on said frame.

8. A combined complex pumping plant according to Claim 7, wherein servo valves for controlling said pressure chambers in said housings are provided independently of each other.

9. A combined complex pumping plant according to Claim 7, wherein said arms fitted movably in said housings have limit switches for said servo valves.

FIG. 1

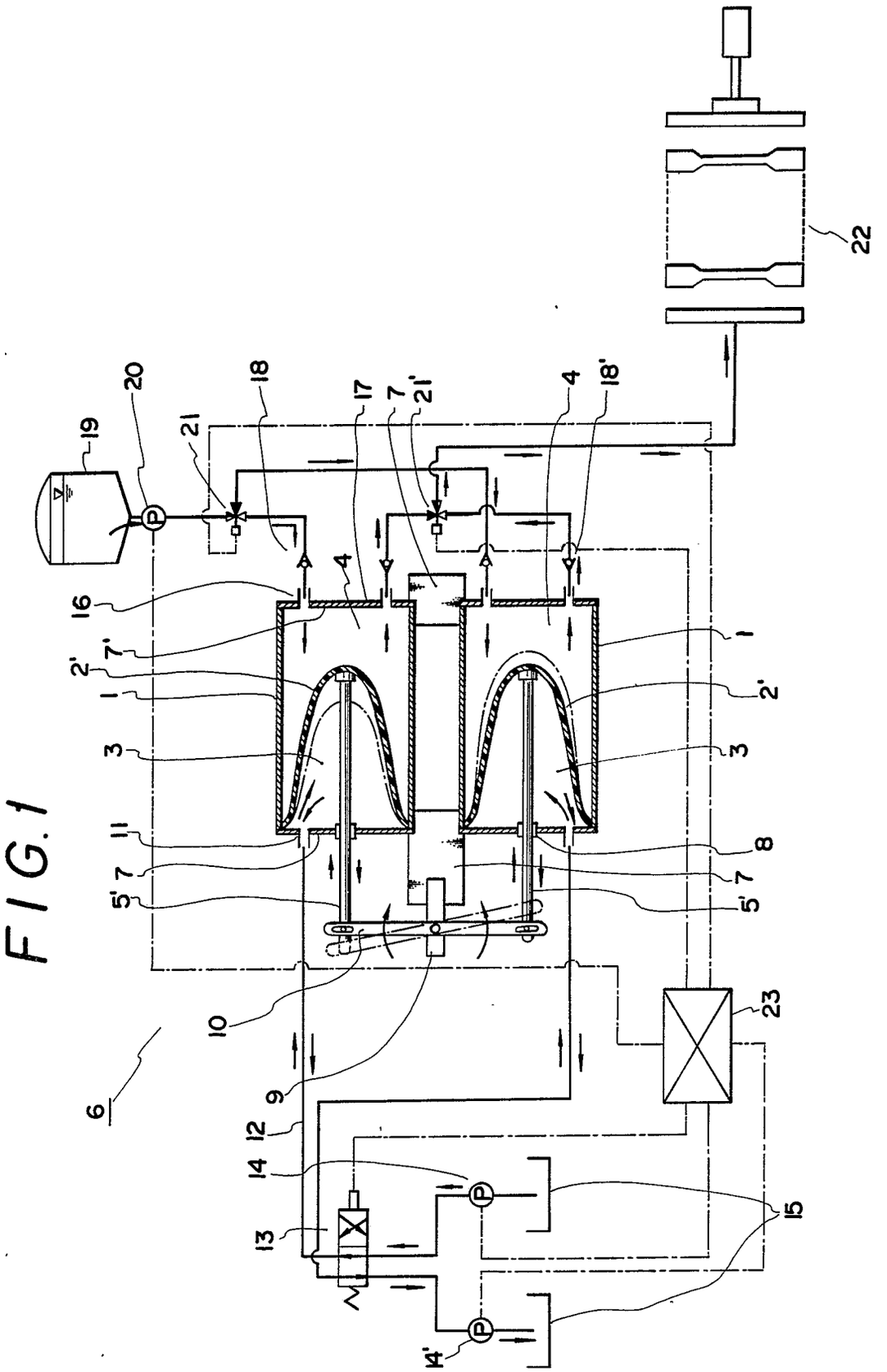


FIG. 2

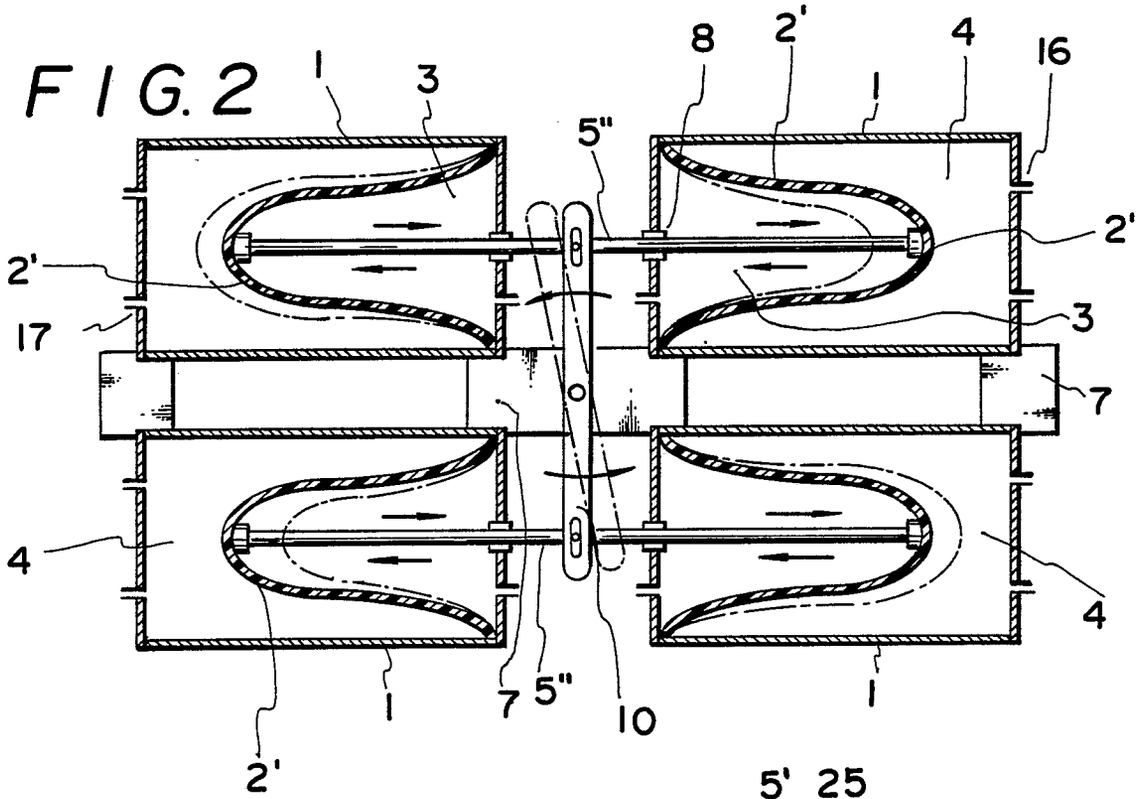


FIG. 3

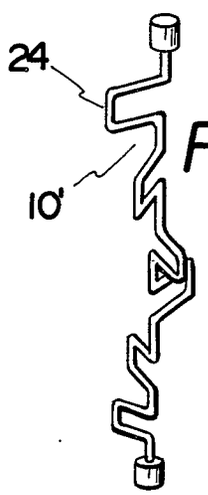


FIG. 4

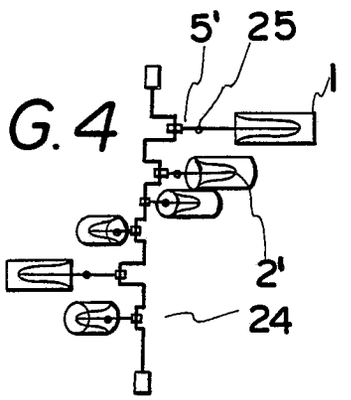


FIG. 5

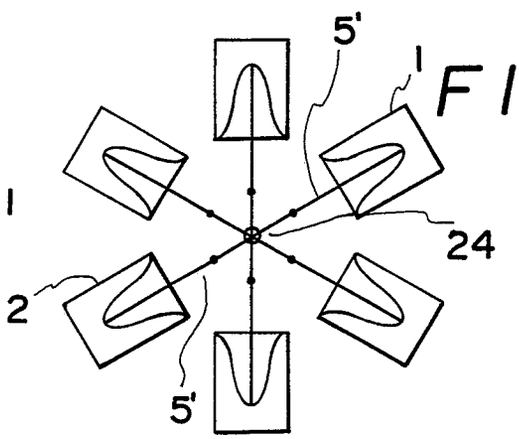
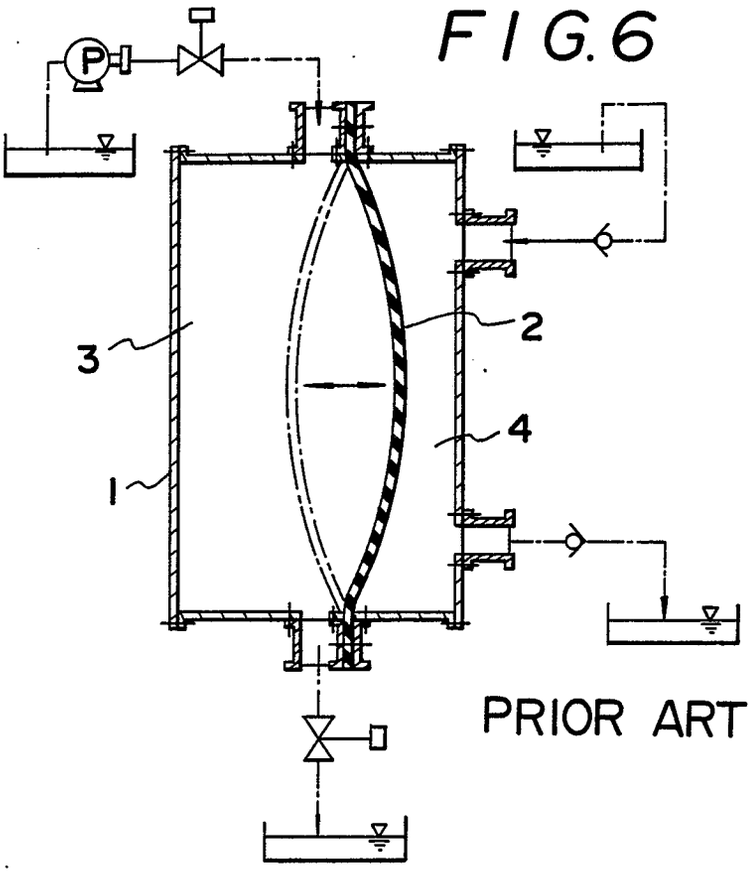
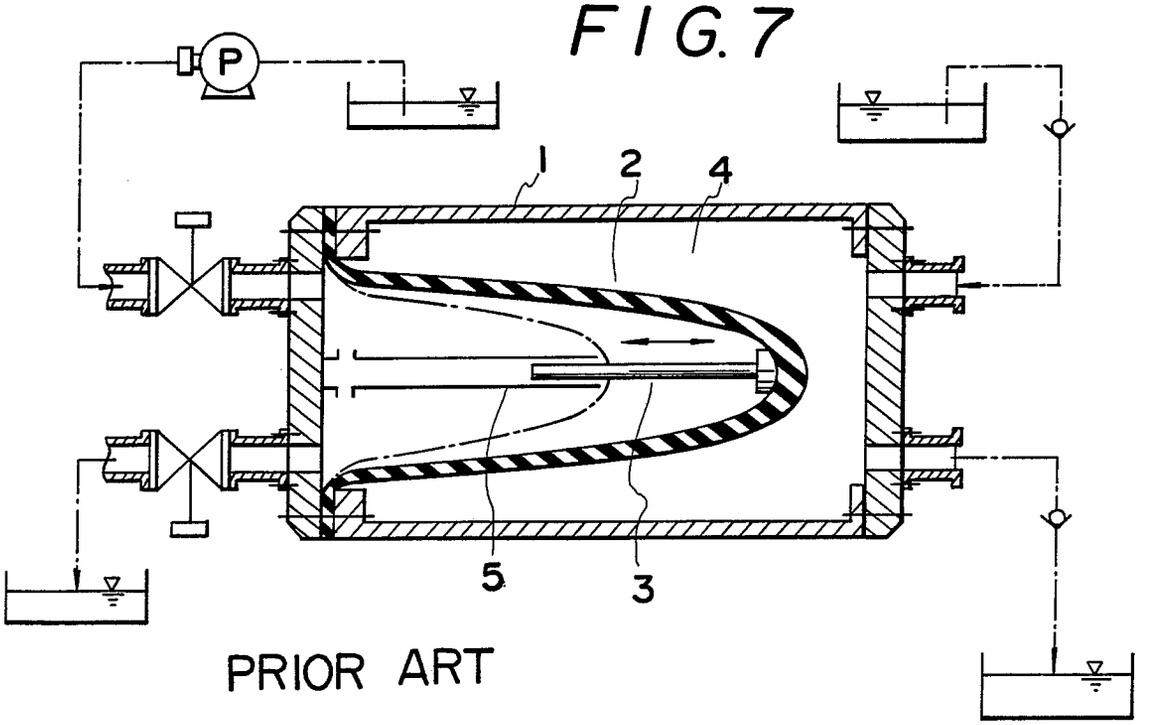


FIG.6



PRIOR ART

FIG.7



PRIOR ART

European Patent Office

EUROPEAN SEARCH REPORT

Application number

DOCUMENTS CONSIDERED TO BE RELEVANT

EP 86116315.2

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	PATENT ABSTRACTS OF JAPAN, unexamined applications, section M, vol. 1, no. 141, November 17, 1977 THE PATENT OFFICE JAPANESE GOVERNMENT page 4912 M 77 * Kokai-no. 52-81 605 (KOBE-SEIKOSHO) *	1,2,6,7	F 04 B 43/00 F 04 B 43/02
Y	PATENT ABSTRACTS OF JAPAN, unexamined applications, field M, vol. 6, no. 86, May 25, 1982 THE PATENT OFFICE JAPANESE GOVERNMENT page 135 M 131 * Kokai-no. 57-24 462 (NITTO KOUKI) *	1,2	
A	EP - A1 - 0 102 780 (INOUE-JAPAX) * Totality *	1,2	TECHNICAL FIELDS SEARCHED (Int. Cl.4) F 04 B 1/00 F 04 B 9/00 F 04 B 15/00 F 04 B 23/00 F 04 B 27/00 F 04 B 43/00 F 04 B 49/00
Y	GB - A - 8 536/A.D. 1901 (WUHRMANN) * Totality; especially fig. 3,5 *	6	
Y	DE - A1 - 3 042 328 (FAR EAST) * Totality; especially fig. 1 *	7	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	18-09-1987	WERDECKER

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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