Dec. 8, 1953 W. E. KUENTZEL 2,661,938

ELECTROMAGNETIC STIRRER FOR HIGH-PRESSURE CONTACTORS

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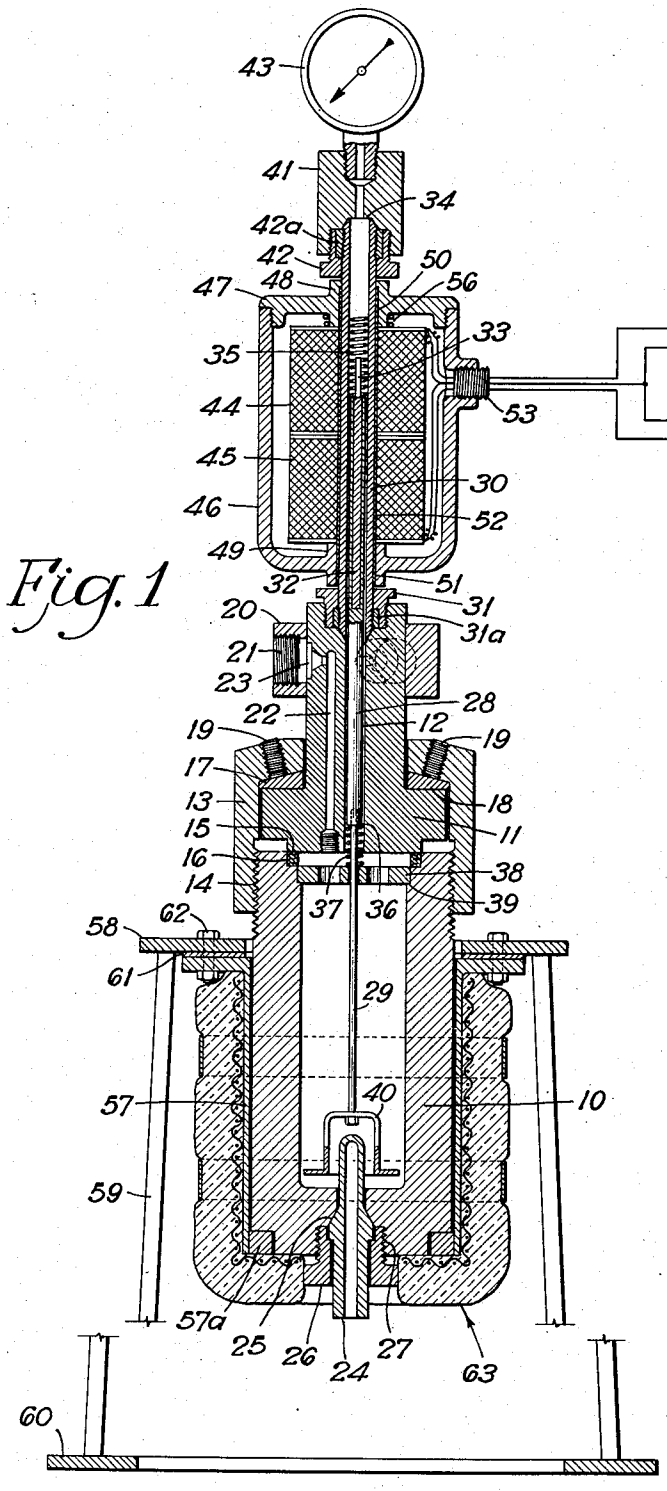


Fig. 1

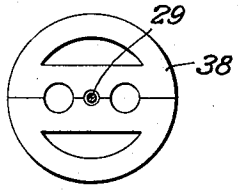


Fig. 2

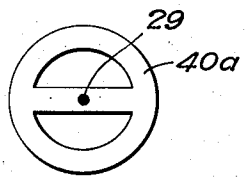


Fig. 3

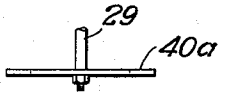


Fig. 4

INVENTOR.
Ward E. Kuentzel
BY
Everett A. Johnson
ATTORNEY

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ELECTROMAGNETIC STIRRER FOR HIGH-PRESSURE CONTACTORS

Ward E. Kuentzel, Whiting, Ind., assignor to Standard Oil Company, Chicago, Ill., a corporation of Indiana

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8 Claims. (Cl. 261—81)

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This invention relates to high pressure contacting apparatus and it pertains, more particularly, to improved apparatus for effecting contact between separate phases, one of which is a liquid and the other phase or phases being either gaseous, liquid, or solid, under extremely high pressure conditions and under closely controlled temperature conditions.

An object of the invention is to provide a stirring apparatus which is adapted for obtaining close control in the contacting of immiscible phases at pressures in the range of 1,000 to 15,000 pounds per square inch and at an elevated temperature up to 750° F. or higher. A more specific object is to provide an improved stirring mechanism which is entirely closed within the high pressure apparatus and which is separable from the stirrer actuating mechanism. A further object of the invention is to provide a heating and temperature control system from which the high pressure contacting apparatus per se is readily separable. Still another object of the invention is to provide an improved stirrer actuating means adapted for long and efficient operation. An additional object is to provide a stirrer linkage which is convertible to applying the stirring action in the lower half of the contacting vessel for agitation of the liquid and at the interface between liquid and gaseous phases. Still another object is to provide a stirred contacting chamber which is adapted for manual stirring at ordinary pressure before or after the high pressure contacting. These and other objects of the invention will become apparent as the detailed description of the apparatus and method proceeds.

In accordance with the invention, an upright, open-ended contactor of thick walled construction is provided. A removable head for the contactor vessel includes an axially extending tube through which the stirrer is actuated. To accomplish the mixing or stirring, a plunger-type mixer is reciprocally mounted in the contactor through the head. The stirrer or dasher is positively actuated by the electromagnetic effect of two tandem solenoids on a paramagnetic portion of the stirrer rod or stem which extends above the upper end of the head closure. The "floating" stirrer rod assembly permits removal of the head and solenoid means from the contacting chamber proper without disturbing the stirrer within the chamber, and this has many advantages.

The floating stirrer makes it unnecessary to handle the entire head, cap, solenoid, and gage assembly while draining the reaction products

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from the stirrer or while cleaning the stirrer. Likewise, damage to the delicate dasher element, which frequently happens when the stirrer is attached to the head, is avoided. Another important advantage is that by providing a separable stirrer, the contents of the reactor can be manually stirred when the head closure is not on the bomb. Likewise, solids may be placed in the reactor after the stirrer is in place and thus stirred into solution or suspension. In prior devices all of the components were necessarily admixed without immediate stirring which causes balling up and agglomeration of the solids.

Solenoid means including a pair of solenoid coils is used. One solenoid functions positively to raise the stirrer shaft mechanism and the other positively lowers it in accordance with an electronic timing mechanism of any type known to the art so that both the frequency and speed of the upward and downward movements can be controlled with great precision. Opposing coil springs serve to regulate the length of the stroke and to cushion the reversal of direction of the stirring shaft means. Thus the springs may be of different length and may be placed to control the upper and lower limits of travel of the dasher within the contactor, depending upon whether it is desired to effect mixing of immiscible liquid phases in a lower part of the vessel or to mix an upper gaseous phase with a lower liquid phase or phases.

The invention will be more clearly understood from the following detailed description of a specific example thereof, read in conjunction with the accompanying drawings, in which

Figure 1 is a schematic view, partly in section, of the improved apparatus assembly;

Figure 2 is a plan view of the spring thrust plate; and

Figures 3 and 4 illustrate another form of stirrer head.

As an example of the invention, an apparatus will be described which is designed to obtain closely controlled contacting of gases with liquids at a predetermined temperature which may be as high as 750° F. or more and at an extremely high pressure which may be as high as about 15,000 pounds per square inch.

Referring to the drawings, the reactor or contactor assembly is formed chiefly by the upright, open-ended cylindrical pressure vessel 10 which may have walls about 0.75 inch thick, an inside diameter of about 1.25 inches, and a height of about 6.0 inches. A reactor head 11 having bore 12 is secured to the open end of the vessel 10 by threaded closure cap 13 which slides over the

axially extending portion of the head 11 and engages the external threads 14 at the top of the vessel 10. The upper end of the vessel 10 is provided with a seat 15 which accommodates the head closure gasket 16 for fluid and pressure tight seal between the head 11 and the vessel 10.

A thrust ring 17 is provided between the lower face of the closure cap 13 and the shoulder 18 on the head 11. A plurality of set screws 19 are threaded through the cap 13 and equalize the pressure exerted on the tapered thrust ring 17 and the shoulder 18 on head 11. This assembly is readily adjustable, is pressure tight, and yet can be demounted quickly.

The reactor head 11 is provided with a high pressure connection ring 20 carrying two or more ports 21, all but one of which connect to the central bore 12 of the head 11. The excepted port connects to a separate bore 22 in head 11 which terminates interiorly in a threaded connection whereby a dip tube (not shown) may be inserted for withdrawing samples of contents without opening the reactor. Reactants or any fluid may be introduced into the reactor 10 through any of the ports 21, and one of them is preferably attached to a frangible safety disc means (not shown) which is designed to rupture if excessive pressure is attained.

A thermocouple casing 24 extends upwardly into the bottom of the reactor 10, said casing having a shoulder 25 which is held in place by a gland nut 26 which is threaded to engage threads in a recess 27 in the bottom of the reactor 10.

Referring to the stirring assembly in Figures 1 and 2, an operating shaft means as shown comprises the stem 28 which engages the upper end of stirring rod 29 which is of smaller diameter than stem 28. This operating shaft means passes within the bore 12 in head 11 and within magnet core tube 30 which is secured by gland nut 31 and collar 31*a* to the upper end of the head 11 in alignment with the bore 12. A magnetic core 32 is carried by the upper end of the stem 28 and this core 32 can be fabricated, for example, by drilling out stainless steel stem 28 and filling the cavity with soft iron wire and capped with a stainless steel weld.

At the upper end of the magnet tube 30 is a spring stop 34 provided by the block 41. The coil spring 35 is interposed between this stop 34 and the top of core 32 which has a short projection 33 at the upper end for guiding the spring 35. A shoulder 36 is provided on the operating shaft means which shoulder rests on coil spring 37. A spring stop 38 is supported in an annular stop seat 39 machined in the inner wall of the reaction vessel 10 just below the head closure gasket seat 15. The spring stop 38 may suitably comprise a diametrically split plate as shown in Figure 2 so that the two halves can be separated for removal of the stirring rod 29 and the dasher 40 from the vessel 10.

With this arrangement, the spring 37 and plate 38 limit the downward travel of the stirrer which is adjusted in length so that it reaches nearly to, but does not strike, the bottom of the reactor 10 when the spring 37 is compressed. Spring 35 at the top of the magnetic core 32 is one inch longer than spring 37 when compressed and serves to limit the upward movement of the stirrer assembly. The length of these springs is so adjusted that with the shorter spring 37 at the lower position and the longer spring 35 at the upper position, the dasher 40 remains submerged in any liquid charge occupying the lower

half of the reactor 10. By using a relatively shorter spring in the upper position, the throw of the dasher 40 is changed so that it operates at a higher level and splashes the liquid into the gaseous phase and thereby facilitates liquid-gas contacting. If desired, a disc type dasher such as shown in Figures 3 and 4 can be used for the splashing operation. Such dasher can also be used where the thermowell 24 is in the side wall of the vessel 10 instead of extending through the bottom as shown in the drawings.

The top of the magnet core tube 30 may be machined as shown with a cone seat and threaded to collar 42a and gland nut 42 for attachment to block connector 41 into which a standard gage 43 may be mounted as shown. Surrounding the magnet core tube 30 are two solenoids 44 and 45 arranged in tandem and enclosed within a magnetic metal housing 46 having closure 47 threaded into the open end of the housing. Aligned hubs 48 and 49 have bores 50 and 51 which accommodate the ends of an axial aluminum tube 52 which fits about the magnetic core tube 30. Thus, the non-magnetic tube 52 and spring 53 support the coils 44 and 45 in resilient but fixed position with the housing. In addition to protecting the electrical equipment, the magnetic housing and closure serve to concentrate the magnetic flux at the core 32, thus improving the stirring efficiency of the solenoid means.

Current to the solenoid 44 is controlled by relay 54 and the current to solenoid 45 is controlled by relay 55. The current is applied alternately to each relay by a timer 64 which permits individual control of the "on" time of each. Any dual control timer which regulates the action from about four cycles per second to one cycle every 5 to 10 seconds can be used. By having two separate solenoids and having each solenoid separately controlled by an electronic timer, the movement of the stirrer is positively actuated in both upward and downward directions and it may be controlled with great precision. The dasher 40 moves back and forth over a maximum linear distance of approximately 2.5 inches to accomplish the required agitation. Various sizes and shapes of stirrers may, of course, be employed depending upon such factors as the type of miscible fluids being contacted, their viscosity, etc. However, all the stirrers are characterized by being of very low weight or mass and are adapted to be moved rapidly up and down by the positive action of the particular solenoid coil 44 or 45.

The reactor head 11, magnet core tube 30, stem 28, and springs 34 and 37 are made of non-magnetic material, preferably stainless steel of austenitic structure, although copper, brass and the like non-magnetic metals can be used.

A useful support for the complete reactor and stirrer mechanism may comprise a support flanged tube 57 fitted about the vessel 10 and bolted to a stand comprising support ring 58, legs 59, and base ring 60. A heat insulating material or gasket 61 is interposed the flange 57 and the ring 58. Bolts 62 or other fastening means can be used to secure the support flange of tube 57 to the stand ring 58. It is desirable that the legs 59 spread outwardly as illustrated so as to give more room under the reactor 10. This permits the removal of the heating unit 63 and the substitution of a liquid cooling bath (not shown) without dismantling or lifting the assembly. The strip heater 63 about the reactor 10 is preferably of the well known "Glascol" type (described in U. S. Patents 2,231,506 and

2,282,078) since such a heat source is easily controlled and removed from the reactor. However, other heating means, such as steam or liquid heating jackets can be used. Likewise, it is contemplated that a strip heater can be applied to the closure cap 13. Lugs 57a welded to the lower periphery of flanged tube 57 support the lower end of vessel 10 in the cut-outs on its base and prevent rotation of the vessel within the stand.

Although the invention has been described with reference to particular embodiments thereof, it is to be understood that this is by way of illustration only. Accordingly, it is contemplated that modifications and variations can be made in the invention by those skilled in the art in light of the preceding description without departing from the spirit of the invention or the scope of the appended claims.

What I claim is:

1. Apparatus for contacting separate phases at controlled temperature and under high pressure which comprises a pressure vessel, a thermowell extending into the base of said vessel and removably secured therein, an elongated non-magnetic head means for said pressure vessel, a bore within said head means communicating with said vessel and in substantial axial alignment therewith, a mixer element within said vessel having an operating shaft means, a movable magnetic core in said bore, means for separably linking said core to said shaft means, a solenoid means substantially surrounding said core within said head means, a housing for said solenoid means supported by said elongated head means, a timer for controlling the energizing of said solenoid means, a first coil spring means surrounding said shaft means within said bore, a spring stop plate arranged across the mouth of said vessel below the said head and adapted to support the lower end of said first coil spring means, said stop plate having a diameter greater than the diameter of said vessel and comprising two apertured semi-circular disc members, and a second coil spring means above the upper end of said core and within said bore, each of said coil spring means being adapted to resiliently limit the stroke of said core means vertically within said solenoid means.

2. Apparatus for contacting separate phases at controlled temperature and under high pressure which comprises a pressure vessel, a removable head for said pressure vessel, an axial bore within said head communicating with said vessel, a non-magnetic tubular means aligned with said bore, a mixer element within said vessel, a movable magnetic core in said tubular means, a non-magnetic operating stem for said mixer removably fixed to the lower end of said core, a removable spring stop plate arranged across the upper end of said pressure vessel and below said head, said stop plate having a diameter greater than the diameter of said vessel and comprising two apertured semi-circular disc members, coil spring means surrounding said stem with opposite ends abutting a shoulder on said stem and the upper face of said stop plate, a solenoid means surrounding said core, a casing for said solenoid means supported by said tubular means, a timer for alternately energizing separate portions of said solenoid means, and a second coil spring means above the upper end of said core detachably mounted on said core and abutting a shoulder in an end closure block, said coil spring means being of substantially different length whereby the level at which the mixer element operates within the pressure vessel is adjustable vertically within said solenoid means.

3. Apparatus for contacting separate phases at controlled temperature and under high pressure which comprises a pressure vessel, a thermocouple casing removably extending into said vessel, an elongated head for said pressure vessel, a bore within said head communicating with said vessel and in substantial axial alignment therewith, an apertured and divided plate within the upper end of said pressure vessel and below said head, a shoulder in the upper end of said vessel providing support for said plate, a mixer element within said vessel having a non-magnetic operating stem extending within said bore and through said plate, a movable magnetic core in said bore fixed to said stem, said stop plate having a diameter greater than the diameter of said vessel and comprising two apertured semi-circular disc members, coil spring means surrounding said stem within said bore and extending between the lower end of said core and said plate, a solenoid means surrounding said core within said head, a casing for said solenoid means supported by said elongated head, a timer for controlling the energizing of said solenoid means, and a second coil spring means above the upper end of said core and within said bore, each of said coil spring means being adapted to resiliently limit the stroke of said core means vertically within said solenoid means.

4. Apparatus for contacting separate phases at controlled temperature and under high pressure which comprises a pressure vessel, said vessel having an internal cylindrical chamber of substantially uniform diameter, a removable head for said vessel, an elongated tube means of non-magnetic material communicating with said vessel through said head and in substantial axial alignment therewith, a spring stop comprising a divided and centrally apertured plate removably extending across the upper end of said pressure vessel and below said head, said plate having a diameter greater than the diameter of said cylindrical chamber, a mixer element within said vessel having an operating shaft means extending into said tube means and through said plate, a movable magnetic core means in said tube, disengageable means for connecting the said core means to the said shaft means, a solenoid means substantially surrounding said core within said tube, a timer for controlling the energizing of said solenoid means, a first coil spring means surrounding said shaft means within said tube and abutting said plate, and a second coil spring means above the upper end of said core and within said tube, said coil spring means being of different length whereby the throw of the mixer element may be adjusted.

5. The apparatus of claim 4 wherein the solenoid means comprises a non-magnetic axial tube, a pair of opposed solenoid coils in tandem arranged about said tube, a magnetic housing substantially completely enclosing said tube and coils, and relay means controlled by said timer for alternately energizing each of said coils.

6. Apparatus for contacting separate phases at controlled temperature and under high pressure which comprises a pressure vessel, said vessel having an internal cylindrical chamber of uniform diameter, a removable head for said vessel, an elongated tube means of non-magnetic material communicating with said vessel through said head and in substantial axial alignment therewith, a spring support across the upper end

of said pressure vessel and below said head, said support comprising a diametrically divided plate having a central aperture, a mixer element within said vessel having reciprocating rod means extending into said tube means and through said aperture, a movable magnetic core in said tube, a stem threaded to the lower end of said core and to the upper end of said rod means, a solenoid means substantially surrounding said core within said tube, said solenoid means comprising a non-magnetic axial tube, a pair of opposed solenoid coils in tandem arranged about said tube, a magnetic housing substantially completely enclosing said tube and coils, a timer for controlling the energizing of said solenoid means, relay means controlled by said timer for alternately energizing each of said coils, a first coil spring means surrounding said stem within said tube and abutting said support, and a second coil spring means above the upper end of said core and within said tube, the first of said coil spring means being about one-half the length of said second coil spring means whereby the throw of the mixer element is positioned in a low portion of said vessel.

7. Apparatus for stirring a sealed contactor comprising an elongated cylindrical vessel closed at the bottom and open at the upper end, a removable sealing head means over said open end, an axial bore extending through said head means and closed at its upper end, a plunger-type mixer assembly within said vessel, an apertured partition removably supported across the open end of said contactor below said head means, said partition being in at least two complementary parts and having a central aperture, said partition having a diameter greater than the diameter of said plunger type mixer operating within said axial bore, a shaft means extending within said axial bore and through said central aperture for actuating said assembly, a movable magnetic core separably fixed to the upper end of said shaft, a solenoid means surrounding said core and actuating said plunger-type mixer through said shaft means; an axial projection on said core having a smaller diameter than said core, a first coil spring means surrounding said shaft within said tube and abutting said partition, and a second coil spring means about said projection on the upper end of said core within said tube, each of said spring means being adapted alternately to limit the stroke of said core means vertically within said axial bore as actuated by said solenoid means.

8. The apparatus of claim 3 which includes a flanged tube fitted about said vessel, at least one cut-out at the periphery of the base of said vessel, and at least one lug extending radially inward from the bottom of said tube for engagement with said cut-out, whereby said vessel is removably supported within said tube and is held against rotation.

WARD E. KUENTZEL.

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