

June 4, 1935.

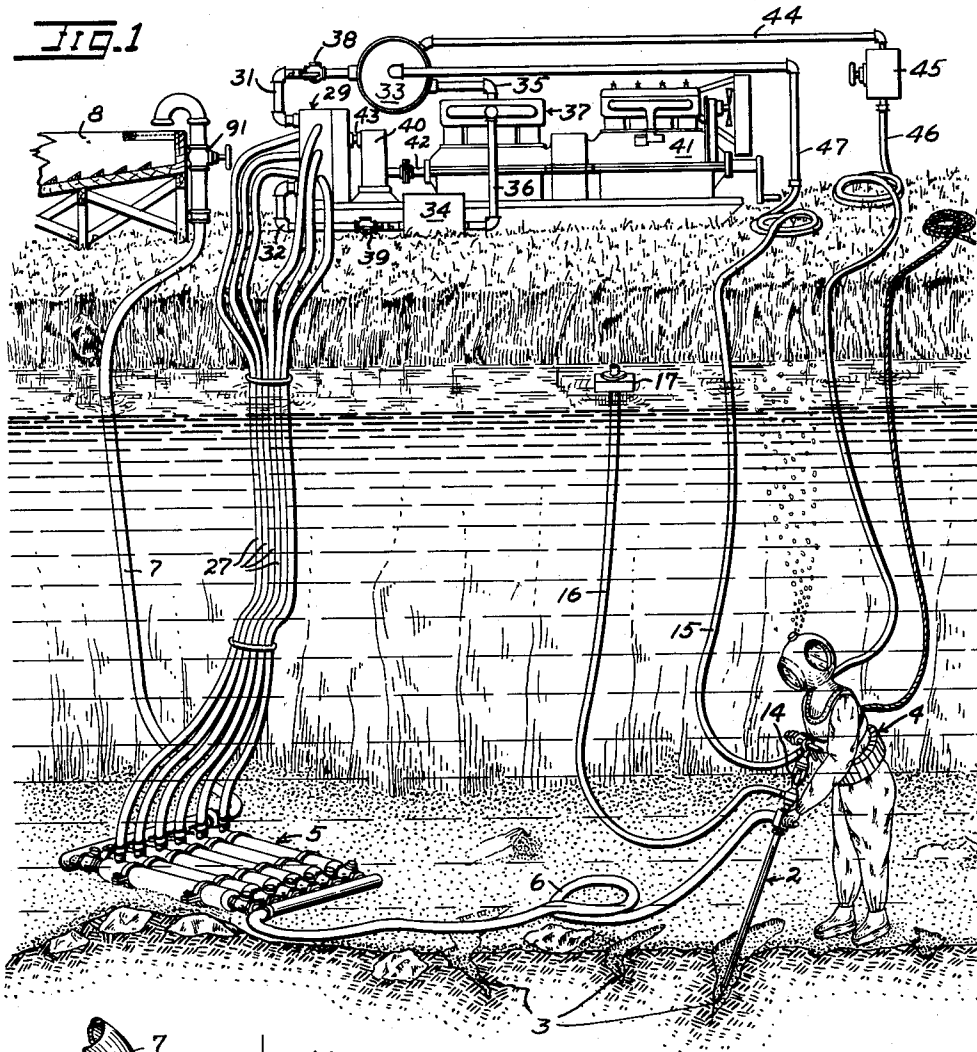
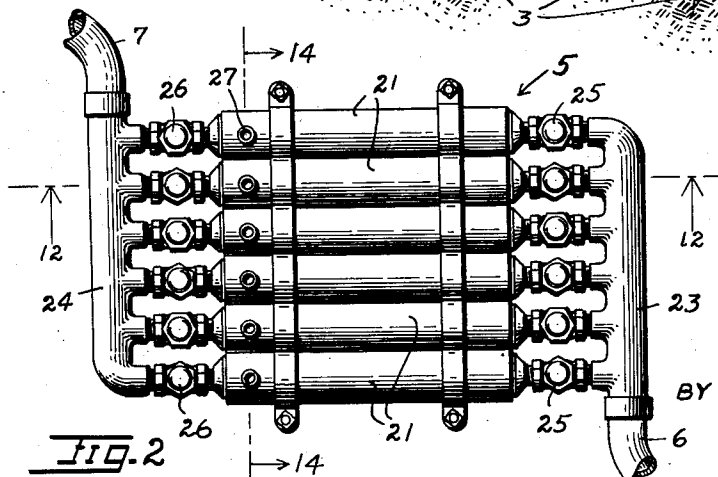
G. A. YEDD

2,003,779

MINING SYSTEM AND APPARATUS

Filed March 7, 1933

3 Sheets-Sheet 1



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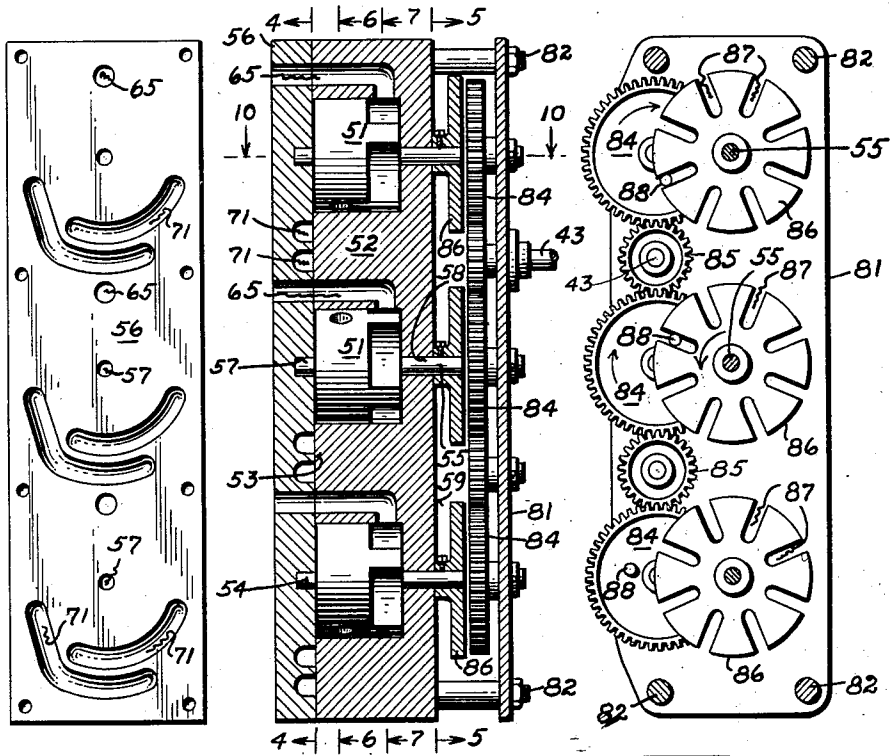
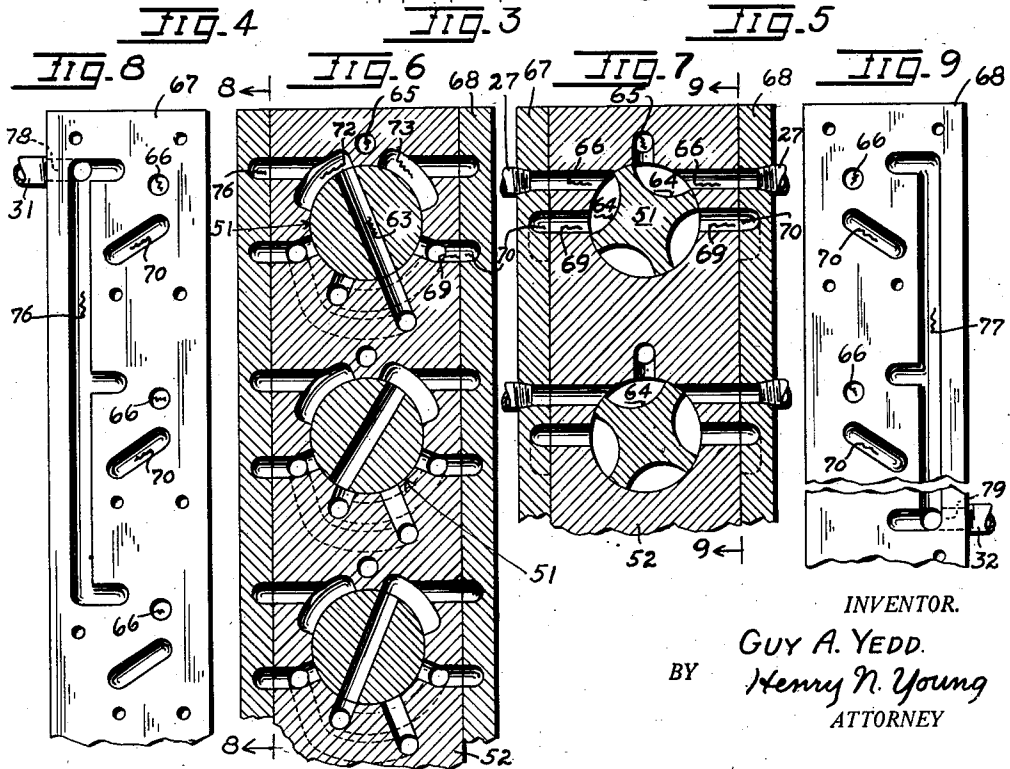
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MINING SYSTEM AND APPARATUS

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3 Sheets-Sheet 2



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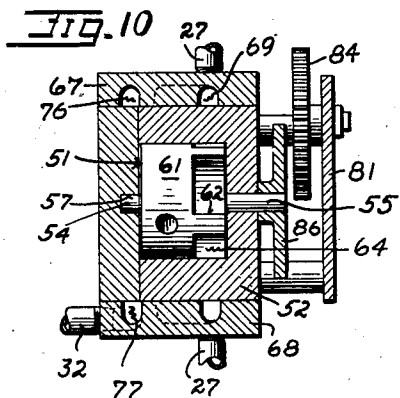
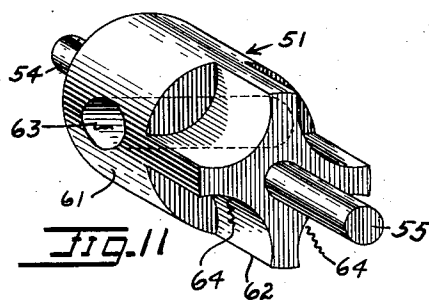
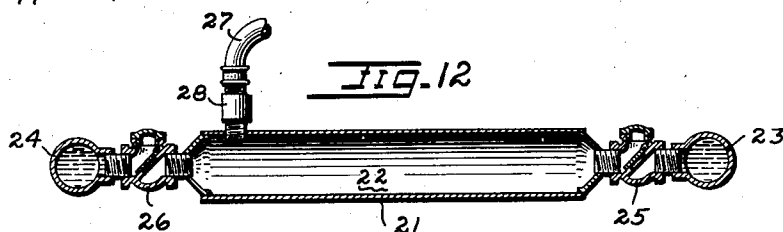
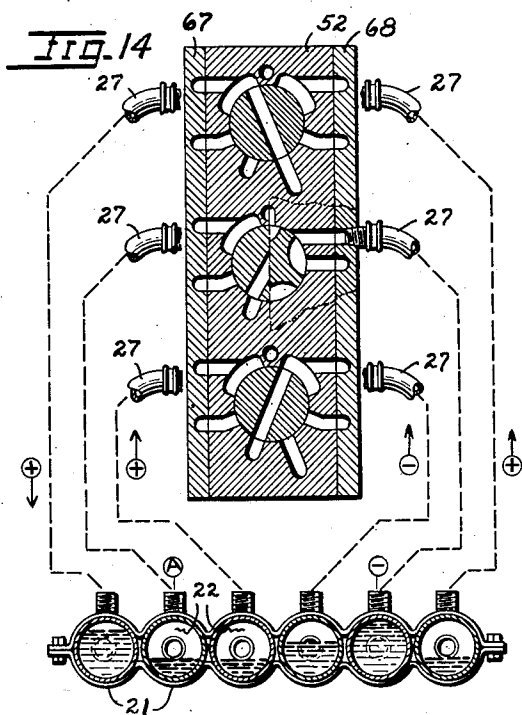
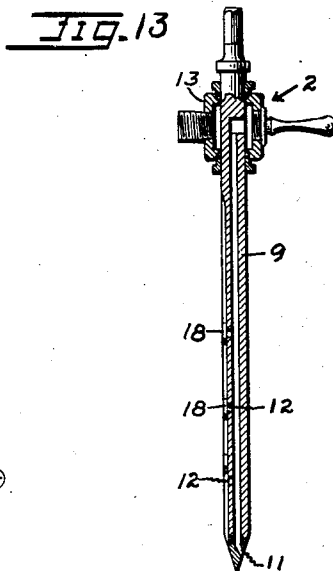
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MINING SYSTEM AND APPARATUS

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3 Sheets-Sheet 3



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2,003,779

MINING SYSTEM AND APPARATUS

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Application March 7, 1933, Serial No. 659,934

8 Claims. (Cl. 262—2)

The invention relates to a device for underwater mining.

A general object of the invention is to provide a generally improved application of the dredging principle to the mining of submerged deposits of precious metals.

A more specific object is to provide for the direct and most efficient application of a suction nozzle by a submerged diver for removing river-bed and other deposits.

Another object is to provide for the application of a maximum degree of suction at the nozzle through the use of a dredger pump means for which the suction intake head is negligible.

A further object is to provide an improved pumping device which is particularly adapted for use in the indicated manner, said pumping device pneumatically actuated and lacking pistons or similar moving parts.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth or be apparent in the following description of a typical embodiment thereof, and in the accompanying drawings in which,

Figure 1 is an assembly view showing the apparatus in use for mining.

Figure 2 is a plan view of a unit of the pumping means of the apparatus.

Figure 3 is a vertical section through a valve unit of the pumping means.

Figure 4 is taken at 4—4 in Figure 3 and comprises a face view of a member which is shown in section in the latter figure.

Figure 5 is a view at 5—5 in Figure 3 and discloses valve actuating mechanism of the valve unit.

Figures 6 and 7 are fragmentary sections at 6—6 and 7—7 respectively in Figure 3.

Figures 8 and 9 comprise views taken at 8—8 and 9—9 in Figures 6 and 7 respectively, and present face views of elements which are shown in section in the latter figures.

Figure 10 is a plan section at 10—10 in Figure 3.

Figure 11 is an enlarged perspective view of a rotary valve of the valve unit.

Figure 12 is a section at 12—12 in Figure 2.

Figure 13 is a longitudinal section through a suction nozzle of the apparatus.

Figure 14 is a somewhat diagrammatic assembly view of the pump units taken in part at 6—6 and 7—7 in Figure 3, and in part at 14—14 in Figure 2.

The mining system for which the present apparatus is particularly designed essentially comprises the direct application of a suction nozzle 2 to underwater deposits 3 by a diver 4 who manipulates the nozzle to the best advantage for removing the deposits therethrough. In order to provide a maximum working suction at the nozzle inlet for removing solid particles from a deposit 3 and in a water-borne condition, a pumping means has been devised in which a working chamber unit 5 is disposed as closely as possible to the level of working of the nozzle, said unit receiving the water-borne material by suction and discharging the received material at a higher level by pressure. As particularly illustrated in Figure 1, the nozzle 2, is arranged to deliver the removed material to the unit 5 through a flexible hose 6, and the unit 5 discharges the received material through a flexible hose 7 into a sluice-box 8 or other suitable receptacle. Normally, and as illustrated, the pump unit 5 would rest directly on the stream bed, though it might be suspended from a barge or the like, if such were more expedient.

The nozzle 2 is disclosed and described in greater detail in my copending application, Ser. No. 659,935, for United States Letters Patent on a Suction nozzle, and essentially comprises a tubular shaft 9 provided with end and side inlet ports 11 and 12 respectively and adapted to discharge radially into a collector head 13 adjacent its upper end, said head connected to the hose 6. The upper shaft end is engaged in the chuck of a pneumatic hammer 14 which is arranged to receive compressed actuating air therefor through a hose 15 for an optional operation of the hammer, and to exhaust the expanded air therefrom through a hose 16 terminating at a float 17. The lower, and working, portion of the shaft 9 is arranged for application as a reamer or exploring drill means as may be desired by the diver 4 manipulating the nozzle assembly. Closure elements 18 are provided for the side intake ports 12 of the shaft 9 whereby said ports may be open or closed as required.

By reference to Figures 1, 2, 12 and 14 it will be seen that the disclosed embodiment of the pump unit 5 comprises a plurality of like tubular elements 21 secured together in mutually parallel and coplanar relation and providing working chambers 22 having corresponding ends thereof connected with manifolds 23 and 24 which are in turn respectively connected with

the intake and discharge ducts provided by the hoses 6 and 7. One-way intake and discharge valves 25 and 26 are respectively interposed in the connections between the manifolds 23 and 24 and each chamber 22. In the present instance, the unit 5 is arranged to be disposed with its plane substantially horizontal while in use, and the valves 25 and 26 are of a gravity-controlled flap type; it is to be understood, however, that the specific type of one-way valve used is generally immaterial to the present invention.

It will now be noted that the creation of a sub-atmospheric pressure in an empty working chamber 22 is arranged to effect a delivery of liquid thereinto from the manifold 23, and that the creation of a super-atmospheric pressure in a liquid-filled chamber 22 is arranged to effect a discharge of the liquid from the chamber into the manifold 24. Means are accordingly provided for alternately producing sub-atmospheric and super-atmospheric pressure conditions in each chamber for alternately filling and emptying the same of water-borne material, or water alone, which has been delivered by the nozzle 2 to the intake manifold 23. By providing a sufficient number of the working chambers 22, and producing the aforesaid conditions therein in rotation, the liquid movement to and from the manifolds 23 and 24 may be held at a constant flow rate whereby the nozzle intake and pump discharge may be continuous; the present unit 5 is arranged for operation in this manner, as will hereinafter be brought out in greater detail.

For producing the aforesaid alternation of pressure conditions in the chambers 22, each chamber is connected at an upper point thereof with an air hose 27 through a valve 28 mounted on the element 21 which provides the chamber. The valves 28 are preferably of a liquid check type which constantly permits a gas flow therethrough, while permitting only a downward flow of a liquid therethrough; in this manner a suction condition in a hose 27 and the associated chamber 22 for filling the latter with liquid is prevented from drawing liquid into the hose after the chamber is filled. While the valves 28 are not shown in structural detail, it is noted that the same may be of a ball check type wherein the ball will be floated by rising liquid to a passage-closing position and a free passage for air and liquid is provided around the ball when the same is below such position. For producing the desired alternation of pressure conditions in the chambers 22, means are provided for alternately connecting each hose 27 with pressure and suction pipes 31 and 32, said means comprising a valve unit 29 which effects the required connections in properly timed sequence.

As particularly shown in Figure 1, the pipes 31 and 32 are respectively connected with pressure and vacuum tanks 33 and 34 in which super-atmospheric and sub-atmospheric pressure conditions are maintained through connection of the tanks with the discharge and intake pipes 35 and 36 of a compressor 37. Preferably, the pressure conditions in the tanks 33 and 34 must be kept substantially constant, and automatic and adjustable relief valves 38 and 39 are accordingly provided in the pipes 31 and 32. In the present instance, the compressor 37 is shown as driven by an internal combustion engine 41 with the shaft of which one end of

its shaft 42 is directly connected. The other end of the compressor shaft 42 is connected through suitable change-speed means 40 with a shaft 43 by which the valve mechanism of the valve unit 29 is actuated. The tank 33 is also arranged to supply the diver 4 and hammer 14 with air, the necessary connections to the diver being made through a pipe 44 and a pressure regulator means 45 and a hose 46, while the hammer connections comprise a pipe 47 connected to the hose 15.

It will now be noted that the pressure in the tank 33 is preferably at least one hundred fifty pounds per square inch (about ten atmospheres), while that in the vacuum tank 34 would probably be no less than five pounds per square inch (about one third of an atmosphere). Under these conditions, to connect a just-emptied chamber 22 which contains compressed air at the super-atmospheric pressure of the tank 33 with the tank 34 would seriously raise the pressure in the latter tank and so decrease, or at least delay, the full suction action for refilling the chamber from the intake manifold 23 of the submerged pump unit. It is accordingly desirable to relieve the chamber pressure to atmosphere before connecting the chamber with the vacuum tank 34, and this as arranged to be effected in and by the valve unit 29. A similar condition obtains when the filled chamber is connected with the pressure tank 33, but the effect is very much less, both because only the hose and valve passages need be filled with expanding air and because any temporary lowering of pressure in the tank would constitute but a very small percentage of the tank pressure. While it will thus be evident that such is not absolutely essential, the present valve unit also provides for connecting the chamber with the atmosphere following the filling of the chamber with liquid by reason of its connection with the vacuum tank 34, and before a connection is made with the pressure tank 33.

In view of the foregoing, it will be understood that the valve unit 29 is arranged to repetitively provide a four-phase operating cycle for each chamber 22; that the successive phases of said cycle may be briefly described in terms of chamber pressures as sub-atmosphere—atmosphere—super-atmosphere—atmosphere; and that the alternating intake and discharge operations for the chamber take place while the sub-atmospheric and super-atmospheric pressures respectively obtain therein. It will be noted that the hydraulic head determined by the depth of submergence of the chamber will aid in forcing the liquid into the chamber through the nozzle 2 and so increase the intake velocity at the suction nozzle during intake to a chamber, the effect increasing with the depth of submergence of the chamber.

If relief to atmosphere should be omitted following intake and before discharge for a given working chamber 22, the resulting three-phase pressure cycle would be sub-atmosphere—super-atmosphere—atmosphere; since such a three-phase cycle would produce the desired pumping effect, the same is understood as coming within the scope of the present invention. It will further be noted that the present three-phase cycle may also be described as comprising intake—discharge—pressure relief, while the previously described four-phase cycle may be described as comprising intake—suction relief—discharge—pressure relief.

It will now be noted that in order to maintain a continuous inflow of water-borne material at the nozzle 2 while each working chamber 22 is going through the described four-phase cycle, there must preferably be at least six such chambers in the unit 5 whereby to provide an overlap of operative phases as between the chambers and so insure the desired continuity of action. In the present instance six chambers 22 are provided, and the valve unit 29 controls the pressure conditions in said chambers through appropriately timed and progressive settings of three rotary and like valves 51, each valve 51 controlling the pressure conditions in two said chambers through air lines 27.

In the present unit 29, the valves 51 are mounted in cylindric bores provided in a valve block 52, said bores extending from an outer face 53 of said block. At one end thereof, each valve 51 is provided with an axial trunnion 54, while a stem or shaft 55 extends axially from the other valve end. A plate member 56 is mounted against the outer block face 53 and provides bearing sockets 57 receiving the trunnions 54. Bearing bores 58 extend from the cylinder bores through the block for receiving the valve stems 55 to extend beyond the inner block face 59.

Each valve 51, it will now be noted, comprises body portions 61 and 62 having circular and generally cross-shaped cross-sections respectively, the portion 61 being nearest the trunnion 54. A port or duct 63 extends diametrically through the valve portion 61, while the portion 62 provides four like external depressions 64 symmetrically arranged about the valve axis and arranged to provide passages circumferentially along the valve face. Intermittent forty-five degree rotations of each valve 51 between successive operative settings thereof are arranged to be effected whereby eight valve settings are made for each complete revolution of a valve, and each valve so controls the pressure conditions in two air lines 27 as to provide the previously described four-phase operative cycle for the chambers connected therewith.

As is particularly shown in Figures 2 to 7 inclusive, ducts 65 are provided through the block 52 and in the plane of the valve depressions 64 for connecting the top points of the valve-receiving bores with the atmosphere; in the present structure, said bores have inner portions thereof radial to the valves and other portions thereof extending axially of the valves through the plate 56 to the air. Ducts 66 extend from points of the valve bores opposite the plane of the valve depressions 64 and at opposite sides of the ports of the ducts 65 for connection with air lines 27. As illustrated, the inner ends of the ducts 66 are spaced forty-five degrees from the ports of the ducts 65, and the ducts 66 extend horizontally and oppositely through the block 52 and through plate members 67 and 68 fixed at opposite sides of the block 52 to connections with the air lines 27.

Ducts 69 extend from points of the valve bores in the plane of the depressions 64 and are spaced forty-five degrees circumferentially from the ducts 66 and ninety degrees from the valve ports of the ducts 65; as is brought out in Figures 6 to 9, the ducts 69 extend laterally through the block 52 to the plates 67 and 68, through diagonal grooves 70 provided at the inner faces of the said plates, and again through the block to the valve-receiving bores at points thereof in

the plane of the valve ducts 63. The ducts 69, it is noted, are each utilized for alternately connecting the different air lines 27 with the pressure and suction pipes 31 and 32.

By particular reference to Figure 6, it will be noted that the ducts 69 are branched whereby they each terminate at two ports at the valve-receiving bore, said ports of each duct ninety degrees apart and the ports of the different ducts mutually staggered whereby the four ports extend in an arc of one hundred thirty-five degrees. As shown, branch portions of the ducts comprise arcuate grooves 71 provided in the inner face of the plate 56. Arcuate ports 72 and 73 are provided in the valve-receiving bore in the plane of the ports 69 and of the valve duct 63. The ports 72 and 73 each extend through an arc slightly exceeding forty-five degrees and lie diametrically opposite the end pairs of the ports for the ducts 69; in this manner, each of the ports 72 and 73 may be connected with each of the ducts 69 as the valve is rotated to its successive operative positions.

Ducts extend laterally through the block 52 from the ports 72 and 73 to manifold grooves 76 and 77 provided in the plates 67 and 68 respectively, and ducts 78 and 79 extend from said manifold grooves to outer points of the plates for connection with the pressure and suction pipes 31 and 32 respectively, said pipes shown as threadedly engaging in the bore ends. It will be noted that the grooves 71 of the plate 56 are disposed opposite flat portions of the block face 53, and that the grooves 70 and 76 and 77 of the plates 67 and 68 are disposed in opposition to flat edge faces of the block 52 and plate 56; in this manner, laterally closed duct portions are defined along the different faces in a particularly simple manner. While such are not shown, it will be understood that suitable gaskets may be placed between the mutually opposed surfaces of the block and the various plates for sealing the jointures provided. It will be further noted that the plates 67 and 68 are mutually complementary in the arrangement of their grooves and perforations by reason of their application at opposite sides of the block 52.

Referring now to the disclosed setting of the upper valve 51 of the valve unit 29, it will be noted that one air line 27 thereat is connected to the atmosphere through a duct 66, a valve passage 64 and the duct 65, while the other air line is connected with the pressure pipe 31 through a duct 66, a valve passage 64, a duct 69, the valve duct 63, the port 72, the pressure manifold 76, and the duct 78. If now the valve be turned one-eighth of a revolution in the indicated direction, the first air line 27 will be connected to the duct 69 and so to the suction manifold 77 through the valve duct 63 and the port 73, while the second air line 27 is connected with the atmosphere through the valve passage 64 for relief of the chamber pressure following the discharge of liquid from the chamber; it is noted that the present valve setting is that shown for the middle valve of the valve unit. The next one-eighth turn of the valve 51 will again connect the first air line 27 with the atmosphere through the duct 65 whereby to relieve the vacuum following a filling of the chamber 22, the second air line being simultaneously connected with the suction pipe through the valve duct 63. A following one-eighth turn of the valve will connect the first air line with

the pressure pipe 31 through the valve duct 63, while the other air line is relieved to atmosphere through a valve passage 64. The succeeding, and fourth, one-eighth valve turn restores the original conditions.

From the foregoing, it will now be understood that while the chamber associated with the first air line of the upper valve 51 is successively subjected to the operating cycle of pressure relief—suction—suction relief—pressure, the chamber of the second air line is simultaneously subjected to the operating cycle of pressure—pressure relief—suction—suction relief, in order. It is noted that the cycle thus provided is that which is previously described as being required for carrying out the purposes of the pumping means of the invention. Since each valve 51 has an identical control action with respect to the pressure conditions in the working chambers which it controls, it will be understood that only a proper relative timing of the valves is required for producing uniform pressure conditions in the pump manifolds 23 and 24.

By reference to the showing of Figures 3 and 5, it will be noted that a plate 81 is mounted on and forwardly of the valve block 52 by means of spacer bolts 82, and carries a gear train between the plate and block. The gear train comprises three gears 84 alternating and meshing with two gears 85, the gears 84 being of like size whereby they are arranged to rotate together at like rates and in the same rotative direction. The outer end of the valve drive shaft 43 is journaled in the plate 81 and carries one of the aforesaid gears fixed thereto; as particularly shown, a gear 85 is mounted on the shaft 43, it being noted that the gears 85 comprise idlers in the gear train. Radially slotted discs 86 are mounted on the protruding ends of the valve stems 55 in partial opposition to the gears 85, and each disc 86 is provided with eight radial slots 87 for receiving a pin 88 extending axially from the opposed gear 85 and into its plane whereby a pin 88 engaging a slot 87 of a disc 86 is arranged to effect a one-eighth turn of the valve stem for each revolution of the gear.

With the present valve operating means, each valve 51 is rotatively advanced and reset once for each rotation of a gear 84, it being noted that the intermittent coaction of each pin and disc is a form of Geneva movement. By engaging the gears 85 to dispose the pins 88 one hundred twenty degrees, or one third of a gear turn apart, the three double valves 51 are arranged to be reset in evenly timed succession, the disclosed arrangement effecting such an overlap of the operative cycles of the chambers 22 that the desired continuity of pumping action is provided.

In order to insure completion of the working phases of the operating cycles for the working chambers 22, the valve drive shaft 43 must be driven at an appropriate speed to provide the best timing for the chamber-emptying phase whereby the ejection pressure may cease when the chamber is emptied; with the compressor operating at a fixed speed, and necessary valve speed adjustment may be effected at the change speed means 40 which is interposed between the shaft 43 and the compressor shaft 42, it being noted that the specific structure of said means is generally immaterial to the present invention. Since the intake and discharge phases for the chambers 22 are arranged to endure for the same length of time, it may be necessary to adjust

the rate of discharge from the unit 5 to allow for a filling of each chamber 22 at intake; as shown, a valve 91 is provided in the discharge line 7 at an out-of-water point thereof for appropriate adjustment for the purpose. It will, of course, be evident that the operative elements of the described system must be appropriately adjusted for the best operation under variable factors effecting operation, such factors including the depths of the diver and the unit 5, the length of the liquid-carrying ducts required, the nature of the deposits to be removed, the operative speed of the compressor, etc.

By reference to Figure 14, it will be seen that the valve settings shown are those of Figures 6 and 7. In this figure, the conditions simultaneously existent in the various chambers 22 are indicated in connection with the chamber, both as to pressure conditions and liquid contents, pressure and suction being indicated by plus and minus signs respectively, and atmospheric pressure being indicated by the letter A.

From the foregoing description taken in connection with the accompanying drawings, the advantages of the construction and method of operation will be readily understood by those skilled in the art to which the invention appertains, and while I have described the principle of operation, together with a device which I now consider to be a preferred embodiment thereof, I desire to have it understood that the device shown is merely illustrative, and that such changes may be made, when desired, as fall within the scope of the appended claims.

Having thus described my invention, I claim as new and desire to secure by Letters Patent of the United States the following:

1. In apparatus for subaqueous dredging, a suction nozzle for underwater manipulation by a diver for application to submerged material to be removed, a sluice box, a combined suction and lift pump comprising a submerged and cylindric working chamber disposed in axially prone position and having inlet and discharge connections with said nozzle and sluice box respectively, one-way valves operative in said connections and for the chamber, a flexible hose providing an air duct connecting with said chamber, and means operative through said hose duct to alternately create suction intake and pressure discharge conditions in said hose and chamber, said chamber disposed substantially at the level of said nozzle whereby substantially the full intake suction for the chamber is operative at said nozzle.

2. In hydraulic dredging apparatus, a suction nozzle for application to submerged material to be removed therethrough, a combined suction and lift pump having a cylindric working chamber for submerged disposal in axially prone position at substantially the same level as the material to be removed, means providing inlet and discharge passages for said chamber at opposite ends thereof, one-way valves in the respective passages, means providing a duct connecting said nozzle with said inlet passage, means providing a duct from said discharge passage for discharging above the water, and means operative through said duct to alternately create working suction and pressure conditions in said chamber for alternately filling and emptying the same with the water-borne material received through said nozzle.

3. In hydraulic dredging apparatus for remov-

ing divided solid material from the submerged bed of a stream or the like, pump means comprising a cylindric working chamber for supported disposal on said bed in an axially prone position thereof, means providing one-way inlet and discharge connections for said chamber at opposite ends thereof, said inlet connection including a suction nozzle for application to said material, and means to successively create sub-atmospheric and super-atmospheric pressure conditions in said working chamber to alternately effect the intake and discharge of said liquid-borne material with respect to the chamber.

4. In hydraulic dredging apparatus, dredger pump means comprising a working chamber for submerged disposal in a body of liquid, means providing one-way suction inlet and pressure discharge connections for said chamber, means providing an air duct to said chamber, air exhaust means, air compressor means, and valve means for actuation to alternately connect said air duct with said exhaust and compressor means, said exhaust and compressor and valve means all disposed outside of the body of liquid.

5. In hydraulic dredging apparatus, dredger pump means comprising a working chamber for submerged disposal, means providing one-way inlet and discharge connections for said chamber, means providing an air duct to said chamber, air exhaust means, air compressor means, and valve means for continuous actuation to connect said duct with said exhaust and compressor means and with the atmosphere in such order as to alternately create sub-atmospheric and super-atmospheric pressure conditions in said working chamber and thereby alternately effect the intake and discharge of dredged material with respect to said chamber.

6. In hydraulic dredging apparatus, dredger pump means comprising a working chamber for submerged disposal, means providing one-way inlet and discharge connections for said chamber, means providing an air duct to said chamber, air exhaust means, air compressor means,

and valve means for continuous actuation to connect said duct with said exhaust and compressor means for alternately creating sub-atmospheric and super-atmospheric pressure conditions in the chamber, said valve means further operative to connect said duct with the atmosphere following its connection with the exhaust means and before its connection with the compressor means.

7. In hydraulic dredging apparatus, dredger pump means comprising a working chamber for submerged disposal, means providing one-way inlet and discharge connections for said chamber, means providing an air duct to said chamber, air exhaust means, air compressor means, and valve means for continuous actuation to provide a succession of pressure cycles in the chamber wherein said duct is successively connected with the said exhaust means and the atmosphere and the said compressor means and the atmosphere for alternately creating sub-atmospheric and super-atmospheric pressure conditions in said working chamber to thereby effect a dredging action of the pump means.

8. In hydraulic dredging apparatus, a suction nozzle for application to submerged material, a discharge duct, dredger pump means comprising a plurality of working chambers in unitary association for submerged disposal, means providing mutually independent one-way inlet and discharge connections for each of said chambers, an inlet manifold connecting said nozzle with said inlet connections, a discharge manifold connecting said discharge connections with said discharge duct, air exhaust means, air compressor means, means providing independent air ducts to said chambers, and valve means for continuous actuation to alternately connect the different said air ducts with said exhaust and compressor means for overlapping periods of time whereby the intake suction at said nozzle and the discharge pressure in the said discharge duct are arranged to be and remain constant.

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