

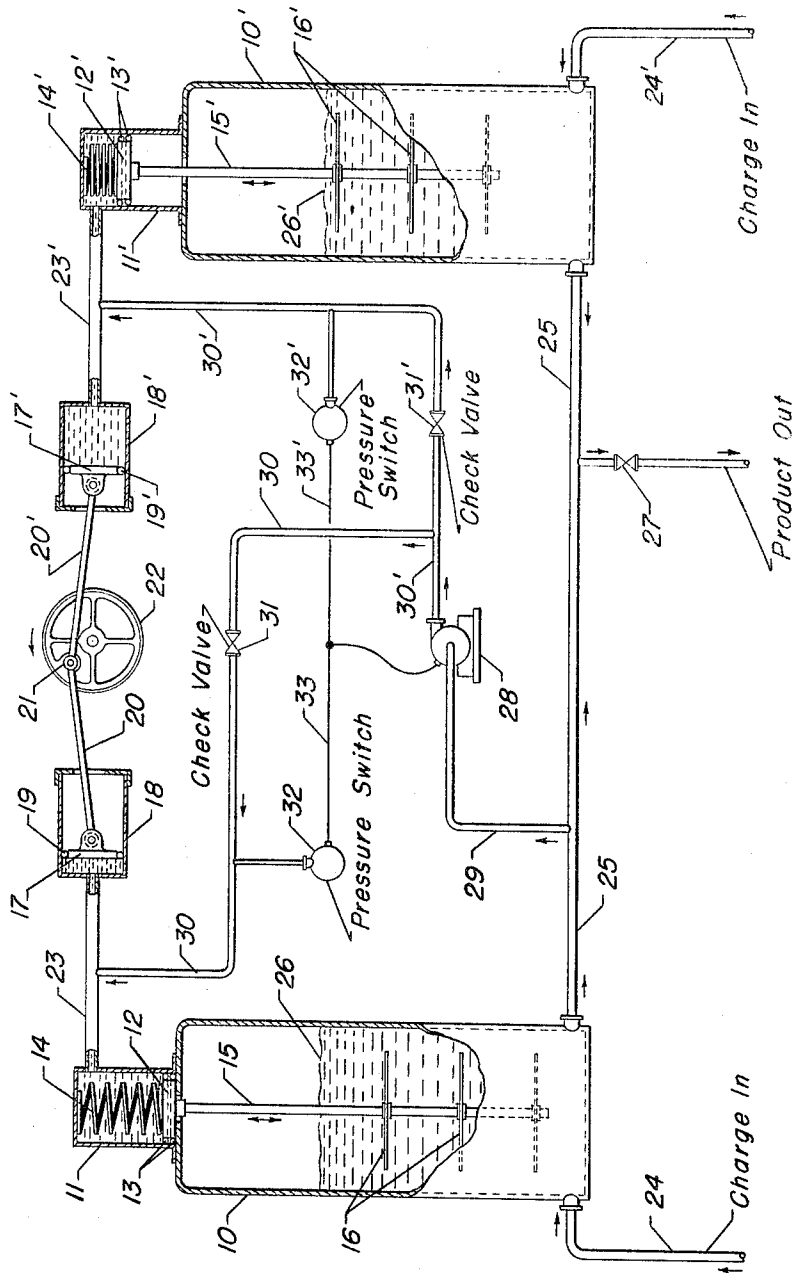
Aug. 16, 1966

J. G. GATSIS ETAL

3,266,782

DUPLEX AGITATOR

Filed July 8, 1964



INVENTORS:
John G. Gatsis
Peter Urban
BY: *James R. Hootson Jr.*
William H. Page II
ATTORNEYS

1

3,266,782

DUPLEX AGITATOR

John G. Gatsis, Des Plaines, and Peter Urban, Northbrook, Ill., assignors to Universal Oil Products Company, Des Plaines, Ill., a corporation of Delaware

Filed July 8, 1964, Ser. No. 381,000

6 Claims. (Cl. 259—71)

This invention relates to the art of fluid mixing and, more particularly, concerns improved fluid agitating apparatus of the vibratory type suitable for high pressure, high temperature applications.

A number of schemes have been devised for agitating a mixture of materials inside an autoclave. Designs which transmit mechanical energy to a rotating impeller or vibrating plate within the vessel by means of a shaft extending through the vessel wall require a shaft seal that is difficult to maintain under conditions of high temperature and/or high pressure. The difficulties inhering in maintaining a tight seal increase with increasing size of the apparatus. Consequently, although there are available various stirred vessels of laboratory size, there has heretofore been no satisfactory design for a large scale unit suited to commercial use.

The present invention is directed to a vibratory type mixing apparatus which altogether eliminates the shaft seal and can be readily scaled up to any desired size. The shaft carrying the mixing member is totally enclosed within the pressure vessel and the energy for reciprocating the shaft is supplied through a hydraulic medium. Furthermore, in accordance with the invention, there are provided two generally identical mixing vessels connected in tandem or push-pull manner whereby the work expended in driving the shaft of one vessel through its travel path in one direction is partially recovered in the next half cycle of operation when the shaft of the other vessel is driven through its travel path in said one direction, and vice versa. Thus the net work input to the system is minimized and is mostly that required for fluid agitation, permitting the use of a much smaller prime mover than would otherwise be necessary and attainment of high efficiency. In a specific aspect thereof the invention overcomes the problem of leakage loss of hydraulic liquid by passing a portion of the liquid being mixed or agitated to the hydraulic system thereby to replenish such loss; therefore a completely tight system is unnecessary and hydraulic seals of simple design and low cost may be utilized.

One embodiment of this invention provides a fluid mixing apparatus comprising two fluid-tight liquid-retaining vessels, each of said vessels including a closed plunger housing opening inwardly of the vessel, a reciprocable plunger within the housing, spring means operatively engaging the plunger and arranged to oppose the inward movement thereof, a shaft connected to the plunger which is adapted to extend into a body of liquid within the vessel, a transversely enlarged mixing member attached to said shaft and positioned to be wholly immersed in said liquid; a plunger drive means comprising a piston chamber, a pair of axially spaced reciprocable pistons transversely placed in the chamber, means mechanically connecting said pistons, reciprocating drive means coupled to said connecting means for alternately and simultaneously advancing and retracting the pistons in opposed relationship; conduit means connecting each end of the piston chamber to

2

a corresponding one of said plunger housings; and hydraulic fluid filling the spaces defined by the plunger housings and their respective plungers, said conduits, and the spaces between the end walls of said piston chamber and the pistons.

The apparatus of this invention may be employed for mixing or intimately contacting a liquid with a gas and/or a finely divided solid contact material such as a catalyst to promote chemical reactions, or for generating an emulsion of two or more immiscible liquids. One specific application of the instant apparatus is the use thereof as a reactor in the catalytic hydrorefining of heavy petroleum stock such as crude oil, topped crude or vacuum gas oils to remove therefrom heavy metals, sulfur, nitrogen and asphaltenes and/or to hydrocrack the stock to diesel oil or gasoline boiling range material. Such hydrotreating is carried out in the presence of hydrogen and hydrogenation and/or hydrocracking catalyst at temperatures in the range of 700°–850° F. and pressures of 1000–5000 p.s.i.g. The catalyst may be a solid particle-form catalyst such as nickel or vanadium on silica-alumina or an oil-soluble catalyst such as nickel acetylacetonate or vanadium acetylacetonate.

The present invention may be further described and its advantages set forth by reference to the accompanying drawing and the following description thereof. In the drawing there are shown two vertically elongated closed mixing vessels 10 and 10'. The vessels and their respective operative parts are of generally similar construction, wherefore the description thereof will be focused on a single vessel 10. A closed plunger housing 11 extends from the upper end wall of vessel 10 and the lower end of housing 11 opens into the vessel. A reciprocable plunger member 12 is slidably disposed within housing 11, the periphery of the plunger carrying sealing rings 13 in sliding contact with the housing wall. A helical tension spring 14, connected to the upper end wall of housing 11 and to plunger 12, supports the plunger and at the same time opposes its downward movement. An elongated axial shaft 15 is connected to plunger 12 and extends downwardly into a body of liquid undergoing agitation in vessel 10, the liquid level being indicated by numeral 26. To the lower end portion of shaft 15 are fixedly attached one or more transversely enlarged mixing members 16 so located with respect to liquid level 26 as to be totally submerged in the liquid regardless of the instantaneous vertical displacement of shaft 15. These mixing members may be in the form of perforated or imperforate flat plates, cups, frustoconical rings or other suitable construction known in the art of vibratory mixing. Liquid is charged to vessels 10 and 10' through conduits 24 and 24', respectively.

Plungers 12 and 12' are hydraulically actuated in alternating relationship by a duplex plunger drive mechanism comprising a pair of spaced reciprocable pistons 17 and 17' slidably disposed within piston chambers 18 and 18'. Chambers 18 and 18' may be two physically separate chambers or may be simply opposite ends of a single chamber. The peripheries of pistons 17 and 17' carry sealing rings 19 and 19' in sliding contact with the walls of chambers 18 and 18'. Both of pistons 17 and 17' are mechanically linked, each to the other, through connecting rods 20 and 20' which pivotally engage eccentric pin 21 carried by a flywheel 22. Flywheel 22 is rotated by a suitable motor not here illustrated. Hydraulic fluid

transfer conduits 23 and 23' connect the ends of piston chambers 18 and 18' with the respective plunger housings 11 and 11' to complete the hydraulic power transmission system. Housings 11, 11', conduits 23, 23' and piston chambers 18, 18' are filled with a suitable hydraulic fluid (relatively incompressible) which may be oil, water or a highly compressed gas.

In a preferred embodiment of the invention, vessels 10 and 10' are interconnected by a pressure-equalizing line 25. This line assures that the static pressures in both vessels are substantially equal, thereby providing a balanced load for plungers 12 and 12' and the plunger drive means. While line 25 may connect with vessels 10 and 10' above or below liquid levels 26 and 26', it preferably connects below the levels and at the same elevation to equalize the levels so that, when the apparatus is employed as a continuous flow reactor, uniform residence times are automatically obtained.

Vessels 10 and 10' may be charged with liquid through one of lines 24 and 24' and conduit 25 when operated as a batch mixer, product being withdrawn through valve 27 when the mixing step is completed. For operation as a continuous flow reactor, charge may be continuously admitted through both of lines 24 and 24' and continuously withdrawn through valve 27, which valve may be automatically controlled by the liquid level in either of vessels 10 and 10'.

Rotation of flywheel 22 causes pistons 17 and 17' to alternately and simultaneously advance and retract in opposed relationship, that is, the piston displacements are approximately 180° out of phase. As hydraulic fluid is forced into housing 11 to drive plunger 12 downwardly, the other plunger 12' is driven upwardly by the mechanical energy stored in its spring 14', thereby functioning as a power cylinder furnishing a force which is transmitted via the hydraulic medium, pistons 17 and 17' and connecting rod linkage 20 and 20' to said downwardly moving plunger. In the next half revolution of flywheel 22, the function is just the reverse. In other words, during the time that work is performed on one plunger, the other plunger is supplying work. By means of such push-pull or balanced load operation, most of the net work input to the system is simply that consumed by fluid agitation, friction and mechanical losses being held at a minimum.

As an example the utilization of the apparatus as a hydro-refining reactor, crude oil containing in solution therewith 1% by weight of nickel acetylacetonate catalyst, at a temperature of 775° F., is charged to vessels 10 and 10'. Hydrogen is admitted to the vessels either through lines 24 and 24' in admixture with the liquid feed or through separate conduits connecting with the vessels. The reaction mixture is maintained at a total pressure of 2000 p.s.i.g. and is agitated at a frequency in the range of 0.5-100 cycles per second with a liquid residence time of from about 10 minutes to about 2 hours. Hydrorefined product is then withdrawn from the vessels through line 25 and valve 27.

As is often the case with hydraulic power systems, some unavoidable loss of hydraulic fluid by leaking around rings 13, 13' and 19, 19' may be anticipated. However, a specific aspect of the invention provides a means for restoring such loss which is particularly useful when the liquid undergoing agitation is a hydrocarbon oil relatively free of solids. With further reference to the drawing, there is indicated a pump 28, which may be a small capacity rotary gear pump, taking suction from line 25 through line 29 and discharging through branched lines 30 and 30' and check valves 31 and 31' to conduits 23 and 23'. Pressure switches 32 and 32' responsive to pressure in lines 30 and 30' and electrically connected to suitable pump motor controls via leads 33, 33', are arranged to start up the pump whenever the pressure in either of lines 30 and 30' falls below a predetermined level, the same indicating excessive loss of hydraulic fluid from the closed systems. In this manner the liquid under-

going mixing is withdrawn from either or both of vessels 10, 10' and is charged to either or both of plunger housings 11, 11' to replenish leakage of loss of hydraulic liquid therefrom. In fact, a fairly large leakage rate around rings 13 and 13' may be tolerated without ill effect; therefore a simple and inexpensive design for such sealing rings may be employed, and the apparatus may be operated for prolonged periods without the necessity for maintenance shutdown.

Various modifications and equivalent constructions of the invention may be made without departing from the broad scope thereof. With respect to the plunger drive means, electromagnetic drive means may be substituted for the connecting rod-flywheel assembly wherein, for example, the two pistons are defined by opposite ends of a cylindrical magnetic core (which may itself be permanently magnetized) adapted to slide back and forth within and in sealing contact with an elongated non-magnetic housing. Axially spaced electromagnetic coils, disposed within or around the outside of the housing, are appropriately energized so as to cause the core to pulsate or oscillate back and forth within the housing. It will be appreciated that this arrangement is fairly equivalent to that shown in the drawing, the pistons being mechanically connected by a rigid member, instead of an articulated member, which functions to transmit force from the expanding chamber of the compressing chamber.

Plunger springs 14 and 14' may be installed so as to be in compression instead of tension. For example, the lower end of housing 11 may be provided with an annular seating plate having a central opening large enough to permit free movement of shaft 15 therethrough, and the compression spring may be fitted between the undersurface of plunger 12 and such seating plate whereby to support the plunger and to resist its downward movement. The plunger housings 11 and 11' need not extend outwardly from the remainder of vessels 10 and 10' but may be totally enclosed within their respective vessels.

We claim as our invention:

1. Fluid mixing apparatus comprising in combination:

(1) two fluid-tight liquid-retaining vessels, each of said vessels comprising (a) a closed plunger housing opening inwardly of the vessel, (b) a reciprocable plunger within said housing, (c) spring means operatively engaging said plunger and arranged to oppose the inward movement of the plunger, (d) a shaft connected to said plunger and adapted to extend into a body of liquid within the vessel, (e) a transversely enlarged mixing member attached to said shaft and positioned to be wholly immersed in said liquid;

(2) a plunger drive means comprising (a) a piston chamber, (b) a pair of spaced reciprocable pistons within said chamber, (c) means mechanically connecting said pistons, (d) reciprocating drive means coupled to said connecting means for alternately and simultaneously advancing and retracting the pistons in opposed relationship;

(3) a conduit connecting each end of said piston chamber to a corresponding one of said plunger housings; and

(4) hydraulic fluid filling the spaces defined by the plunger housings and their respective plungers, said conduits, and the spaces between the end walls of said piston chamber and the pistons.

2. The apparatus of claim 1 further characterized in the provision of a pressure equalizing conduit connecting said two vessels and providing open fluid communication therebetween.

3. The apparatus of claim 2 further characterized in that said pressure equalizing conduit connects with said vessels below the respective liquid levels therein.

4. The apparatus of claim 1 further characterized in that said hydraulic fluid is a liquid.

5. The apparatus of claim 4 further characterized in the provision of means for withdrawing the liquid under-

going mixing from one of said vessels and passing it to one of said plunger housings whereby to replenish leakage loss of hydraulic liquid therefrom.

6. The apparatus of claim 4 further characterized in the provision of means for withdrawing the liquid undergoing mixing from both of said vessels and passing it to both of said plunger housings whereby to replenish leakage loss of hydraulic liquid therefrom.

References Cited by the Examiner

UNITED STATES PATENTS

683,483	10/1901	New	259—71
2,661,192	12/1953	Horsley et al.	259—113
2,763,666	9/1956	Mastagli	259—113

WALTER A. SCHEEL, *Primary Examiner.*