

[54] **HYDRAULICALLY OPERATED FLUID AGGREGATE PUMP**

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[63] Continuation-in-part of Ser. No. 766,137, Oct. 9, 1968, abandoned.

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[51] Int. Cl. .. **F04b 35/00, F04b 41/06, F04b 39/08**

[58] Field of Search..... **417/900, 318, 519, 417/343**

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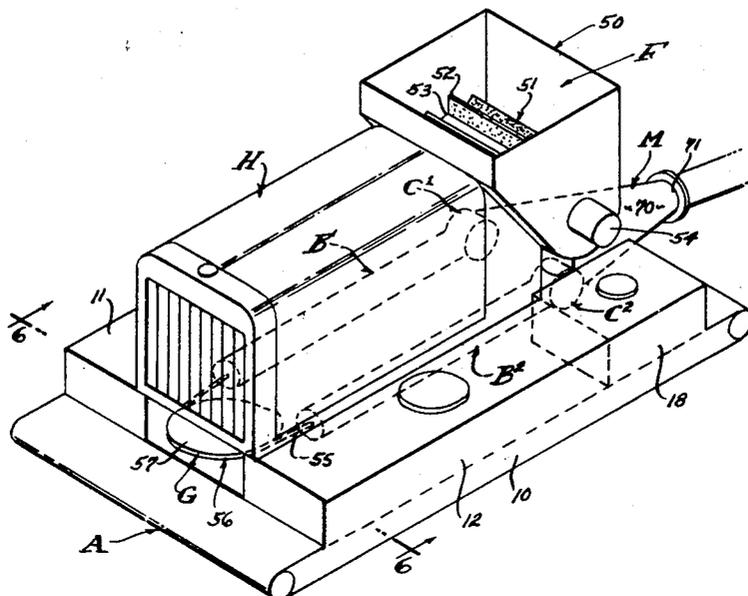
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[57] **ABSTRACT**

A pump for fluid aggregate and the like, characterized

by its reciprocating action conductive to substantially continuous delivery of fluid aggregate under pressure. A feature of the invention is the combining therein of a single acting duplex pump with a single acting duplex motor, there being a pair of pistons coupled by means of a tension element that returns one piston upon advance of the other, the two pistons being dependently operable in a pair of cylinders adapted to deliver fluid aggregate into a common manifold. The two cylinder and piston units involve cooperatively related pump sections and motor sections, with the tension element extending between the motor sections. The two motor sections of the two cylinders are alternately charged with hydraulic operating pressure in order to move the pistons therein so as to displace fluid aggregate from the pump sections and through reversely operable valves and into the manifold, there being a valve at the aggregate handling end of each cylinder and said valves being adapted to completely close off or isolate the complementary cylinders, and to alternately isolate a supply of fluid aggregate and the delivery manifold to each cylinder. A feature of the pump is the three positions of the two valves which move oppositely; one, to open its complementary cylinder to the supply of fluid aggregate while the other is closed in this respect and is open to the delivery manifold; two, the reciprocally opposite positions; and three, the simultaneous closing of both valves to the supply of fluid aggregate and to the manifold. Accordingly, the pump and motor combination includes unique controls and hydraulic means to effect the foregoing, and preferably in the form of a self-sustaining system or unit, flexible as to stroke and power application and adaptable to a wide range of fluid aggregate viscosity; that is for example, adapted to pump "low slump" as well as "high slump" concrete.

**19 Claims, 12 Drawing Figures**



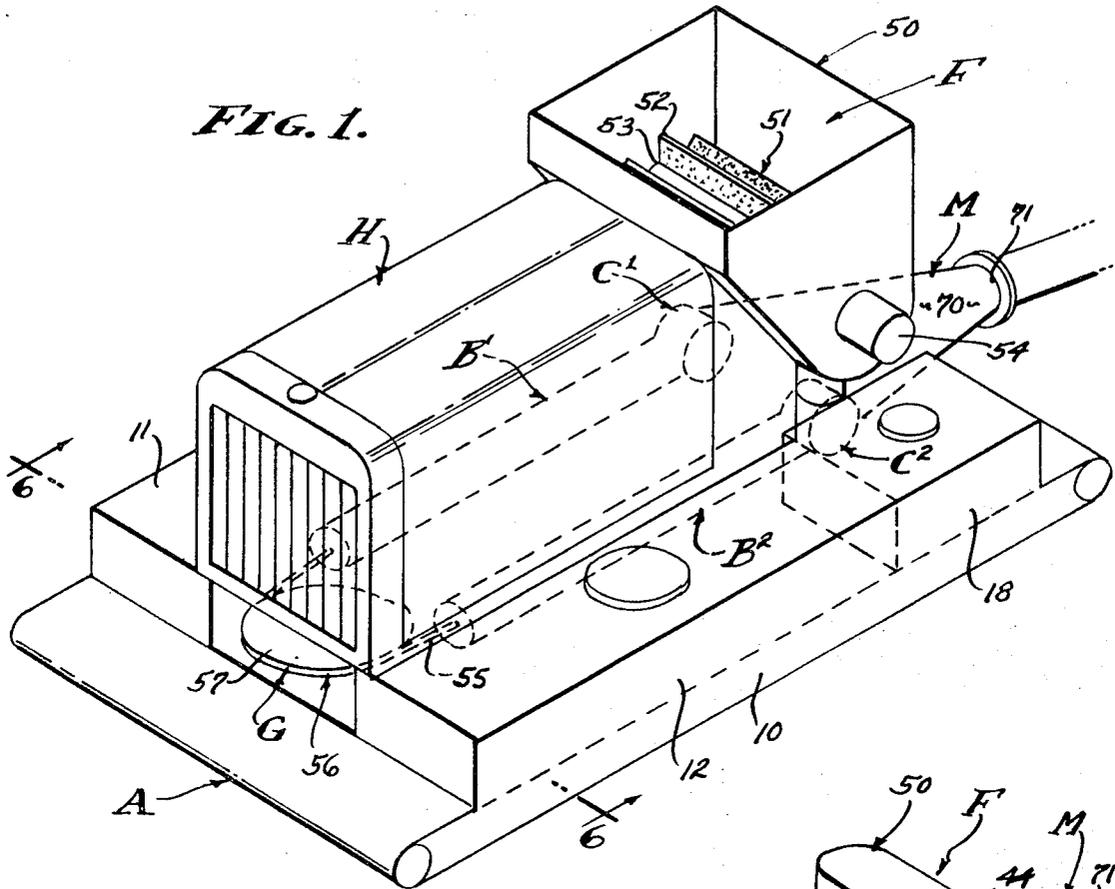


FIG. 1.

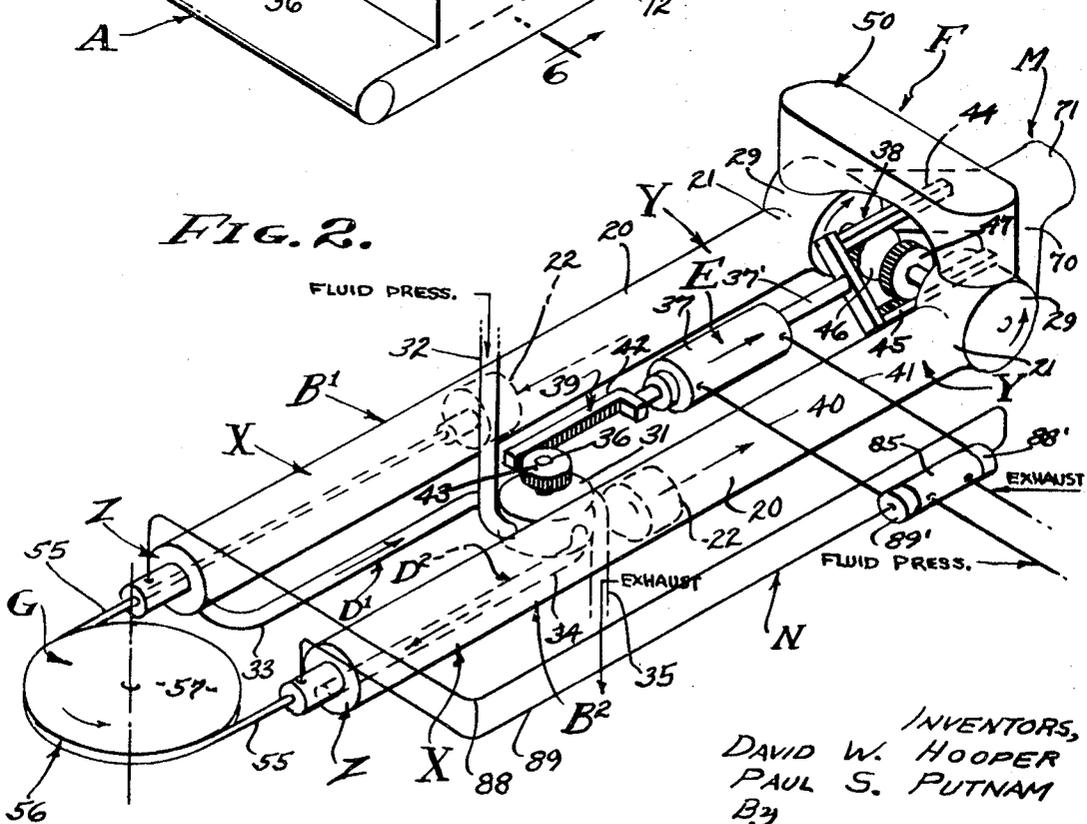
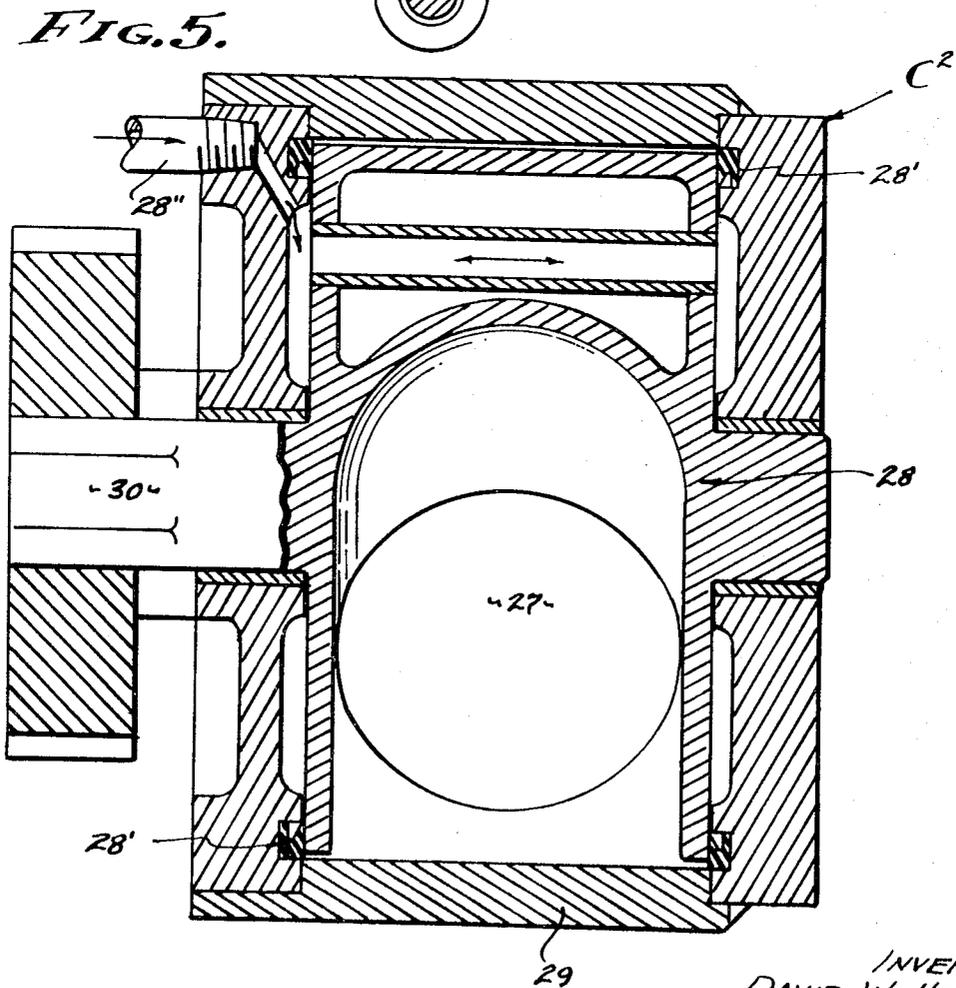
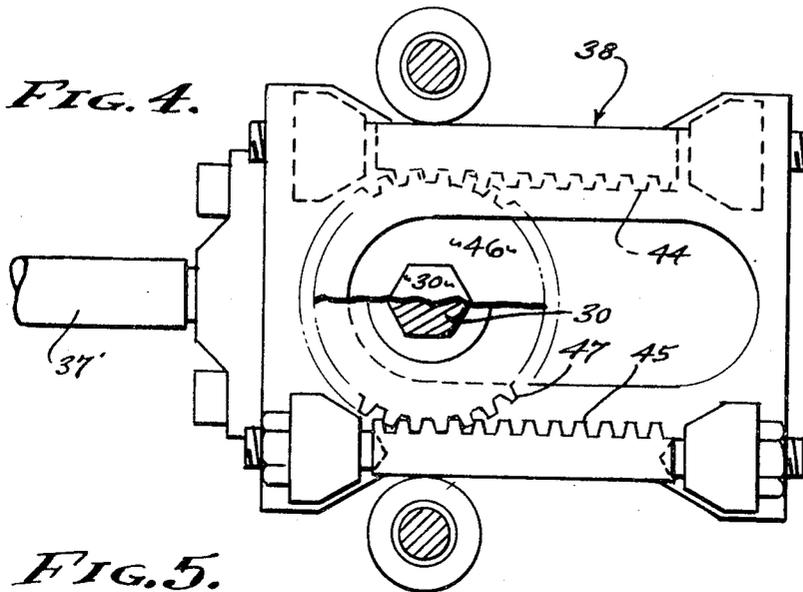


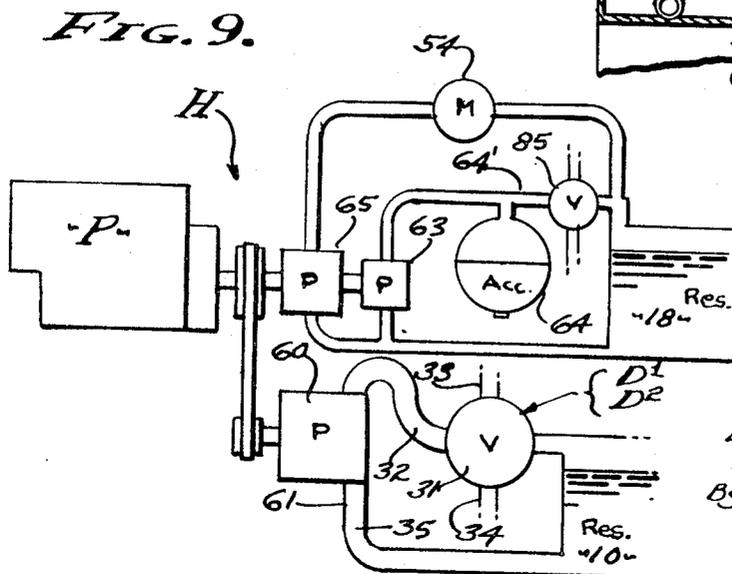
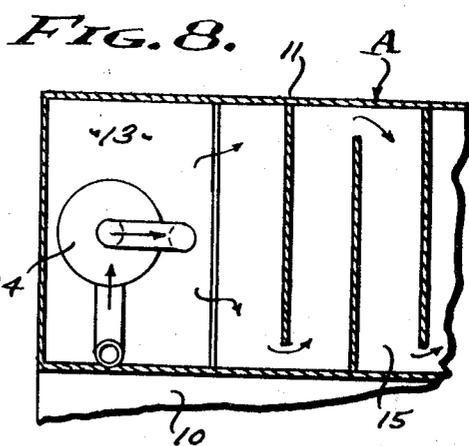
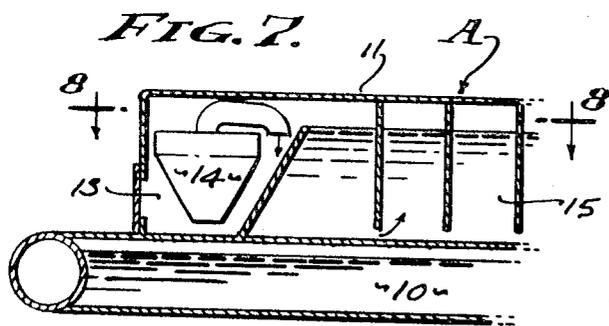
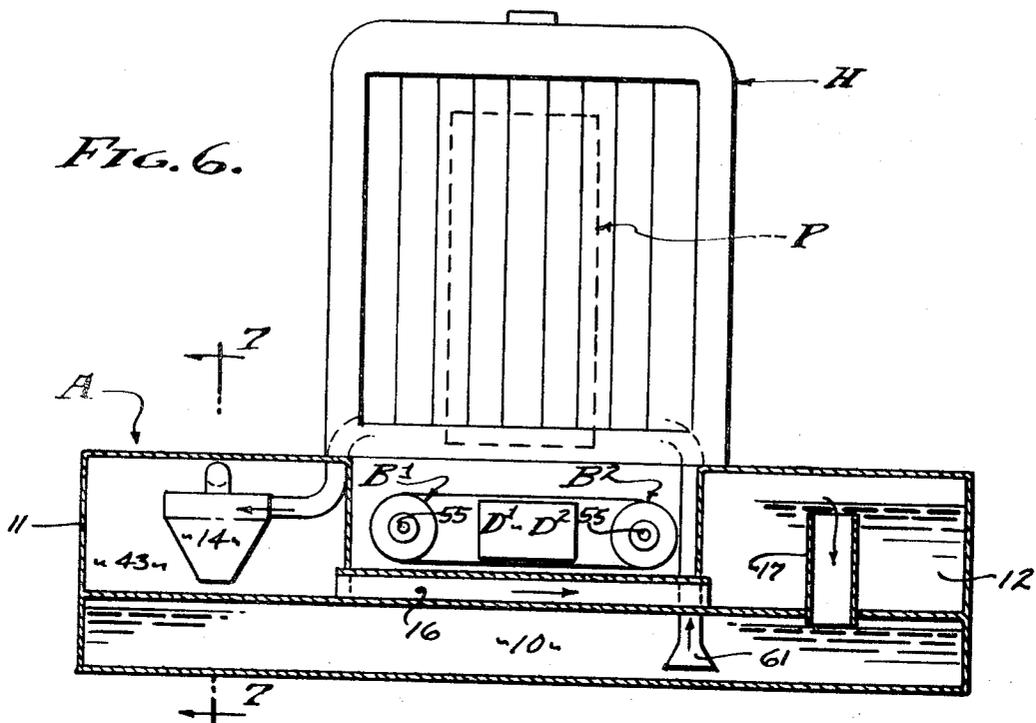
FIG. 2.

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FIG. 10.

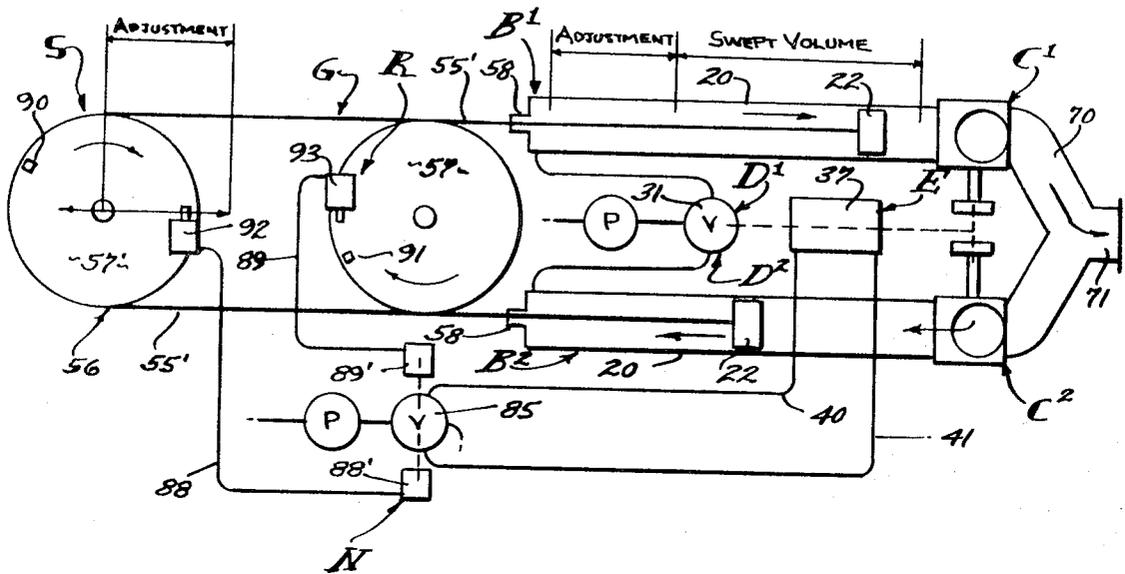
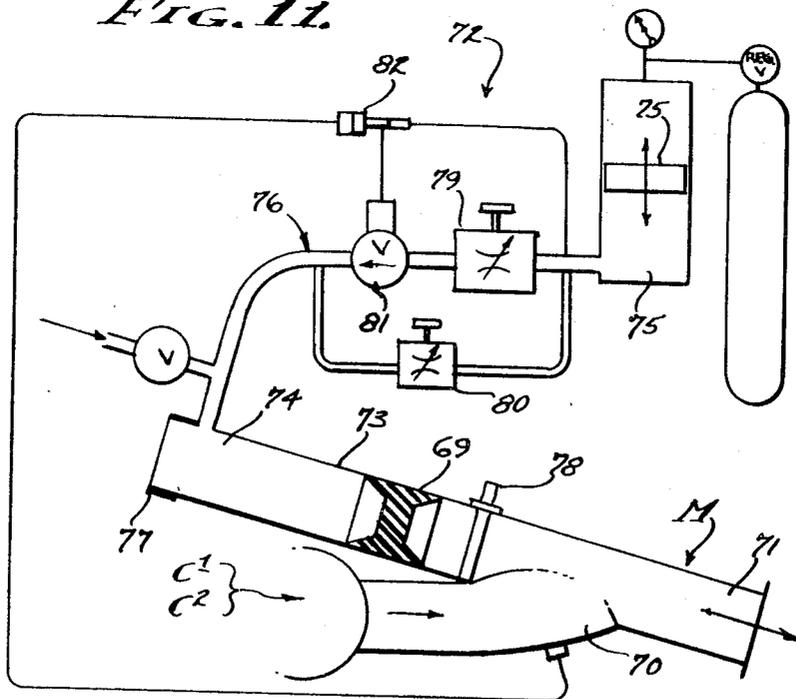


FIG. 11.



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## HYDRAULICALLY OPERATED FLUID AGGREGATE PUMP

This application is a continuation-in-part of application Ser. No. 766,137, filed Oct. 9, 1968 and now abandoned.

The prior art has developed a number of positive displacement type pumps for concrete mixes and the like, and which for the most part are characterized by a pair of oppositely reciprocating cylinder and piston units that are mechanically coupled in one way or another and driven by separate and distinct prime movers; and as a consequence the mechanisms are necessarily heavy and cumbersome. Another characterized feature of prior art pumps is that the controls causing reciprocable movement are complex and not all together reliable; and again most control features are mechanical and of necessity heavy and bulky and often complicated by combination mechanical-hydraulic-electrical functions. Still another feature of such prior art pumps is the inadequate control over the stiff "low slump" mixtures that must be handled; and in this respect reference is made to the questionable adequacy of the prior art pumps not permitting the full charging of the pump cylinders and in the compensating for fluid hammer as caused by pulsations in the flow continuity at the discharge from the alternately operable cylinder and piston units. Generally therefore, it is an object of this invention to provide a self-powered pump of the type under consideration from which the usual heavy and cumbersome mechanical synchronization between cylinder and piston units is eliminated; wherein the controls are simplified and reliability thereof assured; and wherein fluid aggregate, even of the lowest slump value, is adequately pumped with regard to providing a substantially continuous flow with minimized fluid hammer.

A primary object of this invention is to consolidate a single acting pump with a single acting motor therefor and to provide continuous operation thereof by employing a duplex arrangement so that delivery of fluid material is continuous. A unique feature herein disclosed is the utilization of common cylinder and piston units for the pumps and motors, and the coupled engagement of the alternately operating pistons which are otherwise free but which are pulled one by the advancement of the other to effect an intake stroke, respectively, in preparation for the mix following power and delivery stroke. As will be described, the pump and motor units are double ended and divide into pump sections and motor sections, while in each instance the pumps and motors remain single acting.

A shortcoming of the usual pump of the type under consideration is inability to be held in operative abeyance with the fluid aggregate in supply and in the charging cylinders, and with the delivery manifold filled and isolated, thereby permitting each functional face to maintain its status without effecting the others. It is an object therefore, to provide a valve action between the supply, the cylinders and the delivery manifold which enables the said isolation position; and further to provide a fully swept valve in each instance and wherein there is a self-cleaning action of aggregate material or slurry therefrom.

Another object of this invention is to provide a new and improved differential valve drive for the reciprocable control of the oppositely operating cylinder and piston units, whereby the pistons thereof operate alter-

nately. With the present invention, the two fully swept valves are independently adjustable as to position and are positively placed in any one or three operative positions.

5 It is still another object of this invention to provide an apparatus for the features and innovations thus far referred to wherein the functional phases are separately maintained in cooperatively related modules. In practice, the functional phases are categorized as hydraulic supply, motor-pump and power; these three categories being contained in separately replaceable and serviceable modules. In carrying out the invention, the hydraulic supply module is embodied in the frame of the apparatus and is characteristically a weldment of tanks built in sled form and includes therein all necessary fluid process means; the motor-pump module is accommodated within the confines of the tanks of the frame and includes the duplex arrangement of cylinder and piston units and the related valves, drives and actuators therefor; and the power module embraces the tanks of the frame and is superimposed over the motor-pump module and includes a prime mover and pumps operated thereby and associated components supplying fluid under pressure, all as hereinafter described.

25 It is another object of this invention to provide a fluid aggregate supply feeder or charger that is adapted to de-cavitate fluid aggregate and particularly low slump mixtures and to compact the same into the pump cylinders.

30 It is also an object of this invention to provide a unique coupling for the oppositely reciprocable operation of the pistons, in a hydraulic cylinder and piston type device. With the present invention, the motor actuation is hydraulic with the application of fluid pressure in the cylinders against pistons free to advance therein and with a load to be moved ahead thereof for discharge at the open end of the cylinders.

40 It is still another object of this invention to provide a unique return means for the retraction of one piston through the work operation of the other, there being a flexible tension element, preferably in the form of a wire line of cable, extending between the two pistons and sealed as it projects through the heads of the two cylinders.

45 It is still a further object of this invention to provide an hydraulically sensitive control system wherein a servo unit is operable to alternately shift the material controlling valves in timed relation to the motor functions that move the pistons. With the present invention, pockets are provided in the two cylinders and into which pilot pistons enter so as to alternately pressure a servo that shifts the differentially positioned valves herein above referred to. As a consequence, control operation is essentially hydraulic and devoid of mechanical elements and all linkages.

55 In accordance with the nature of the equipment involved, cleaning is essential and accordingly unique charge means is provided to damp pulsations during operation and to follow the charge through the manifold and into the delivery pipe or tube, as a swab for the complete ejection of all fluid aggregate and/or slurry therefrom.

60 The various objects and features of this invention will be fully understood from the following detailed description of the typical preferred form and application thereof, throughout which description reference is made to the accompanying drawings, in which:

FIG. 1 is a perspective view showing the hydraulically operated aggregate pump assembled of its modular components. FIG. 2 is a perspective schematic view of the motor-pump module. FIG. 3 is a diagram illustrating the functions of the module shown in FIG. 2, showing the characteristic opposite positioning of the valve means. FIG. 3a illustrates the intermediate position of the valve means. FIG. 4 is a detailed view of the differential drive for the valve means. FIG. 5 is a detailed cross sectional view of one of the valve means taken as indicated by line 5—5 on FIG. 3. FIG. 6 is a transverse sectional view of the modular apparatus taken substantially as indicated by line 6—6 of FIG. 1. FIG. 7 is a sectional view of a portion of the apparatus taken as indicated by line 7—7 on FIG. 6. FIG. 8 is a view taken as indicated by line 8—8 on FIG. 7. FIG. 9 is a diagrammatic view showing the prime mover and pump components of the power module enclosed within the housing shown in FIG. 1. FIG. 10 is a simplified schematic similar to FIG. 3 showing a modified embodiment of the invention wherein stroke adjustment is a feature. FIG. 11 is a diagrammatic view of a portion of the apparatus illustrating the material delivery means that serves as a surge damper and cleaning swab.

Such pumps and positive displacement means of the type under consideration are expected to have a piston or rod that slides through a gland in the head of a cylinder, maintaining a reciprocal motion and shifting to depress fluid within the cylinder while providing a mechanical connection. The cylinder and piston units are usually provided as complementary pairs, interconnected and driven by means of cranks or chain drives, or by double acting cylinder and piston motor and the like; that is, the pistons are mechanically interconnected in order to effect a return stroke and suction to draw a new charge into the cylinder. For these reasons, such pumps are characterized by piston rods which return the pistons, and to the end that such units are single acting. Therefore, the stroke of the usual external and separate actuating mechanism must be equal to the effective charging stroke; and it is this feature which renders such pumps bulky and cumbersome, providing means is available to return the piston in order to affect the intake stroke. And it is in this respect that we have combined a hydraulic motor and mechanical return operating under tension between the oppositely moving pistons so that one returns the other. In practice, there is a wire line coupling, flexible in nature, adapted to enter through the cylinder heads, being sealed therewith and remaining under tension, whereby the advance of one piston retracts the other. A practical disposition of the two cylinder and piston units is the duplex configuration as shown side by side in parallel relation, and in which case the invention is characterized by a wheel over which the wire line is warped to extend tangentially and project into the motor cylinders through glands provided in the heads thereof.

Referring now to the drawings, the pumping unit involves generally, a frame A, a pair of cylinder and piston units B1 and B2, pump valve means C1 and C2 controlling the intake and delivery strokes of the units B1 and B2, motor valve means D1 and D2 controlling the power and exhaust strokes of the units B1 and B2, actuating means E positioning the said valve means C and D and coordinating the same, fluid material supply means F, piston return means G, hydraulic power means H, fluid material delivery means M, and control

means N coordinating the functioning of the aforementioned valve means and actuating means therefor. Each of the foregoing elements or means includes various refinements that will be described, and all of which are cooperatively combined to establish the pumping unit as a self-sustaining apparatus, there being a prime mover P operating one or more pumps that hydraulically powers the unit.

The frame A of the hydraulic supply module can vary in construction and is preferably a welded fabrication comprised of fluid handling compartments that contain and process the fluids for hydraulic operation while furnishing structural support for the various components involved. As shown in FIGS. 1 and 6, there is a coextensive underlying reservoir 10 for the containment of water to be used in hydraulically powering the cylinder and piston units B1 and B2, and there is a pair of cleaning tanks 11 and 12 overlying opposite sides of the reservoir 10 and defining space therebetween for the accommodation of the module comprising cylinder and piston units B1 and B2 and the associated elements and means. Tank 11 receives exhaust water from the cylinder and piston units B1 or B2 and includes a trap 13 with a centrifuge separator 14 (see FIGS. 7 and 8) discharging solids into an accessible clean-out sump and delivering water into a baffled chamber 15 for the further collection of solids. Tank 12 receives water from tank 11 through a transfer pipe 16 for further settlement of solids, and after which the water overflows through pipe 17 and into the reservoir 10. In the example given, a cement pump, the hydraulic fluid is water which is compatible with the aggregate mixture being pumped. Further, and in the particular embodiment illustrated, the tank 12 is compartmented and includes a separate oil reservoir 18 which is utilized in supplying hydraulic oil to the control means E for high pressure actuation of the pump valve means C1 and C2. A feature of the frame A is the extensive surface area exposed thereby to the fluids processed therein and to the surrounding environmental air, thereby providing for adequate heat dissipation.

The cylinder and piston units B1 and B2 of the pump-motor module characterize the present invention and are provided as a duplex pair of single acting hydraulically powered pumps each incapable in itself of effecting a return stroke; this latter function being supplied by the piston return means G hereinafter described. In accordance with the invention, the cylinder and piston units B1 and B2 are identically made as a pair, and each comprises a pump section X, a motor section Y and a head Z closing the latter section. Each unit includes a cylinder 20 (for example 5 inch diameter  $\times$  10 foot length) the pump section X thereof extending rearwardly from a charging end 21 in open communication with the complementary valve means C1 or C2, the motor section Y thereof extending forwardly from the head Z at the end of the cylinder opposite said charging end 21. The cylinders 20 are spaced and parallel and arranged side by side on horizontal axes, and each with a piston 22 free to reciprocate therethrough between the extreme ends thereof. In practice, the pistons are provided with elastomeric rings or cups 23 and 24 faced in opposite directions, the cups 23 to seal against the forwardly imposed hydraulic pressure, and the cups 24 to seal against the charge of aggregate fluid to be discharged forwardly. As shown, the pump section X is single acting, and likewise the motor section Y is also

single acting, each section capable of cooperatively working to move the aggregate charge forwardly when hydraulic pressure is applied through the head Z.

The pump valve means C1 and C2 of the pump-motor module are like pressure balanced valves that control the intake and discharge of fluid aggregate at the charging ends 21 of the cylinders 20. The valve means C1 and C2 are identical and alternately operative at each cylinder 20, with regard to intake and discharge of fluid, the intake to unit C1 being open while the discharge thereof is closed and the intake to unit C2 being closed while the discharge thereof is open. The valves of means C1 and C2 are three-way valves having two extreme positions (FIG. 3) and having a closed intermediate position (FIG. 3a). The two valves are coaxial rotary valves each having an intake port 25, a charging port 26, a discharge port 27 and a rotor 28 rotatable within a cylindrical chamber in a body 29. The rotor 28 is comprised of axially spaced discs embracing the said ports and integral with a circumferential blinding wall that extends therebetween through an arc of approximately 140° and spaced from the center of rotation, thereby leaving the greater portion of the rotor open for the passage therethrough of fluid aggregate. Each disc engages a circumferential seal 28', there being a fluid pressure supply 28'' into the valve chamber at the outside of each disc and within the seals 28', thereby pressure balancing the valves. The intake port 25 is disposed to face upwardly for the reception of fluid aggregate, while the ports 26 and 27 are disposed horizontally or nearly so (see FIG. 5). A feature of the valves is the next adjacent spacing of the ports 25 and 27 with the openings thereof within said 140° arc, so as to be simultaneously closed by the rotor 28; while the charging port 26 is spaced from the ports 25 and 27 at the opposite side of the valve body 29 with the opening thereof and the opening of either port 25 or 27 in open communication outside said 140° arc. As is shown therefore, with an arcuate blinding wall extending 140°, the rotor 28 is rotated through an operative arc of 140° or slightly more, in order to alternately open the intake ports 25 and discharge ports 27 through the charging port 26 and into open communication with the charging ends 21 of the two cylinders 20. It is to be understood that the arcuate measurements indicated are for example only, and that said measurements and port sizes can be varied as circumstances require. Each rotor 28 has a stub shaft 30 by which it is revolved to said alternate positions, and driveably coupled together, as later described, so that the two valves C1 and C2 are simultaneously at the intermediate positions (see FIG. 3a) closing both ports 25 and 27 respectively and simultaneously isolating ports 26 and the cylinders in communication therewith.

The motor valve means D1 and D2 of the pump-motor module that controls the power and exhaust strokes of the cylinder and piston units B1 and B2 is operative through the ends of the cylinders 20 closed by the heads Z. In practice, the means D1 and D2 comprise water pipes extending from a reversing valve 31 and into the heads Z of the two cylinder and piston units respectively. The reversing valve 31 is preferably a four-way valve adapted to receive high pressure-high volume water through a pipe 32, to alternately charge pipes 33 and 34 to the alternately operable cylinder and piston units B1 and B2, and to exhaust expended water through a pipe 35 and into the separator 14 for

reprocessing as hereinabove described. As shown, the reversing valve 31 is a rotary valve having two alternate positions, and closely positioned to the water pressure source and to the cylinder and piston units to be powered thereby. The reversing valve 31 has a stub shaft 36 by which it is revolved to said alternate positions.

The actuating means E of the pump-motor module that positions the pump valve means C1 and C2 and the motor valve means D1 and D2 is shown as a powered gear drive, a requirement of the apparatus being repeated and positive reversal of piston 22 and pump valve means C1 and C2. Accordingly, the actuating means E reverses an actuator 37 that revolves a gear drive 38 reversely positioning the pump valve means C1 and C2, and that revolves a gear drive 39 positioning the reversing valve 31. The actuator 37 is preferably a cylinder and piston motor with a piston rod 37' projecting from opposite ends thereof to operate the drives 38 and 39, in each instance a rack and pinion drive. The actuator cylinder is supplied with oil pressure through pipes 40 and 41 entering into the opposite heads thereof, and is disposed on a horizontal axis lying between the two cylinders 20, with one end of the piston rod 37' carrying a rack 42 engaged with a pinion 43 to rotatably reverse the valve 31, and with the other end of the piston rod 37' carrying a pair of yoke with opposed racks 44 and 45 reversely rotating pinions 46 and 47 to reversely position the rotors 28 of the pump valve means C1 and C2. As shown, the pinion 43 is fixed on the stub shaft 36, and the pinions 46 and 47 are fixed on the stub shafts 30 of the two pump valves respectively. Thus, reciprocal motion of the actuator 37 simultaneously reverses the operative positions of the several valve means, all of which are geared so as to operate together in timed relationship.

The fluid material supply means F is a separate module and comprises primarily a hopper 50 into which the fluid aggregate is fed, said hopper being vertically disposed and in vertical communication with said intake ports 25, there being open communication to both pump valve means C1 and C2 through the respective ports therefor. Included in the means F is an agitator 51 that decavitates the fluid mix being pumped and compacts the same through the pump valves and into the cylinders 20. As shown, the hopper 50 has downwardly and inwardly convergent opposite walls between which paddles 52 of elastomeric material revolve. The paddles 52 are of thick cross section as they extend longitudinally of the agitator 51 and normally project radially from the hub 53 thereof. The peripheral edges of the paddles strike the plane of the hopper wall and wipe therealong to move fluid aggregate into the ports 25; and following said ports in the direction of rotation the opposite wall of the hopper is spaced from the hub 53 a distance substantially equal to the thickness of each elastomeric paddle 52. The approach of the wall to the hub is gradual as shown, and the spaced paddles form pockets that receive fluid aggregate when they are upwardly faced. As a consequence, the paddles deflect and are sequentially turned down to seal with said opposite wall of the hopper and thereby force the fluid aggregate through the ports 25, compacting the same. A fluid powered motor 54 drives the hub 53 to revolve the agitator 51 and compact the fluid aggregate so as to compress any air pockets therefrom and thereby reducing any cavities.

The piston return means G of the pump-motor module is unique with the present invention and comprises, generally, a tension element that extends between and from the motor sides of the pistons 22. That is, the said tension element extends through and/or from the motor section Y to interconnect the pistons, so that advancement of one piston retracts the other. In practice, the tension element is advantageously a flexible wire line 55 operating under tension over a wheel 57 and providing a space saving concept without resort to double acting fluid motors. As they are illustrated, the motor unit sections Y remain single acting, being fluid powered only from the heads Z thereof; and consequently each moves the piston thereof forwardly only when power is applied by admitting water under pressure into the cylinder 20. And conversely, water is exhausted out of the cylinders 20 when the pistons thereof are retracted rearwardly. In carrying out the invention, the 5 inch cylinders 20 are axially spaced 20 inches on centers and they are arranged parallel and disposed end adjacent end so that forward and return movements are the same in each instance. Therefore, the return means G is characterized by alignment means 56 adapted to maintain axial alignment of the opposite live ends of the wire line 55 with the cylinder and piston axes. The means 56 can take various forms and is preferably a wheel 57, in the case illustrated 20 inches in diameter, from which the wire line 55 pays tangentially to enter the two cylinders 20 coaxially thereof. The opposite live ends of the wire line 55 wrap onto the wheel 57 and pay therefrom tangentially to project under tension through seals 58 in the heads Z and into coupled engagement with the pistons 22. The seals 58 are packed for both external and internal pressures, employing flexible chevron type rings that engage into the irregular surfaces of the wire line to be sealed therewith. It will be apparent that the wheel 57 is adapted to be fixedly journaled on an axis midway between the cylinder axes and so as to extend the apparatus length but a nominal 20 inches while permitting unrestricted cylinder length as circumstances require. Although not necessary, the wire line 55 can be wound one or more turns onto the wheel and/or used for supplemental purposes as later described.

The power module or hydraulic power means H can be operated as a single pumping unit, but advantages are derived by separation of the fluid power sources according to environment and work requirements. The environment presented by the cylinder and piston units B1 and B2 that handle concrete slurry and such aggregates is best operable with water and the work load requires a constant high pressure-high volume supply thereof; and consequently a high speed multi stage turbine pump 60 is best adapted to receive water from the sump 10 through a suction pipe 61 and to deliver high pressure water through the pipe 32. The environment presented by the actuator 37 is best suited by oil and intermittantly requires a limited but immediately available high pressure source of fluid; and accordingly a low volume high pressure pump 63 is best adapted and employed to charge an accumulator 64 that is depleted at intervals through the pipes 40 and 41. The environment presented by the agitator 51 is best adapted to a low volume medium pressure pump 65. Accordingly, the pumps 60, 63 and 65 are driven by the prime mover P, the former drawing water from sump 10 and the latter two pumps drawing oil from the compartmented oil

reservoir 18. In each instance, the expended liquid is returned to and is stored in the reservoirs as indicated.

The fluid material delivery means M of the pump-motor module comprises a manifold 70 receiving fluid aggregate alternately discharged through the ports 27, and a common discharge duct 71 for the continuous delivery of said fluid aggregate. The manifold 70 is essentially of a convergent "Y" configuration and is comprised of passages in each instance substantially equal to the diameter of the cylinders 20 and the porting through the pump valve means C1 and C2. Included in the means M is a pressure responsive surge damper 72 which comprises a riser 73 in open communication with the discharge duct 71, a piston-swab 69 to reciprocate in said riser, a liquid column means 74 in communication with the riser, an accumulator 75 in pressure communication with said liquid column means, and pressure releasable flow restriction means 76 in the liquid column means between the said piston-swab and said accumulator. As shown in FIG. 11, the riser 73 is in the nature of a cylinder and has a removable head 77 for the insertion therein of the piston-swab 69 movable in the riser between the manifold and head. A releasible stop 78 prevents entry of the piston-swab into the discharge duct 71 into which it can be released when clean out is desired. The liquid column means 74 involves a closed liquid chargeable system, preferably water, extended between the piston-swab 69 and piston 75' of the accumulator 75. The flow restriction means 76 comprises high and low volume adjustable flow valves 79 and 80, arranged in parallel, the valve 79 being in series with a pressure responsive releasible check valve 81 that unseats for flow of fluid from the accumulator to the riser, being unseated when pressure drop occurs within the manifold 70. A differential pressure shuttle valve 82 responds to drop of pressure in manifold 70 and pressures a servo from the accumulator to open valve 81. Thus, a differentially timed and controlled by-pass is normally permitted to occur through the valves 79 and 80, and upon the occurrence of pressure drop the check valve 81 permits control flow to the riser 73 through the high volume valve 79. It will be seen that the surge damper 72 is conducive to a smooth and continuous flow of fluid aggregate from the manifold 70 despite the periodic reversal action of the cylinder and piston units which cause periodic pressure drops. The surge damper 72 is responsive to the difference between pressure of material in the discharge duct 71 and pressure in the accumulator 75, and maintains a substantially steady pressure and flow of said material, thereby assuring a steady continuous flow thereof.

The control means N that coordinates the function of the means hereinabove described is a hydraulic servo means responsive to the termination of each power stroke and activated thereby to reverse the position of the actuator 37. In accordance with the full stroke concept of this pump unit, the actuator 37 is reversed in position at the end of each return stroke of a piston 22 as effected by the advancement of the other piston 22 coupled thereto through the wire line 55. The actuator 37 is controlled by a pilot operated four-way valve 85 delivering and exhausting oil to the opposite ends of the actuator through the pipes 40 and 41 and receiving oil under pressure from the accumulator 64 through pipe 64'. A feature of the control is the pressure pocket operation of the pilot valve 85 which automatically shifts

with the completion of each return stroke. Accordingly, each cylinder head Z has an internal coaxial cylinder pocket 86 therein facing the piston 22, and each of said pistons has a pilot piston 87 aligned with and projecting therefrom to enter into the complementary pockets to displace the liquid therefrom through pilot tubes 88 and 89 to opposite actuators at 88' and 89' that alternately position the pilot valve 85. As a consequence, a pilot piston 87 enters a pocket 86 at the end of each return stroke of a piston 22 and thereby shifts the pilot valve 85 to cause a subsequent power stroke which automatically follows.

Referring now to the adjustable stroke form of the pump shown in FIG. 10, the tension element of the piston return means G' is employed to vary the swept volume of cylinders 20. For example, there are circumstances when a low slump material will require a shorter stroke, in which case it would be impractical to sweep the pistons 22 full length of the cylinders 20, and in which case it is desirable to confine operation of the pistons at the open ends 21 of said cylinders. Therefore, the wire line 55' is lengthened as required by providing stroke adjustment means S and by providing stroke limit means R coordinated therewith. In accordance with the invention, the stroke adjustment means S comprises a second wheel 57' complementary to the wheel 57 and journaled on a parallel axis in the same plane and adjustably positioned relative to the axis of said first wheel. The wire line 55' is wrapped around both said wheels, and the spacing of the wheel axes determines the length of wire line 55' and the stroke of the live ends thereof. For example, the wire line 55' is effectively shortened by increasing the space between the wheels. The stroke limit means R can vary as circumstances require and is shown as stop lugs 90 and 91 operating pilot pressure cylinders 92 and 93 at the ends of alternate return strokes. As shown, the pilot pressure cylinders 92 and 93 are fixedly positioned, while the stop lug 90 for one cylinder unit B1 is selectively placed on the periphery of wheel 57', while the stop lug 91 for the other cylinder unit B2 is selectively placed on the periphery of wheel 57'. It will be seen that the first described pressure pockets and pilot pistons can be circumvented and the pilot tubes 88 and 89 routed to the cylinders 92 and 93.

Having described only a typical preferred form and application of our invention, we do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to ourselves any modifications or variations that may appear to those skilled in the art:

Having described our invention, we claim:

1. A hydraulically operated fluid material pump comprising, a pair of cylinder and piston units and each having a bore with contiguous pump and motor sections and a piston operable therein, a head closing the bore at the motor section end of each cylinder, reversibly operable pump valve means in open communication with the bore at the pump section end of each cylinder, there being a fluid material intake port and a cylinder charging port and a discharge port in and controlled by each of said pump valve means, reversely operable motor valve means in communication with the bore of each cylinder through the head at the motor section, piston return means comprising a flexible element connected to and extending under tension between the two pistons and through seals in the heads at the motor sections to couple the said pistons for return

of one piston by forward movement of the other, hydraulic power means supplying fluid under pressure, and means alternately positioning the two pump valve means and motor valve means at the two cylinder and piston units to open said discharge port from said charging port and open the motor valve means from the fluid pressure of the hydraulic means and through one head for forward movement of one piston and simultaneously to open said inlet port to said charging port and open the motor valve means to exhaust for return of and suction intake of material by the other piston, whereby fluid material is alternately delivered from one cylinder and piston unit while being induced to enter the other.

2. The hydraulically operated fluid material pump as set forth in claim 1 and wherein the piston return means is a flexible wire line connected to and tensioned between the two pistons.

3. The hydraulically operated fluid material pump as set forth in claim 1, wherein the cylinder and piston units are disposed on separated axes, and wherein alignment means guides the flexible element of the piston return means under tension to connect with the two pistons.

4. The hydraulically operated fluid material pump as set forth in claim 1, wherein the cylinder and piston units are disposed on separated axes, and wherein the flexible element of the piston return means extends under tension over alignment means comprised of at least one wheel from which the said element pays tangentially along said separated axes to connect with the pistons respectively.

5. The hydraulically operated fluid material pump as set forth in claim 1, wherein the cylinder and piston units are disposed on separated axes, and wherein the flexible element of the piston return means extends under tension over alignment means comprised of a wheel over which said element is warped with opposite live ends paying tangentially along said separated axes to connect with the two pistons respectively.

6. The hydraulically operated fluid material pump as set forth in claim 1, wherein the cylinder and piston units are disposed on spaced parallel axes, and wherein the flexible element of the piston return means extends under tension over alignment means comprised of a wheel having a diameter equal to the spacing of said parallel axes and over which said element is warped with opposite live ends paying tangentially along said spaced parallel axes to connect with the two pistons respectively.

7. The hydraulically operated fluid material pump as set forth in claim 1 and wherein the means alternately positioning the two pump valve means and motor valve means is responsive to an element positioned by the piston return means extending under tension between the two pistons.

8. The hydraulically operated fluid material pump as set forth in claim 1, wherein the cylinder and piston units are disposed on separated axes and alignment means guides the piston return means under tension to connect with the two pistons, and wherein the means alternately positioning the two pump valve means and motor valve means is responsive to an element on and positioned by said alignment means.

9. The hydraulically operated fluid material pump as set forth in claim 1, wherein the cylinder and piston units are disposed on separated axes, wherein the flexi-

ble element of the piston return means extends under tension over alignment means comprised of a wheel from which the said element pays tangentially along said separated axes to connect with the pistons respectively, and wherein the means alternately positioning the two pump valve means and motor valve means is responsive to an element on and positioned by said wheel.

10. The hydraulically operated fluid material pump as set forth in claim 1 and wherein the means alternately positioning the two pump valve means and motor valve means comprises an axially aligned cylinder pocket in the head and facing the bore closed thereby at the motor section of each cylinder, an axially aligned pilot piston projected by each of the pistons operable in said cylinder bores to enter the cylinder pockets at the ends of alternate return strokes of said pistons respectively, and a cylinder and piston servo in fluid communication with said cylinder pockets and alternately positioning said pump valve means and motor valve means in response to the successive return of one piston by forward movement of the other.

11. A hydraulically operated fluid material pump comprising, a pair of cylinder and piston units and each having a bore with contiguous pump and motor sections and a piston operable therein, a head closing the bore at the motor section end of each cylinder, reversely operable pump valve means in open communication with the bore at the pump section end of each cylinder, there being a fluid material intake port and a cylinder charging port and a discharge port in and controlled by each of said pump valve means, reversely operable motor valve means in communication with the bore of each cylinder through the head at the motor section, piston return means comprising a flexible element connected to and extending under tension between the two pistons and through seals in the heads at the motor sections to couple the said pistons for return of one piston by forward movement of the other, hydraulic power means supplying fluid under pressure, and actuating means geared to and alternately positioning the two pump valve means and motor valve means at the two cylinder and piston units to open said discharge port from said charging port and open the motor valve means from the fluid pressure of the hydraulic means and through one head for forward movement of one piston and simultaneously to open said inlet port to said charging port and open the motor valve means through the other head to exhaust for return of and suction intake of material by the other piston, whereby fluid material is alternately delivered from one cylinder and piston unit while being induced to enter the other.

12. The hydraulically operated fluid material pump as set forth in claim 11 and wherein the actuating means comprises reversely actuatable means operable to reversely position the reversely operable pump valve means at the pump section of each cylinder.

13. The hydraulically operated fluid material pump as set forth in claim 11 and wherein the actuating means comprises an actuatable means operable to reversely position the reversely operable motor valve means at the motor section of each cylinder.

14. The hydraulically operated fluid material pump as set forth in claim 11 and wherein the actuating valve means comprises reversely actuatable means operable to reversely position the reversely operable pump valve

means at the pump section of each cylinder, and an actuatable means operable to reversely position the reversely operable motor valve means at the motor section of each cylinder.

15. The hydraulically operated fluid material pump as set forth in claim 11 and wherein the actuating means comprises a reciprocably reversible motor, and reversely actuated means shifted thereby and operable to reversely position the reversely operable pump valve means at the pump section of each cylinder.

16. The hydraulically operated fluid material pump as set forth in claim 11 and wherein the actuating means comprises a reciprocably reversible motor, and an actuatable means operable to reversely position the reversely operable motor valve means at the motor section of each cylinder.

17. The hydraulically operated fluid material pump as set forth in claim 11 and wherein the actuating means comprises a reciprocably reversible motor, and reversely actuatable means operable to reversely position the reversely operable pump valve means at the pump section of each cylinder, and an actuatable means operable to reversely position the reversely operable motor valve means at the motor section of each cylinder.

18. The hydraulically operated fluid material pump as set forth in claim 12, wherein the actuating means comprises a reciprocably reversible cylinder and piston motor geared to and alternately positioning the two pump valve means and motor valve means, an axially aligned cylinder pocket in the head and facing the bore closed thereby at the motor section of each cylinder, an axially aligned pilot piston projected by each of the pistons operable in said cylinder bores to enter the cylinder pockets at the ends of alternate return strokes of said pistons respectively, and a cylinder and piston servo in fluid communication with said cylinder pockets and alternately positioning a reversing valve supplying said power means fluid pressure to and exhausting the same alternately from opposite ends of said reversible cylinder and piston motor in response to the successive return of one piston by forward movement of the other.

19. A hydraulically operated fluid material pump comprising, a pair of cylinder and piston units and each having a bore with contiguous pump and motor sections and a piston operable therein, a head closing the bore at the motor section end of each cylinder, reversely operable pump valve means in open communication with the bore at the pump section end of each cylinder, there being a fluid material intake port and a cylinder charging port and a discharge port in and controlled by each of said pump valve means, reversely operable motor valve means in communication with the bore of each cylinder through the head at the motor section, piston return means coupling the said pistons for return of one piston by forward movement of the other, hydraulic power means supplying fluid under pressure, and means alternately positioning the two pump valve means and motor valve means at the two cylinder and piston units and comprising an axially aligned cylinder pocket in the head and facing the bore closed thereby at the motor section of each cylinder, an axially aligned pilot piston projected by each of the pistons operable in said cylinder bores to enter the cylinder pockets at the ends of alternate return strokes of said pistons respectively, and a cylinder and piston servo in fluid communication with said cylinder pocket

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ets and alternately positioning said pump valve means and motor valve means in response to the successive return of one piston by forward movement of the other, said means being operable to open said discharge port from said charging port and open the motor valve means from the fluid pressure of the hydraulic means and through one head for forward movement of one

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piston and simultaneously to open said inlet port to said charging port and open the motor valve means to exhaust for return of and suction intake of material by the other piston, whereby fluid material is alternately delivered from one cylinder and piston unit while being induced to enter the other.

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