Oct. 11, 1938. B. M. BIRD ET AL 2,132,377

AIR CONTROLLED WATER JIG AND VALVE THEREFOR

Original Filed July 23, 1934 2 Sheets-Sheet 1

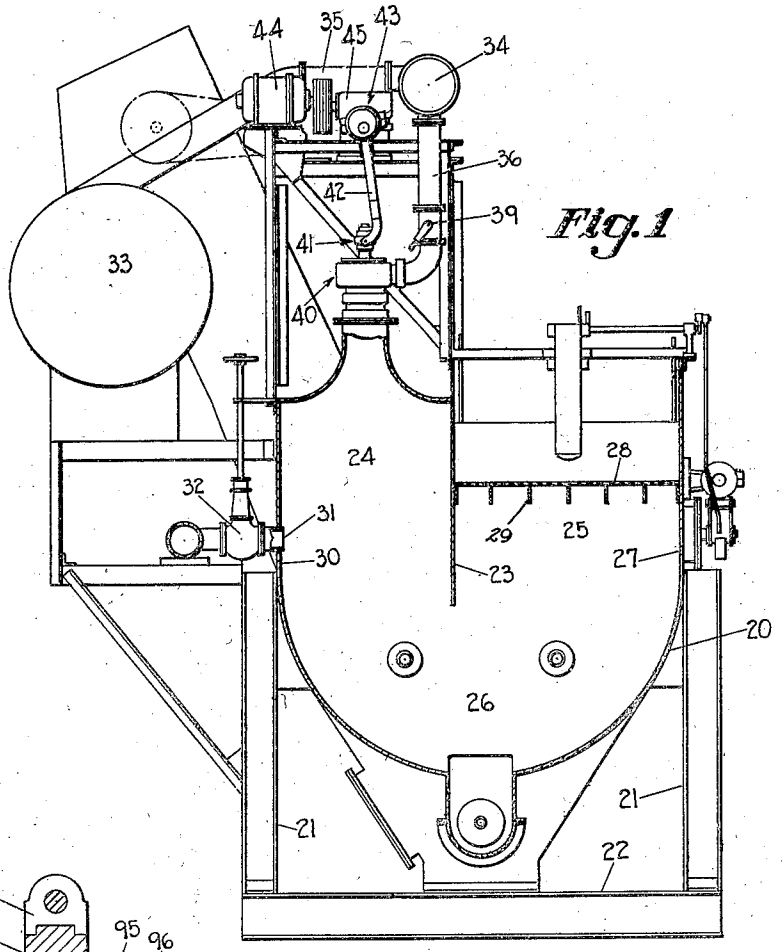


Fig. 1

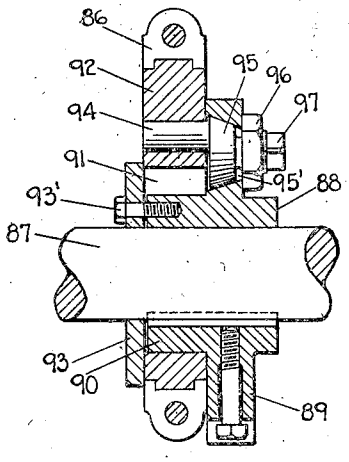


Fig. 4

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AIR CONTROLLED WATER JIG AND VALVE THEREFOR

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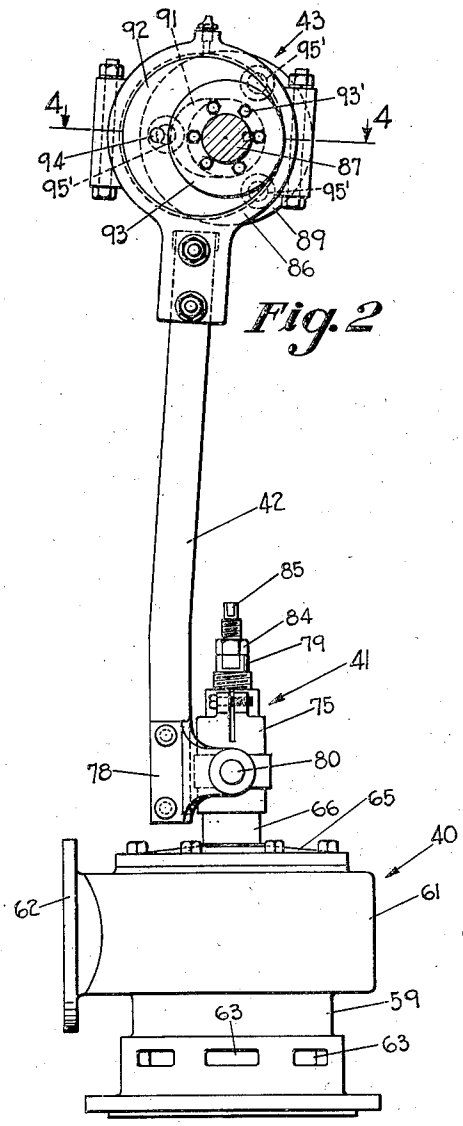


Fig. 2

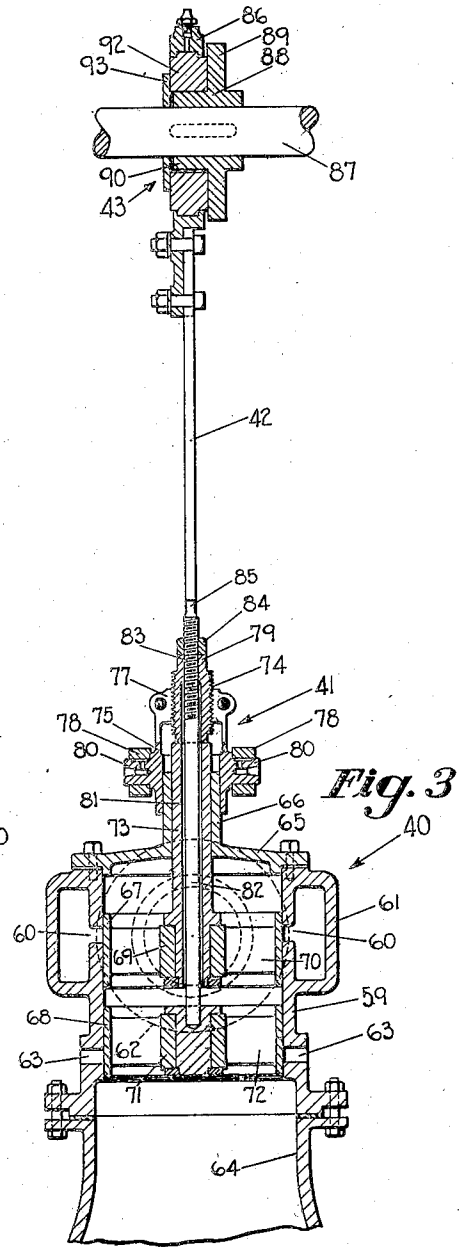


Fig. 3

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UNITED STATES PATENT OFFICE

2,132,377

AIR CONTROLLED WATER JIG AND VALVE THEREFOR

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Application July 23, 1934, Serial No. 736,444. Renewed June 22, 1938. In Great Britain July 24, 1933

17 Claims. (Cl. 209—500)

This invention relates to an air controlled water jig and valve therefor and, particularly, to a valve adapted to be used to control the flow of air into and out of an air controlled jig which employs a liquid, as the jigging fluid.

An object of the invention is to provide a valve, particularly of the above mentioned type, in which the rate of air admission and air exhaust to the air chamber of a jig may be controlled with extreme flexibility.

More specifically, an object of the invention is to provide an air control valve in which the period of air admission to a chamber and air exhaust from a chamber may be flexibly controlled and which may be adjusted so that the air chamber may be effectively sealed during any desired period.

Still another object of the invention is to provide an air valve in which the rate of opening and the rate of closing of the inlet and exhaust ports, respectively, of said valve may be variably determined.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

In the drawings:

Fig. 1 is an elevational end view of one form of jigging apparatus employing the valve of our invention;

Fig. 2 is an enlarged detailed elevational view of the valve of our invention and a variable throw eccentric mechanism which may be employed to operate said valve;

Fig. 3 is a sectional elevational view of the device of Fig. 2; and

Fig. 4 is a sectional view of the eccentric mechanism of Figs. 2 and 3, taken on the line 4—4 of Fig. 2.

Referring particularly to Fig. 1 of the drawings, there is seen a jigging device comprising a tank 20 mounted between the uprights 21, 21 carried on the base member 22 comprising a supporting frame. Projecting downwardly into the tank 20 and longitudinally disposed in respect thereto is a plate 23 which, with the bottom of the tank 20, form a U-shaped compartment providing an air chamber 24 and a washing chamber 25. Below said chambers 24 and 25 and comprising a part of the tank 20, is a hutch 26. Carried between the plate 23 and one side wall 27 of the tank 20, is a sieve 28 which may be in the form of a screen or a perforate plate. Said sieve 28 is provided with reinforcing ribs 29 and, as viewed in Fig. 1, extends along a horizontal line. The sieve 28 is adapted if desired, to slope downwardly from the material receiving end toward the material discharging end. Adjacent the side wall 30 of the tank 20, there is provided a water inlet conduit 31 in communication with any desired source of water supply. A hand-operated valve 32 is provided in said conduit 31 to regulate the flow of water to the hutch 26. At 33 there is seen a source of air pressure which may comprise a blower, the output of which is delivered to a pressure tank 34 by the conduit 35. From said pressure tank 34 extends a conduit 36 in communication with the chamber 24. The conduit 36 may be provided with a manually-operable control valve 39 and has communication with the upper part of the chamber 24 under the control of an eccentric-operated periodically-reciprocating valve 40. The structural details of the valve 40 which comprise our invention are illustrated in detail in Figs. 1 and 2.

The plunger 41 of the valve 40 is connected by a connecting rod 42 to an eccentric-operated mechanism 43 operated from the motor 44 through the gear reduction mechanism 45. The eccentric mechanism 43 is preferably of the variable throw or stroke type and is illustrated somewhat in detail in Figs. 2 and 3. The specific structural details of the eccentric mechanism, per se, do not constitute a part of our invention but are the invention of another party. However, the combination of the valve structure and a variable throw or stroke eccentric mechanism constitutes part of our invention.

In the operation of the jig illustrated in Fig. 1, material, as coal, to be cleaned is fed on the sieve 28 at one end thereof and forms a bed of material. This bed of material is subjected to the cyclic influence of the jigging fluid as it passes upwardly and downwardly with respect to the sieve 28. The bed of material carried on said screen is thereby stratified, the clean coal forming at the top of the bed and the refuse at the bottom of said bed. The refuse is removed by any desired means into an appropriate refuse discharge chute from which it may be removed, as by elevator mechanism. The clean coal is carried by the excess water over a baffle or dam and discharged into any desired receptacle. To provide for the jigging cycle of the water with respect to the sieve 28, the valve 40 is cyclically operated by the motor 44 to control the admission and discharge of the air to and from the chamber 24.

Referring to Figs. 2 and 3, there is illustrated in detail the eccentric-operated valve mechanism comprising our invention. The valve 40 comprises a cylinder 59 provided in the upper

part thereof with a circumferential inlet port 60 comprising an annular opening communicating with a circumferential chamber 61 provided with a pipe fitting 62. Adjacent the lower part of said cylinder 59 is a plurality of discharge ports 63 communicating with atmospheric pressure. In place of the discharge ports 63, we may employ a continuous annular discharge port similar to the inlet port 60 provided with a circumferential chamber therefore similar to the chamber 61. In this case, the circumferential chamber would be provided with one or more exhaust ports similar to the ports 63.

The bottom part of said cylinder 59 communicates with a belled conduit 64 forming the upper part of the air chamber 24. The upper part of the cylinder 59 is provided with a head 65 having an integral guide sleeve 66. Within the cylinder 59 is a pair of pistons 67 and 68. The piston 67 is adapted to control the opening and closing of the inlet port 60 and the piston 68 is adapted to control the opening and closing of the discharge ports 63. The piston 67 is provided with a central hub 69 and axially-extending spokes 70. The spokes 70 permit the free movement of the air received through the inlet port 60 through the cylinder 59 to the conduit 64 and into the air chamber 24 when said piston 67 is in inlet port opening position. The piston 68 is also provided with a hub 71 and spokes 72 in order to allow the above mentioned free passage of air through the cylinder 59.

Rigidly attached to the hub 69 is a hollow sleeve 73 adapted to be guided in the guide sleeve 66. The upper end of said hollow sleeve 73 is screw-threaded, as illustrated at 74, and is adapted to receive screw-threadedly a split guide thimble 75 which may be clamped rigid thereto after having been adjusted to a desired position with respect to the threaded neck portion 77 of said guide thimble 75. The inner cylindrical surface of said guide thimble 75 is adapted to slide on the outer surface of the guide sleeve 66. A U-shaped link 78, carrying a connecting rod 42, is pivoted to laterally-extending lugs 80, 80 of the thimble 75.

Projecting through the longitudinal opening 81 of the hollow sleeve 73 is a shaft 82 rigidly attached at its lower end with the hub 71 of the piston 68 and adjustably connected to the hollow sleeve 73 at its upper end by screw threads 83. A clamping nut 84 is provided for clamping said shaft 82 rigid with said hollow sleeve 73 after the former is adjusted to a desired position. To provide for the adjustment of said shaft 82 with respect to said hollow sleeve 73, the top of said shaft 82 is preferably squared as indicated at 85 whereby a wrench may be employed to rotate said shaft 82 and thereby effect its adjustment. The portion 79 of sleeve 73 is also squared to receive a tool and thus prevent its turning with shaft 82 during its adjustment.

As the piston 67 is rigidly attached to the hollow sleeve 73 and as the piston 68 is rigidly attached to the shaft 82, it is obvious that by rotating said shaft 82, which is screw-threaded at 83 with said hollow sleeve 73, the position of the piston 68 may be adjusted with respect to the piston 67. This adjustment may be made within wide limits and, when any desired adjustment is effected, it may be maintained by the clamping home of the clamp nut 84. After said adjustment is made between said pistons 67 and 68, said pistons are adapted to move in unison under the control of the connecting rod 42. By virtue of the adjustability afforded by the screw-threaded connection between the threaded portion 74 of the hollow sleeve 73 and the cooperating threaded portion of the guide thimble 75, said guide thimble 75 may be adjusted with respect to said hollow sleeve 73 and thus the positions of said pistons 67 and 68 may be adjusted with respect to the connecting rod 42.

The upper end of the connecting rod 42 is connected to an eccentric mechanism 43. Said eccentric mechanism is preferably of the variable throw type and may be of any well-known construction.

There is illustrated in Figs. 2 and 3, a particular type of variable throw eccentric which is well adapted for use in conjunction with our valve. Said eccentric mechanism comprises a split strap 86 rigidly connected with the connecting rod 42. Mounted upon the shaft 87 for rotation therewith, is a bushing 88 provided with a circumferential flange 89 and a cylindrical hub 90. Said hub 90 is adapted to fit into an oval-shaped opening 91 having parallel side walls in an eccentric plate 92, which plate is rotatably mounted between the flanges of the strap 86 and is carried between the flange 89 and the retaining washer 93, bolted to said bushing 88, as by bolts 93'. The stroke of the connecting rod 42 is, of course, controlled by the spacing between the axis of rotation of the eccentric plate 92 and the axis of rotation of the shaft 87. That is, the stroke will be twice this spacing. In order to control variably the stroke of said connecting rod 42, the eccentric plate 92 is made adjustable with respect to the bushing 88, whereby said axial spacing may be controlled at will. The oval-shaped opening 91 permits relative adjustment between the eccentric plate 92 and said bushing 88. To effect this adjustment, the flange 89 is provided with three angularly-positioned conical holes 95' adapted selectively to receive the frusto-conical head 95 of a pin 94, the axis of which is displaced with respect to the axis of said pin 94. Said pin 94 is adapted to be received in a drill hole in the plate 92. The axial extension of said conical head 95 is screw-threaded to receive a nut 96 and, at its extremity, is squared to receive a tool. By virtue of this adjusting device, the position of the bushing 88 with respect to the eccentric plate 92 may be adjustably determined and fixed in a determined position. This is accomplished by placing the head 95 in one of the three angularly-spaced holes 95' and rotating the pin 94 about its axis to move the plate 92 with respect to the bushing 88 whereby it may assume any desired position in the oval-shaped opening 91 where it may be held by clamping home the nut 96. The retaining washer 93 is also effective to maintain this adjustment when clamped by bolts 93'. As illustrated in Fig. 4, the distance between the outer wall of the hub 90 within the oval-shaped opening 91 and the wall defining said opening 91 may be adjusted by the rotation of the pin 94 about its axis. This may be effected by a wrench fitted on the square head 97. Along the section line illustrated in Fig. 4, the mentioned walls are spaced at substantially their maximum distance. By rotating the head 95, the axis of the frusto-conical pin 94 will be moved downwardly, as viewed in Fig. 4, and will decrease the mentioned distance. This affords the above mentioned adjustment of the length of the stroke of the connecting rod 42. In addition to the above mentioned adjustment, by removing the retaining washer 93 it is possible to move the eccentric

plate 92 axially sufficient to disengage the head 95 from the conical hole 95' in which it is positioned and to rotate this plate either 120 or 240 degrees and then place said head 95 in another conical hole. That is, plate 92 may have any one of three positions relative to the bushing 88. By this expedient, where a plurality of valves are driven from a common shaft 87, their operation may be displaced either 120 or 240 degrees in phase relation. This provides for non-synchronous admission of air to various chambers of a jig where a multiple compartment jig is employed. By employing the adjustable eccentric mechanism and the dual piston valve mechanism illustrated in Figs. 2, 3 and 4, very flexible control of the admission, maintenance, and discharge of air under pressure to the chamber 24 is provided. The adjustable eccentric mechanism provides for an adjustable stroke of the connecting rod 42 and a resulting adjustable stroke for the pistons 67 and 68 and for adjusting the phase relation between two or more valves when a plurality of valves is operated from a single shaft. The adjustable thimble 75 provides for an adjustable determination of the position of the piston 67 with respect to the connecting rod 42 which, in turn, determines the limits of movement of said piston 67 for any given adjustment of the eccentric mechanism 42; and the adjustment between the shaft 82 and the hollow sleeve 73 provides for an adjustable determination of the piston 68 with respect to the piston 67.

Instead of employing the eccentric mechanism 43 for operating the valve 40, we may employ a cam device and the cam surface may be given any desired configuration for operating said valve 40 during any cycle of operation. If desired, a plurality of interchangeable cams may be provided to afford greater flexibility of operation of said valve 40.

With the valve 40 and the eccentric mechanism 43 adjusted, as illustrated in Figs. 2 and 3, and with the shaft 87 rotated in a counterclockwise direction, as viewed in Fig. 2, the cycle of operation of the admission, maintenance, and discharge of the air to the chamber 24 and the sealing of said chamber 24 under initial atmospheric pressure will be substantially as follows:

With valve 40 in the position illustrated in Fig. 3, both the inlet port 60 and discharge ports 63 are closed and the chamber 24 is sealed following a period of exhaustion of chamber 24. As the shaft 87 rotates and the pistons 67 and 68 are moved downward, the inlet port 60 is opened as the eccentric device 43 approaches the lower limit of its stroke. The discharge ports 63 are maintained closed through this portion of the cycle. It may be noted that as the inlet port 60 does not begin to open until the eccentric 43 has approached the downward extremity of its stroke that the rate of opening of said port 60 will be small in comparison with what it would have been had said port started to open at approximately the instant the axis of the eccentric plate 92 passed below the axis of the shaft 87. With the connecting rod 42 in its extreme downward position of the stroke, the inlet port 60 will be at maximum opening and the discharge ports 63 will be closed. Under these conditions, the fluid under pressure would be admitted to the chamber 24 to produce upward movement of the jigging fluid through the sieve 28. On the return movement of the connecting rod 42 under the control of the eccentric 43, the inlet port 60 is closed while the outlet ports 63 are maintained closed. Under these conditions, the chamber 24 is effectively sealed under pressure and this condition is maintained until ports 63 are open due to the upward movement of rod 42 under the control of the eccentric mechanism 43. While connecting rod 42 completes its upward stroke, said discharge ports 63 remain open, the inlet port 60 is maintained closed, and the chamber 24 is free to exhaust at atmospheric pressure. During the following downward movement of pistons 67 and 68, exhaust ports 63 are closed while inlet port 60 is maintained closed and the chamber 24 is effectively sealed. This completes a cycle of operation.

In the specification and claims, the period during which inlet port 60 is open and fluid under pressure is added to the chamber 24 is designated the inlet period. The following period during which ports 60 and 63 are both closed is designated the expansion period. The following period during which ports 63 are open is called the exhaust period and the final period during which ports 60 and 63 are closed under initial atmospheric pressure is called the compression period. It may be noted that with this particular valve construction, the expansion and compression periods are of necessity the same duration, while the inlet and exhaust periods may be varied within wide limits and be of different duration.

By lowering the position of the piston 67 with respect to the connecting rod 42, the period during which the inlet port 60 is maintained open may be increased and by raising said piston with respect thereto said period may be reduced. This period may be varied between wide limits, from 20 degrees to 300 degrees of movement of shaft 87, by controlling the position of said piston 67 on said hollow sleeve 73. Likewise, by lowering the position of piston 68 with respect to connecting rod 42, the period during which the discharge ports 63 may be reduced and by raising said piston with respect thereto said period may be increased. This period may also be varied between the limits above mentioned for piston 67. It is to be noted that the length of the piston 67 is such that under no condition may said piston be moved upwardly sufficient to open the inlet port 60. This requires the opening of the inlet port 60 to take place only during the downward movement of the connecting rod 42. The piston 68 is also of such length and is preferably so adjusted that under no condition will the discharge ports 63 be opened during a downward movement of the connecting rod 42. That is, inlet port 60 under the control of the piston 67 is adapted to be opened only in response to a downward movement of the connecting rod 42 and discharge ports 63 under the control of piston 68 are adapted to be opened only in response to an upward movement of the connecting rod 42. Furthermore, the pistons 67 and 68 are preferably so adjusted that under no condition will ports 60 and 63 be opened at the same time for, if this condition exists, the air under pressure will enter the cylinder 59 through the inlet port 60 and be discharged to the atmosphere through the discharge ports 63 thereby wasting the air and doing no useful work.

It is obvious that the portion of any cycle of operation during which inlet port 60 may be opened and discharge ports 63 closed may be varied within wide limits and the portion of the cycle during which discharge ports 63 are opened and inlet port 60 is closed may likewise be varied

within wide limits. In addition, the condition under which both the inlet port **60** and the discharge ports **63** are closed may be varied within wide limits and, in fact, this period may be reduced to substantially 0 or increased to substantially 150 degrees. It may be noted, however, that with this valve construction this period cannot exceed, even theoretically, 180 degrees and as a practical matter the limit is probably about 150 degrees. In addition, the rate at which the ports **60** and **63** are opened or closed once their respective pistons commence an opening or closing operation may be varied by varying the stroke of the connecting rod **42** and by varying the instant during any cycle of operation at which said opening or closing operation begins. The latter is, of course, determined to a large extent by the portion of the cycle a valve is adjusted to be opened, while the former is independently adjustable. That is, if the portion of a cycle defining the limits during which port **60**, for example, first starts to open until it is totally closed, is small, such as 60 degrees, then it begins to open when eccentric **43** approaches the lower part of its stroke, during which the rate of movement of piston **67** is relatively small.

It is obvious that with the eccentric-operated valve structure illustrated in Figs. 2, 3 and 4, the period during which fluid is admitted to the chamber **24**, the rate of this admission, the period during which the chamber **24** is sealed after air is admitted, the subsequent period during which the discharge ports **63** are open, the rate of opening of said discharge ports and the subsequent period during which the chamber **24** is sealed under initial atmospheric pressure may each be varied within wide limits thus providing a very flexible means for controlling the number of the jigging liquid with respect to the sieve **28**.

Obviously those skilled in the art may make various changes in the details and arrangement of parts without departing from the spirit and scope of the invention as defined by the claims hereto appended, and we wish therefore not to be restricted to the precise construction herein disclosed.

Having thus described and shown an embodiment of our invention, what we desire to secure by Letters Patent of the United States is:

1. In a valve, the combination of a cylinder having an inlet port and an exhaust port, and a pair of pistons adapted to reciprocate in said cylinder to control the opening and closing of said ports, means for adjusting the relative positions of said pistons comprising a hollow shaft rigid with one of said pistons, a rod rigid with the other of said pistons, said rod and shaft being relatively adjustable.

2. In an air controlled water jig, the combination with a source of air under pressure, of an air chamber adapted to control the pulsating movement of water to effect a jigging operation, cyclically operated means adapted to effect a connection between said source of air and said chamber for a period of each cycle of operation, cyclically operated means adapted to effect an opening of said chamber to discharge air therein for a period during each cycle of operation, and means correlating the action of the two aforementioned cyclically operated means to provide an expansion period during each cycle of operation thereof during which said chamber is sealed against both ingress and egress of air for at least 30 degrees of a cycle of operation of 360 degrees.

3. In an air controlled water jig, the combination with a source of air under pressure, of an air chamber adapted to control the pulsating movement of water to effect a jigging operation, cyclically operated means adapted to effect a connection between said source of air and said chamber for a period of each cycle of operation, cyclically operated means adapted to effect an opening of said chamber to discharge air therein for a period during each cycle of operation, and means correlating the action of the two aforementioned cyclically operated means to provide an expansion period during each cycle of operation thereof during which said chamber is sealed against both ingress and egress of air for at least 60 degrees of a cycle of operation of 360 degrees.

4. In an air controlled water jig, the combination with a source of air under pressure, of an air chamber adapted to control the pulsating movement of water to effect a jigging operation, cyclically operated means adapted to effect a connection between said source of air and said chamber for a period of each cycle of operation, cyclically operated means adapted to effect an opening of said chamber to discharge air therein for a period during each cycle of operation, and means correlating the action of the two aforementioned cyclically operated means to provide an expansion period during each cycle of operation thereof during which said chamber is sealed against both ingress and egress of air for at least 90 degrees of a cycle of operation of 360 degrees.

5. In an air controlled water jig, the combination with a source of air under pressure, of an air chamber adapted to control the pulsating movement of water to effect a jigging operation, cyclically operated means adapted to effect a connection between said source of air and said chamber for a period of each cycle of operation, cyclically operated means adapted to effect an opening of said chamber to discharge air therein for a period during each cycle of operation, and means correlating the action of the two aforementioned cyclically operated means to provide an expansion period during each cycle of operation thereof during which said chamber is sealed against both ingress and egress of air for at least 45 degrees of a cycle of operation of 360 degrees.

6. In an air controlled water jig, the combination with a source of air under pressure, of an air chamber adapted to control the pulsating movement of water to effect a jigging operation, cyclically operated means adapted to effect a connection between said source of air and said chamber for an adjustable period of each cycle of operation, cyclically operated means adapted to effect an opening of said chamber to discharge air therefrom for an adjustable period of each cycle of operation, means correlating the action of the two aforementioned cyclically operated means to determine variably two periods during which said chamber is sealed against both ingress and egress of air whereby an expansion period and a compression period is provided in each cycle of operation, and means for cyclically operating said prior mentioned means in the same time period.

7. In an air controlled water jig, the combination with a source of air under pressure, of an air chamber adapted to control the pulsating movement of water to effect a jigging operation, cyclically operated means adapted to effect a connection between said source of air and said chamber for a period of each cycle of operation, cycli-

cally operated means adapted to effect an opening of said chamber to discharge air therefrom for an adjustable period of each cycle of operation, means correlating the action of the two aforementioned cyclically operated means to determine variably two periods during which said chamber is sealed against both ingress and egress of air whereby an expansion period and a compression period is provided in each cycle of operation, and means for cyclically operating said prior mentioned means in the same time period.

8. In an air controlled water jig, the combination with a source of air under pressure, of an air chamber adapted to control the pulsating movement of water to effect a jigging operation, cyclically operated means adapted to effect a connection between said source of air and said chamber for an adjustable period of each cycle of operation, cyclically operated means adapted to effect an opening of said chamber to discharge air therefrom for a period of each cycle of operation, means correlating the action of the two aforementioned cyclically operated means to determine variably two periods during which said chamber is sealed against both ingress and egress of air whereby an expansion period and a compression period is provided in each cycle of operation, and means for cyclically operating said prior mentioned means in the same time period.

9. In an air controlled water jig, the combination with a source of air under pressure, of an air chamber adapted to control the pulsating movement of water to effect a jigging operation, cyclically operated means adapted to effect a connection between said source of air and said chamber for a period of each cycle of operation, cyclically operated means adapted to effect an opening of said chamber to discharge air therefrom for a period of each cycle of operation, and means correlating the action of the two aforementioned cyclically operated means to determine variably two periods during which said chamber is sealed against both ingress and egress of air whereby an expansion period and a compression period of at least 30 degrees is provided in each cycle of 360 degrees.

10. In an air controlled water jig, the combination with a source of air under pressure, of an air chamber adapted to control the pulsating movement of water to effect a jigging operation, cyclically operated means adapted to effect a connection between said source of air and said chamber for a period of each cycle of operation, cyclically operated means adapted to effect an opening of said chamber to discharge air therefrom for a period of each cycle of operation, and means correlating the action of the two aforementioned cyclically operated means to determine variably two periods during which said chamber is sealed against both ingress and egress of air whereby an expansion period and a compression period of at least 60 degrees is provided in each cycle of 360 degrees.

11. In an air controlled water jig, the combination with a source of air under pressure, of an air chamber adapted to control the pulsating movement of water to effect a jigging operation, cyclically operated means adapted to effect a connection between said source of air and said chamber for a period of each cycle of operation, cyclically operated means adapted to effect an opening of said chamber to discharge air therefrom for a period of each cycle of operation, and means correlating the action of the two aforementioned cyclically operated means to determine variably two periods during which said chamber is sealed against both ingress and egress of air whereby an expansion period and a compression period of at least 90 degrees is provided in each cycle of 360 degrees.

12. In an air controlled water jig, the combination with a source of air under pressure, of an air chamber adapted to control the pulsating movement of water to effect a jigging operation, cyclically operated means adapted to effect a connection between said source of air and said chamber for a period of each cycle of operation, cyclically operated means adapted to effect an opening of said chamber to discharge air therefrom for a period of each cycle of operation, and means correlating the action of the two aforementioned cyclically operated means to determine variably two periods during which said chamber is sealed against both ingress and egress of air whereby an expansion period and a compression period of at least 45 degrees is provided in each cycle of 360 degrees.

13. In an air controlled water jig, the combination with a source of air under pressure, of an air chamber adapted to control the movement of water, valve means adapted cyclically to admit air to said chamber from said source and to seal said chamber against air ingress or egress for a portion of each cycle of operation not less than 45 degrees of a cycle of 360 degrees, said valve means comprising means defining a valve chamber, an inlet port in said chamber, connecting means between said port and source of air under pressure, means affording communication between said valve chamber and said air chamber, means providing an air discharge port communicating with said air chamber, movable port opening and closing means associated with said inlet port and discharge port, and means for operating said movable port opening and closing means cyclically, said movable port opening and closing means being constructed, arranged and correlated with respect to said ports to produce the aforesaid cycles of operation.

14. In an air controlled water jig, the combination with a source of air under pressure, of an air chamber adapted to control the movement of water, valve means adapted cyclically to admit air to said chamber from said source and to seal said chamber against air ingress or egress for a portion of each cycle of operation not less than 30 degrees of a cycle of 360 degrees, said valve means comprising means defining a valve chamber, an inlet port in said chamber, connecting means between said port and source of air under pressure, means affording communication between said valve chamber and said air chamber, means providing an air discharge port communicating with said air chamber, movable port opening and closing means associated with said inlet port and discharge port, and means for operating said movable port opening and closing means cyclically, said movable port opening and closing means being constructed, arranged and correlated with respect to said ports to produce the aforesaid cycles of operation.

15. In an air controlled water jig, the combination with a liquid containing tank, of a bed supporting perforate member therein, an air chamber, a source of air under pressure, means for periodically controlling the application of said air under pressure to said air chamber to force water upwardly through said perforate member, and to discharge air under pressure from said air chamber while providing a period of not less than

30 degrees of a cycle of 360 degrees during which said air chamber is sealed against both ingress and egress of air, said means comprising a valve chamber communicating with said air chamber, means providing an air inlet port, means connecting said air inlet port and said source of air under pressure, means providing an air exhaust port associated with said valve chamber, port controlling piston means associated with said ports, means connecting said piston means to provide the aforementioned air chamber sealing period, and means for cyclically operating said piston means.

16. In an air controlled water jig, the combination with a liquid containing tank, of a bed supporting perforate member therein, an air chamber, a source of air under pressure, means for periodically controlling the application of said air under pressure to said air chamber to force water upwardly through said perforate member, and to discharge air under pressure from said air chamber while providing a period of not less than 60 degrees of a cycle of 360 degrees during which said air chamber is sealed against both ingress and egress of air, said means comprising a valve chamber communicating with said air chamber, means providing an air inlet port, means connecting said air inlet port and said source of air under pressure, means providing an air exhaust port associated with said valve chamber, port controlling piston means associated with said ports, means connecting said piston means to provide the aforementioned air chamber sealing period, and means for cyclically operating said piston means.

17. In an air controlled water jig, the combination with a liquid containing tank, of a bed supporting perforate member therein, an air chamber, a source of air under pressure, means for periodically controlling the application of said air under pressure to said air chamber to force water upwardly through said perforate member, and to discharge air under pressure from said air chamber while providing a period during which said air chamber is sealed against both ingress and egress of air, said means comprising a valve chamber communicating with said air chamber, means providing an air inlet port, means connecting said air inlet port and said source of air under pressure, means providing an air exhaust port associated with said valve chamber, a pair of adjustable pistons, one associated with said air inlet port and one associated with said air exhaust port, and means adjustably connecting said pistons to adjust said air chamber sealing period.

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