Aug. 2, 1938. W. B. CAMPBELL 2,125,283

PUMP FOR SEMIFLUIDS

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Fig. 1.

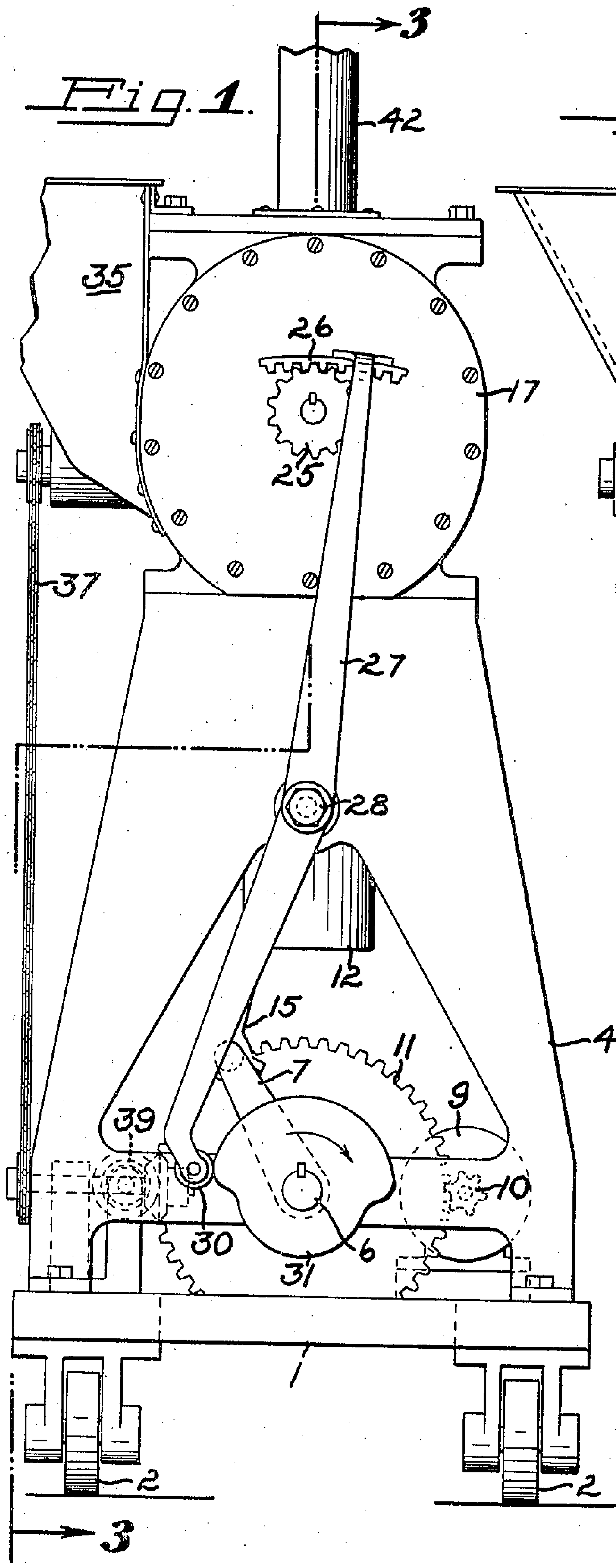

Fig. 2.

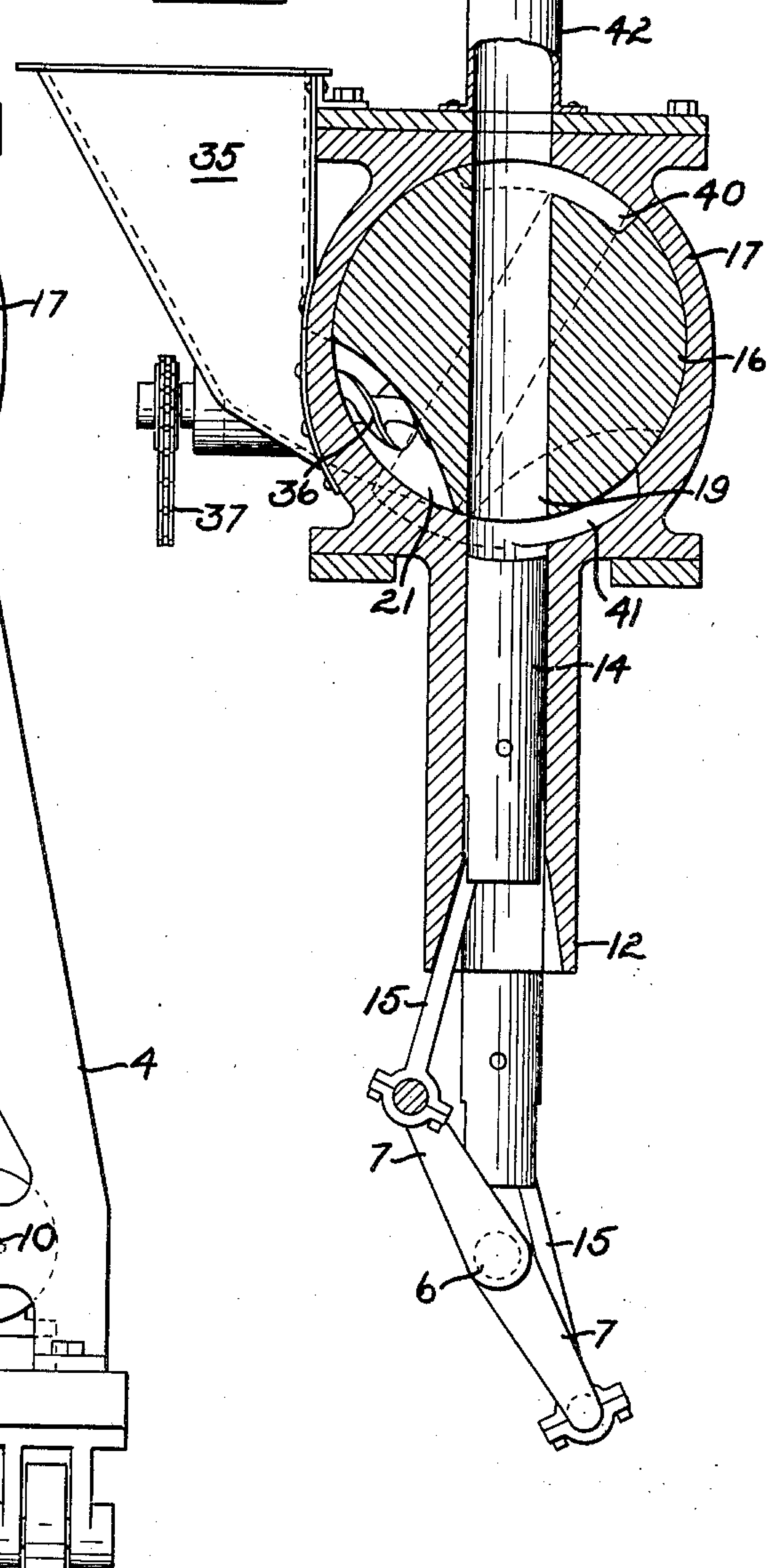

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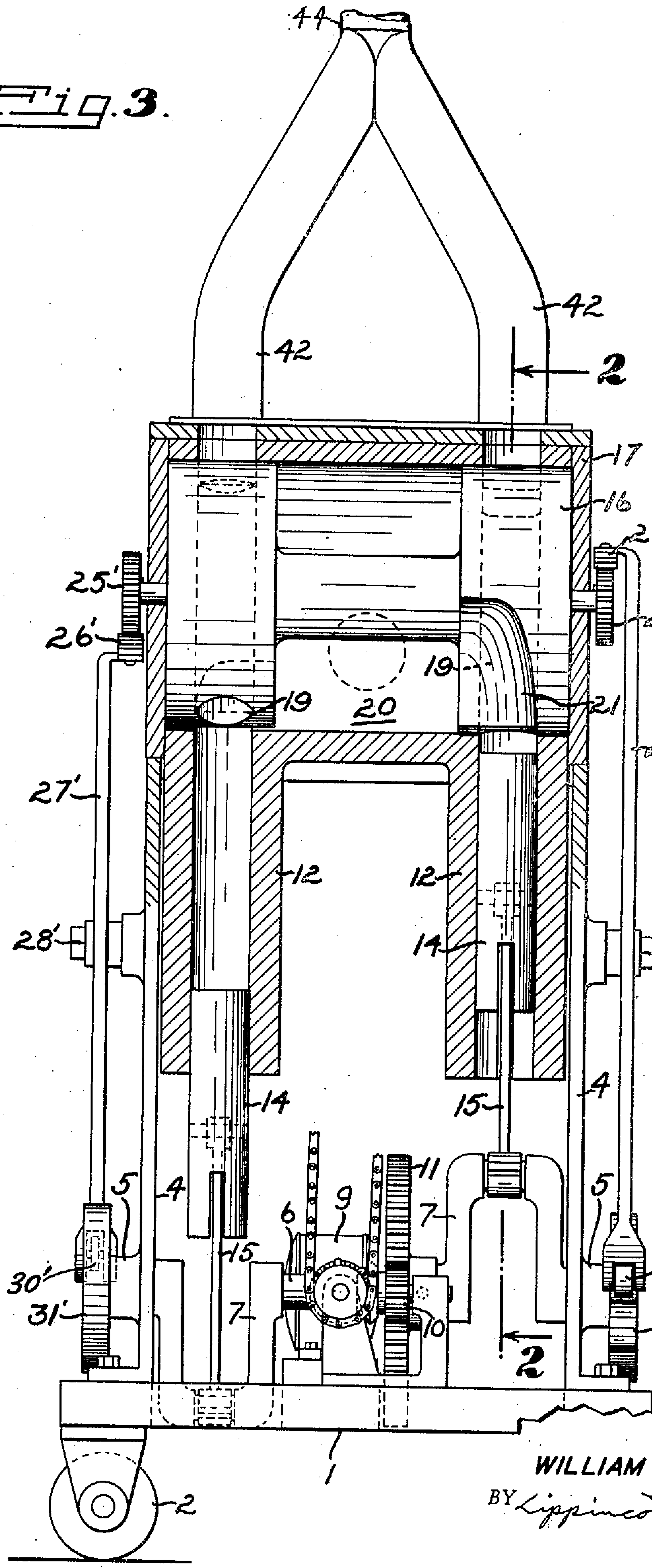
Fig. 3.



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PUMP FOR SEMIFLUIDS

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5 Claims. (Cl. 103—227)

My invention relates to pumps, and particularly to pumps for semi-fluids, i. e., to materials wherein pressure applied in one direction is to a certain extent transmitted in all directions as is the case with true fluids, but wherein the internal friction of the material is sufficiently great so that the pressure thus transmitted is not equal in all directions. Examples of such semi-fluids are dry cement, mixed concrete ready for pouring, loose, dry materials such as beans or dry sand, and viscous liquids such as molasses or heavy oils.

One of the primary uses of my invention is to pump wet concrete mixes from a central location to the form where it is to be poured. Another is the transportation of dry cement and cement clinker in mills which produce these products.

In moving materials of the class described, and particularly in moving them over any but the shortest distances, the controlling factor is the extremely high internal friction of the semi-liquids. This property so accentuates and aggravates the difficulties and losses due to any constrictions or sharp bends in the passageway through which the material is pumped, as to make ordinary pumps, and particularly the valve mechanisms thereof, entirely impractical for commercial use.

The primary purpose of this invention is to provide a pump which will satisfactorily handle semi-fluids, and, in order that this may be accomplished, secondary objects of this invention are to provide a pump mechanism wherein the outlet port of the pump is of the full diameter of the cylinder; to provide a cylinder and valve mechanism wherein the cylinder, on the working stroke of the system, discharges into a substantially straight passage which is substantially free from either enlargement or restriction, so that the material pumped moves as a single column with a sharply defined shearing plane between the material of the column and the walls of the passageway, and there only; to provide a valve wherein discrete particles of material size, such as coffee beans or the largest stone in a concrete aggregate can neither jam the valve orifice to prevent its closing nor themselves be sheared between the opposed edges of the closing port; to provide a pump and valve mechanism wherein the material to be pumped is fed into the cylinder under pressure, preferably that of gravity, so that the load taken in by the cylinder is not dependent upon suction produced therein; to provide a pump wherein two cylinders may be served by a common valve mechanism, and the pistons in said cylinders operated in opposed phase relationship so that the flow supplied by the combined cylinders may be kept substantially uniform.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of the invention herein described, as various forms may be adopted within the scope of the claims.

Referring to the drawings, Figure 1 represents an end elevation of a pump embodying this invention. This drawing is largely diagrammatic, its various parts being disproportionately formed in view of the loads that would in practice be imposed upon them, in order to show more clearly the relationship of the parts rather than their actual proportions.

Figure 2 is a vertical sectional view of the pump shown in Figure 1, the plane of section being indicated by the line 2—2 of Figure 3.

Figure 3 is a side view of the pump, shown partly in elevation and partly in section, the line of section being indicated by the dot and dash line 3 of Figure 1.

The embodiment of my invention which I have chosen for detailed description is one primarily adapted for the pumping of concrete mixes. When used for such purposes the equipment is preferably mounted on a platform 1 which is supported by rollers 2, so that the device may be readily moved as construction progresses. Mounted on the platform is a pair of A frames 4, which carry on their lower transverse portions bearings 5 for a crank shaft 6, which shaft has two oppositely disposed cranks, 7. The platform also supports a suitable motor 9, which drives the crank shaft by means of a pinion 10, and gear 11.

The upper ends of the A frames support a pair of vertically disposed cylinders 12, which are preferably spaced apart by at least their own diameter. Conventional trunk pistons 14 reciprocate within the cylinders and are driven by means of the cranks 7 and connecting rods 15.

Mounted on the A frame above the cylinders, with its axis in the plane of the cylinder axes but perpendicular to said axes, is a cylindrical valve member 16. This member is enclosed by and journaled in a valve housing 17.

The maximum diameter of the valve member 16 is largely a matter of choice, but it must be at least 41% larger than the diameter of the cylinder 12, since passing through the valve, in the plane of each cylinder, is a bore 19 whose calibre is substantially the same as that of the cylinder and which may be aligned with the cylinder by rotating the valve to a suitable position so the bore is practically a continuation of the cylinder.

The two bores are angularly displaced from each other to a degree slightly greater than the angle subtended at the periphery of the valve member by the bore itself. Hence when one bore is aligned with its cylinder the other cylinder will be completely closed. The minimum valve diameter which permits of this relationship is 1.41 times the piston diameter in which case the bores are displaced 90°. A larger valve diameter may be used if desired, in which case less angular rotation is necessary to open one cylinder and close the other. The diameter of the valve member is reduced in its central portion, between the two cylinders, so that an annular chamber **20** is formed between the enlarged end portions, each of these enlarged end portions carrying one of the bores. A portion of the periphery of each of the enlarged ends of the valve member is cut away to form an inlet channel **21** leading from the central chamber **20** laterally toward the respective cylinders. These channels **21** are so disposed in respect to the bores, that when the bore at one end of the valve member is aligned with its cylinder the other bore is completely out of alignment with its respective cylinder, but there is a direct passageway formed by the channel **21** from the central chamber **20** into the cylinder.

Means are provided for oscillating or rotating the valve member in time with the operation of the pistons. I prefer to use a cam driven gear mechanism for accomplishing this, mounting one cam and gear at each end of the device. As shown in Figure 1 this mechanism comprises a pinion **25** mounted on the shaft of the valve member **16** and meshing with an internal gear section **26** which is carried by a lever **27**, pivoted upon a stub shaft **28** on the A frame **4**. The lower end of this lever carries a rolling cam follower **30**, which engages a cam **31**. The mechanism at the opposite end of the pump is similar except for the fact that the gear **25'** meshes with an external gear segment **26'**, so that the lever **27'** is slightly shorter than the lever **27** and the cam **31'** is slightly larger and has a slightly different conformation from the cam **31**. The cams **31** and **31'** are complementary so that if the cam follower **30** were held in contact with the cam **31**, the follower **30'** would be driven by the motion thus imparted to the valve member to trace out the contour of the cam **31'**. The reciprocal relation would also, of course, hold. By this arrangement the valve member is at all times positively actuated, each follower being held in contact with its cam by the action of the other cam and follower, so that no spring or other device of the kind is necessary for the purpose. Any other gear or link mechanism which will rotate the valve in time with the pistons may be substituted for that described.

The cams and valve actuating gears are so proportioned that the valve member is rotated only when the pistons are at the extreme limits of travel. I have found in practice that it is possible to accomplish the entire necessary rotation of the valve during the period when the crank is within ten degrees on either side of dead center, top and bottom. Under these circumstances the piston accomplishes less than two per cent of its total travel after the valve has started to move. Since the intake channel starts to open before the outlet bore is entirely closed, and since nearly all semi-fluids contain voids and are therefore compressible, the loss of efficiency due to this relatively small motion is negligible.

Means are provided to feed the material to be pumped into the chamber **20** under pressure, and preferably to agitate it while it is thus being fed. In the present instance this feeding means comprises a hopper **35** into which the cement mix can be poured, and from which it will feed into the chamber under the pressure of the mass above it. Agitation is provided for by means of a short section of screw conveyor **36** which feeds from the hopper into the chamber **20**, and is driven by means of a sprocket chain **37** from suitable bevel gearing **39** actuated by the motor **9**.

The device as thus far described will pump such semi-fluids as dry cement, molasses, or heavy oil. Since, however, the present equipment has been specified as designed for handling concrete mixes, and since these mixes usually contain aggregates having relatively large gravel or crushed rock therein, it will be seen that if the valve member fitted tightly into its casing these particles might be caught between the orifice at the mouth of the cylinder and the trailing edge of the valve bore, with the result that the particles thus caught would be sheared or crushed at the expense of a large waste of power, or else that either the valve member or the cylinder would be damaged. I accordingly provide a groove or recess **40** extending from the top of the bore in the direction away from the direction of rotation of the valve and equal in length to the distance through which the end of the valve bore is moved. This groove is made equal to or of the same order of magnitude in depth as the diameter of the largest particles of the aggregate which it is desired to handle. As a result of this arrangement no shearing action occurs at the valve orifices. The recesses may be formed in either this valve member itself, as in the case of the recesses **40** at the top of the valve, or in the valve housing, as in the case of the recesses **41** adjacent the cylinders. In either case the recess extends away from the aligned passages in the direction of the relative movement of the element within which the recess is formed.

At the result of the construction described there is a passage presenting relatively low friction from the hopper **35** into the bore of one cylinder which is opened just as the piston in this cylinder starts to drop. Suction is not relied upon to draw the material into the cylinder, but the pressure of the mass of material above, augmented by the action of the screw conveyor **36**, actually forces the semi-fluid into the cylinders. When the piston reaches the bottom of its stroke the valve member rotates, bringing its bore into alignment with the cylinder, and forming a straight substantially continuous path of uniform diameter which includes the cylinder, the bore, and the discharge pipe **42**. The discharge pipes are preferably formed with sweeping curves of long radius which join some distance above the cylinders into a main pipe **44** of substantially the same diameter as the discharge pipe **42**, although the main discharge may be larger in diameter if desired. When the piston advances it thus forces a charge of the material to be pumped through a passage which offers the lowest possible friction to the material, since in general the friction of the material pumped against the smooth wall of the passages is materially less than the shearing stresses involved in moving a portion of such material through its own mass i. e., the friction of the semi-fluid against the walls of its channel are less than its own internal friction. It is true that the semi-fluid is sheared to some degree at the edges of the recesses **40** and **41**, but these shear sections are small and are negligible in comparison with the total frictional load.

It might be thought that since there is always a continuous passage from the outlet pipe **42** through the recesses **40**, the bore **19**, and the recess 41 into the cylinder, even during the time when the piston is on its down or retraction stroke, there would be a material back flow through the pump which would accordingly be of low efficiency. Because of the viscosity or internal friction of the material handled by such devices, however, the resistance offered by a tortuous passage such as that just described is extremely large, and therefore the back flow is of negligible magnitude even when the pressures developed in the opposite cylinder and across the partly closed valve member, due to the height of the columns of the semi-fluid, are extremely high. It is, furthermore, a characteristic of the material handled that the lower the viscosity and the greater the tendency to flow back through such channels, the smaller the depth of the recesses 40 and 41 can be made, and the higher the frictional resistance through them will be.

It is advantageous so to proportion the parts that when the pistons are at the upper ends of their strokes they are in contact with the valve member, and to make the top of the pistons cylindrically concave so as to fit against the valve. Under these conditions the edges of the valve bores scrape the piston heads as the valve rotates, removing any accumulations of material which might otherwise adhere thereto. This is of especial importance where concrete mixes are being pumped, since in this case adherent mix might set between the occasions that the pump is used, and thus cause blocking and breakage.

I claim:

1. A pump for semi-fluids comprising a substantially vertical cylinder having its mouth uppermost, a piston within said cylinder, means for reciprocating said piston, a cylindrical valve of greater diameter than said piston positioned transversely across the mouth of said cylinder completely to close the same and having a transverse bore therethough of substantially the same calibre as said cylinder and alignable therewith, said valve member having a laterally extending intake channel formed therein adjacent to but not communicative with said bore, a casing circumferentially enclosing said valve and having an extension communicating with said channel, means for intermittently rotating said valve to bring said bore into alignment with said cylinder at the bottom of the stroke of said piston and to bring said channel into alignment with said cylinder at the top of the piston stroke, and means for feeding the material to be pumped into the extension of said valve casing.

2. A pump for semi-fluids comprising a pair of spaced parallel pump cylinders, a piston in each of said cylinders, means for reciprocating said pistons in opposite phase relationship, a cylindrical valve member of larger diameter than said cylinders mounted transversely across the tops of both of them, said valve member having a pair of bores therethrough of substantially the diameter of the cylinders and alignable respectively therewith, said bores being angularly displaced by more than the angle subtended by the orifices of said bores, and said valve member having a section of reduced diameter between said bores and input channels leading laterally outwardly into the full diameter portions of said valve member on opposite sides of the respective bores in positions such that when one of the bores is aligned with a cylinder an intake channel will be aligned with the other cylinder, a cylindrical housing surrounding said valve member and forming a chamber about the reduced section thereof, means operative at the ends of the piston strokes to rotate said valve member to bring one of said bores into alignment with its respective cylinder, and means for feeding material to be pumped into said chamber.

3. A pump for semi-fluids comprising an aligned cylinder and discharge pipe of substantially equal calibre, a piston in said cylinder, means for reciprocating said piston, a rotary valve member interposed between said cylinder and discharge pipe having a diameter at least 40% greater than said cylinder and having a bore therethrough of substantially the same diameter as said cylinder and discharge pipe and alignable therewith, means for rotating said valve member to bring the bore into alignment with the cylinder when the piston is substantially fully retracted and to bring said bore out of alignment when said piston is substantially fully advanced, and a casing member closely surrounding said rotary valve member, recesses being formed in at least one of said members at their surface of contact, said recesses subtending an arc equal to the arc of rotation of said valve and extending circumferentially from the bore in the direction opposite to the relative movement of the member in which the recess is formed, the depth of such recesses being of the order of magnitude of the largest solid particles in the material to be pumped.

4. In a pump for semi-fluids comprising a cylinder, a discharge pipe of equal diameter axially aligned therewith, a piston reciprocally disposed in said cylinder, a rotary valve member having a diameter at least forty per cent greater than, and a bore therethrough of diameter equal to the diameter of said cylinder disposed between said cylinder and said discharge pipe and having said bore axially alined with said cylinder discharge pipe, said piston having a cylindrically concave head with the same radius of curvature as said rotary valve member and adapted to contact said valve once during each reciprocal movement of said piston, means for rotating said valve member to bring the bore into registry with the cylinder when the piston is retracted, and to turn said bore out of alignment when said piston is advanced, a casing member forming a sliding fit about said valve member, recesses formed in said members at their contact surface, said recesses subtending an angle equal to the angle of rotation of said valve and having a depth of the order of magnitude of the largest solid particles in the material to be pumped.

5. A pump for semi-fluids comprising a pair of spaced parallel pump cylinders, a cylindrical valve housing member engaging an end of each cylinder, a rotary valve member within said housing member having a bore disposed through each end thereof of diameter equal to that of said cylinders, said bores being angularly displaced each from each by a greater amount than the angle subtended by the orifices of said bores, said valve member having a portion of reduced diameter central of said bores, said reduced diameter portion forming a feeding chamber, each of said end portions having therein an intake channel adapted to communicate laterally with said feeding chamber when the opposite bore is in line with the corresponding cylinder, an aperture into said feeding chamber, means for feeding material to be pumped into said chamber, and means for rotating said valve member reciprocally at the end of each piston stroke.

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