Dec. 30, 1958 J. C. FOUREY 2,866,441

HYDRAULIC MOTOR FOR A JIG

Filed Feb. 25, 1955 2 Sheets-Sheet 1

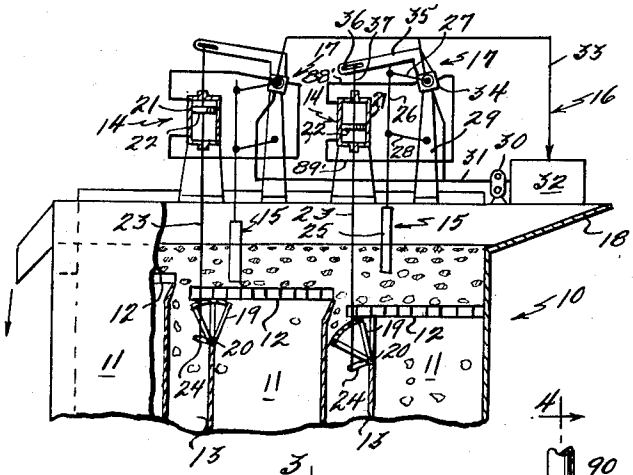

FIG. 1

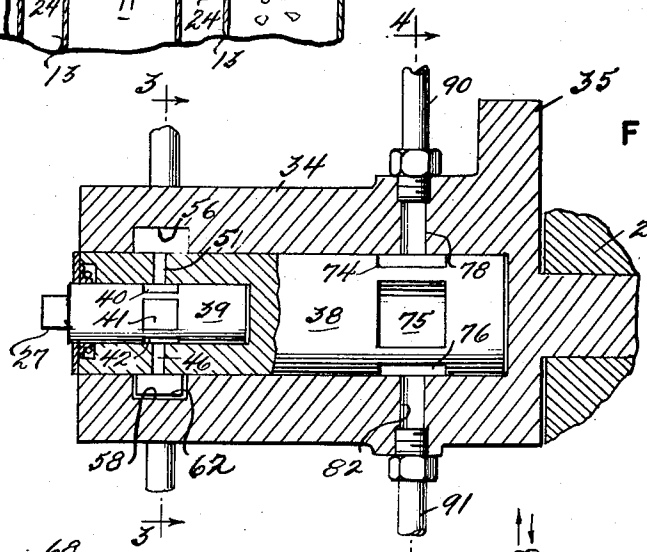

FIG. 2.

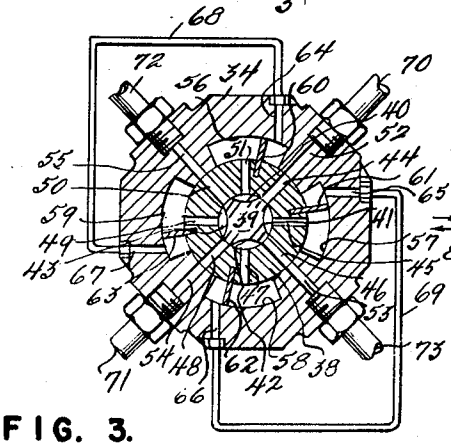

FIG. 3.

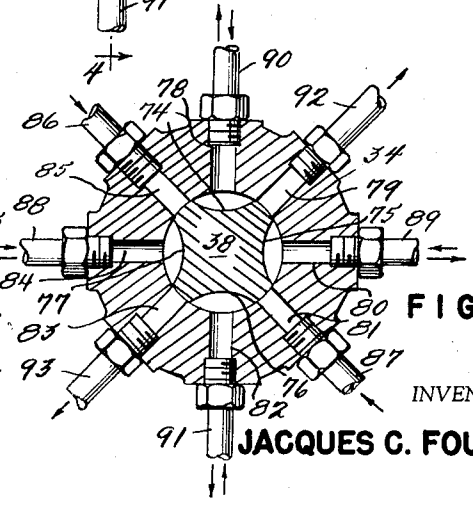

FIG. 4

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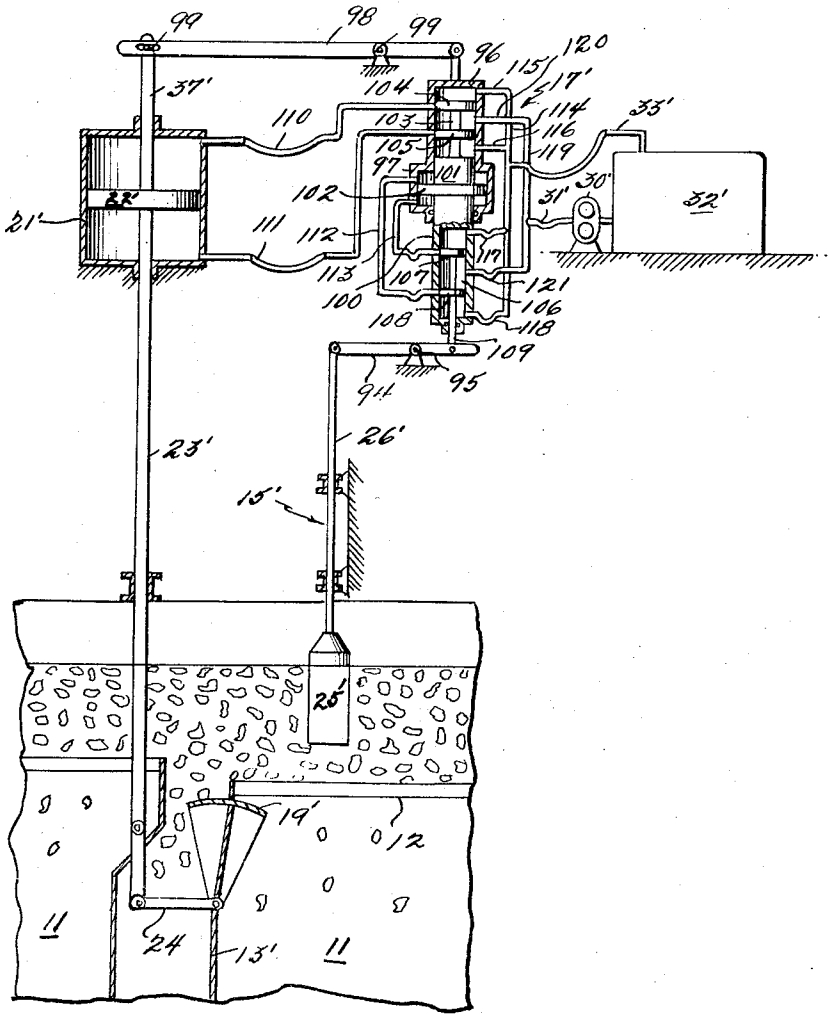
Dec. 30, 1958 J. C. FOUREY 2,866,441

HYDRAULIC MOTOR FOR A JIG

Filed Feb. 25, 1955 2 Sheets-Sheet 2

FIG. 5



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HYDRAULIC MOTOR FOR A JIG

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6 Claims. (Cl. 121—41)

This invention relates to apparatus for washing granular material such as coal, ore and the like, and has more particular reference to such apparatus of the type commonly known as washing jigs which involve the densimetric classifying of the granular material in a fluid medium submitted to pulsations, and the separate removal of the stratified products.

The known jigs include several washing compartments in which the products to be cleaned are carried, the whole of the products stratified in relation with the specific gravity form the washing bed. Each compartment communicates with a neighboring chamber in which a piston or a membrane causes an alternative motion of the water masses, which lifts, at a determined frequency, the washing bed which rests upon a perforated grate, completed or not with compartments containing feldspar or similar products. It is also possible to obtain the alternative motion of the water masses by means of subjecting it to pulsated compressed air. These pulsations enable the classification of the material in the jig into several densimetric layers, the light products coming to the surface of the washing bed while the heavy products settle at the bottom. These heavy products are discharged through the washing table with or without filter bed or at the end of the jig through fixed outlets.

To adjust these evacuations, automatic devices are generally used, including a float placed in the bed. The level of this float is the function of the composition of the stratified products and a connecting member actuates the opening and closing of an air cock more or less forming the regulating member of the heavy product discharge. The tonnage of the products discharged into these jigs is in relation to the washing table area and in the installations where large outputs are to be treated, either very large jigs or several parallel ones must be adopted.

A drawback of the known jigs consists in the fact that the pulsation normally produces three different and combined results:

The classification of the products.

The discharge of the heavy products across the table.

The advancing of the superficial light products.

If the qualitative constitution of the products to be treated varies, and particularly if the percentage of heavy products in regard to that of the light ones lessens considerably, the float reacts and the intensity is considerably reduced, causing a slowing down of the advance of the light superficial products, while, in fact, their output effectively increases. Equally, this reduction of the intensity leads to a reduction of the classifying efficiency, which does not enable some heavy products to reach the lower layers.

Jigs are also known in which the discharge of the products is effected at the end of the table by outlets presenting a varying opening section according to the amount of heavy products to be discharged, these openings being governed by the handling of the washing tables

articulated on a horizontal axle which lifts or lowers itself, according to the amount of the product to be discharged.

A drawback of these sloping tables, particularly so far as filter bed washing jigs are concerned, is that they entail a travel of the feldspar in each of the squares, the result being that the pulsations and the discharge of heavy products are unequal. In certain cases it happens that the feldspar passes from square to square and is finally driven across the discharge sill.

The primary object of the present invention is to provide an improved jig for washing coal, ore, or other granular solid products for overcoming these drawbacks and defects.

Another object of the present invention is to provide an improved jig, as characterized above, having at least one washing compartment in which the discharge of the heavy products is effected across the washing table and through a chute extending transversely of the jig at the rear end of the table, and the rate of discharge of the heavy products is automatically adjusted in response to the amount of heavy products to be discharged.

Another object of the present invention is to provide an improved jig, as characterized above, having a plurality of washing compartments, each with a washing table having a chute at its rear end positioned to receive and evacuate the heavy products in the strata of products as they advance across the table, and means for automatically controlling the rate of discharge of heavy products through each chute in response to the amount of heavy products to be discharged in the strata of material on the table associated with the chute.

Another object of the present invention is to provide an improved washing jig, as characterized above, wherein the table in each succeeding compartment is positioned at an increased vertical height so that the forward edge of a table is at a higher level than that of the after edge of the preceding table, whereby products passing from a forward edge to an after edge of a table are separated at the level corresponding to the densimetric sections which are to be effectively treated upon the table.

A further object of the present invention is to provide an improved jig, as characterized above, wherein the means for automatically controlling the rate of discharge of products through the chute in each of the washing boxes includes a valve mounted in the chute operated by a hydraulic servo-motor device which, in turn, is actuated by the movement of a float detecting device which detects the amount of heavy products to be discharged.

Other objects and advantages of the invention will appear in the following description when considered in connection with the accompanying drawings, wherein:

Fig. 1 is a fragmentary diagrammatic elevational view, partly in cross section, of one embodiment of a washing jig constructed in accordance with the present invention;

Fig. 2 is an elevational view, partly in vertical cross section, of an interlocked feeder with a sensitive core;

Fig. 3 is a sectional view taken on the line 3—3 of Fig. 2;

Fig. 4 is a sectional view taken on the line 4—4 of Fig. 2; and

Fig. 5 is a fragmentary diagrammatic elevational view, partly in cross section, of a modified form of jig.

In general, the present invention provides an improved jig for washing granular mineral products such as coal and ore, or the like, comprising a plurality of washing compartments, each provided with a washing table comprising a perforate plate which may be covered with a layer of feldspar or the like and each communicating with an adjacent compartment provided with means for

pulsating the water filling the compartments up to a common level to cause an alternate up and down motion of the water, which lifts at a determined frequency, the washing bed which rests upon the perforated plate; means associated with each of the tables for removing the heavy products which pass across the table, including a chute extending transversely of the jig and positioned at the rear end of the table, a valve member mounted within the chute and operable to regulate the amount of heavy products passing therethrough, and means including a device which detects the amount of heavy products to be discharged from the table for automatically controlling the operation of the valve in the evacuating chute, whereby the discharge of heavy products is automatically adjustable in relation to the amount of heavy products to be discharged.

The invention further contemplates positioning the table in each succeeding washing compartment at increased vertical heights so that the forward edge of a table is at a higher level than that of the after edge of the preceding table, so that products passing from a forward edge to an after edge of the table are separated at the level corresponding to the densimetric sections which are to be effectively treated upon this table.

Referring now to the drawings, there is diagrammatically shown in Fig. 1, a jig embodying the improvements of the present invention. The jig is shown as comprising a tank or vat **10** provided with a plurality of washing boxes or compartments **11**, three such being shown, each having a washing table **12** mounted therein and each being adjacent to and in communication with a pulsation compartment (not shown) provided with any suitable usual means for pulsating the water in the washing boxes up and down through the washing table, the washing table in each washing box being positioned a predetermined height above the washing table in the preceding box; looking toward the entrance end of the jig; a plurality of valved evacuation chutes **13**, one for each washing compartment except the last, each extending transversely of the washing box and positioned below the rear end of the washing table, for evacuating the heavy products which cross the table; a plurality of operating devices indicated generally at **14**, each positioned and connected to actuate the valve in one of the chutes **13**; a plurality of detecting devices, indicated generally at **15**, each positioned to operate in one of the wash boxes to detect the amount of heavy products present therein; a hydraulic servo-motor system, indicated generally at **16**, including a plurality of fluid operated control devices **17**, each connected to control and actuate one of the devices for operating the valves in the evacuation chutes.

The products to be treated enter the jig by means of an inlet chute **18** and are stratified in the washing boxes **11** by the up and down motion of the pulsating water passing through the washing tables in the washing boxes, into layers of products having different specific gravities, with the heaviest products forming the bottom layer, the intermediate products the middle layer, and the light products the top layer in each washing box. As the heaviest products in each washing box advance across the table, some will pass through the interstices or openings in the washing table and the remainder will move across the table and be evacuated through the evacuation chute **13** positioned at the after end of the table. The amount of heavy products passing through the evacuation chutes **13** is controlled by means of a horizontal valve or shutter **19** extending the length of the chute and fixedly attached to a rod **20** for rotation therewith.

The operating devices **14** for actuating the valves or shutters **19** in the evacuation chutes are identical in construction, and, as shown in Fig. 1, each comprises a drive cylinder **21** suitably mounted on the jig frame; a piston **22** slidably mounted for up and down movement therein in response to hydraulic pressure on the top or bottom of the piston, a depending rod **23** connected at its upper end to the piston **22** and connected at its lower end to the axis rod **20** of the shutter **19** by means of a crank arm **24**.

The flow of hydraulic fluid to and from the top and bottom of each of the cylinders **21** is controlled by means of the detecting devices **15**, one of which is associated with each of the washing boxes and controls and actuates the control device **17** which, in turn, controls the flow of the hydraulic fluid to and from the cylinder associated therewith.

In this particular embodiment of the invention the detecting devices **15** are identical in construction, and, as shown, each comprises a float **25** connected to a rod **26** which, in turn, is mounted for up and down movement, as by means of vertically spaced parallel arms **27**, **28**. The lower arm **28** is pivotally connected at one of its ends to the rod **26** and has its other end pivotally connected to a support **29** suitably secured to the jig frame. The upper arm **27** has one end pivotally connected to the rod **26** and the other end connected to the control device **17**, in a manner hereinafter to be explained.

The hydraulic system **16** is shown as comprising a pressure pump **30** having its discharge line **31** connected to each of the control devices **17** and its suction connected to a tank **32**, and a return line **33** connected to each of the control devices **17** for returning the hydraulic fluid to the tank **32**.

The control devices **17** are identical in construction and, in this particular embodiment of the invention, each is shown as comprising a feeder member **34** mounted for rotary movement in the support **29** and having an integral arm **35** provided with a slot **36** in its outer end in which is slidably connected the upper end of a stem **37** connected to the piston **22** in the cylinder **21** for a purpose hereinafter to be explained.

Rotatably mounted within the feeder **34** is a cylindrical relay member **38**, and rotatably mounted within the outer end portion of the relay member **38** is a sensitive hub **39**, the outer end of which is fixedly attached to the outer end of the upper arm **27** connected to the float rod **26**. Thus, any up and down movement of the float rod **26** will result in angular movement of the sensitive hub **39**.

The sensitive hub **39** is provided with four circumferentially spaced recesses or grooves **40**, **41**, **42**, **43**, the surfaces between the recesses forming lands. Hydraulic fluid under pressure is admitted to and withdrawn from these recesses through eight circumferentially spaced radial holes **44**, **45**, **46**, **47**, **48**, **49**, **50** and **51**, formed in the outer end of the relay member **38** and through four circumferentially spaced radial holes **52**, **53**, **54**, **55**, formed in the outer end of the feeder **34** and by means of four circumferentially spaced recesses or grooves **56**, **57**, **58**, **59**, formed in the inner surface of the bore in the feeder **34** in which the relay member **38** is mounted (see Figs. 2 and 3).

Four circumferentially spaced radially and outwardly extending blades **60**, **61**, **62** and **63** are mounted on the outer end of the sensitive hub **38** and extend into the recesses **56**, **57**, **58** and **59**, respectively, for a purpose hereinafter to be explained.

Four circumferentially spaced radial bores or holes **64**, **65**, **66** and **67** are formed in the outer end portion of the feeder **34** and communicate with recesses **56**, **57**, **58** and **59**, respectively, formed on the inner surface of the bore in the outer end of feeder **34**. A pipe line **68** connects bores **64** and **67**, and a pipe line **69** connects bores **65** and **66**, all for a purpose hereinafter to be explained. A pipe line **70** connects bore **52** in member **34** to a source of oil under pressure and a pipe line **71** connects bore **54** to a source of oil under pressure, a pipe line **72** connects bore **55** to evacuate the oil, and a pipe line **73** connects bore **53** to evacuate the oil (see Fig. 3).

The inner end of the relay member **38** is provided with four circumferentially spaced troughs or recesses

74, 75, 76 and 77, the spaces between the recesses forming lands which slidingly and sealingly engage the surface of the bore of the feeder 34.

Oil under pressure is admitted to and withdrawn from these recesses through eight circumferentially spaced radial holes 78, 79, 80, 81, 82, 83, 84 and 85, formed in the inner end of the member 34. A pipe line 86 connects bore 85 to a source of oil under pressure and a pipe line 87 connects bore 81 to a source of oil under pressure. A pipe line 88 connects bore 84 to the bottom of the cylinder 21, and a pipe line 89 connects bore 80 to the bottom of the cylinder 21. A pipe line 90 connects bore 78 to the top of the cylinder 21, and a pipe line 91 connects bore 82 to the top of the cylinder 21. A pipe line 92 connects bore 79 to the return pipe line 33 leading to the oil tank 32, and a pipe line 93 connects bore 83 to the return pipe line 33 leading to the oil tank 32.

The operation of the device is as follows, assuming the various movable parts to be in the positions shown in Figs. 2, 3 and 4:

Then, an upward movement of the float rod 26 would, through angular movement of the upper arm 27, rotate the sensitive hub 39 clockwise, as viewed in Fig. 3, thereby uncovering the bores 44 and 48 in the member 38 and permitting oil under pressure to flow into the recesses 40 and 42 in the member 39, then through bores 51 and 47 in the member 38 into recesses 56 and 58 in the member 34. In recesses 56 and 58, the oil pressure acting against the blades 60 and 62 will cause a clockwise movement of the member 38 until the bores 44 and 48 are closed. During the clockwise movement of the member 38 the oil in recess 56, clockwise of the blade 60, is pushed by the blade through bore 64 in the member 34, pipe line 68 and bore 67 in the member 34 into recess 59 where it acts on the blade 63 to increase the clockwise motion of member 38. Similarly, the oil in recess 58 clockwise of the blade 62, is pushed by the blade through bore 66 in the member 34, pipe line 69 and bore 65 in the member 34 into recess 57 where it acts on the blade 61 to increase the clockwise motion of the member 38.

During the clockwise movement of the member 38, the oil in the recess 57 on the clockwise side of the blade 61 is pushed through bore 45 in the member 38 into recess 41 and then through bores 46 and 53 into pipe line 73, thence to pipe line 33, through which it passes to the tank 32. Likewise, during the clockwise movement of the member 38, the oil in recess 59 on the clockwise side of blades 63 is pushed by the blade through bore 49 in the member 38 into recess 43 and then through bores 50 and 55 into pipe line 72, thence through pipe line 33 through which it passes into the tank 32.

In like manner when the float rod 26 moves downward, the upper arm 27 rotates the sensitive hub 39 counterclockwise as viewed in Fig. 3, thereby uncovering the bores 44 and 48 in the member 38 and permitting oil under pressure to flow into recesses 41 and 43 in the member 38, then through bores 45 and 49 in the member 38 into the recesses 57 and 59 in the member 34. In the recesses 57 and 59 the oil pressure acting against the blades 61 and 63 will cause a counterclockwise movement of the member 38 until the bores 52 and 54 are closed. During the counterclockwise movement of the member 38, the oil in recess 57 on the counterclockwise side of the blade 61 will be pushed by the blade through bore 65 in the member 34, pipe line 69 and bore 66 in the member 34 into recess 58, where it acts on the blade 62 to increase the counterclockwise movement of the member 38. Similarly, the oil in recess 59 on the counterclockwise side of the blade 63 is pushed by the blade through bore 67 in the member 34, pipe line 68 and bore 64 in the member 34 into recess 56 where it acts on the blade 60 to increase the counterclockwise movement of the member 38. During the counterclockwise movement of the member 38, the oil in the recess 56 on the counterclockwise side of the blade 60 is pushed through bore 51 in the member 38 into recess 40 and then through bores 50 and 55 into pipe line 72, then to pipe line 33 through which it passes to the tank 32. Likewise, during the counterclockwise movement of the member 38, the oil in recess 58 on the counterclockwise side of the blade 62 is pushed by the blade through bore 47 in the member 38 into recess 42, then through bore 46 in member 38 and bore 53 in member 34 into pipe line 73, and thence through pipe line 33 to the tank 32.

Thus, it is seen that an upward movement of the float rod 26 causes the member 38 to move clockwise as viewed in Fig. 3, and a downward movement of the float rod 26 causes the member 38 to move counterclockwise.

Referring now to Figs. 2 and 4, it will be seen that when the member 38 is moved clockwise, as viewed in Fig. 4, the bores 81 and 85 in the members 34 are uncovered and oil under pressure is admitted into the recesses 75 and 77 and from these recesses passes through bores 80 and 84 and pipes 89 and 88 into a pipe line 89' leading to the bottom of the cylinder 21, causing piston 22 therein to move upward, thereby opening the valve or shutter 19. The upward movement of piston 22 forces the oil in the top of the cylinder through a pipe line 88' leading from the top of the cylinder to pipe lines 90 and 91 and bores 78 and 82, respectively, into recesses 74 and 76, respectively, and from these recesses out through bores 79 and 83 and pipe lines 92 and 93 into the pipe line 33, thence to tank 32.

As the piston moves upward, arm 35 is moved in a clockwise direction, causing feeder 34 to move in a clockwise direction until bores 81 and 85 in the member 34 are closed by the lands in members 38, i. e., the initial starting position, as shown in Fig. 4.

During the clockwise rotation of the feeder 34, the oil in the recesses of blades 60–63 acts on the blades to move them and thereby the member 38 in a clockwise direction. This rotation of the member 38 by the blades 60–63 results in an angular clockwise displacement between the member 38 and the sensitive hub 39. This angular clockwise movement of the member 38 relative to the hub 39 continues until bores 44, 46, 48 and 50 are open to communication with recesses 57, 58, 59 and 56, respectively, when the oil in recesses 56 and 58 will be forced out and oil under pressure admitted to recesses 57 and 59, thereby causing the member 38 to be moved in a counterclockwise direction until the bores 44, 46, 48 and 50 are again closed. This counterclockwise movement of the member 38 causes the bores 79, 81, 83 and 85 in the feed cylinder 34 to be closed, thus bringing the entire system back into immobilized balance.

In a similar manner, when the member 38 is moved in a counterclockwise direction, as viewed in Fig. 4, the bores 81 and 85 are uncovered and oil under pressure is admitted into the recesses 76 and 74, and from these recesses passes through bores 82 and 78 and pipes 91 and 90 into pipe line 88' and then into the top of the cylinder 21, causing piston 22 to move downwardly therein, thereby moving the valve or shutter 19 to closed position. The downward movement of the piston forces the oil in the bottom of the cylinder through pipes 88 and 89 and bores 84 and 80 into recesses 77 and 75, and from these recesses through bores 83 and 79 and pipes 93 and 92 and pipe line 33 into tank 32.

As the piston moves downwardly, the arm 35 is moved in a counterclockwise direction, causing the feeder 34 to move in a counterclockwise direction until the bores 81 and 85 in the member 34 are closed by the lands on the member 38, i. e., the initial starting position, as shown in Fig. 4.

During the counterclockwise rotation of the feeder 34, the oil in the recesses of blades 60–63 acts on the blades to move them and thereby the member 38 in a counterclockwise direction. This rotation of the member 38

by the blades 60–63 results in an angular counterclockwise displacement between the member 38 and the sensitive hub 39. This angular counterclockwise movement of the member 38 relative to the hub 39 continues until bores 44, 46, 48 and 50 are open to communication with recesses 56, 57, 58 and 59, respectively, when the oil in recesses 57 and 59 will be forced out and oil under pressure admitted to recesses 56 and 58, thereby causing the member 38 to be moved in a clockwise direction until the bores 44, 46, 48 and 50 are again closed. This clockwise movement of the member 38 causes the bores 79, 81, 83 and 85 in the feed cylinder to be closed, thus bringing the entire system back into immobilized balance.

Thus, it is seen that the floats 25 registering in each washing box the quantity of heavy products to be discharged, displace the sensitive hub 39 of the control device 17 associated therewith, which results in the operation of the feeder 34, the working of the piston 22, and the opening or closing of the shutter 19.

The sensitive hub 39, of very small dimensions, is perfectly balanced and, in effect, forms a sensitive relay serving to actuate the cylindrical member 38, the valved inner end of which in cooperation with the feeder member 34, in effect, forms a power relay controlling the flow of the hydraulic fluid to and from the cylinder 21 to drive the piston 22 therein and operate the valve 19.

In Fig. 5 there is shown a jig generally similar to the jig shown in Fig. 1, but provided with a modified form of detecting device, indicated generally at 15', and a modified form of control device, indicated generally at 17', for controlling the flow of the hydraulic fluid to and from the top and bottom of the cylinder 21' to thereby control the opening and closing of the shutter 19' mounted in the chute 13' by means of the up and down movement of the piston 22' in the cylinder 21' through the rod 23', and the crank arm 24'.

In this particular embodiment, each of the detecting devices 15' are identical in construction and, as shown, each comprises a float 25' connected to a rod 26' slidably mounted for up and down movement in a suitable support fixedly attached to the jig frame and with its upper end pivotally connected to one end of a lever 94 having its fulcrum 95 mounted on a support fixedly attached to the jig frame. The other end of the lever 94 is pivotally connected to the control device 17' in a manner hereinafter to be explained.

The hydraulic system is generally similar to that shown in Fig. 1 and comprises a pressure pump 30' having its discharge line 31' connected to the control device 17' and its suction connected to a tank 32', and a return pipe line 33' connected to the control device 17' for returning the hydraulic fluid to the tank 32'.

The control devices 17' are identical in construction and, as shown in Fig. 5, each comprises a jacket member 96 in the form of a hollow cylinder having a closed upper end and an open-ended enlargement 97 formed in its bottom end. The upper end of the jacket member 96 is pivotally connected to one end of a lever 98 having its fulcrum 99 mounted on a support fixedly attached to the jig frame. The other end of the lever 98 is provided with a slot in which is slidably connected the upper end of the piston stem 37' of the piston 22'.

Slidably mounted within the cylindrical jacket member 96 is a reciprocating feeder 100. The feeder 100 comprises, as a unitary member, a central solid cylindrical portion 101 extending through the enlarged open-ended portion 97 of the jacket 96 and provided with an integral collar 102. An upstanding stem 103 is secured to the upper end of the feeder 100 and has fixedly secured thereto vertically spaced piston-like members 104 and 105. The lower portion of the feeder 100 is hollow to provide a cylinder 106 in which is slidably mounted a vertically spaced pair of pistons 107 and 108 carried by a stem 109, the bottom end of which is pivotally attached to the forward end of the lever 94.

The top and bottom portions of the cylinder 21' are connected to the upper end of the jacket member 96 by means of flexible pipe lines 110 and 111. The enlarged portion 97 of the jacket member 96 is connected to the cylinder 106 in the bottom end portion of the feeder 100 by means of flexible pipe lines 112 and 113. A manifold pipe 114 is connected to return pipe line 33', which, in turn, is connected to the tank 32'. The manifold pipe line 114 has two branch pipe lines 115 and 116 connected to the top and bottom portions of the upper portion of the jacket member 96 and two flexible branch pipe lines 117 and 118 connected to the top and bottom portions of the cylinder 106 formed in the bottom portion of the feeder 100.

A pipe line 119, connected to the discharge pipe line 31' of the pump 30' has an upper branch pipe line 120 connected to the intermediate portion of the upper portion of the jacket member 96 and a lower flexible branch pipe line 121 connected to the intermediate portion of the cylinder 106 formed in the bottom portion of the feeder 100.

The operation of the device is as follows; assuming the various movable parts to be in position as shown in Fig. 5:

The hydraulic fluid maintained under pressure by the pump 30' is admitted to the space within the jacket cylinder 96 between the upper and lower piston valves 104 and 105, through pipe lines 31', 119 and branch pipe line 120, and is admitted to the space within the cylinder 106 between the upper and lower piston valves 107 and 108 through pipe lines 31', 119 and flexible branch pipe line 121. The system is now in balance and all moveable parts are immobilized with the position of the valve 19' corresponding to the position of the float 25'.

Now, a downward movement of the float 25' would result in an upward movement of the sensitive feed valves 107, 108, thereby permitting a flow of oil under pressure through flexible pipe line 113 into the enlarged cylindrical portion 97 of the jacket member 96 below the collar 102 on the member 101, thereby forcing the member 101 upwardly. As the member 101 moves upwardly the oil in the enlarged cylindrical portion 97 above the collar 102 will be forced through flexible pipe line 112 into the space within the cylinder 106 below the piston valve 108 and out through flexible branch pipe line 118, pipe line 114, into pipe line 33' and thence into tank 32'. As the member 101 moves upward, the distributive valves 104, 105 carried by the member move upwardly, thereby permitting the oil under pressure to flow through flexible pipe line 110 into the top of the cylinder 21', forcing the piston 22' downward in the cylinder. As the piston 22' moves downward the valve 19' will be moved toward its closed position.

As the piston 22' moves downward in the cylinder 21', the oil in the cylinder below the piston will be forced through flexible pipe line 111 into the space within the jacket cylinder 96 below the piston valve 105 and out through branch pipe line 116, pipe line 114 into pipe line 33', and thence back into tank 32'.

The downward movement of the piston 22' will, through lever 98, cause the jacket member 96 to be moved upward until the flow of fluid through pipe lines 110 and 111 is closed off by valves 104 and 105 and the flow of fluid through pipe lines 112 and 113 is closed off by the valves 108 and 107; then, the system will become immobilized with the valve 19' held in a position corresponding to the new position of the float 25'.

During the upward movement of the jacket member 96, the oil trapped between the piston 102 and the bottom of its cylinder interlocks the member 100 and the jacket member 96 and both members move upwardly while the valves 107 and 108 remain stationary until such upward movement brings pipe line 113 into position above the valve 107, thereby permitting the trapped oil to pass into the cylinder 100 above the valve 107 and

from there through pipe line 117 back to the tank 32' and, at the same time, pipe line 112 will be positioned above the valve 108, thereby permitting oil under pressure to pass into the cylindrical portion 97 above the piston valve 102 and force the piston valve downwardly until the openings to pipes 110, 111, 112 and 113 are closed by the valves 104, 105, 108, and 107, respectively, thus bringing the system back into immobilized balance.

In like manner, when the float rod 26' is moved upwardly by the float 25', the sensitive feed valves 107 and 108 will be moved downwardly, thereby permitting a flow of oil under pressure through flexible pipe line 112 into the enlarged cylindrical portion 97 of the jacket member 96 above the collar 102 on the member 101, thereby forcing the member 101 downwardly.

As the member 101 moves downwardly, the oil within the enlarged cylindrical portion 97 below the collar 102 will be forced through flexible pipe line 113 into the sapce within the cylinder 106 above the piston valve 107 and out through flexible branch pipe line 117, pipe line 114 into pipe line 33' and thence into tank 32'.

Also, as the member 101 moves downwardly, the distributive valves 104, 105 carried by the member move downwardly, thereby permitting oil under pressure to flow through flexible pipe line 111 into the bottom of the cylinder 21', forcing the piston 22' upwardly in the cylinder. As the piston 22' moves upwardly, the valve 19' will be moved toward its open position.

As the piston 22' moves upwardly in the cylinder 21', the oil in the cylinder above the piston will be forced through flexible pipe line 110 into the space within the jacket cylinder 96 above the piston valve 104 and out through branch pipe line 115, pipe line 114 into pipe line 33' and thence back into tank 32'.

The upward movement of the piston 22' will through lever 98, cause the jacket member 96 to be moved downward until the flows of fluid through pipe lines 110 and 111 are cut off by the valves 104 and 105, and the flows of fluid through pipe lines 112 and 113 are closed off by the valves 108 and 107; then the system will again become immobilized with the valve 19' held in a position corresponding to the new position of the float 25'.

During the downward movement of the jacket member 96 the oil trapped between the piston 102 and the top of its cylinder interlocks the member 100 with the jacket member 96 and both members move downwardly, while the valves 107 and 108 remain stationary until such movement brings pipe line 112 into position below the valve 108, thereby permitting the trapped oil to pass into the cylinder 100 below the valve 108 and from there through pipe line 118 back to the tank 32', and, at the same time, pipe line 113 will be positioned below the valve 107, thereby permitting oil under pressure to pass into the cylindrical portion 97 below the piston valve 102 and force the piston valve upwardly until the openings to pipe lines 110, 111, 112, and 113 are closed by the valves 104, 105, 108 and 107, respectively, thus bringing the system back into immobilized balance.

In this embodiment of the invention, the slide valves 107 and 108, in effect, form a sensitive relay which actuates the valves 104 and 105 which, in effect, form the power relay which controls the flow of the hydraulic fluid to and from the cylinder 21'.

From the foregoing, it will readily be seen that there has been provided a novel and improved jig for washing coal, ore, and similar solid products having a plurality of washing compartments each provided with a washing table having a valved discharge chute extending along its rear edge for the evacuation of the heavier products which pass across the table, and hydraulic control means operative in response to the amount of heavy products to be discharged from the table, as determined by a detecting device, for controlling the operation of the valve in the discharge chute.

Obviously, the invention is not restricted to the particular embodiments thereof herein shown and described.

What is claimed is:

1. A double stage servo-motor for controlling the movement and the direction thereof of a hydraulically driven member comprising a power relay including movable valve means mounted in a movable feed cylinder for controlling the flow of fluid under pressure to move said driven member in either of two directions determined by the displacement of said valve means; a sensitive relay for actuating said power relay including a second valve means movable in either of two directions to cause by hydraulic means commensurate movement in the same direction of said first named valve means; and means actuatable by the movement of said driven member for moving said movable feed cylinder to shut off the flow of hydraulic fluid through said power relay when said driven member has effected a movement commensurate with the movement of said second named movable valve means.

2. Apparatus as set forth in claim 1, wherein said movable feed cylinder is mounted for substantially rectilinear reciprocatory movement; and said first named and second named movable valve means are reciprocatory slide valves.

3. Apparatus as set forth in claim 1, wherein said movable feed cylinder is mounted for substantially rectilinear reciprocatory movement; wherein said first named movable valve means includes a piston valve mounted in said feed cylinder and having a stem formed on its upper end carrying a pair of spaced valves and a cylindrical chamber formed on its lower end; and wherein said second named valve means includes a stem carrying a pair of slide valves mounted within said cylindrical chamber.

4. A double stage servo-motor for controlling the movement and the direction thereof of a hydraulically driven member comprising a power relay including a cylindrical valve rotatably mounted in a rotatable feed cylinder journaled in a fixed bearing for controlling the flow of fluid under pressure to move said driven member in either of two directions determined by the angular displacement of said valve; a sensitive relay for actuating said power relay including a rotatable balanced core operative when angularly displaced in either direction to cause by hydraulic means an equal angular displacement in the same direction of said cylindrical valve; and means actuatable by the movement of said driven member for rotating said feed cylinder to shut off the flow of hydraulic fluid through said power relay when said driven member has effected a movement commensurate with the angular displacement of said balanced core.

5. A double stage servo-motor as set forth in claim 4, wherein said feed cylinder is provided with a plurality of circumferentially spaced radial ports adjacent its inner end, and said cylindrical valve comprises an elongated cylindrical member having a plurality of circumferentially spaced recesses formed in its outer surface adjacent its inner end and positioned to communicate with said ports as said valve is angularly displaced relative to said feed cylinder.

6. A double stage servo-motor as set forth in claim 5, wherein said feed cylinder is provided with a plurality of circumferentially spaced radial ports adjacent its outer end and has a plurality of circumferentially spaced recesses formed in its inner wall, one positioned between each pair of said radial ports in said outer end; wherein said cylindrical valve carries a plurality of circumferentially spaced upstanding radial blades on its outer end portion, each positioned to extend into one of said recesses formed on the inner wall of said feed cylinder and has a plurality of circumferentially spaced radial ports formed in its outer end opening into an axially extending recess formed therein; and wherein said balanced core is rotatably mounted in the axial recess formed in the outer end of said cylindrical valve and has a plurality of circumferentially spaced recesses formed on its outer surface positioned to be brought into communication with the radial

ports formed in said cylindrical valve as said core is angularly displaced, said core having means formed on its outer end adapted to be connected to an externally actuated member for angular displacement by said member as it is actuated.

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