Sept. 5, 1961 K. B. TRIEBEL 2,998,781

PUMP FOR PLASTIC CONCRETE

Filed Nov. 28, 1960 3 Sheets-Sheet 1

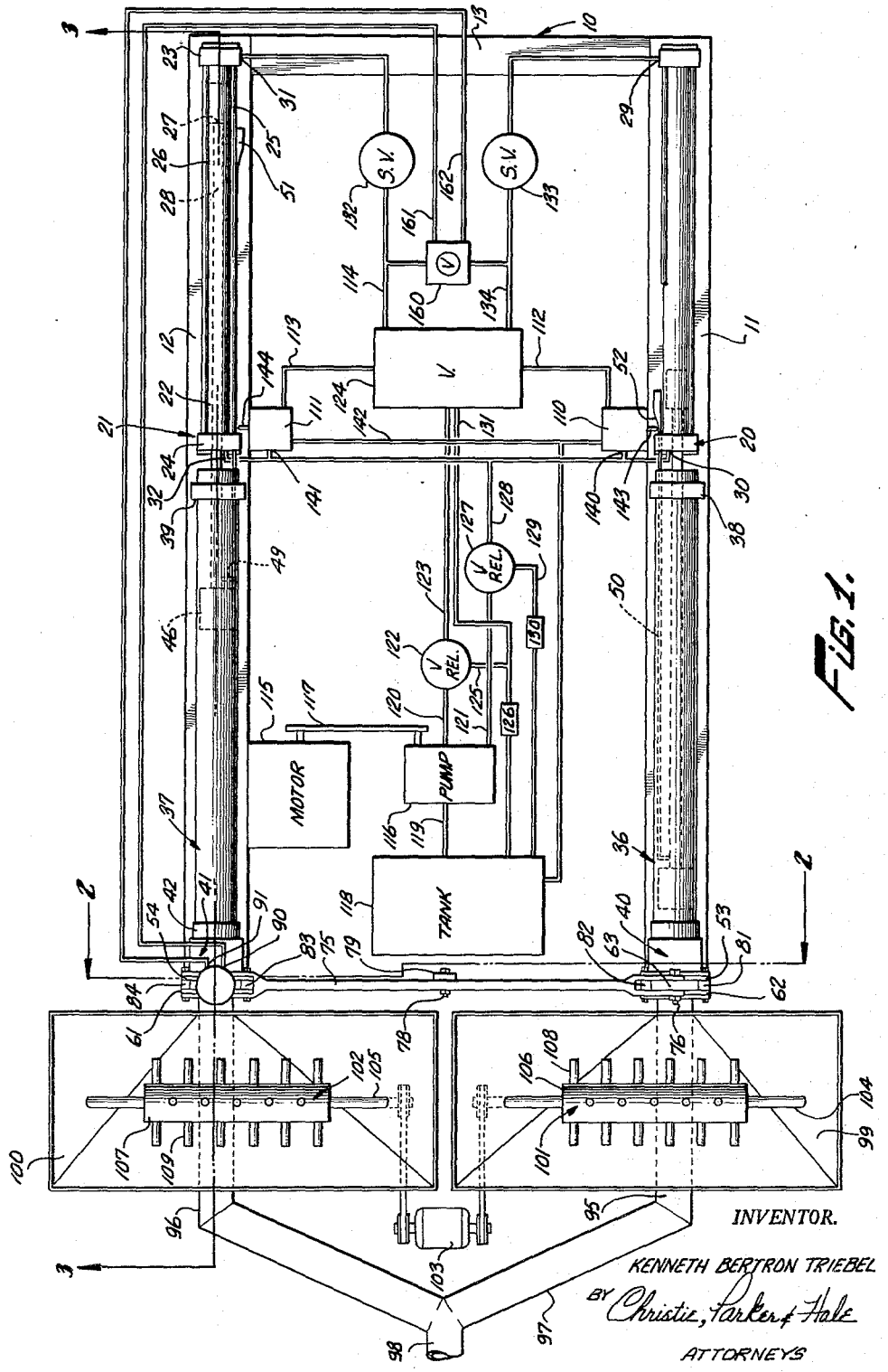

Fig. 1.

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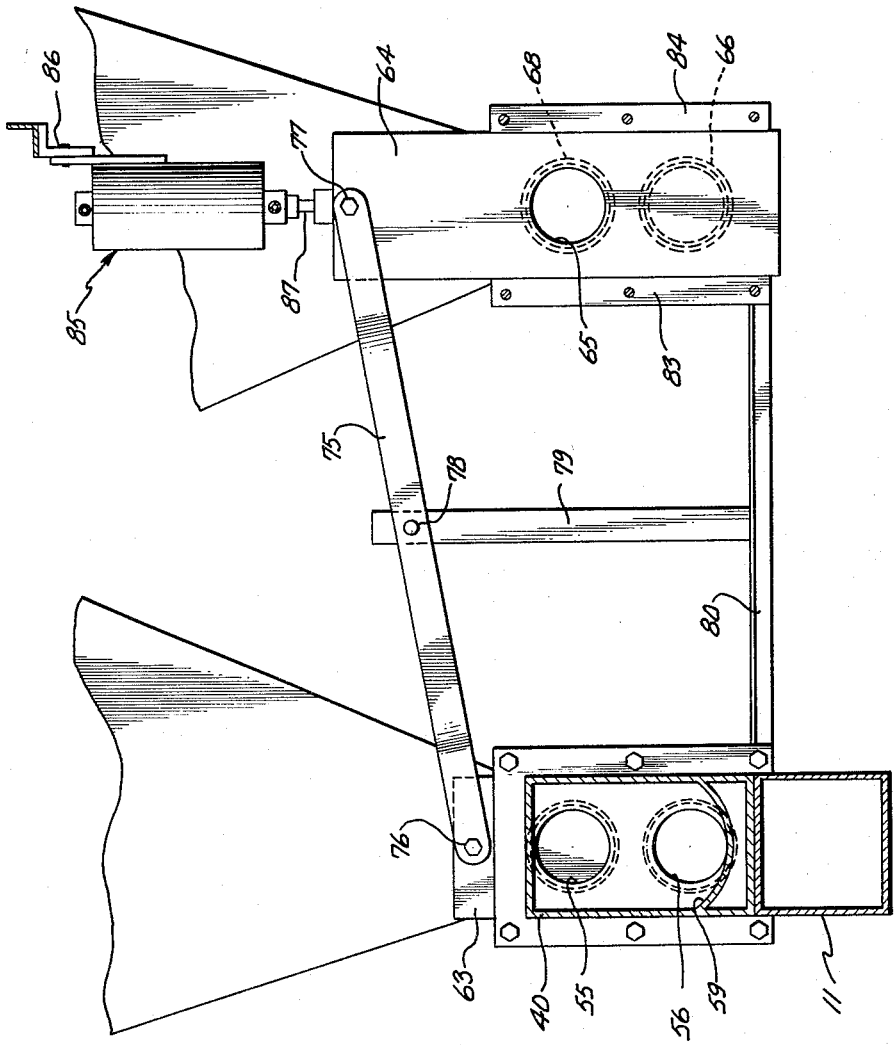

Fig. 2.

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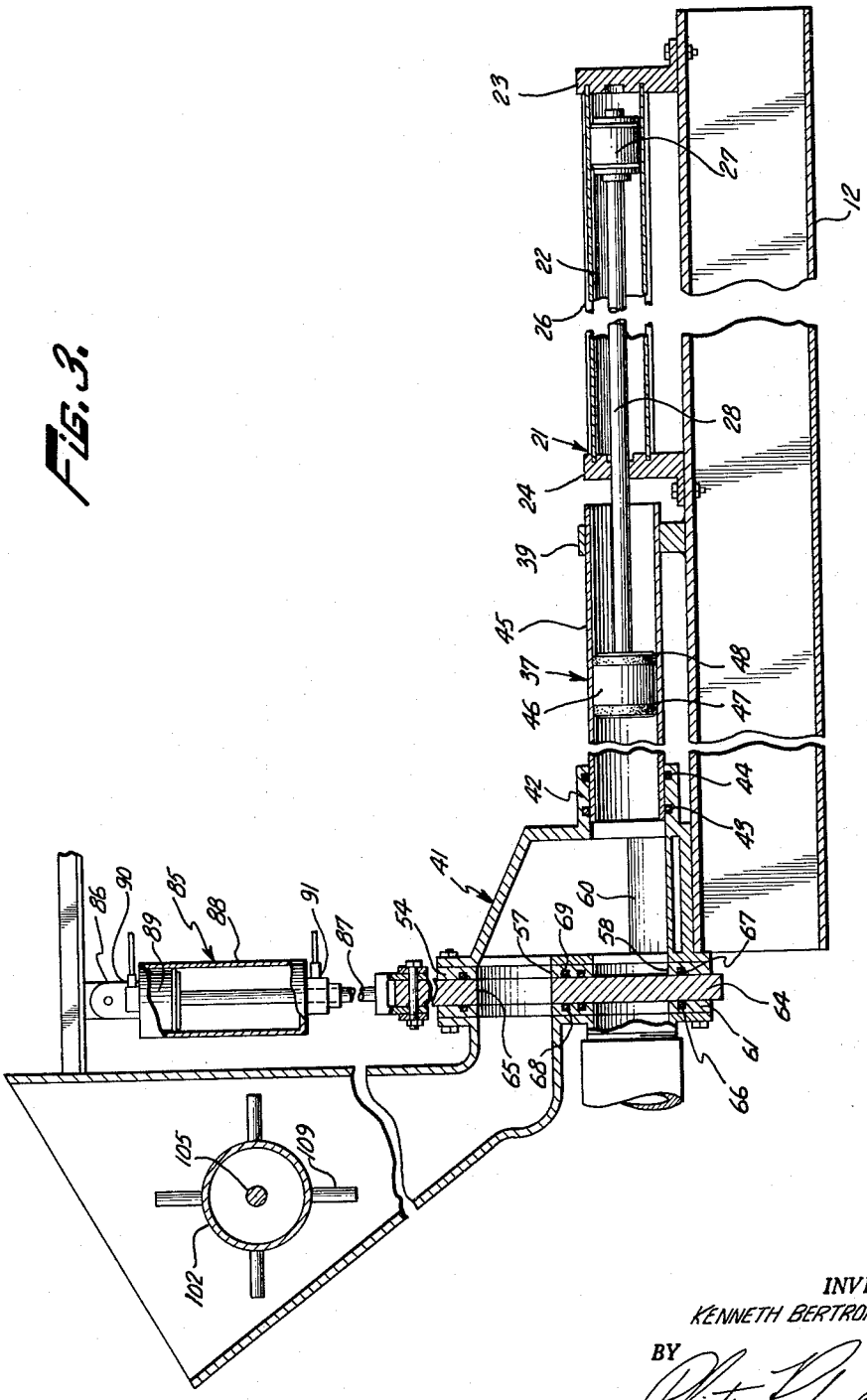
FIG. 3.



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2,998,781

PUMP FOR PLASTIC CONCRETE

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Filed Nov. 28, 1960, Ser. No. 72,239
8 Claims. (Cl. 103—49)

The invention relates to pumps for pumping thick pasty masses such as concrete or other cementitious materials in plastic state, and particularly to such pumps of the reciprocating piston type.

The pumping of plastic concrete and other plastic cementitious materials presents special problems because of the very viscous and granular nature of such materials. Particular difficulty has been experienced in some conventional concrete pumps in the valving of the inlet and outlet ports of the pump. Ball valves and the like used within the inlet and outlet passageways obstruct the area for flow of concrete and thus tend to produce clogging of such passageways. Various types of complicated rotary valves have been utilized, but these valves may present narrow passageways, often with bends, which inhibit free flow of concrete through the valve.

Another problem in some conventional concrete pumps is the absence of means whereby the discharge pressure and flow rate of the concrete may be varied and selected as desired.

The inventive apparatus comprises a concrete pump which does not present the above disadvantages and problems. The pump effectively handles concrete with coarse aggregate, up to an inch or two in size, without clogging, and embodies valve structure for the inlet and outlet ports of the pump which is anti-clogging due to the absence of constrictive passageways and the absence of valve members disposed within such passageways, as well as due to the design and operation of such valve structure as described below. The inventive apparatus also provides means whereby the discharge pressure and flow rate of the concrete may be selected as desired.

The inventive apparatus includes broadly a pair of spaced pump cylinders in fixed position, valve guides on one end of each pump cylinder defining linearly aligned and spaced inlet and outlet ports communicating through the valve guides between the interior of the pump cylinder and the exterior of the valve guides, a concrete supply hopper connected to each inlet port in the valve guides, a discharge conduit connected to each outlet port in the valve guides, a valve slide disposed slidably on the valve guides for reciprocative movement of the valve slide, the valve slide defining an opening aligned with the inlet and outlet ports in the valve guides, means for intermittently moving each valve slide in opposite directions alternately to align the opening in each valve slide alternately with the inlet port and the outlet port in the valve guides associated therewith and for simultaneously moving both valve slides in opposite directions relative to each other, means for reciprocating the pistons in the pump cylinders, means for synchronizing and phasing the reciprocative movement of the pistons in the pump cylinders so that they simultaneously move in opposite directions and in opposite phase, and means for synchronizing and phasing the movement of the pistons in the pump cylinders with movement of the valve slides so that during the discharge stroke of one pump cylinder the valve slide associated therewith is disposed with its opening aligned with the outlet port in the valve guides associated therewith and the other valve slide is positioned with its opening aligned with the inlet port in the valve guides associated therewith.

The invention will be understood from a reading of the following description in conjunction with the accompanying drawings, in which:

FIG. 1 shows a schematic plan view of the inventive apparatus;

FIG. 2 is a fragmentary sectional view along the line 2—2 in FIG. 1; and

FIG. 3 is a fragmentary sectional view along the line 3—3 in FIG. 1.

Referring to FIG. 1, the reference numeral 10 designates a frame on which the apparatus is mounted. The frame 10 includes parallel longitudinal side girders 11 and 12 and end cross girder 13, as well as such additional cross girders and braces (not shown) as may be necessary to produce desired rigidity and strength. For convenience in moving the apparatus, the frame 10 may be mounted on wheels or skids in conventional manner.

A pair of hydraulic main cylinders 20 and 21 are mounted on frame 10 in fixed position near one end thereof, one main cylinder on side girder 11 and the other main cylinder on side girder 12. The main cylinders 20 and 21 are identical and conventional. They are double-acting hydraulic cylinders and, if desired, may have a conventional hydraulic cushion at each end. For example, each main cylinder may be a "Vickers Incorporated" hydraulic cylinder model WA–2222–H–20. Each main cylinder includes, as shown for main cylinder 21, a cylinder barrel 22 closed at one end with a head end cap 23 and at its other end with a rod end cap 24 secured on the barrel by means of tie rods, such as indicated at 25 and 26, extending between and fixed to the end caps. A piston 27 is disposed slidably within the barrel 22 with a double fluid seal for fluid pressure from either side of the piston in order that the piston is double acting. The piston 27 is fixed to a piston rod 28 which extends through and is slidably mounted in the rod end cap 24. A conventional fluid seal (not shown) is effected between the rod end cap 24 and the piston rod 28. The main cylinders 20 and 21 are fixed to frame 10 in parallel relation and are aligned with each other in a direction transverse to their parallel extent. The head end cap and rod end cap of each main cylinder have internal ports in order that hydraulic fluid under pressure can be admitted to the head end and rod end of each cylinder at 29 and 30 for main cylinder 20 and at 31 and 32 for main cylinder 21.

A pair of pump cylinders 36 and 37 are mounted in fixed position on frame 10. The pump cylinder 36 is mounted on side girder 11 coaxially with main cylinder 20, and pump cylinder 37 is mounted on side girder 12 coaxially with main cylinder 21. Each pump cylinder is mounted with its rod end adjacent to and spaced from the rod end of its coaxial main cylinder. The pump cylinders 36 and 37 are parallel and aligned with each other in a direction transverse to their parallel extent. The rod end of each pump cylinder adjacent its coaxial main cylinder is mounted on the side girder in fixed position by means of a conventional support 38 for pump cylinder 36 and support 39 for pump cylinder 37. The other end, or head end, of each pump cylinder extends within a separate valve chamber with the full extent of the bore of the pump cylinder open to the valve chamber, these valve chambers being indicated at 40 for pump cylinder 36 and 41 for pump cylinder 37. As best shown in FIG. 3, the head end of pump cylinder 37 is received within valve chamber 41 by a collar 42 on the valve chamber. Conventional O-rings 43 and 44 effect a seal between the pump cylinder and collar 42 which permits slight movement of the pump cylinder 37 relative to the valve chamber 41 in order to absorb vibrations of the apparatus in operation. The two pump cylinders are identical in structure, and, as best shown in FIG. 3 for pump cylinder 37, include a cylinder barrel 45 open at its rod end and within which is slidably

mounted a piston 46 connected to the end of piston rod 28. Conventional cup seals 47 and 48 effect a sliding seal between piston 46 and cylinder barrel 45. It is thus apparent that reciprocative motion of piston 27 in main cylinder 21 is transmitted directly to pump piston 46 in the pump cylinder by means of connecting rod 28 extending between the two. As best shown in FIG. 1, a trip arm 49 is fixed to piston rod 28 at a point adjacent piston 46 and extends within cylinder barrel 45 through its open rod end and along main cylinder 21. Suitable guides (not shown) may be provided adjacent main cylinder 21 to carry trip arm 49 and permit it to reciprocate synchronously with piston 46 in the pump cylinder. A similar trip arm 50 is provided for pump cylinder 36. At the end of each trip arm 49 and 50 is a cam portion 51, 52, respectively, the function of which will be described below.

The valve chambers 40 and 41 are fixed on side girders 11 and 12, respectively, in conventional manner at the end of frame 10 opposite the end thereof at which the main cylinders are mounted. A pair of valve guides 62, 53 is mounted on valve chamber 40 and a similar pair of valve guides 61, 54 is mounted on valve chamber 41. Each pair of valve guides is axially spaced from the pump cylinder connected to its valve chamber and extends vertically at right angles to the axis of such pump cylinder to close the end of the valve chamber remote from the pump cylinder. The valve guides 53, 54 define circular inlet ports 55, 57, respectively, extending through them and circular outlet ports 56, 58, respectively, also extending through them. The inlet and outlet ports 55, 56 in valve guide 53 are linearly aligned along a straight line passing through their centers and are vertically spaced from each other along such axis of alignment, and the inlet and outlet ports 57, 58 in valve guide 54 are similarly aligned and are spaced from each other in the same manner and the same amount as the inlet and outlet ports 55, 56. The surface of valve guides 53, 54 opposite the interior of their respective valve chambers 40, 41 is planar. The valve guides 62, 61 on valve chambers 40, 41, respectively, are each spaced from valve guides 53, 54, respectively, in a direction parallel to the axis of the pump cylinder and define circular inlet and outlet ports geometrically congruent to and aligned with the inlet and outlet ports in valve guides 53 and 54, respectively. The surface of valve guides 62, 61 juxtaposed and adjacent to the planar exterior surface of valve guides 53, 54, respectively, is planar and is parallel to such planar surface of valve guides 53, 54, respectively. Each pair of valve guides 53, 62 and 54, 61 are secured together along their vertical edges in conventional manner by means of bolts and spacers 81, 82 for valve guides 53, 62 and spacers 83, 84 for valve guides 54, 61 so that the spacing of the juxtaposed planar surfaces of the valve guides and the parallel relationship of such surfaces is maintained. The spacers 81, 82 and 83, 84 also have inside vertical edges which are parallel to the axis of alignment of the inlet and outlet ports and spaced from each other to guide the valve slides as explained below. Each valve chamber has a curved bottom approximately tangent to the outlet port 56 or 58 for that chamber in order to inhibit solidification of cement in the bottom of the valve chamber, as shown at 59 for valve chamber 40 and at 60 for valve chamber 41. The valve chambers have a substantial extent axially of their respective pump cylinders in order to facilitate reversal of direction of flow of plastic concrete entering the valve chamber through the inlet port and discharged therefrom through the outlet port. Due to the viscous nature of plastic concrete, this relatively large volume provided for reversal of the direction of flow of such substance is an important feature and contributes considerably to proper operation of the apparatus. Moreover, the outlet ports 56, 58 for valve chambers 40, 41, respectively, are coaxial with pump cylinders 36, 37, respectively, connected to the valve chamber in order that plastic concrete drawn into the valve chamber and into the bore of the pump cylinder as a result of the piston in the pump cylinder moving away from the valve chamber on its intake stroke is discharged in a lineal direction directly from the pump cylinder through the outlet port without any change in direction of flow when the piston in the pump cylinder is on its discharge stroke by moving toward the valve chamber. This feature also contributes considerably to proper operation of the apparatus. It is to be understood that the valve guides may be mounted directly on the pump cylinders so that the head end of the bore of each pump cylinder functions as the valve chamber.

Identical valve slides 63 and 64 are disposed between valve guides 53, 62 and 54, 61, respectively. Each valve slide has planar parallel surfaces which slidably engage the juxtaposed parallel planar surfaces of the valve guides between which the valve slide is disposed. Each valve slide is mounted in its valve guides for reciprocative movement in a direction parallel to the axis of alignment of the inlet and outlet ports in such guides and is elongated in the direction of such axis of alignment so that it at all times during operation of the apparatus extends over both the inlet and outlet ports in the valve guides and exteriorly of such guides. The edges of each valve slide 63, 64 in the direction of the elongate extent of the valve slide are parallel and slidably engage the spacers 81, 82 and 83, 84, respectively, so that the direction of reciprocative movement of the valve slide is constrained to a direction parallel to the axis of alignment of the inlet and outlet ports. Each valve slide defines a circular opening extending through it between its parallel planar surfaces which is geometrically congruent to the inlet and outlet ports in the valve guides and is aligned with such ports along their axis of alignment. The opening in valve slide 64 is indicated at 65, and a similar opening is formed in valve slide 63. Each valve slide extends on both sides of the opening therein in a direction parallel to the axis of alignment of the inlet and outlet ports in the valve guides an amount which is greater than the spacing of the inlet and outlet ports along their axis of alignment so that when the opening in the valve slide is aligned with either the inlet port or the outlet port in the valve guides, a solid portion of the valve slide extends over the other portion the valve guides with which the opening in the valve slide is not aligned. Thus, reciprocative movement of each valve slide aligns the opening in the valve slide alternately with the inlet and outlet ports in its valve guides and also alternately blocks or closes the inlet and outlet ports therein. The valve guides and valve slides are heavy plate steel members and the openings and ports through them form a clean edge with their planar surfaces so that concrete aggregate which may be caught between the valve guides and a valve slide during reciprocative movement of the valve slide is subjected to a powerful shearing action due to the movement of the valve slide and is effectively sheared so that it does not block the movement of the valve slide relative to its guides and thus jam operation of the appartus. The surfaces of sliding engagement between the valve guides and the valve slides are suitably hardened or chrome plated in order to provide a wear-resistant slidable engagement. As best shown in FIG. 3 for valve slide 64, a seal is provided between the valve slide and its valve guides by means of O-rings 66 and 67 disposed in circular recesses in the juxtaposed planar surfaces of valve guides 54 and 61 and surrounding outlet port 58 of valve chamber 41, and similar O-rings 68 and 69 are received in similar circular recesses surrounding inlet port 57 of the valve chamber. These O-rings are made of "Teflon," neoprene, or natural rubber and engage the valve slide to effect a seal between the valve slide and its guides to prevent leakage from the inlet and outlet ports. Similar O-rings are provided for the valve guides on valve chamber 40. As an alternative to the use of O-rings, the planar juxtaposed surfaces of the valve guides against

which the valve slide slides may be planarly faced with neoprene or rubber and the valve slide disposed between such planar faced surfaces in sliding engagement therewith.

A valve lever 75 extends between valve slides 63 and 64 and has its opposite ends pivotally attached at 76, 77, respectively, to the top of each valve slide. The pivotal attachment of the ends of the valve lever 75 to the top of each valve slide may be by means of a pivot pin extending through receiving holes in the valve lever and valve slides. Such receiving holes in the valve lever are elongated slightly in the direction of the length of the valve lever to compensate for arcuate movement of its ends as it pivots about a pivot mount 78 at its center. The valve lever 75 is pivotally mounted at its center at 78 on a support 79 fixed to a cross brace 80 extending between side girders 11 and 12. The single opening in each valve slide, such as the opening 65 in valve slide 64, are each spaced the same amount from the pivot points 76 and 77 so that when the opening in the valve slide 63 is aligned with outlet port 56 of valve chamber 40, the similar opening in valve slide 64 is aligned with inlet port 57 of valve chamber 41, and the inlet port of valve chamber 40 and outlet port of valve chamber 41 are blocked by the solid portion of their respective valve slides and therefore closed, as illustrated in FIGS. 2 and 3.

Attached to valve lever 75 is a hydraulic valve cylinder 85 which is mounted in fixed position by means of a conventional support bracket 86. The valve cylinder 85 is conventional and has a piston rod 87 which extends within a cylinder barrel 88 and is fixed to a piston 89 slidably received within the cylinder barrel in fluid sealed relation. As illustrated, piston rod 87 is pivotally attached to valve lever 75 at 77 coincident with the pivotal attachment of the valve lever to valve slide 64. The fluid seal between piston 89 and cylinder barrel 88 seals against fluid pressure on both sides of the piston so that the valve cylinder is double acting, as described above in connection with main cylinders 20 and 21. Fluid under pressure is admitted to the head end of the valve cylinder through a port at 90 and to the rod end thereof through a port at 91. Thus, alternately pressurizing opposite ends of the valve cylinder results in reciprocative movement of piston 89 within cylinder barrel 88 and consequently oscillatory movement of valve lever 75 about its pivot mount 78. This oscillatory movement of valve lever 75 results in valve slides 63 and 64 simultaneously reciprocating vertically in opposite phase, that is, in opposite directions relative to each other and with simultaneous reversals of direction of motion. The stroke of valve cylinder 85 is equal to the spacing between the inlet and outlet ports of each valve chamber along their vertical axis of alignment so that the opening in each valve slide is alternately aligned with the inlet and outlet port in the valve guides associated therewith. It is apparent that valve cylinder 85 may have a different stroke, and, through suitable linkage within the province of one skilled in the art, the amplitude of oscillatory movement of the valve lever and hence the magnitude of reciprocative displacement of each valve slide may be set at an amount equal to the spacing between the inlet and outlet ports of each valve chamber measured along their axis of alignment.

Discharge pipes 95 and 96 are connected to outlet ports 56, 58 of valve chambers 40 and 41, respectively, by means of conventional attachment to the exterior of valve guides 62 and 61, respectively. The discharge conduits 95 and 96 are connected by a Y 97 to a single discharge pipe 98. Concrete hoppers 99 and 100 are connected to inlet ports 55, 57 of valve chambers 40, 41, respectively, by means of conventional attachment to the exterior of valve guides 62 and 61, respectively. The concrete hoppers 99, 100 are conventional and have inclined sides which converge from a large entrance opening to a relatively small discharge outlet at the bottom of the hopper which is connected to the inlet port of the appropriate valve chamber, as described above. Rotatably mounted within each hopper 99, 100 is an agitator 101, 102, respectively. As shown schematically in FIG. 1, the agitators 101, 102 consist of shafts 104, 105, respectively, rotatably mounted in hoppers 99, 100, respectively, on which is mounted a concentric cylindrical hub 106, 107, respectively. A plurality of spokes extend radially from each hub, such as spoke 108 on hub 106 and spoke 109 on hub 107. The shafts 104, 105 of the agitators extend to the exterior of hoppers 99, 100 and, by means of a belt and pulley drive, are connected to a motor 103 which rotatively drives the agitators. It is to be understood that other motive means for rotatively driving the agitators may be provided. The function of the agitators is to facilitate flow through the discharge outlet of the hoppers and through the inlet ports of the valve chambers of plastic concrete placed in the hoppers.

The apparatus is hydraulically operated. The hydraulic system is illustrated schematically in FIG. 1. The several elements of the hydraulic system are mounted on various conventional supports attached to side girders 11 and 12 of frame 10, which supports are omitted from the drawings for clarity. A motor 115, which may be an electric motor or an internal combustion engine, is connected to a positive displacement double discharge hydraulic pump 116 by conventional means 117, such as a clutch and belt drive. The pump 116 receives conventional hydraulic fluid from a supply tank 118 through conduit 119 and discharges through conduits 120 and 121 on the pressure side. The pump 116 is conventional and, for example, a "Vickers Incorporated" double hydraulic pump model No. V2234–11–2-1CC–20 has been found satisfactory. The discharge conduit 120 is connected to a conventional relief valve 122, a "Vickers Incorporated" relief valve model No. CT–06–B–10 having been found satisfactory. The relief valve 122 is set for a preselected discharge pressure within the range of 800 to 1000 pounds per square inch through high pressure conduit 123 to a pilot controlled four-way main valve 124. The over-pressure discharge conduit 125 of relief valve 122 is connected to supply tank 118 through a conventional filter 126. The fluid pressure in conduit 123 is relatively high and is hereinafter referred to as high pressure. The other discharge conduit 121 of pump 116 is connected to a relief valve 127 identical to the above described relief valve 122 and discharges therefrom through conduit 128 at a relatively low preselected pressure of about 300 pounds per square inch, which is hereinafter referred to as secondary pressure. The over-pressure discharge conduit 129 of relief valve 127 discharges to tank 118 through a filter 130 in the same manner as described above for the conduit 125 of relief valve 122. The relief valves 122, 127 are utilized to control the pressure and discharge rate of concrete from the apparatus by setting them at such preselected pressures as will produce the desired discharge rate and pressure of concrete. The main valve 124 is actuated by pilot valves 110, 111 which supply secondary pressure to the main valve 124 through pilot conduits 112 and 113, respectively. The main valve 124 functions to connect simultaneously the high pressure conduit 123 with the main cylinder conduit 114 and the main cylinder conduit 134 with a discharge conduit 131 discharging to tank 118 when only pilot conduit 112 has been pressurized with secondary pressure through actuation of pilot valve 110 to actuate main valve 124. When only pilot conduit 113 is pressurized with secondary pressure, the main valve is actuated to connect high pressure conduit 123 to main cylinder conduit 134 and main cylinder conduit 114 to discharge conduit 131. The main valve 124 is conventional and, for example, it has been found satisfactory to use a "Vickers Incorporated" pilot operated four-way valve model C–2440–S9. The main

cylinder conduit 114 is connected through a conventional sequence valve 132 to the head end of main cylinder 21 where high pressure fluid enters the cylinder through an inlet port at 31. The sequence valve 132 is selectively preset as desired to a given pressure at or above which it permits hydraulic fluid to pass, but below which it prevents such flow of fluid. The sequence valve 132 also permits free reverse flow of fluid through it. The purpose of sequence valve 132 is to provide a small time delay between the supplying of high pressure fluid to main cylinder conduit 114 at main valve 124 and the supplying of such high pressure fluid to the head end of main cylinder 21 to commence the power stroke of such cylinder. Such time delay is on the order of a fraction of one second and occurs as a result of the time required for the build-up of fluid pressure on the inlet side of the sequence valve to the pressure at which the sequence valve has been selectively preset after the main cylinder conduit 114 and high pressure conduit 123 have been connected by appropriate actuation of main valve 124. The purpose of this time delay is to permit actuation of valve cylinder 85 just prior to actuation of the main cylinder as explained below. The sequence valve 132 is conventional and, for example, it has been found satisfactory to utilize a "Vickers Incorporated" sequence valve model RCT–06–D2–10. The main cylinder conduit 134 is connected through a sequence valve 133 to the head end of main cylinder 20 through an inlet port at 29. The sequence valve 133 is identical in structure, function, and purpose to the above described sequence valve 132. The secondary pressure conduit 128 is connected to the rod end of each main cylinder through ports at 30 for main cylinder 20 and at 32 for main cylinder 21. The secondary pressure conduit 128 is also connected at 140 to pilot valve 110 and at 141 to pilot valve 111. The two pilot valves 110, 111 have a common drain conduit 142 connected to tank 118. Both of the pilot valves 110, 111 are internally biased to closed condition relative to secondary pressure at 140, 141. In such normally closed condition, the pilot valves connect pilot conduits 112 and 113 to drain conduit 142. The pilot valves are actuated by means of a plunger 143 for valve 110 and 144 for valve 111. When plunger 143 or 144 engages the cam portion 52 or 51, respectively, it is displaced and actuates the pilot valve to momentarily connect secondary pressure at 140 to pilot conduit 112 for pilot valve 110 or secondary pressure at 141 to pilot conduit 113 for pilot valve 111. When the pilot control valve is in such actuated position, drain conduit 142 is closed. The pilot valves are conventional and, for example, a "Vickers Incorporated" four-way control valve model C2–572–E may be utilized by plugging its No. 1 port and connecting it to function as described above, which is well within the province of one skilled in the art. It is thus apparent that when pilot valve 110 is actuated through engagement of its plunger 143 with cam portion 52, pilot conduit 112 is pressurized to actuate main valve 124 to connect high pressure conduit 123 to main cylinder conduit 114 and to connect main cylinder conduit 134 to drain conduit 131. Once main valve 124 is actuated to one position or the other, it remains in such position until secondary pressure is introduced to actuate it to its other position. As a consequence, only momentary pressurization of the pilot conduits 112 or 113 is necessary to actuate main valve 124, and, once so actuated, the pilot conduit 112 or 113 pressurized to effect such actuation need not remain pressurized to maintain the actuated position. A manually operated four-way reversing valve 160 is connected between main cylinder conduits 114 and 134 between main valve 124 and sequence valves 132 and 133. The reversing valve 160 is conventional and, for example, a "Vickers Incorporated" model C–430–CA manually operated four-way valve may be utilized. For normal operation of the apparatus, reversing valve 160 is manually set to interconnect main cylinder conduit 114 and valve conduit 161 connected at 90 to the head end of valve cylinder 85 to introduce hydraulic fluid to the interior of such cylinder through a port at 90. Such setting of reversing valve 160 also connects together main cylinder conduit 134 and valve conduit 162 which is connected at 91 to the rod end of valve cylinder 85 to introduce fluid to the interior of such cylinder through a port at 91. Thus, pressurization of main cylinder conduit 114 similarly pressurizes valve conduit 161 and pressurization of main cylinder conduit 134 similarly pressurizes valve conduit 162. When main cylinder conduits 114 or 134 are not pressurized, valve conduits 161 or 162, respectively, are similarly unpressurized. The reversing valve 160 may be manually set so that the valve conduits 161, 162 are pressurized and depressurized reversely to that described above, namely, valve conduit 162 is pressurized and depressurized concurrently with pressurization and depressurization of main cylinder conduit 114, and valve conduit 161 is pressurized and depressurized concurrently with pressurization and depressurization of main cylinder conduit 134. This setting of reversing valve 160 operates the apparatus in reverse in the manner and for the purpose described below.

In operation, it is apparent from the above description that when the head end of one main cylinder 20 or 21 is pressurized, the head end of the other main cylinder is not pressurized and that secondary pressure is introduced through conduit 128 into the rod end of each main cylinder. As a consequence, main cylinders 20, 21 and pump cylinders 36, 37, respectively, operate in opposite phase with each other in that as one main cylinder is performing its power stroke by the piston moving from the head end to the rod end of the cylinder, the other main cylinder is performing its return stroke by the piston therein moving from the rod end to the head end of the cylinder and the pistons in the main cylinders simultaneously commence their return and power strokes respectively. The pump cylinders, since they are directly connected to the main cylinders, perform their discharge and intake strokes in opposite phase relative to each other and in phase with the power and return strokes, respectively, of the main cylinder connected thereto. As shown, main cylinder 20 is near the end of its power stroke, and main cylinder 21 is near the end of its return stroke, although neither has completed its power or return stroke respectively. In this condition of the apparatus, main valve 124 is in such position that high pressure conduit 123 is connected to main cylinder conduit 134 and main cylinder conduit 114 is connected to drain conduit 131. Also valve conduit 162 is pressurized, and, as shown in FIG. 3, this has resulted in displacement of piston 89 in valve cylinder 85 upwardly, thereby having moved valve lever 75 to the position illustrated in FIG. 2 and consequently opened the inlet port of valve chamber 41 while closing its outlet port and opened the outlet port of valve chamber 40 while closing its inlet port. It is thus apparent that plastic concrete is being discharged from pump cylinder 36 through valve chamber 40 and through its outlet port 56 to discharge line 95 and at the same time concrete from hopper 100 is entering, through inlet port 57, valve chamber 41 and pump cylinder 37. While the power stroke of main cylinder 20 is caused by the high pressure admitted to the head end thereof at 29, the return stroke of main cylinder 21 is produced by fluid pressure entering its rod end at 32. The power stroke of one main cylinder is thus a major factor in producing the return stroke of the other through the conduit 128 connecting together their rod ends at 30 and 32. As explained above, in this condition of the apparatus, valve conduit 161 and main cylinder conduit 114 are connected through main valve 124 to drain conduit 131 so that hydraulic fluid in main cylinder 21 from the preceding power stroke thereof is discharged from the head end

thereof to tank 118. Also, in this condition of the apparatus, both pilot valves 110, 111 are in their normally unactuated condition, and, consequently, secondary pressure at 140 and 141 is blocked and pilot conduits 112 and 113 are connected to drain conduit 142. Now, as main cylinder 20 completes its power stroke by moving a small additional amount to the left in FIG. 1, cam portion 52 actuates pilot valve 110 and actuation of this valve connects together secondary pressure at 140 and pilot conduit 112. This pressurizes pilot conduit 112 and thus actuates main valve 124 in the manner described above to connect main cylinder conduit 114 to high pressure conduit 123 and to connect main cylinder conduit 134 to drain conduit 131. This actuation of the main valve discharges a small amount of hydraulic fluid through pilot conduit 113 which is conveyed to tank 118 through drain conduit 142, since pilot valve 111 remains in unactuated condition and thus interconnects pilot conduit 113 and drain conduit 142. The pressurization of main cylinder conduit 114 also pressurizes valve conduit 161, admitting high pressure hydraulic fluid to the head end of valve cylinder 85 and thus causing a down stroke of the piston within such cylinder. Such down stroke of the valve cylinder discharges at 91 the hydraulic fluid previously admitted therein at 91, and this fluid is conveyed through valve conduit 162, reversing valve 160, main cylinder conduit 134 and drain conduit 131 to tank 118. The pressurization of valve cylinder 85 resulting in the down stroke of the piston therein oscillates valve lever 75 to the opposite position from that shown in FIG. 2 so that inlet port 55 in valve chamber 40 is open and outlet port 56 therein is closed while outlet port 58 in valve chamber 41 is open and inlet port 57 therein is closed. During the time interval that the piston in valve cylinder 85 is shifting to actuate the valve lever as described above, the high pressure in main cylinder conduit 114 has not been admitted at 31 to the head end of main cylinder 21 because sequence valve 132 has delayed same during the very short time interval required for the fluid pressure on its inlet side to build up to full pressure as selectively preset on the sequence valve. This delay is a fraction of a second and is a very important time delay because it enables the valve cylinder to correctly shift the valve slides before the power stroke of main cylinder 21 is commenced. When full pressure is built up on the inlet side of sequence valve 132, it releases and permits fluid under such pressure to enter the head end of main cylinder 21 through a port at 31, thus producing the power stroke of the piston 27 therein and the discharge stroke of piston 46 within pump cylinder 37. During the power stroke of main cylinder 21, main cylinder 20 is on its return stroke in the manner described above and pump cylinder 36 is on its intake stroke responsive to such return stroke of the main cylinder. When main cylinder 21 completes its power stroke, cam portion 51 actuates pilot valve 111 momentarily and the cycle above described is repeated for main cylinder 20, there again being a slight time delay before high pressure is admitted at 29 to the head end of main cylinder 20 as a result of sequence valve 133 in order that the high pressure in valve conduit 162 will actuate valve cylinder 85 and valve lever 75 to proper position for the power stroke of main cylinder 20 and the discharge stroke of pump cylinder 36, as well as the return stroke of main cylinder 21 and the intake stroke of pump cylinder 37.

When reversing valve 160 is set to reverse position as described above, the phase relation between valve cylinder 85 and main cylinders 20 and 21 is reversed so that on the power stroke of a main cylinder, the consequential discharge stroke of the pump cylinder associated therewith discharges through the normal inlet port of its valve chamber into its hopper and on the return stroke of such main cylinder and consequential intake stroke of the pump cylinder, cement is intaken through the normal outlet port of the valve chamber from the discharge conduit connected thereto. This reversal of operation is advantageous for clearing clogging or the like which may have occurred in the apparatus, because the intake strokes of the pump cylinders intake from the normal discharge conduits and the discharge strokes of the pump cylinders discharge into the cement hoppers.

It is to be understood that "Vickers Incorporated" as used herein refers to Vickers Incorporated, a division of Sperry Rand Corporation, having a place of business at 14420 Linwood Avenue, Detroit 32, Michigan, which manufactures and sells commercially various hydraulic pumps, valves and controls.

I claim:

1. A pump for pumping plastic concrete comprising a first pump cylinder and slidable piston and a second pump cylinder and slidable piston, each pump cylinder being fixed in position and opening at one end into a separate valve chamber, a pair of valve guides on each valve chamber, each pair of valve guides having spaced parallel surfaces and defining an inlet port and an outlet port each extending through the valve guides and through their parallel surfaces and communicating between the interior of the valve chamber and the exterior of the valve guides, the inlet and outlet ports in each pair of valve guides being linearly aligned along a common axis and spaced from each other along such axis, plastic concrete supply hoppers connected to the inlet ports in the valve guides exteriorly of the valve guides, plastic concrete discharge conduits connected to the outlet ports in the valve guides exteriorly of the valve guides, a valve slide disposed slidably between the spaced parallel surfaces of each pair of valve guides, said valve slide being slidable in a direction parallel to the axis of alignment of the inlet and outlet ports in the valve guides, each valve slide having parallel planar surfaces slidably engaging the parallel surfaces of the valve guides and being elongated over the inlet and outlet ports in the valve guides and defining a port extending through the valve slide between its parallel surfaces which is aligned with the axis of alignment of the inlet and outlet ports in the valve guides, means for intermittently sliding each valve slide alternately in opposite directions to align the port in the valve slide alternately with the inlet port and the outlet port in the valve guides associated with the valve slide and for simultaneously moving both valve slides in opposite directions relative to each other, hydraulic cylinders operatively connected to the pistons in the pump cylinders for reciprocating the pistons in the pump cylinders, means for synchronizing and phasing the reciprocative movement of the pistons in the pump cylinders so that such piston simultaneously move in opposite directions and in opposite phase, and means for synchronizing and phasing the movement of the pistons in the pump cylinders with the movement of the valve slides so that during movement of the piston in a pump cylinder toward the valve chamber associated therewith the valve slide associated with that valve chamber is positioned with its port aligned with the outlet port in the valve guides on that valve chamber and the other valve slide is positioned with its port aligned with the inlet port in the valve guides on the other valve chamber.

2. A pump for pumping plastic concrete comprising a pair of spaced, parallel pump cylinders in fixed position each with a piston slidably carried therein, a pair of valve guides on one end of each pump cylinder, each pair of valve guides having spaced parallel surfaces extending transversely to the axis of the pump cylinder and defining an inlet port and an outlet port each extending through the valve guides and through their parallel surfaces and communicating between the interior of the pump cylinder and the exterior of the valve guides, the inlet port and the outlet port in each pair of valve guides being linearly aligned along a common axis and spaced from each other

the same amount along such axis, a valve slide disposed slidably between the spaced parallel surfaces of each pair of valve guides, said valve slide being slidable in a direction parallel to the axis of alignment of the inlet and outlet ports in the valve guides and in a plane transverse to the axis of the pump cylinder, each valve slide being elongated in the direction of the axis of alignment of the inlet and outlet ports in the valve guides and extending over such inlet and outlet ports and exteriorly of the valve guides and having parallel planar surfaces slidably engaging the parallel surfaces of the valve guides, each valve slide defining a port extending through the valve slide between its parallel surfaces which is aligned with the axis of alignment of the inlet and outlet ports in the valve guides, means for intermittently sliding each valve slide alternately in opposite directions to align the port in the valve slide alternately with the inlet port and the outlet port in the valve guides associated with the valve slide with both valve slides moving simultaneously in opposite directions and in opposite phase relative to each other, means for reciprocating the pistons in the pump cylinders, means for snychronizing and phasing the reciprocative movement of the pistons in the pump cylinders so that the pistons simultaneously move in opposite directions and in opposite phase, and means for synchronizing and phasing the movement of the pistons in the pump cylinders with the movement of the valve slides so that during movement of the piston in a pump cylinder toward the valve guides associated therewith the valve slide associated with those valve guides is positioned with its port aligned with the outlet port in those valve guides and the other valve slide is positioned with its port aligned with the inlet port in the valve guides on the other pump cylinder.

3. A pump for pumping plastic concrete comprising a pair of spaced, parallel pump cylinders in fixed position each with a piston slidably carried therein, a separate hydraulic main cylinder in fixed position coaxially aligned with each pump cylinder and axially spaced therefrom, a piston slidably disposed in each main cylinder, a piston rod extending between and fixed to the pistons in each coaxially aligned pump cylinder and main cylinder, a pair of valve guides on one end of each pump cylinder, each pair of valve guides having spaced parallel surfaces extending transversely to the axis of the pump cylinder and defining an inlet port and an outlet port each extending through the valve guides and through their parallel surfaces and communicating between the interior of the pump cylinder and the exterior of the valve guides, the inlet port and the outlet port in each pair of valve guides being linearly aligned along a common axis and spaced from each other the same amount along such axis, a plastic concrete supply hopper connected to each inlet port exteriorly of the valve guides, a discharge conduit connected to each outlet port exteriorly of the valve guides, a valve slide disposed slidably between the spaced parallel surfaces of each pair of valve guides, said valve slide being slidable in a direction parallel to the axis of alignment of the inlet and outlet ports in the valve guides and in a plane transverse to the axis of the pump cylinder, each valve slide being elongated in the direction of the axis of alignment of the inlet and outlet ports in the valve guides and extending over such inlet and outlet ports and exteriorly of the valve guides and having parallel planar surfaces slidably engaging the parallel surfaces of the valve guides, each valve slide defining a port extending through the valve slide between its parallel surfaces which is aligned with the axis of alignment of the inlet and outlet ports in the valve guides, means for intermittently sliding each valve slide alternately in opposite directions to align the port in the valve slide alternately with the inlet port and the outlet port in the valve guides associated with the valve slide with both valve slides moving simultaneously in opposite directions and in opposite

phase relative to each other, means for reciprocating the pistons in the main cylinders, means for synchronizing and phasing the reciprocative movement of the pistons in the main cylinders so that the pistons simultaneously move in opposite directions and in opposite phase, and means for synchronizing and phasing the movement of the pistons in the main cylinders with the movement of the valve slides so that during movement of the piston in a main cylinder toward the valve guides on its coaxial pump cylinder the valve slide associated with those valve guides is positioned with its port aligned with the outlet port in those valve guides and the other valve slide is positioned with its port aligned with the inlet port in the valve guides on the other pump cylinder.

4. A pump for pumping plastic concrete comprising a pair of spaced, parallel pump cylinders in fixed position each with a piston slidably carried therein and each pump cylinder having its bore at one end opening into a separate valve chamber, each valve chamber extending from the pump cylinder in a direction parallel to the axis of the pump cylinder and having substantial volume, a separate hydraulic main cylinder in fixed position coaxially aligned with each pump cylinder and axially spaced therefrom, a piston slidably disposed in each main cylinder, a piston rod extending between and fixed to the pistons in each coaxially aligned pump cylinder and main cylinder, a pair of valve guides on each valve chamber spaced from the pump cylinder in the direction of the axis of the pump cylinder, each pair of valve guides having spaced parallel surfaces extending at approximately right angles to the axis of the pump cylinder and defining an inlet port and an outlet port each extending through the valve guides and through their parallel surfaces and communicating between the interior of the valve chamber and the exterior of the valve guides, the inlet port and the outlet port in each pair of valve guides being linearly aligned along a common axis and spaced from each other the same amount along such axis, a plastic concrete supply hopper connected to each inlet port exteriorly of the valve guides, a discharge conduit connected to each outlet port exteriorly of the valve guides, a valve slide disposed slidably between the spaced parallel surfaces of each pair of valve guides, said valve slide being slidable in a direction parallel to the axis of alignment of the inlet and outlet ports in the valve guides and in a plane at approximately right angles to the axes of the pump cylinders, each valve slide being elongated in the direction of the axis of alignment of the inlet and outlet ports in the valve guides and extending over such inlet and outlet ports and exteriorly of the valve guides and having parallel planar surfaces slidably engaging the parallel surfaces of the valve guides, each valve slide defining a port extending through the valve slide between its parallel surfaces which is aligned with the axis of alignment of the inlet and outlet ports in the valve guides, a valve lever extending between the valve slides and pivotally connected to each, said valve lever being pivotally mounted for pivotal movement in a plane at approximately right angles to the axes of the pump cylinders, a hydraulic valve cylinder and piston connected to the valve lever and oscillating the valve lever about its pivot axis with an amplitude such that the port in each valve slide is alternately aligned with the inlet port and the outlet port in the valve guides associated therewith, means for reciprocating the pistons in the main cylinders simultaneously in opposite directions and in opposite phase, means for intermittently actuating the piston in the valve cylinder in opposite directions, means for phasing the actuation of the piston in the valve cylinder to occur just prior to each reversal of direction of movement of the pistons in the main cylinders, and means for phasing said valve cylinder and main cylinders so that the port in the valve slide associated with the pump cylinder and main cylinder in which the pistons are moving toward

the valve guides associated therewith is an alignment with the outlet port in such valve guides and the port in the other valve slide is in alignment with the inlet port of the other valve guides associated therewith.

5. A pump for pumping plastic concrete comprising a pair of spaced, parallel pump cylinders in fixed position each with a piston slidably carried therein and each pump cylinder having its bore at one end opening into a separate valve chamber extending from the pump cylinder in a direction parallel to the axis of the pump cylinder and having substantial volume, a separate hydraulic main cylinder in fixed position coaxially aligned with each pump cylinder and axially spaced therefrom, a piston slidably disposed in each main cylinder, a piston rod extending between and fixed to the pistons in each coaxially aligned pump cylinder and main cylinder, a pair of valve guides on each valve chamber spaced from the pump cylinder in the direction of the axis of the pump cylinder, each pair of valve guides having spaced parallel surfaces extending at approximately right angles to the axis of the pump cylinder and defining an inlet port and an outlet port each extending through the valve guides and through their parallel surfaces and communicating between the interior of the valve chamber and the exterior of the valve guides, the inlet port and the outlet port in each pair of valve guides being linearly aligned along a common axis and spaced from each other the same amount along such axis, the outlet port in each pair of valve guides being aligned with the axis of the pump cylinder associated therewith, a plastic concrete supply hopper connected to each inlet port exteriorly of the valve guides, a discharge conduit connected to each outlet port exteriorly of the valve guides, a valve slide disposed slidably between the spaced parallel surfaces of each pair of valve guides, said valve slide being slidable in a direction parallel to the axis of alignment of the inlet and outlet ports in the valve guides and in a plane at approximately right angles to the axes of the pump cylinders, each valve slide being elongated in the direction of the axis of alignment of the inlet and outlet ports in the valve guides and extending over such inlet and outlet ports and exteriorly of the valve guides and having parallel planar surfaces slidably engaging the parallel surfaces of the valve guides, each valve slide defining a port extending through the valve slide between its parallel surfaces which is aligned with the axis of alignment of the inlet and outlet ports in the valve guides, a valve lever extending between the valve slides and pivotally connected to each, said valve lever being pivotally mounted for pivotal movement in a plane at approximately right angles to the axes of the pump cylinders, a hydraulic valve cylinder and piston connected to the valve lever and oscillating the valve lever about its pivot axis with an amplitude such that the port in each valve slide is alternately aligned with the inlet port and the outlet port in the valve guides associated therewith, a hydraulic pump with outlets for supplying at its outlets hydraulic fluid under pressure, a supply of hydraulic fluid supplying the hydraulic pump, a main valve connected by fluid contacts to an outlet of the pump and to one end of each main cylinder, said main valve being operable to supply pressurized hydraulic fluid to the main cylinders alternately, means for actuating the main valve to supply pressurized hydraulic fluid to each main cylinder when the piston in such main cylinder is at that end of such main cylinder at which pressurized hydraulic fluid can be admitted and the piston in the other main cylinder is at the end of that main cylinder opposite the end thereof at which pressurized hydraulic fluid can be admitted, a fluid conduit communicating between the ends of the main cylinders opposite the ends thereof at which pressurized hydraulic fluid from the main valve can be admitted and also communicating with an outlet of the pump, means for preselecting the pressure of the hydraulic fluid supplied to the main valve, means for preselecting the pressure of the hydraulic fluid supplied to the ends of the main cylinders opposite the ends thereof at which pressurized hydraulic fluid from the main valve can be admitted, the pressure of the hydraulic fluid supplied to the main valve being preselected at a higher pressure than the pressure of the hydraulic fluid supplied to said ends of the main cylinders opposite the ends at which hydraulic fluid from the main valve can be admitted, delay means connected to each fluid conduit extending between the main valve and each main cylinder for delaying flow of pressurized hydraulic fluid between the delay means and the interior of the main cylinder for a preselected time interval, a first fluid conduit communicating between one end of the valve cylinder and one of the fluid conduits extending between the main valve and one of the main cylinders at a point intermediate the main valve and the delay means, a second fluid conduit communicating between the other end of the valve cylinder and the other fluid conduit extending between the main valve and the other main cylinder at a point intermediate the main valve and the other delay means, the actuation of the main valve to supply pressurized hydraulic fluid to one of the main cylinders being operative to supply such pressurized hydraulic fluid to the valve cylinder to actuate the piston in same to move the valve lever and valve slides and align the port in one valve slide with the outlet port in the valve guides associated with the pump cylinder and main cylinder which is to receive pressurized hydraulic fluid from the main valve and the port in the other valve slide with the inlet port in the valve guides associated therewith, said actuation of the valve cylinder being effected during the delay time interval produced by the delay means in the fluid conduit extending between the main valve and the main cylinder which is to receive pressurized hydraulic fluid from the main valve, so that the pistons in the main cylinders reciprocate in opposite phase and just prior to each reversal of direction of movement of such pistons the piston in the valve cylinder is actuated to oscillate the valve lever and align the port in one valve slide with the inlet port in one pair of valve guides and the port in the other valve slide with the outlet port in the other pair of valve guides in order that plastic concrete is alternately drawn into each valve chamber and pump cylinder from the supply hopper associated therewith and discharged from such valve chamber and pump cylinder through the discharge conduit associated therewith with one pump cylinder intaking plastic concrete when the other pump cylinder is discharging plastic concrete to produce a continuous discharge of plastic concrete jointly from the two pump cylinders.

6. In a pump for pumping plastic concrete, a pump cylinder, a piston slidably disposed within the pump cylinder for reciprocative movement, a first valve guide on one end of the pump cylinder, said first valve guide having a seating surface extending transversely to the axis of the pump cylinder, said first valve guide defining first and second ports communicating between its seating surface and the interior of the pump cylinder, said first and second ports being linearly aligned on a common straight axis and being spaced from each other along such axis of alignment, a second valve guide having a seating surface spaced from and parallel to the seating surface of the first valve guide and defining first and second ports communicating between its seating surface and the exterior of the second valve guide, said first and second ports in the second valve guide being juxtaposed to and aligned with the first and second ports respectively in the first valve guide, a valve slide disposed slidably between the seating surfaces of the first and second valve guides, said valve slide being slidable in a direction parallel to the axis of alignment of the first and second ports in the first and second valve guides, said valve slide being elongated in the direction of such axis of alignment of the first and second ports and having a first planar surface

in sliding engagement with the seating surface of the first valve guide and a second planar surface parallel to its first planar surface in sliding engagement with the seating surface of the second valve guide, and said valve slide defining a single port extending through it between its first and second planar surfaces and aligned along the axis of alignment of the first and second ports in the valve guides, the elongate extent of the valve slide in each direction from the port therein being greater than the maximum spacing between the first and second ports in the valve guides along their axis of alignment.

7. In a pump for pumping plastic concrete, a pump cylinder with its bore at one end communicating with a valve chamber extending from the pump cylinder in a direction parallel to the axis of the pump cylinder, a piston slidably disposed within the pump cylinder for reciprocative movement, a first valve guide on the valve chamber having a substantially planar surface extending transversely to the axis of the pump cylinder, said first valve guide defining first and second ports communicating between its substantially planar surface and the interior of the valve chamber, said first and second ports being linearly aligned on a common straight axis and being spaced from each other along such axis of alignment, a second valve guide having a substantially planar surface spaced from and parallel to the substantially planar surface of the first valve guide and defining first and second ports communicating between its substantially planar surface and the exterior of the second valve guide, said first and second ports in the second valve guide being juxtaposed to and aligned with the first and second ports respectively in the first valve guide, a valve slide disposed slidably between the first and second valve guides, said valve slide being slidable in a direction parallel to the axis of alignment of the first and second ports in the first and second valve guides, said valve slide being elongated in the direction of such axis of alignment of the first and second ports and having a first planar surface in sliding engagement with the substantially planar surface of the first valve guide and a second planar surface parallel to its first planar surface in sliding engagement with the substantially planar surface of the second valve guide, and said valve slide defining a single port extending through it between its first and second planar surfaces and aligned along the axis of alignment of the first and second ports in the valve guides, the elongate extent of the valve slide in each direction from the port therein being greater than the maximum spacing between the first and second ports in the valve guides along their axis of alignment.

8. In a pump for pumping plastic concrete, a pump cylinder with the full extent of its bore at one end communicating with a valve chamber extending from the pump cylinder in a direction parallel to the axis of the pump cylinder and having substantial volume, a piston slidably disposed within the pump cylinder for reciprocative movement, a first valve guide on the valve chamber spaced from the pump cylinder axially thereof and having a substantially planar surface extending at approximately right angles to the axis of the pump cylinder, said first valve guide defining first and second ports communicating between its substantially planar surface and the interior of the valve chamber, said first and second ports being linearly aligned on a common straight axis and being spaced from each other along such axis of alignment, said second port being approximately aligned with the axis of the pump cylinder, a second valve guide having a substantially planar surface spaced from and parallel to the substantially planar surface of the first valve guide and defining first and second ports communicating between its substantially planar surface and the exterior of the second valve guide, said first and second ports in the second valve guide being juxtaposed to and aligned with the first and second ports respectively in the first valve guide, a discharge conduit connected to the second port in the second valve guide exteriorly thereof, a valve slide disposed slidably between the first and second valve guides, said valve slide being slidable in a direction parallel to the axis of alignment of the first and second ports in the first and second valve guides, said valve slide being elongated in the direction of such axis of alignment of the first and second ports and having a first planar surface in sliding engagement with the substantially planar surface of the first valve guide and a second planar surface parallel to its first planar surface in sliding engagement with the substantially planar surface of the second valve guide, and said valve slide defining a single port extending through it between its first and second planar surfaces and aligned along the axis of alignment of the first and second ports in the valve guides, the elongate extent of the valve slide in each direction from the port therein being greater than the maximum spacing between the first and second ports in the valve guides along their axis of alignment, the first and second ports in the first and second valve guides and the port in the valve slide all being approximately the same size and defining cutting edges at their intersection with the substantially planar surfaces of the valve guides and the first and second planar surfaces of the valve slide respectively.

References Cited in the file of this patent

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2,549,851	Pope	Apr. 24, 1951
2,797,645	Kastner	July 2, 1957

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,998,781 September 5, 1961

Kenneth Bertron Triebel

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 44, for "portion" read -- port in --; column 10, line 53, for "piston" read -- pistons --; column 13, line 1, for "an" read -- in --; line 59, for "contacts" read -- conduits --.

Signed and sealed this 6th day of March 1962.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents