Oct. 17, 1939. N. C. PRICE 2,176,360

FLUID FORCING SYSTEM

Filed Aug. 21, 1937

FIG-2-

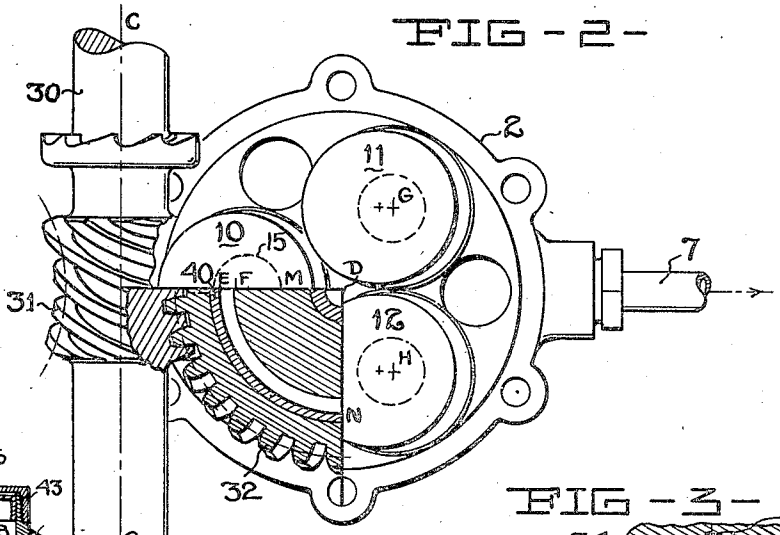


FIG-3-

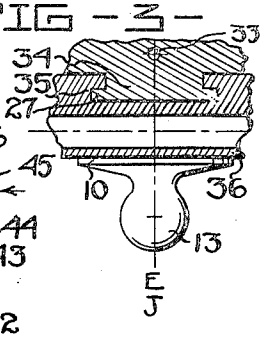
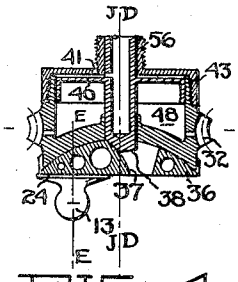


FIG-4-



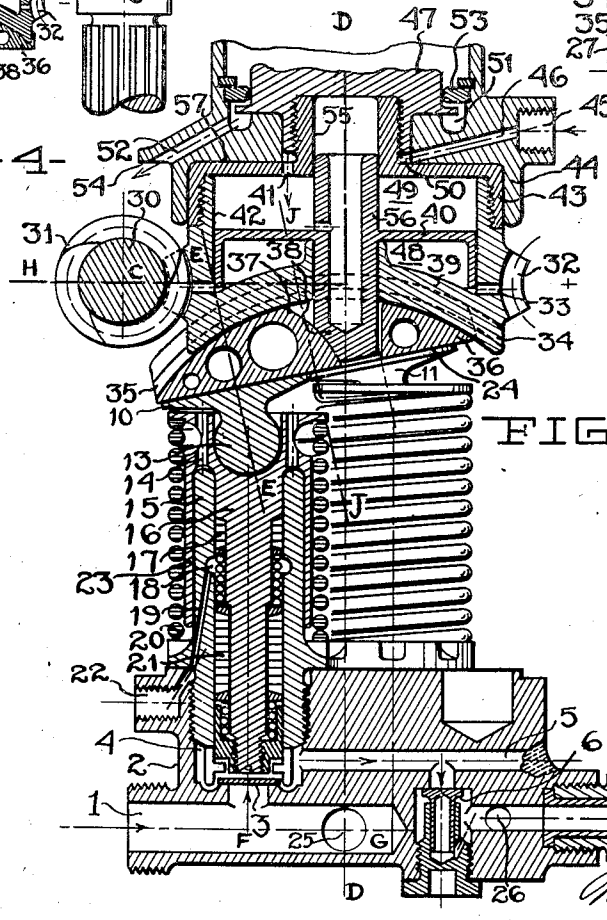


FIG-1-

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FLUID FORCING SYSTEM

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10 Claims. (Cl. 103—173)

My invention relates to fluid forcing systems in general, and particularly to those which must supply fluid at very high discharge pressures.

An object of the invention is to provide a pumping mechanism which may be controlled to operate throughout a wide pressure range without variation of quantity of fluid discharged therefrom.

Another object of the invention is to supply a pumping system which may be controlled to operate throughout a broad range of speeds without variation of quantity of fluid discharged therefrom.

A further object of the invention is to provide a pumping mechanism which may be used to force fluids under stable flow and at high cycle efficiency within a controllable range of outputs, speeds, and pressure rises.

A still further object of the invention is to supply a fluid forcing system readily connected to relatively low speed drives, and also to high speed drives such as are sometimes made available from turbines and electric motors.

Another objective of the invention is to supply a highly compact and rugged pump, which has uniform discharge substantially free from destructive pulsations.

Other objectives are attained, such as capability of very rapid change of pump output from no discharge to full discharge and without harmful pressures or accelerations of the working elements.

A typical use for the invention is exemplified by feedwater pumping for high pressure once-through boilers. In such application the pump must sometimes have a fully controllable discharge regardless of its speed or pressure rise. Working discharge pressure sometimes reaches 250 atmospheres.

Figure 1 diagrammatically illustrates a vertical section through a preferred form of the fluid forcing system.

Figure 2 describes diagrammatically a plan view of this system with a portion of the mechanism removed. A fragment bounded by the lines M and N is shown in plan section along a plane H of Figure 1.

Figure 3 illustrates a section of a cam and of a gear body in the pumping system along a plane E of Figure 1.

Figure 4 demonstrates along the same section as Figure 1 a position of the cam and some hydraulic cam actuating elements thereof when the pumping system is being controlled for no discharge.

The described invention may be embodied in other similar shapes. The exact forms shown in these specifications are merely representative or preferable. The utility of the device for pumping applies to various fluids and also to mixtures of fluids.

In Figure 1 a triple thread cone worm 31 of a driven shaft 30 on a horizontal axis of rotation C drives a worm gear 32 on a vertical axis of rotation D. The gear 32 is restrained by a shoulder 43 attached thereto to rotate within a concave bearing 57 of a stationary housing 44.

Lubricating oil for the bearing 57 is admitted under pressure at an inlet 45, and is advanced along a duct 46 to an annular space 58 from which it may spread to form a load supporting film between the shoulder 43 and the bearing 57.

Furthermore the oil pressure at the inlet 45 is responsive to a control and is used for regulating the pump discharge. For instance, the oil may be fed at 100 pounds per square inch for adjusting the action of the pump mechanism for maximum pump output, or may be fed at 15 pounds per square inch to produce a relatively small pump discharge. Intermediate oil pressures cause rates of pump output ranging between maximum and minimum discharge.

Briefly, the method for this output regulation comprises hydraulic variation of the angle of a rotating cam. Thereby the length of stroke imparted to pumping plungers is controlled.

The relatively high oil pressure of 100 pounds per square inch forces a circular piston 40 to the bottom of a cylinder 42 formed by the shoulder 43 and by the gear 32. This is as illustrated in Figure 1. A circular side cam 36 having a geometric axis J is joined to the gear 32 by a curved rail 34 of the gear. This rail may slide along a groove 35 of the cam 36. The position of the cam 36 relative to the gear 32 is determined by the degree of wedging action afforded by a plug 38, extending from the piston 40, against a slot 37 centrally located in the cam 36. As the piston 40 seeks downward position, shown in Figure 1, the plug 38 moves the slot 37 laterally. The axis J departs from the axis D as the cam 36 tilts. The rail 34 slides tangentially in the groove 35. The cam 36 is continuously being rotated about the axis D by the gear 32 regardless of the angle between the axis J and the axis D. Since a face 24 of the cam 36 is normal to the axis J, this face will be characterized by a wobbling motion during rotation of the gear 32.

The magnitude of the wobbling motion, resultant from the degree of the angularity between

the axis J and the axis D, determines the output of the pump.

The described relatively high oil pressure for forcing the piston 40 downward is always admitted to a space 49 above the piston 40 through an orifice 41. For providing a differential pressure across the piston, the space 48 below the piston is maintained at substantially atmospheric pressure by some bleed holes 33.

An oil channel 51 and an oil sealing thread 53 in the housing 44 prevent oil leakage of the bearing 57 from travelling upward along a cap shaft 47. Instead the leakage must flow along a draining duct 52 through a mounting flange 54 and pours upon the worm 31. The shaft 47 may be employed for driving an associated accessory such as a speed governor. The piston 40 is laterally stabilized by a shaft 56 fitted to a guide 55.

As the face 24 of the cam rotates about the axis D motion will be imparted to the three pumping plunger systems having parallel axes F, G, and H. Each may be characterized by one plunger pumping system, as follows: A pivotal segment 10, having an axis E and a spherical bearing 13 in a plunger 16, slides along the wobbling face 24 of the cam 36. The pivotal segment acquires a harmonic motion in three directions, and this harmonic motion is resolved into a harmonic axial reciprocation of the plunger 16 in a cylinder 15. The plunger 16 is shaped to jacket the outside of the cylinder 15 by a sleeve 23. An extended lateral thrust bearing surface is thereby attained and some relief ducts 14 are preferably incorporated in the plunger 16 so that lubricant will not be trapped during reciprocation of the plunger. A coil spring 20 supplies plunger return force against the pivotal segment and presses the pivotal segment against the cam 36. The segments and sleeves are bathed in oil leakage from the cam 36 and the gear 32.

The plunger 16 is provided with some packings for preventing intercontamination between the pump lubricant and the fluid being pumped. A first spring loaded packing 17 tends to seal a relief groove 18 in the cylinder 15 from pump lubricant. However any lubricant which seeps past the packing 17 flows along a duct 19 in the cylinder 15 and is wasted from a fitting 22 in a pump body 2. A second spring loaded packing 21 tends to seal a plunger pumping chamber 4 from the groove 18. Fluid from the chamber 4 which has worked past the packing 21 into the slot 18 is likewise wasted out the duct 19 and the fitting 22.

During the plunger reciprocation in the cylinder 15 feed fluid is cyclically drawn from a feed duct 1 past a wafer check valve 3 into the chamber 4. This fluid is discharged in flow pulses along a duct 5 in the body 2, and past a check valve 6 into a discharge duct 7. Each of the three plunger pumping systems along the axes F, G, and H are fed in rotation from the duct 1 and from a branch duct 25 thereof. Sequential discharge occurs from each of the plunger pumping systems through the duct 7 and the branch duct 26 thereof. A substantially uniform aggregate discharge results.

Figure 2 diagrammatically illustrates in plan view the main elements of the pumping system as described in Figure 1. The pivotal segment 10 and some similar pivotal segments 11 and 12 are disposed at 120 degree intervals about the axis D. The main pump cam driving assembly has been removed for better vision of these segments. The fragment bounded by the lines M and N shows a section through the hydraulic force mechanism of the cam 36 along a plane H of Figure 1.

In Figure 3 is illustrated a section along a plane determined by the axis E of the segment 10 and normal to the face of the cam 36 of Figure 1. The interlock of the cam 36 and the gear 32 by the rail 34 and the groove 35 is shown. A protruding land 27 of the rail 34 prevents the cam 36 from being separated from the gear 32.

In Figure 4 is illustrated the position of the hydraulic mechanism of the cam 36 when the pumping system is controlled for no discharge, notwithstanding the fact that the cam 36 and the gear 32 are continuously revolving about the axis D. During this phase a relatively low lubricant pressure, of 5 pounds per square inch for instance, is admitted at the duct 41. Accordingly the piston 40 is maintained in upper position due to stabilization efforts of the pumping plunger systems along the axes F, G, and H. Then the axis J coincides with the axis D, the cam 38 rests upon the upper portion of the cam 37, and the face 24 is normal to the axis D. It is evident that even though the cam 36 is in continuous rotation about the axis D, the pivotal segments 10, 11, and 12 slide along the cam 36 without harmonic motion and spin about their respective axes only. Therefore no fluid pumping results.

I claim:

1. A fluid forcing system comprising a piston for pumping, a rotating cam for actuating said piston along a pumping stroke, and hydraulically operated means rotating with said cam for varying the position of said cam relative to said piston for regulating said stroke.

2. A fluid forcing system comprising a pumping plunger, a rotating cam for driving said plunger, and a hydraulic motor integral with said cam for varying the position of said cam relative to said plunger for regulating the output from said system.

3. A fluid forcing system comprising a driving gear, a motor for rotating said gear, a driven gear having an axis of rotation substantially normal to that of said driving gear, a planar surface projected from said driven gear and at an oblique angle to the axis thereof and integral with said gear, and a plurality of pumping plungers driven by said surface and having the following characteristics: axes thereof substantially parallel to said axis of said driven gear, axes thereof substantially equally spaced about said axis of said driven gear, a common inlet, and a common outlet.

4. A fluid forcing system comprising a pumping plunger, a lubricant under relatively high pressure, a cam for driving said plunger, a first means for conducting said lubricant to said cam for lubrication and a second means for employing said lubricant to vary the position of said cam respective to said plungers to regulate the discharge from said system.

5. A fluid forcing system comprising a rotative element having means to absorb axial thrust, and having means formed with a bearing surface defining a plane disposed generally transversely of the rotative axis and shiftable relative to the first means to tilt the plane of said surface angularly relative to such axis, hydraulic means incorporated in said element and operable to accomplish such shifting of the shiftable means, driving means to rotate said element, a pump chamber, a displacement member reciprocable in said pump chamber, and means bearing upon

the planar surface of said shiftable means, and operatively connected with said displacement member, to effect pumping movement of the latter, as the element rotates, in an amount corresponding to the tilt of said surface.

6. A fluid forcing system comprising a rotative element having means to absorb axial thrust, and having means formed with a bearing surface defining a plane disposed generally transversely of the rotative axis, and shiftable relative to the first means to tilt the plane of said surface angularly relative to such axis, hydraulic means incorporated in said element and operable to accomplish such shifting of the shiftable means, driving means to rotate said element, a pump chamber, a displacement member reciprocable in said pump chamber, means bearing upon the planar surface of said shiftable means, and operatively connected with said displacement member, to effect pumping movement of the latter, as the element rotates, in an amount corresponding to the tilt of said surface, and drain ports leading from said hydraulic means to bearing surfaces of the rotative element, to lubricate such surfaces.

7. A fluid forcing system comprising a rotative element having means to absorb axial thrust, and having means formed with a bearing surface defining a plane disposed generally transversely of the rotative axis, and shiftable relative to the first means to tilt said surface angularly relative to such axis, cam means incorporated in said element and movable to accomplish such shifting of the shiftable means, hydraulic means also incorporated in said element and operatively connected to move said cam means, driving means to rotate said element, a pump chamber, a displacement member reciprocable in said pump chamber, and means bearing upon the planar surface of said shiftable means, and operatively connected with said displacement member, to effect pumping movement of the latter, in an amount corresponding to the tilt of said surface.

8. A fluid forcing system comprising a rotative element having means to absorb axial thrust, and having means formed with a bearing surface defining a plane disposed generally transversely of the rotative axis, and shiftable relative to the first means to tilt the plane of said surface angularly relative to such axis, hydraulic means incorporated in said element and operable to accomplish such shifting of the shiftable means, gear teeth formed on and encircling said element, a driving gear meshing therewith, drain ports leading from said hydraulic means to the exterior of the element, for lubrication of the latter, a pump cylinder, a plunger reciprocable therein, and means bearing upon the planar surface of said shiftable means, and operatively connected with the plunger to effect pumping movement of the latter, as the element rotates, in an amount corresponding to the tilt of said surface.

9. A fluid forcing system comprising a pump chamber, a displacement member reciprocable therein, a rotative element having means, including a pressure element having a terminus movable under the influence of a pressure medium within the pressure element, to absorb thrust axially of the pump chamber, ports communicating to the pressure element for admission and withdrawal of the pressure medium, a cam member having guiding engagement with the rotative element for rotation therewith, and for shifting transversely of the rotative axis, and for coincident tilting, the pressure element's terminus engaging said cam member to effect such shifting and tilting of the latter, and said cam member having a bearing surface operatively engaged with the pump's displacement member, to effect pumping movement of the latter more or less, in accordance with the tilt of the cam member.

10. A fluid forcing system comprising a pump cylinder, a plunger reciprocable therein, a rotative element rotative about an axis parallel to the axis of the cylinder, and having means, including a pressure element having a terminus movable under the influence of a pressure medium within the pressure element, to absorb axial thrust, ports communicating to the pressure element for admission and withdrawal of the pressure medium, a cam member, complemental guides on the rotative element and on the cam member, disposed generally diametrically of the rotative element, for conjoint rotation of the two, and curved about a center substantially in the rotative element's axis of rotation for shifting of the cam member transversely of the rotative element, and for its coincident tilting relative to the latter's axis, the pressure element's terminus engaging said cam member to effect such shifting and tilting, and said cam member having a bearing surface operatively engaged with the pump's plunger, to effect pumping movement of the latter more or less, in accordance with the tilt of the cam member.

NATHAN C. PRICE.