

- | | | | | |
|--|-----------|--------|--------------|---------|
| [54] METHOD FOR HYDRAULICALLY RAISING
ORE AND OTHER MATERIALS | 3,438,142 | 4/1969 | Krutein..... | 37/58 X |
| | 3,693,272 | 9/1972 | Gariel..... | 37/63 |

- [75] Inventors: **Kurt Holzenberger,**
Frankenthal/Pfalz; Otto Schiele,
Neudtadt/Weinstrasse, both of
Germany

Primary Examiner—Clifford D. Crowder
Attorney, Agent, or Firm—Michael S. Striker

- [73] Assignee: **Klein, Schanzlin & Becker
Aktiengesellschaft**, Frankenthal,
Pfalz, Germany

- [22] Filed: Dec. 4, 1972

- [21] Appl. No.: 312,119

Related U.S. Application Data

- [62] Division of Ser. No. 195,920, Nov. 5, 1971, Pat. No. 3,753,303.

[30] Foreign Application Priority Data

- Nov. 10, 1970 Germany..... 2055132

- [52] **U.S. Cl.**..... **37/195**, 37/59, 302/66

- [51] Int. Cl. E02f 3/88

- [58] **Field of Search** 37/58, 59, DIG. 8, 195;
417/435, 149: 302/66, 14: 417/123

[56] **References Cited**

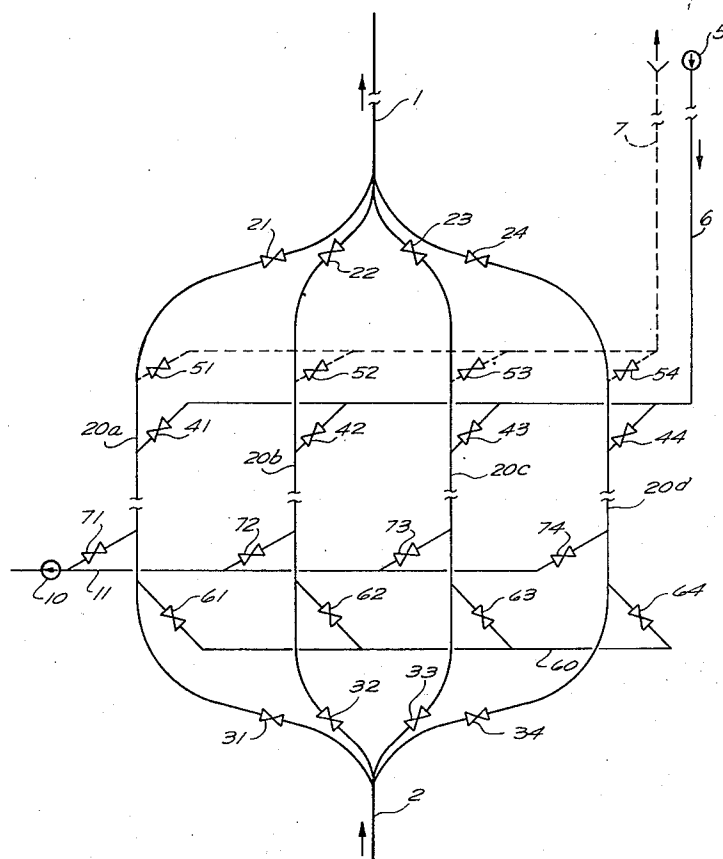
UNITED STATES PATENTS

- 3,260,004 7/1966 Brooks..... 37/59 X

[57] **ABSTRACT**

A plurality of containers in a riser conduit cooperate cyclically with a main suction pump and a flushing pump. Control valves are cyclically operated so that the main suction pump exhausts clear flushing water from one container, whereby a pressure differential is produced for raising an ore-water mixture in the lower portion of the riser conduit to the level of the container, while the ore-water mixture in another container is flushed through the upper riser conduit portion to the surface level. Between two and four containers can be used for the cyclical operation so that the ore-water mixture flows continuously out of the upper riser conduit portion, while any contact between the material and the main suction pump and the flushing pump is avoided.

3 Claims, 12 Drawing Figures



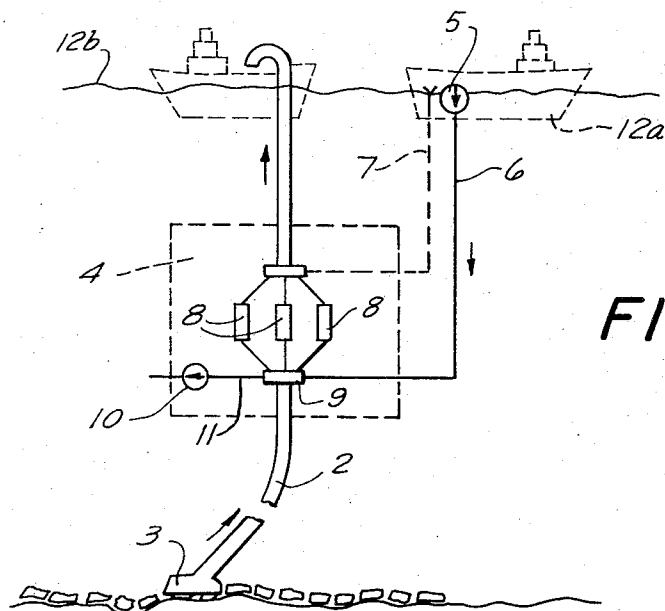


FIG. 1

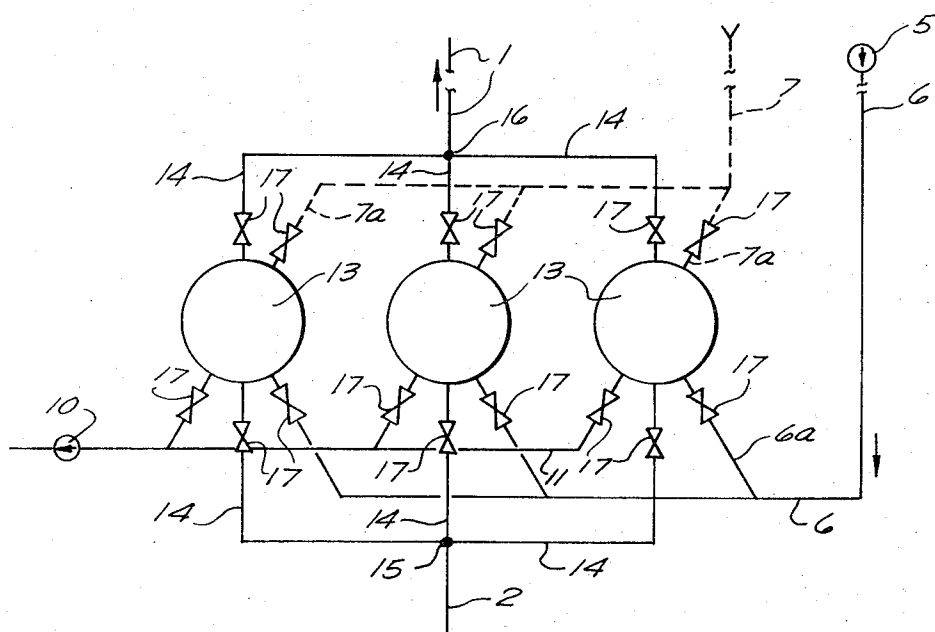
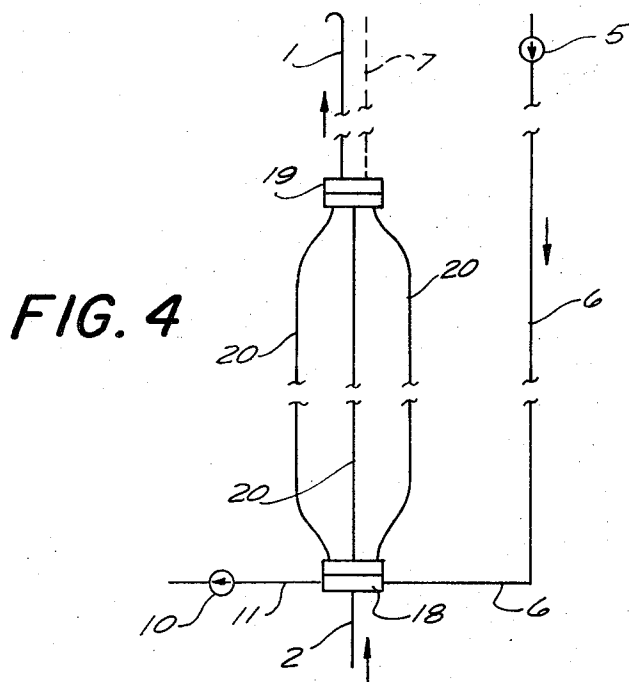
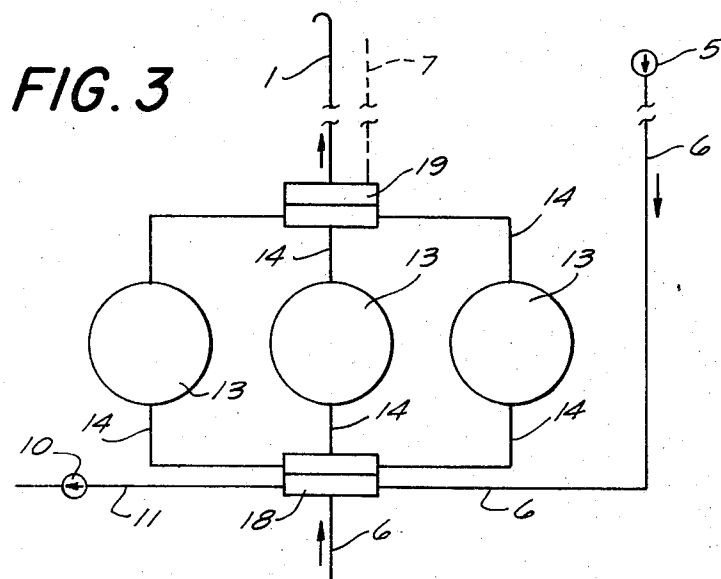


FIG. 2



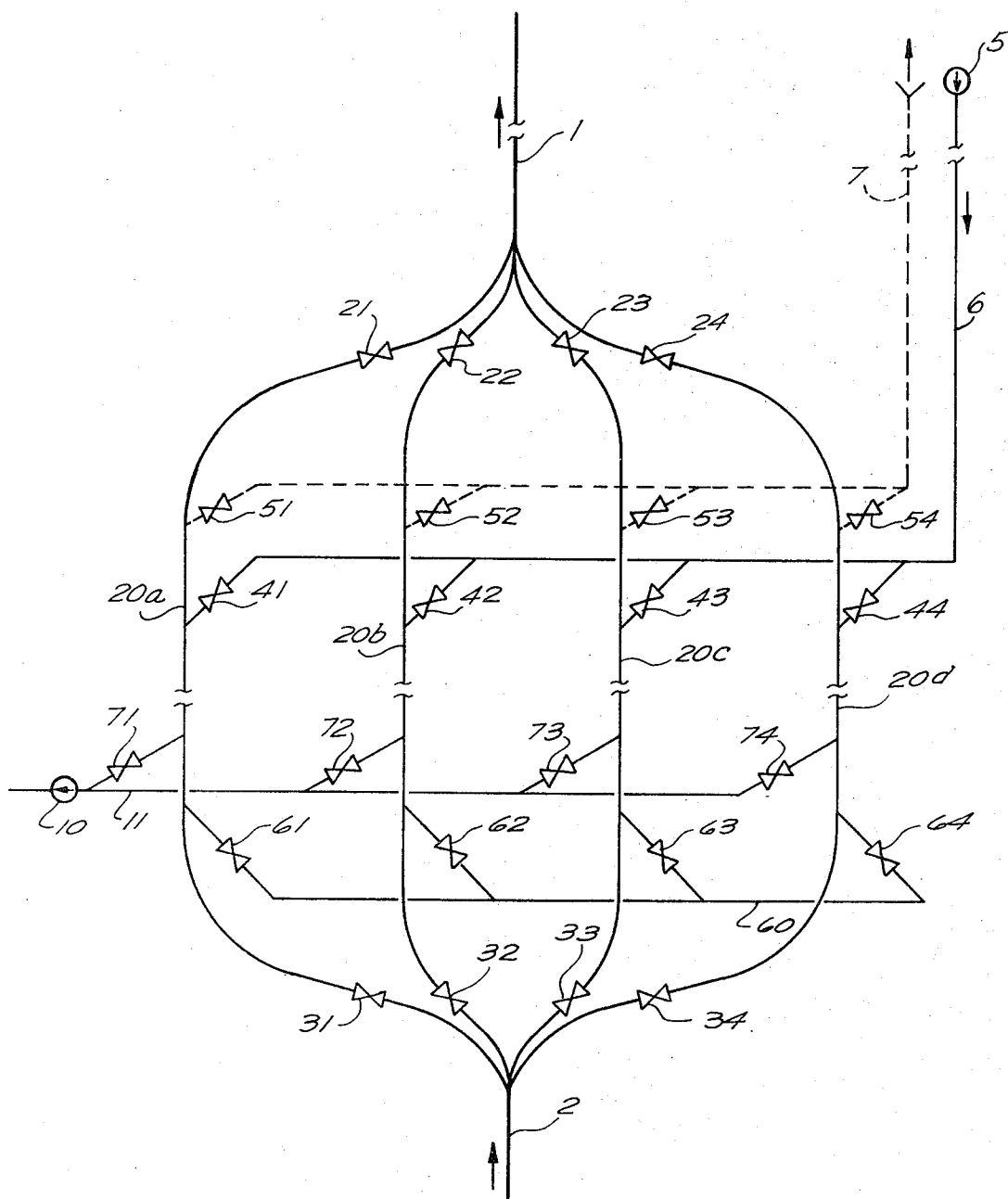


FIG. 5

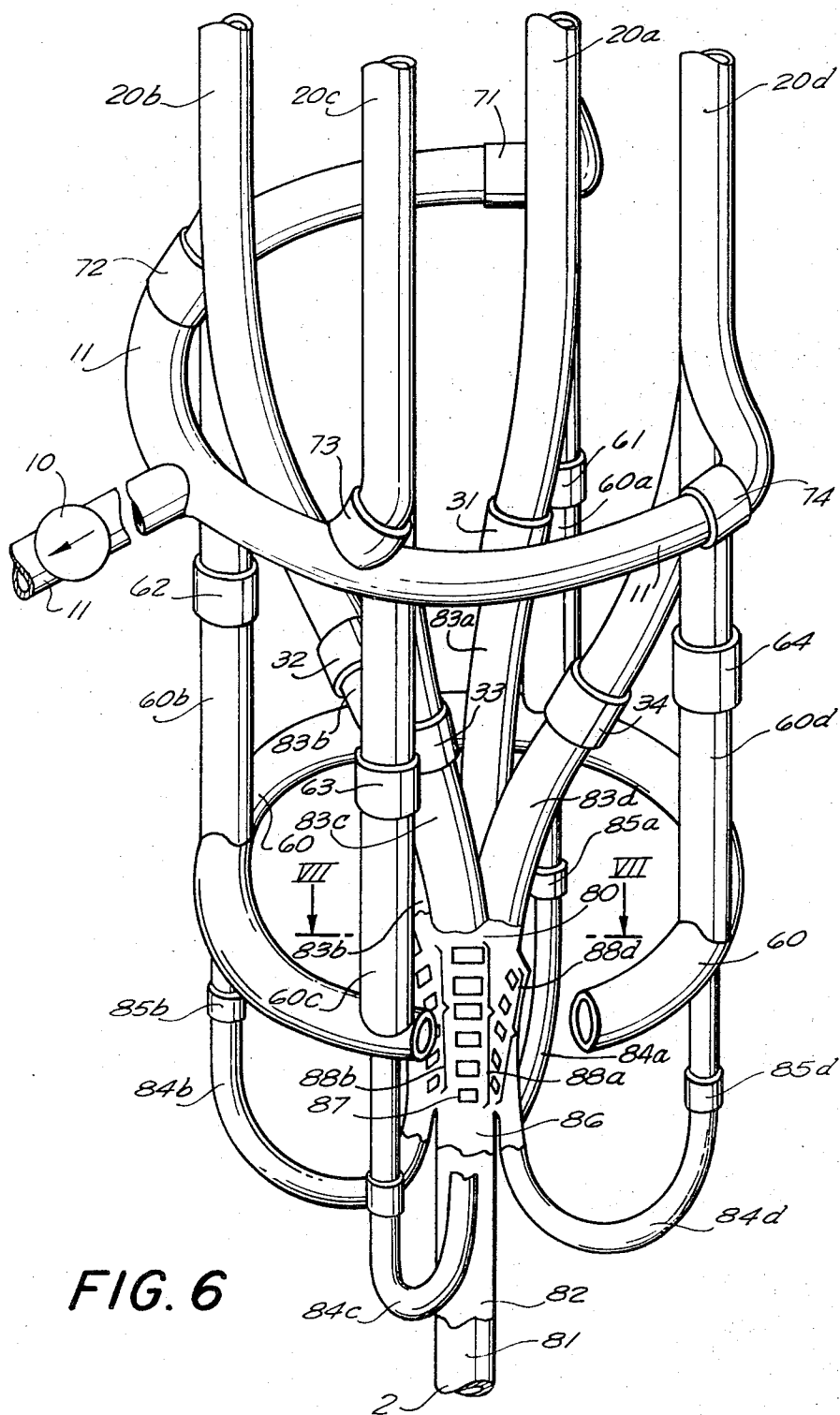


FIG. 7

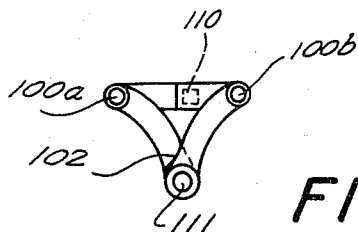
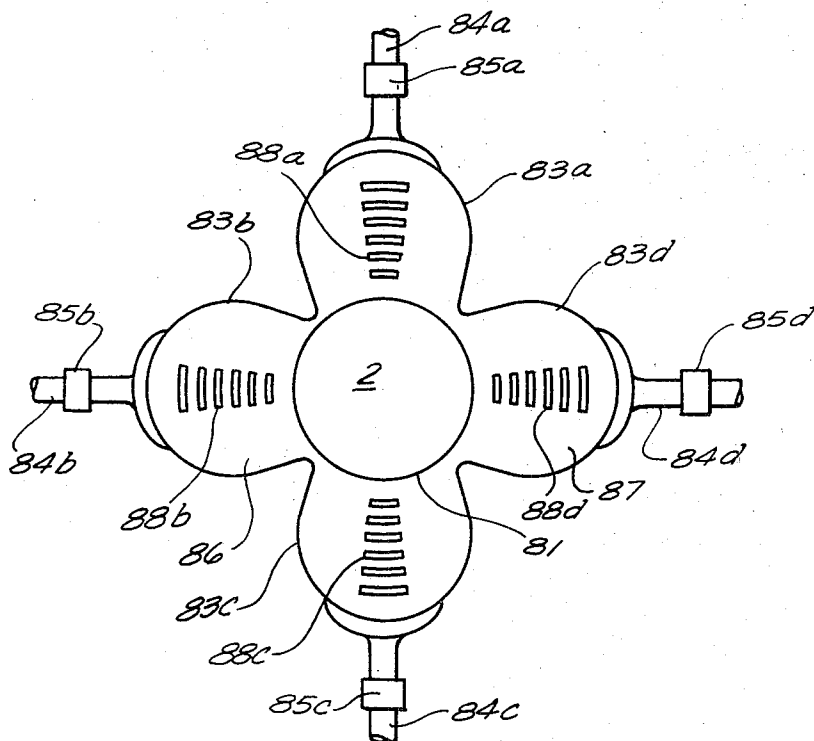


FIG. 10

FIG. 9

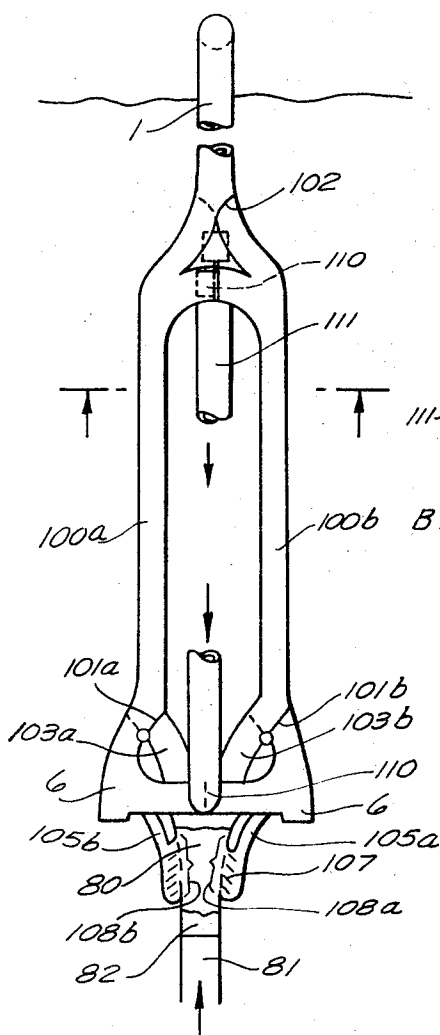
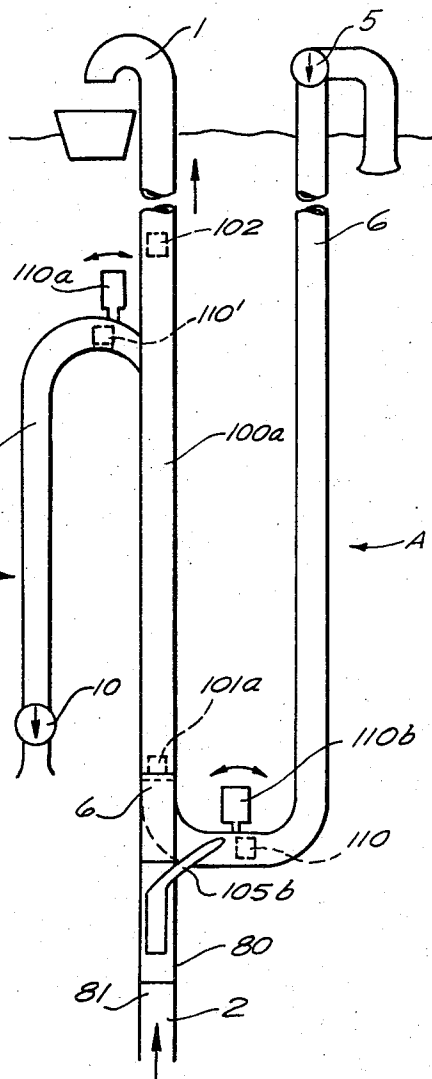


FIG. 8



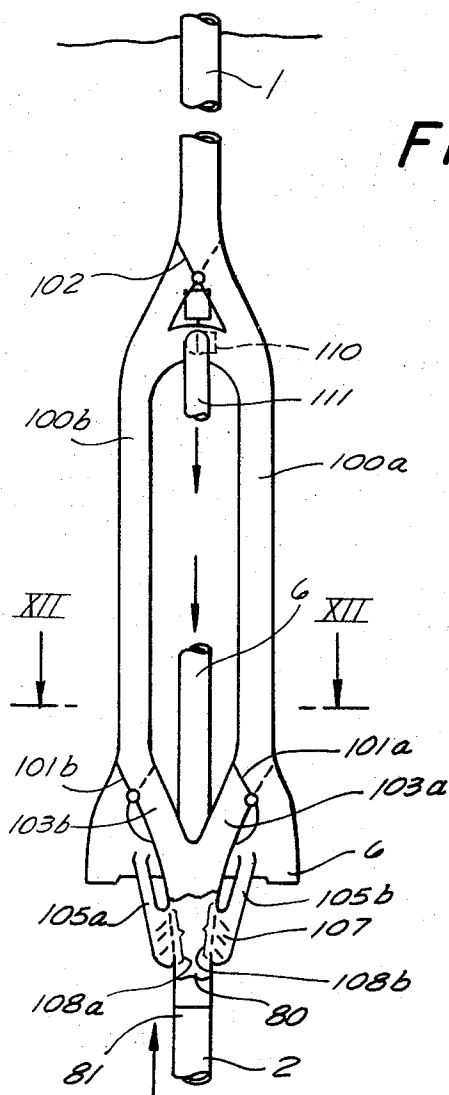


FIG. 11

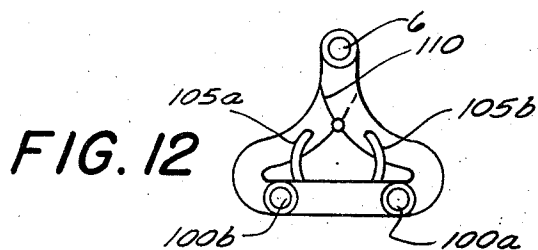


FIG. 12

METHOD FOR HYDRAULICALLY RAISING ORE AND OTHER MATERIALS

This application is a division of application Ser. No. 195,920, filed Nov. 5, 1971, now U.S. Pat. No. 3,753,303, entitled "Apparatus for Hydraulically Raising One and Other Materials."

BACKGROUND OF THE INVENTION

The present invention relates to an apparatus and method for hydraulically transporting ore or other solid materials from a great depth, particularly the bottom of the sea, to the surface level of the sea.

Apparatus serving this purpose is known by which a mixture of water and ore pieces is pumped upwards by pumps located below the surface level in a riser conduit means which extends from the bottom of the sea to the surface. A disadvantage of the prior art is the heavy wear of the pumps caused by the ore pieces passing therethrough. The greater the length of the riser conduit is, and correspondingly the greater the vertical distance which the ore is raised is, the greater is the wear of the pumps. Standard pumps are not very well suited to the transporting of ore bodies, and therefore have a very short span of life, which is a great disadvantage since repair of the pumps or exchange, is very difficult and time consuming due to the difficult access to pumps immersed in the sea below the surface.

It may be possible to provide a very large container below the surface, which is vented to atmospheric pressure and into which a ore-water mixture flows through a long riser conduit due to the pressure differential between the vented container and the bottom of the sea. However, it is necessary to continuously empty the container by pumps pumping the ore-water mixture to the surface, so that the above explained great wear of the pumps would not be avoided.

SUMMARY OF THE INVENTION

It is one object of the invention to provide a method for raising a mixture of solid materials and water by a riser conduit to the surface of the sea, without transporting the mixture through and by pumps.

Another object of the invention is to provide a method for hydraulically raising a material without the use of pumps transporting and pumping the material, using only pumps for pumping clear water.

Another object of the invention is to provide a method for raising a material by means of pumps which are not subject to wear by the raised material.

With these objects in view, the method according to the present invention uses a flushing pump means and a main suction pump means, which pump only clear water, while the ore-water mixture is raised by a pressure differential produced by the main suction pump. The pumps never have contact with the raised ore pieces, or with water from which the ore pieces have been filtered. Nevertheless, a substantially continuous discharge of the ore-water mixture at the surface level is obtained.

For this purpose, a distributing station including a plurality of containers, preferably between two and four containers, is provided in a riser conduit, and the main suction pump and the flushing pump are cyclically used to produce the required pressure differential for raising the ore-water mixture, and for flushing the containers. One or several main suction pumps, prefer-

ably submersed in the water, and one or several flushing pumps, which may be located above the water surface, or below the same, are preferably provided and connected by suitable connecting conduits with the containers at the distributing station.

One embodiment of the invention uses riser conduit means including a lower conduit portion having a lower end for picking up material from the bottom of the sea and an upper conduit portion having an upper end located at the surface level of the sea; a distributing station between the lower and upper conduit portions, and including a plurality of containers, and main pump means; flushing pump means positioned for pumping clear water, preferably at the surface of the sea; connecting conduit means connecting the inlet of the main pump means, the outlet of the flushing pump means, and the lower and upper conduit portions with the containers; and control means including control valve means located in the connecting conduit means between the containers on the one hand, and said main pump means, said flushing pump means and said conduit portions on the other hand.

The control valve means are cyclically operated for effecting exhaustion of clear flushing water from one of the containers for producing a pressure differential between the lower end of the riser conduit means and the container for raising a mixture of the material, such as ore-pieces, and water, in the lower conduit portion of the riser conduit means. At the same time, the mixture is flushed from another container by the flushing pump into the upper conduit portion of the riser conduit and out of the upper end of the same. As a result, the main pump and the flushing pump means pump no solid material, but only clear water, while the mixture of solid material with water flows substantially continuously outward the upper end of the riser conduit means.

A method according to the invention also comprises the steps of reducing the pressure in a container in the riser conduit means for producing a pressure differential between the container and the lower end of the riser conduit means, so that a mixture of the solid material and water rises into the container from the lower conduit portion of the riser conduit means; and flushing the container with clear water so that the mixture is flushed through the upper conduit portion of the riser conduit to the surface of the sea without flowing through a pump.

Preferably, the reduction of the pressure, the filling of the container with the mixture, and the flushing of the container, are cyclically carried out with a plurality of containers, so that one container is flushed while another container is exhausted to produce the pressure differential or filled with the material due to the pressure differential. In this manner, the flow of the flushed mixture in the upper conduit portion to the surface level is substantially continued.

An air venting conduit may be provided between the container and the air above the sea surface so that the pressure in the container is reduced to atmospheric pressure. However, it is also possible to exhaust clear flushing water from a container to create in the same a low pressure approaching the vapor pressure limit of water.

The arrangement used for the invention, in which no pump has contact with solid material raised from a great depth, permits the use of standard inexpensive pumps, which are not subjected to the wear caused by

ore pieces, sand or abrasive substances floating in the water. The control valves in the connecting conduits are also protected from raised solid material.

As noted above, two, three or four containers may be provided at the distribution station for cyclical filling, flushing and exhausting by the pumps. The main suction pump produces a pressure in the respective container below the water pressure at the respective depth, so that the ore-water mixture flows into the respective container until it is full. During this filling operation, the flushing pump flushed the second container, which is filled with the ore-water mixture, with clear water so that the material in the second container is flushed through the upper portion of the riser conduit to the surface of the sea. Evidently, the flushing pump pumps only clear water, and has no contact with the transported solid material. At the same time, while the first container is filled with the mixture, and the second container is flushed by the flushing pump, the main suction pump exhausts a third container to remove the flushing water therefrom that the pressure in the third container is substantially reduced, and a pressure differential is created so that the mixture flows into the third container when the same is connected by control valves with the lower conduit portion of the riser conduit. In this embodiment of the invention, three containers are used, which not only prevents contact of the raised material with the pumps, but also obtains a substantially continuous flow of the ore-water mixture through the upper portion of the riser conduit means to the surface of the sea, and into a vessel. Accordingly, the flows produced by the main suction pump and by the flushing pump are substantially continuous and if an air vent is provided for each container, the air flow into the containers after exhaustion by the main suction pump, is also substantially continuous.

During the filling of a container by the ore-water mixture, air is pushed out of the respective container, but it is not necessary to vent this air to a point above the surface level, but the air can flow from one container into another.

It is another possible to pump the flushing water, after expelling the ore-water mixture from one container, by a submerged pump, which may be the main suction pump, to another container for expelling the ore-water mixture from the same, and so forth, in a cyclical operation. However, such flushing stream will be soiled after some time by remnants of the expelled ore-water mixture, so that this pump would be subject to heavy wear. It is therefore more advantageous to provide a conduit between the flushing pump at the surface level and the containers since the flushing pump is then easily accessible, never has contact with solid particles, and always operates with clear unsoiled water due to these advantages, the additional resistance caused by the conduit connecting the flushing pump with the containers, can be disregarded.

The containers at the distributing station may be spherical or cylindrical and have a diameter greater than the diameters of the connecting conduits. Such an arrangement has the advantage of a short length of the containers, and a compact shape of the distributing station.

In another embodiment of the invention, the containers are long, parallel, horizontal or vertical conduits constructed and arranged in such a manner that solid particles of the raised material are not permitted to set-

tle at any point of the distributing station, so that the ore particles cannot be deposited in the containers. By suitable hydraulic circuit, the result can be obtained that the stream of the ore-water mixture need not change its direction of the conduits forming the three containers, for example, so that its flow velocity is maintained constant even if the mixture has flown into a container, and the flushing operation begins.

In another embodiment of the invention, each of the parallel, preferably adjacent, container conduit portions of the distributing station are constructed as extensions of the flushing conduit which is connected with the flushing pump. Without additional conduits, the advantage is obtained that the lower portion of the flushing conduit can be used as a further container at the distributing station, so that the cycle includes four operations, combining, increasing of the continuity of the discharged stream of the ore-water mixture.

If the apparatus has four containers at the distributing station, the flushing water first flows downward into a container which, at this time, is filled with clear flushing water to expel this water out of the conduit-like container. Thereupon, during the next cycle, the flushing water flows upward into the second conduitlike container filled with the ore-water mixture, so that this mixture is expelled from the second container into the upper portion of the riser conduit means. This modification improves the flushing effect, because in this manner two parallel conduit-like container portions are successively passed by the flushing water stream, so that a wear of the pump by particles remaining from the ore-water mixture at the mixing zone or at boundary layers, is reduced.

Depending on the number of containers and associated connecting conduits, the control means for obtaining cyclically the required connection, include a corresponding number of control valves in the connecting conduits. The number of control valves can be reduced if several control valves are replaced by multi-channel valves connecting the lower and upper conduit portions with the containers. As explained above, the pressure in one of the containers is reduced by removing clear flushing water from the same by means of the main suction pump. In one embodiment of the invention, each container can be connected with atmospheric air or gas, and the main suction pump is connected to the lower ends of the containers. Consequently, the low pressure required for obtaining a substantial pressure differential, becomes equal to the atmospheric pressure. The embodiment requires three or four steps for each cycle and obtains continuous flow of the ore-water mixture through the lower and upper conduit portions of the riser conduit.

In another embodiment of the invention, the pressure is successively reduced in each of said containers to a low pressure approaching the vapor pressure limit of water by the main suction pump. Such an arrangement eliminates the venting conduits, and simplifies the construction and reliability of operation, inasmuch as that only two containers have to be used which operate in a two-step cycle. A reduction of the number of the steps of the cycle to two alternating steps requires that the main suction pump, which is preferably submerged in water, is not connected with the lower ends of the containers, but with the upper ends. In contrast to the embodiments in which three or more containers are provided, in which the magnitude of the low pressure

produced by the main suction pump is determined by the atmospheric pressure, as explained above, the embodiment with only two containers is characterized in that the low pressure alternately produced by the main suction pump in the two containers, which may be conduit types, is maintained by the main suction pump in accordance with its pressure head, while the lowermost pressure is determined by the formation of vapor or steam bubbles. The main suction pump is then protected from cavitation due to the downward extending suction conduits and the corresponding increase of the water pressure. In addition, to the above mentioned reduction of the number of control valves, the embodiment with two containers has the advantage that instead of expensive closure valves, quickly reacting flap valves of simple construction can be used, which are shifted without application of an outer force by the stream passing through the valves.

All embodiments of the invention, irrespective of the number of containers used in the cyclical operation, require a number of connecting conduits and closure control valves, and reliable operating means for the same. The control valves are successively in contact with clear sea water and with the ore-water mixture. Consequently, the control valves should be wear resistant and adaptable to different flowing liquids. Nevertheless, the danger of damage to the control valves exists, when the switched stream of ore-water mixture flows into control valves which are in the process of opening, or closing, or which are still closed. To avoid damage caused to control valves, the present invention provides a diffuser between the lower portion of the riser conduit means and the control valves at the lower ends of the containers which are operated to open and close the containers.

The diffuser is provided with inlet pipes, outlet pipes, and control conduits and has groups of control nozzles at the surface which is in contact with the ore-water mixture. The control nozzles are located in the region between the inlet pipe and the outlet pipes, the number of outlet pipes being the same as the number of groups of control nozzles, and as the number of conduits connected with the groups of nozzles, respectively, which are provided for the flushing water and can be cyclically controlled. The control diffuser influences the flow of ore-water mixture, by means of cyclically varying control streams of clear flushing water so that the ore-water mixture does not impinge closed, or opening or closing control valves. It must be considered that the exchange of even only one damaged control valve, which is below the surface level of the sea, is very expensive and results in a long interruption of the entire operation. In accordance with the invention, the control valves are only operated when the respective diffuser stream has deflected the ore-water mixture in the desired direction, and into the container provided for the respective step of the cycle, and after the control valves to be operated are long through only by the clear flushing water.

A further advantage of the diffuser resides in that the deflection of the ore-water stream is effected hydraulically, and consequently causes no wear.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages

thereof, will be best understood from the following description of specific embodiment when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side elevation schematically illustrating an embodiment used for the invention;

FIG. 2 is a side elevation illustrating a portion of FIG. 1 on a larger scale;

FIG. 3 is a side elevation illustrating a modification of the embodiment of FIG. 2;

FIG. 4 is a schematic side elevation illustrating a modification of the embodiment of FIG. 3 in which three conduit-like containers are provided;

FIG. 5 is a schematic side elevation illustrating an embodiment in which four conduit-like containers are provided;

FIG. 6 is a schematic perspective view illustrating a portion of the embodiment of FIG. 5 provided with a diffuser;

FIG. 7 is a fragmentary cross-section taken on line VII—VII in FIG. 6; and illustrating the diffuser;

FIG. 8 is a side elevation illustrating an embodiment with two containers, provided with a diffuser and flap valves;

FIG. 9 is an elevation of the embodiment of FIG. 8 as viewed in the direction of the arrow A;

FIG. 10 is a cross-sectional view taken on line X—X in FIG. 9;

FIG. 11 is an elevation of the embodiment of FIG. 8 as viewed in the direction of the arrow B in FIG. 8; and

FIG. 12 is a cross-sectional view taken on line XII—XII in FIG. 11.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, which generally illustrates an arrangement according to the invention for the conveying and raising ores and other solid materials from the bottom of the sea to the surface, a riser conduit 1,2 is provided which has a lower conduit portion 2, having a lower end provided with a pick-up means 3 which is located at the bottom of the sea, and an upper conduit portion 1 which has an upper discharge end located above the surface of the sea for discharging material and ore into a vessel 12b. Between the lower conduit portion 2 and the upper conduit portion 1 a distributing station 4 is provided which includes a plurality of containers 8, three containers being shown in FIG. 1, which are connected to each other and to the riser conduit means 1,2 by connecting conduits and control valves, generally indicated at 9. At least one flushing pump with a flushing conduit 6 is connected to the lower ends of the containers 8, while the upper ends of the containers 8 are connected by venting conduit 7 with the air above the surface. The flushing pump 5 may be mounted on a vessel 12a. The distributing station 4 includes a main suction pump 10 also connected to the lower ends of containers 8 by a suction conduit 11.

FIG. 2 illustrates particularly the distributing station 4 and the conduits connected therewith in greater detail. The embodiment has three containers 13 which are cyclically used for carrying out the three steps of a cyclical operation. The upper ends of the spherical containers and also the lower ends of the spherical con-

tainers are connected by connecting conduits 14 to each other, and to the upper conduit portion 1 and to the lower conduit portion 2, respectively. Control valves 17 are located in each of the connecting conduits and also in conduit portions 1 and 2. The upper connecting conduits 14 branch off a point 16 of the upper conduit portion 1, and the lower connecting conduits 14 branch off a point 15 of the lower conduit portion 2. The flushing conduit 6 is connected by three connecting conduit portions 6a with the three containers 13, and the suction conduit 11 is connected by three connecting conduits 11a with the three containers 13. The connecting conduits 11a and 6a are provided with control valves 17, which can be cyclically operated together with the other control valves 17 in conduits 14.

The raising and conveying of a mixture of ore and water from the bottom of the sea through riser conduit means 1, 2 and containers 8 is effected in a cyclical operation including three steps. At any time one of the containers 13 is emptied by the main suction pump 10 from clear flushing water filling the same, as will be explained hereinafter so that the pressure in this container is reduced to atmospheric pressure due to the venting of the first container through the venting conduit 7 and the respective connecting conduit 7a. The reduction of the pressure in the respective container 13 permits a mixture of water and ore to flow upward in the lower conduit portion 2 due to the fact that the very high pressure prevails at the bottom. Consequently, the ore-water mixture fills container 13, expelling the air from the same through connecting conduit 7a and venting conduit 7. The ore-water mixture fills the lower conduit portion 2 due to the pressure differential when the control valve 17 in the respective connecting conduit 14 is opened so that the mixture flows directly into the respective container.

During the filling of one container 13 by the ore-water mixture, a second identical container 13 which has just been filled in the preceding step by the ore-water mixture, is flushed by a stream of clear water taken by flushing pump 5 at the surface level so that the clear flushing water, filling the second container 13, expels the ore-water mixture through the respective connecting conduit 14 and the upper conduit portion 1 into the vessel 12b, leaving the second container 13 filled with clear flushing water.

At the same time, main suction pump 10 exhausts flushing water which has remained in container 13, so that the third container 13 is filled with air from the venting conduit 7 and the respective connecting conduit 7a.

Consequently, the first step, filling of the container with the ore-water mixture, can now be carried out with the third container, as described for the first container so that the three above-described operations are cyclically repeated and the ore-water mixture continuously passes through the upper conduit portion 1 since at any time one of the three containers 13 is filled with the ore-water mixture which is expelled by flushing water from pump 5.

FIG. 3 illustrates a modification of the embodiment of FIG. 2 in which the three control valves in the upper connecting conduit 14 are replaced by a multi-channel, preferably rotary valve 19, and the three control valves 17 in the lower connecting conduit 14 are replaced by similar multi-channel rotary valve 18. The lower multi-

channel valve 18 is connected with conduit portion 2, connecting conduits 14, flushing conduit 6, and suction conduit 11, while the upper multi-channel valve 19 is connected with the upper conduit portion 1, with connecting conduits 14, and with the venting conduit 7. The cyclical operation is the same as described with reference to FIG. 2.

The embodiment illustrated in FIG. 4, has instead of spherical or cylindrical containers, three long parallel vertical pipe portions or conduit portions 20, which serve the purpose of the containers described with reference to FIGS. 2 and 3. Multiple channel control valves 18 and 19 are provided at the ends of the conduit portions 20 for connecting the conduit portions cyclically with suction conduit 11, flushing conduit 6, and the upper and lower portions of riser conduit means 1, 2. Due to the constant diameter of the container conduit portions 20, no material can settle in the same, and be carried with the flushing water to the main pump 10.

The embodiment of FIG. 5 uses four long parallel, vertical pipes 20a, 20b, 20c, 20d as containers in a four step cycle. The flushing conduit 6, which extends downward from the flushing pump 5 at the surface level to the distributing station, participates in the cycle and is connected by individual control valves 41, 42, 43, 44 with the pipes 20a, 20b, 20c, 20d. The upper ends of pipes 20a to 20d have upper ends connected by control valves 21 to 24 with the upper conduit portion 1, and by control valves 51 to 54 with venting conduit 7. All control valves are operated in a predetermined sequence by an automatic operation of means which are not illustrated in the drawing. The control valves may be remote controlled. The lower ends of the pipe containers 20a to 20d are connected by individual control valves 31 to 34, which can be opened and closed, with the lower conduit portion 2 and are connected in this region by conduit 60 which is connected by control valves 61 to 64 with the pipe containers 20a to 20d, respectively. The suction pipe 11 of the main suction pump 10 is connected by control valves 71 to 74 to the four pipe containers 20a to 20d. The raising of the ore-water mixture from the bottom to the surface of the sea is carried out in four step cycles. While the pipe container 20a is under atmospheric pressure, after opening of control valve 31 while control valves 21, 41, 61, 71 are closed, while control valve 51 is opened, pipe container 20a is filled with the ore-water mixture due to the pressure differential between the upper and lower ends of the lower conduit portion 2 of the riser conduit means 1, 2.

At the same time, the pipe container 20b filled with the ore-water mixture during the preceding step of the cycle is flushed from below through connecting conduit 60, and the opened control valve 63 and 62 by flushing water from pipe container 20c so that the ore-water mixture is expelled from pipe container 20b through the upper conduit portion 1, and discharged at the surface. In the same period of time, the flushing pump 5 pumps flushing water through flushing conduit 6 and the opened control valve 43 into the pipe container 20c so that it can flow through control valves 62 and 63 in the pipe container 20b as explained above.

At the same time, the pipe container 20d, which was just filled during the preceding step with flushing water, is exhausted by main suction pump 10 and suction conduit 11 through the open control valve 74, while the

pipe container 20d is connected by venting conduit 7 and the opened control valve 54 with the atmosphere, the other control valves 24, 34, 44, and 64 being closed. By the cyclical operation of all containers by means of opening the respective control valves in a pre-

FIG. 6 illustrates a modification of the embodiment of FIG. 5, which also operates with a four-step cycle. Only the lower portion of the apparatus is illustrated. In this embodiment, a diffuser 80 is provided for protecting the control valves corresponding to control valves 31 to 34 of the embodiment of FIG. 5 which close the lower ends of the four pipe containers 20a to 20d.

In the embodiment of FIG. 6, the connection between the upper end 81 of the lower portion 2 of the riser conduit means and the branch conduits leading to the four containers, is constructed as a diffuser 80. Between the inlet connecting conduit 82, and the four outlet connecting conduits 83a to 83d, control nozzles 87 are arranged in four groups 88a to 88d of control nozzles 87. The nozzle groups 88a to 88d are connected to the annular flushing water conduit 60 by connecting conduits 84a to 84d which have control valves 85a to 85d. Vertical connector pipes 60a to 60d connect the annular flushing water conduit 60 by means of control valves 61, 63, 62 and 64 with the pipe containers 20a to 20d. The main suction pump 10 is connected by an annular portion of suction conduit 11 and control valves 71 to 74 with the pipe containers 20a to 20d.

The raising of the ore-water mixture in a four step cycle is carried out as described with reference to FIG. 5. The diffuser 80 causes a hydraulic deflection of the stream of the ore-water mixture out of the lower conduit portion 2 in a direction toward the pipe container which is to be filled in accordance with the cycle, for example, pipe container 20b. This is accomplished by a control stream of clear flushing water flowing from the respective connecting conduit 84d through the respective nozzle group 88d. A stream of the ore-water mixture is deflected, and separates from the inner surface of the diffuser which curves already toward the outlet connecting conduit 83d, at the side where the nozzles of nozzle group 88d are provided in the inner wall of the diffuser. The deflected flow of the ore-water mixture follows the curved surface of the opposite inner wall which curves toward the outlet pipe connector 88b so that the ore-water mixture flows along the nozzles of the groups of nozzles 88b into the pipe container 20b.

Flushing water entering from connecting conduit 84d through the nozzle group 88d, also enters the three other outlet pipe connectors 83a, 83c, 83d, which at this moment of the cycle do not contain the ore-water mixture, up to the closed control valves 31, 33, 34, so that the same are protected from damage by the arriving stream of the ore-water mixture when opened at the beginning of the respective step of the cycle. In this manner, the surfaces of the control valves 31, 33, 34 which are directed toward the diffuser, are in contact

only with clear flushing water, and are not subjected to the damaging influence of the ore-water stream.

Control valve 32 provided at the lower end of the pipe container 20b is also operated only when in contact with clear flushing water, or when flushing water flows therethrough, and is, for example, only closed when the ore-water mixture has been deflected, pipe container 20b has been filled, and only flushing water flows through control valve 32, while the ore-water mixture is already guided into the pipe container next in the cycle. The above-described operations are repeated in a cyclical sequence for successively filling the four pipe containers, and for raising the ore-water mixture in the upper conduit portion 1.

In order to fill pipe container 20a, for example, with the ore-water mixture, a control stream consisting of clear flushing water flows first from conduit 60 through the connecting conduit 84c to the nozzle group 88c, which is not shown in FIG. 6. During the next following step of the cycle, the control stream for the deflection of the ore-water mixture flows to the nozzle group 88b in order to deflect the ore-water mixture into pipe container 20d or to the nozzle group 88a for deflecting the mixture into pipe container 20c.

Operating means, not shown, open and close the respective control valves to obtain the above-explained sequence of filling and flushing operations.

FIG. 7 schematically illustrates a cross-section of the diffuser 80 which is symmetrical to a central axis and has four groups of nozzles 88a to 88d, associated with the outlet pipe connector 83a to 83d with connecting conduits 84a to 84d and control valves 85a to 85d in the same.

FIGS. 8 to 12 illustrate an embodiment of the invention which basically functions as the other embodiments, but operates in a two step cycle. Two long, parallel, vertical pipe containers 100a and 100b are provided. Preferably, a diffuser 80 is provided between the upper end 81 of the lower conduit portion 2, and the control valve 101a, 101b which closes the lower ends of the pipe containers 100a and 100b. FIGS. 8 and 9 also show the position of the flushing pipe 6 with flushing pump 5, and of suction conduit 111 which leads downward to the main suction pump 10. The diffuser 80 is provided between the inlet pipe connector 82 and the two outlet pipe connectors 103a, 103b. The groups 108a and 108b of control nozzles 107 are provided. Nozzle groups 108a,b are connected by connecting conduits 105a, 105b which do not contain control valves, to the two branches of the flushing conduit 6, as best seen in FIGS. 11 and 9. The two containers 100a, 100b merge into each other at the upper conduit portion 1 of the riser conduit, and can be closed by a by a shiftable flap valve 102. The suction conduit 111 of main pump 10 is connected, near the upper ends of containers 100a, 100b, but below the valve 102, by a branch conduit with each of the two containers 100a, 100b and extends parallel to the same downward to the main suction pump 10, which may be located in the water. The lower end of flushing conduit 6 is provided with a flap valve 110, and the upper end of suction conduit 111 is provided with another flap valve 110'. Valves 110 and 110' are provided with drive means 110a, 110b, respectively.

The transport of the ore-water mixture to the surface is carried out in accordance with the principle described with reference to the three-step and four-step

cycles, the difference being that the ore-water mixture is deflected in diffuser **80** alternately into one of two opposite outlet pipe connectors **103a**, and **103b**.

If an ore-water mixture is to enter container **100b**, a flushing stream of clear flushing water, branch off the flushing conduit **6** by means of the connector conduit **105b**, flows through the nozzle group **108b**. In this manner, a hydraulic deflection of the stream in the outlet pipe connector **103b** is obtained, since the ore-water mixture separates from the surface on the sides of the nozzle group **108b**, and follows the opposite inner wall of the diffuser.

In this manner, the ore-water mixture enters container **100b** since the main suction pump **10** sucks through suction conduit **111**, which is connected to the upper ends of the container, the flushing water still filling container **100b**, so that the low pressure required for raising the ore-water mixture in the lower conduit **2** is obtained. Since no venting is provided, the pressure may be reduced to the vapor pressure limit of water, if desired. During this operation, flushing water flows from below into the other container **100a**, which was filled in the preceding cyclical step with the ore-water mixture. This flushing water is pump by flushing pump **5** downward in the flushing conduit **6** so that the contents of the container are pressed into the upper conduit portion **1** and discharged at the surface level. The flap valves **101a**, **101b** and **102** serve as check valves, and are opened and closed in accordance with the cycle by streams of flushing water which are free of particles of the ore, while the control flap valves **110** and **110a** in flushing conduit **6** and suction conduit **111** are shifted, as required by the cycle, by operating means acting on the drive means **110a** and **110b** so that they are in contact only with clear water free of ore particles.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of apparatus and method for hydraulically raising solid material to a higher level, differing from the types described above.

While the invention has been illustrated and described as embodied in an apparatus and method for raising ore from the bottom of the sea to the surface without contact of the ore-water mixture with a pump, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge readily adapt it for various applications without omitting features, that from the standpoint of prior art, fairly constitute essential

characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

We claim:

1. A method of hydraulically raising material, such as ore, from the bottom of the sea through a riser conduit having upper and lower conduit portions, comprising the steps of providing a distributing station between said lower and upper riser conduit portions including a plurality of vertical conduit-shaped containers; providing a main pump means and a flushing pump means, providing connecting conduit means including a plurality of lower connecting conduits connecting the upper ends of said lower riser conduit portions with the lower ends of said conduit-shaped containers; providing connecting means between the inlet of said main pump means and said conduit-shaped containers; providing connecting means between the outlet of said flushing pump means and said conduit-shaped containers; providing valves in each of said connecting means; reducing the pressure in at least one of said containers via said main pump means while venting said container to the atmosphere for producing a pressure differential between said one container and the respective lower conduit portion of said riser conduit; opening the valve provided in the connecting means between the respective upper end of said riser conduit portion and the lower end of said one container while closing the valve in the connecting means between said main pump means and said one container so that a mixture of said material and water rises into said container through the respective lower conduit portion of said riser conduit without entering said main pump; controlling communication between said containers by producing a pressure differential in one of said containers while effecting flushing of said mixture with clear water from another of said containers by said flushing pump means so that said mixture is flushed through said upper conduit portion of said riser conduit to the sea surface without flowing through either of said pump means, said steps being carried out cyclically with the respective containers, so that the flow of the flushed material in said upper conduit portion to the sea surface level is substantially continuous.

2. A method of hydraulically raising material as defined in claim **1**, wherein the step of reducing comprises reducing the pressure to atmospheric pressure.

3. A method of hydraulically raising material as defined in claim **1**, wherein the step of reducing comprises reducing the pressure to a level approaching the vapor pressure limit of the water.

* * * * *