Sept. 16, 1952 J. S. CLARKE 2,610,836

ROTATING PLATE MIXING DEVICE

Filed June 30, 1950 3 Sheets-Sheet 1

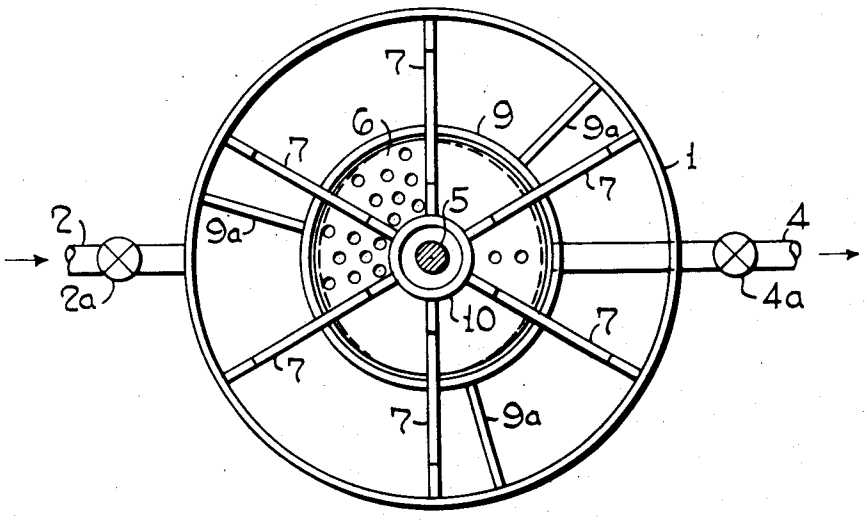


FIG.-2

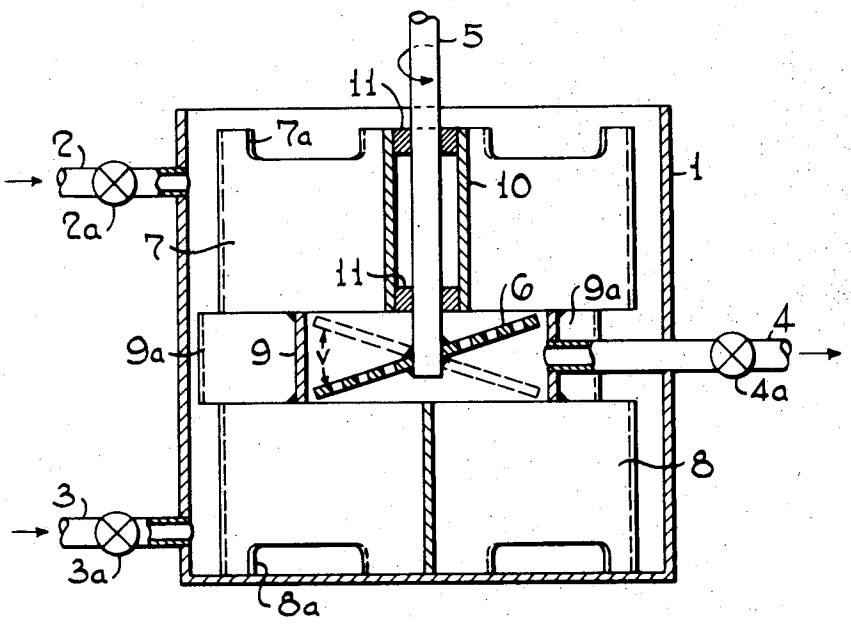


FIG.-1

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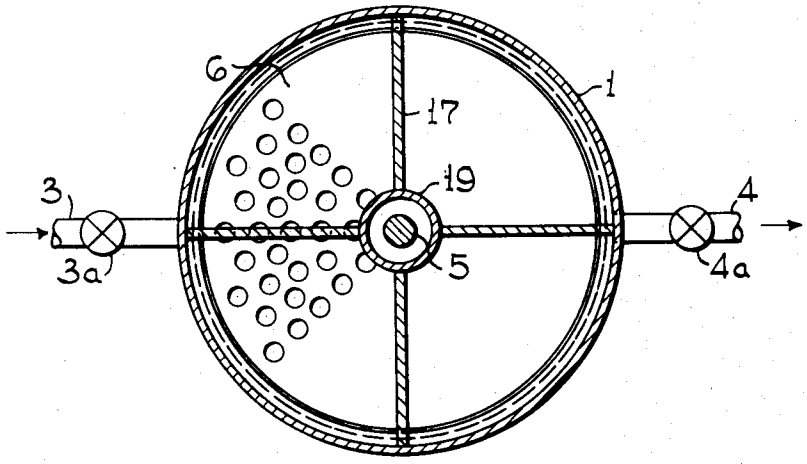


FIG.-4

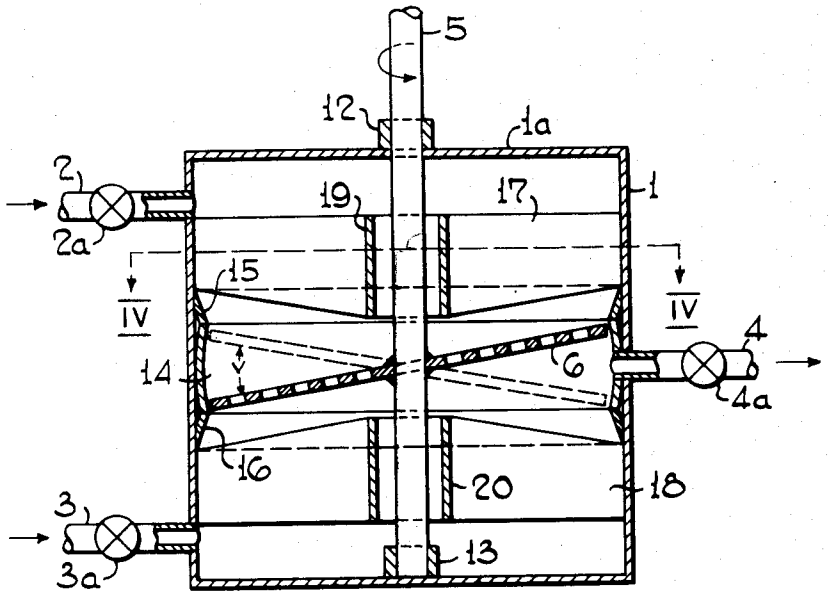


FIG.-3

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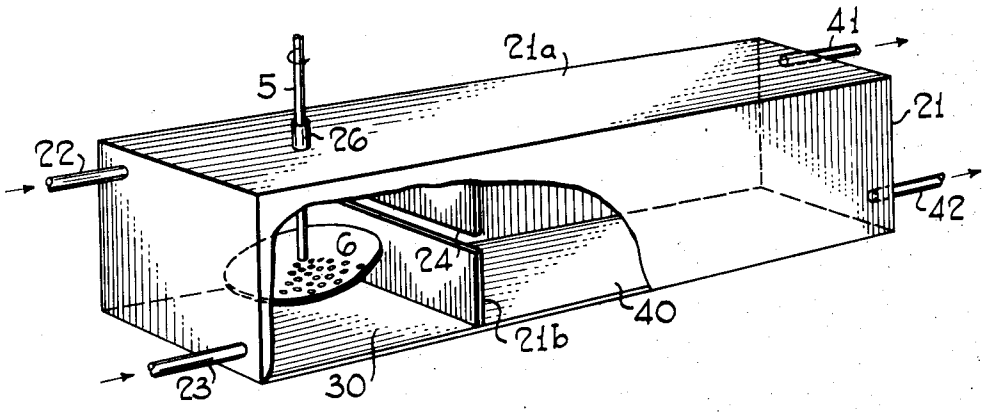


FIG.-5

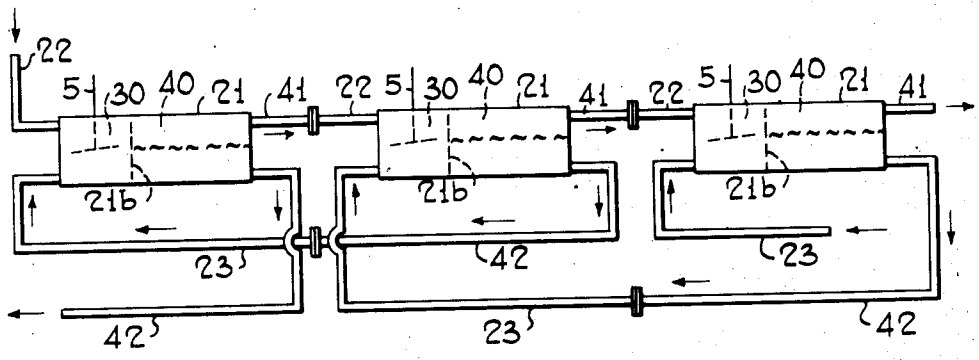


FIG.-6

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UNITED STATES PATENT OFFICE

2,610,836

ROTATING PLATE MIXING DEVICE

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Application June 30, 1950, Serial No. 171,376

9 Claims. (Cl. 259—7)

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The present invention relates to a method and apparatus for mixing or contacting fluids. The fluids may comprise liquids, gases, mixtures of either, suspensions and emulsions. More particularly, the invention relates to such a method and apparatus for mixing or contacting liquids which are immiscible, or only partially miscible.

Normally, in the contacting or mixing of such materials, they may be brought together in a contacting or mixing chamber or zone in which they are indiscriminately agitated. Under other circumstances, the materials may be introduced into a mixing or contacting zone so as to flow therethrough in countercurrent relation, the energy required for mixing, or intimate contact, being derived primarily from the flow velocity or pressure upon the fluids. Various types of mechanical expedients may be employed in the conventional system, such as fixed multiple orifice plates, impellers, and vibrating plate mechanisms. In the last-mentioned system, a perforated plate is disposed at or near and substantially parallel to a predetermined fluid interfacial level, and vibrated by vertically reciprocal movement so as to cause the components of the desired mixture, suspension or emulsion to be jetted into each other through the perforations and thus intimately mixed or contacted. Although adequate and efficient mixing and contacting may be obtained in this fashion, the system is subject to the disadvantage of requiring a reciprocating shaft entering the mixing or contacting chamber, and also is subject to leakage and other problems connected with reciprocal shafts.

It is an object of this invention to provide a method and apparatus having the operational advantages of a reciprocal plate mixing system, without the disadvantages thereof. It is also an object of the invention to provide a contacting and mixing system in which energy expended for mixing of the fluids is not derived frim any energy imparted to the flowing streams of fluids, but from a separate source of energy, which may be employed to vary the degree of mixing action independently of fluid flow.

The invention and its objects may be more fully understood from the following description when read in conjunction with the accompanying drawings, in which

Fig. 1 is a side elevational view of an apparatus of the character contemplated, shown partly in vertical section;

Fig. 2 is a plan view of the apparatus of Fig. 1;

Fig. 3 is a side elevational view, partly in vertical section of another form of the apparatus;

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Fig. 4 is a horizontal section through the apparatus of Fig. 3 taken along the line IV—IV thereof;

Fig. 5 is a view in perspective, and with parts broken away, of still another form of apparatus according to this invention, and

Fig. 6 is a schematic showing of the employment of units such as illustrated in Fig. 5 in a multistage contacting system.

In the drawings, like parts are designated by the same numerals. Referring more specifically to the drawings, in each of Figs. 1 to 4 inclusive, the numeral 1 designates a container vessel or chamber in which fluids may be mixed or contacted, according to the present invention. The vessel 1 is provided with inlet conduit means 2 opening into the upper portion thereof and inlet conduit means 3 opening into the lower portion. Outlet conduit means 4 from the vessel is provided at an intermediate level vertically thereof. Preferably, the conduit means 2, 3 and 4 are provided with valves or other control means 2a, 3a and 4a respectively. Extended vertically into the vessel is a rotatably driven shaft 5 which is connected at its outer end to any suitable source of driving power, although such source is not illustrated in the drawings. Mounted on the shaft 5 in angular relation thereto, and to a horizontal plane intersecting the shaft at right angles, is a plate member 6. This member 6 is preferably a perforate plate of circular form located longitudinally of the shaft within the vessel so as to lie in a plane which angularly intersects a vertical plane diametrically through the shaft, and a horizontal plane intersecting the shaft and vertical plane in perpendicular relation thereto, and substantially coincident with the level of the outlet conduit means 4, so that the line of intersection of the vertical and horizontal planes is substantially contained in the angularly related plane of plate 6. The conduit means 4 normally communicates with the vessel so as to open directly from the operating zone of the plate.

The elements of the apparatus thus far set forth are substantially the minimum required for the mixing or contacting operation contemplated. The minimum structure, however, may be implemented in various ways to improve or supplement the operation of the basic structure as by means of anti-swirl baffles and/or annular shield means encompassing the operating zone of the plate member 6.

As shown in Figs. 1 and 2, the vessel 1 is provided with a series of baffle members 7 and

8, respectively above and below the operating zone of plate member 6, and with an annular shield 9, disposed vertically between the baffle members, substantially encompassing the operating zone of plate 6, both the shield and plate being of substantially smaller diameter than the vessel. The shield 9 may be supported within the vessel 1 as by means of radial plates or ribs 9a extending outwardly from the shield 9 into contact with the vessel walls and secured thereto. Alternately, the shield 9 may be secured to the upper and lower baffles in the vessel in any suitable manner. Preferably, the shield 9 is of a diameter such as to be spaced from the plate 6 at a distance substantially equal to the greatest dimension of the perforations therein, and at least sufficiently so as to avoid possible contact between the plate and shield. Also, as illustrated in Figs. 1 and 2, the baffle members 7 in the upper portion of the vessel extend radially outward from a sleeve 10 encircling the shaft 5 and substantially concentric therewith, the outer ends of the baffles 7 being secured to the vessel walls, and the inner ends to the sleeve 10. As shown, the sleeve 10 is provided with upper and lower shaft bearings 11. The lower baffle elements 8 extend radially outward from a center line substantially coincident with the center line of the shaft 5, being secured together at the center in any suitable fashion and at their outer ends to the vessel wall. Each of the baffle members 7 and 8 is slotted or perforated as at 7a and 8a to permit circulation of the fluids in the upper and lower portions of the vessel while substantially preventing swirling of the fluids in the vessel. The baffle members may be disposed in any convenient fashion with relation to the flow of fluids through the vessel. As shown in Figs. 1 and 2, one pair is normal or at right angles to flow through the vessel from inlet to outlet, and the remaining baffles are disposed in intermediate angular relation thereto.

In the apparatus as illustrated in Figs. 3 and 4, the vessel 1 is fully enclosed, having a fluid-tight top portion 1a. The shaft 5 enters the vessel through the top 1a by way of a stuffing box seal 12 which may also provide a bearing for the shaft. The inner end of the shaft is extended to the bottom of the vessel and is there mounted in a shaft bearing 13. The plate 6 is mounted on the shaft in substantially the same fashion as illustrated in Fig. 1 and is similarly located with reference to the level of the outlet conduit means 4. In this form of the invention, however, the annular shield is composed of an intermediate portion 14 which is a spherical zone section having a radius of curvature slightly greater than the radius of the plate 6. The upper and lower base edge portions of the section are preferably of equal diameter and each is provided with a frusto-conical rim portion 15 and 16 respectively. These rim portions are joined by their smaller ends to a base edge portion of the zone section 14 and extend angularly outwardly therefrom into substantially fluid-tight relation to the vessel walls, being secured thereto in any suitable fashion. The outlet conduit means 4 opens outwardly through both the shield member and the vessel wall. The inlet conduit means 2 and 3 respectively open into the vessel or chamber 1 in vertically spaced relation to the rim portions 15 and 16. As shown in Figs. 3 and 4, the vessel is provided with upper and lower baffle elements 17 and 18 respectively, these elements being distinguished from those employed in the apparatus according to Figs. 1 and 2 in that they are disposed in vertically spaced relation to the top and bottom wall portions of the vessel with those edge portions of the baffle members which adjoin the operating zone of the baffle plate 6 angularly shaped to conform substantially to the smaller angle formed between the plate 6 and the shaft 5. As formed and arranged, the baffles extend angularly into the operating zone of the plate toward the shaft 5. The inner vertical edges of the baffles 17 and 19 are secured to annular sleeve members 19 and 20 respectively encircling the shaft 5 and substantially concentric therewith, the baffles extending radially outwardly therefrom and are joined at their outer vertical edge portions to the vessel walls. In illustrating the structure according to Figs. 3 and 4, the baffle members are shown as normal to and parallel to the flow of fluids through the vessel by way of the inlet conduit means 2 and 3 and outlet conduit means 4, but it is intended that in the structures of Figs. 1 to 4 inclusive, the arrangement of baffles may be varied as desired.

In the apparatus as illustrated by Fig. 5, a vessel 21, having a top wall 21a, is divided by means of an interior partition 21b into a mixing chamber 30 and a settling or separation chamber 40. An outlet from the mixing chamber 30 into the separation chamber 40 is provided by means of a slotted portion 24 in the partition 21b disposed at an intermediate level vertically of the partition. If desired, the slotted portion 24 may be arranged for dimensional adjustment as by means of a sliding plate, not shown, or by any other conventional structural means. Inlet conduit means 22 and 23 open into the mixing chamber 30 through one end wall of the vessel in vertically spaced relation one to another and communicating respectively with the upper and lower portions of the chamber. Outlet conduit means 41 and 42, opening respectively from the upper and lower portions of the chamber 40 through the other end wall of the vessel 21, provide for the removal of materials from the separation chamber. The mixing chamber 30 is also provided with a mixing plate member 6 of the character described with reference to Figs. 1 to 4 inclusive, the plate 6 being mounted on a rotatably driven shaft 5 extending vertically into the chamber through the top wall 21a of the vessel through a bearing and packing gland member 26.

In operation, the mixing and contacting device according to this invention, functions by displacement created by the angular motion of the perforate plate 6 during rotation by the shaft 5. For example, when the shaft is rotated through 180°, the plate 6 reverses its position, as shown in dotted lines in Figs. 1 and 3 and an amount of fluid in the chamber is displaced by the plate which is proportional to the area of the plate and the angle v indicated in Figs. 1 and 3. This angle is a function of the angle at which the plate is mounted on the shaft. If the plate is perforated, a considerable portion of the displaced fluid is forced through the plate perforations as well as around the edges of the plate. Depending upon whether any given portion of the plate is moving upwardly or downwardly, the fluid will be jetted downwardly or upwardly through the perforations and over the plate edge. Jetting of the fluids through perforations in the plate accomplishes a shearing action which tends to increase the mixing or contacting

action of the plate, and the jetting and displacement of the fluids in this fashion produces a zone of agitation in the vicinity of the plate, extending for some distance above and below it, with a zone of high intensity agitation immediately adjacent the plate surfaces. As fluids are withdrawn from the mixing chamber, as by way of the conduit means 4 in Figs. 1 and 3, or the slotted portion 24 of Fig. 5, a fresh supply of fluids flows into the high intensity mixing zone from the upper and lower portions of the vessel respectively. The introduction of the materials to be mixed or contacted is proportioned as desired by controlling flow through the inlet means 2 and 3, and the withdrawal or discharge of the mixed or contacted materials by way of line 4 or slotted portion 24 is adjusted to the total volume of fluids introduced. In the apparatus of Fig. 5, contacted and separated fluids are withdrawn from vessel 21 by way of the conduit means 41 and 42. It is a particular feature of the apparatus illustrated and described that gravity flow within the mixing or contacting vessel is not essential to the operation, and where two substantially immiscible fluids are to be contacted, the lighter may be introduced into the upper portion of the vessel and the heavier into the lower portion as compared with the normal procedure of introducing the heavier fluid above and the lighter fluid below.

The apparatus in any form illustrated and described may be employed for mixing or contacting various fluid materials which may or may not be miscible materials. Gaseous materials may be contacted or mixed with liquids, or liquids with liquids. For example, water gas may be scrubbed with diethanolamine to remove carbon dioxide. Likewise, liquids such as oil and aqueous phenol solutions may be contacted in the apparatus described, introducing the phenol solution by way of the inlet into the lower portion of the vessel and the oil by way of the inlet to the upper portion. Where miscible materials of different gravities are to be combined, the lighter material is also introduced into the upper portion of the vessel and the heavier material into the lower portion.

Where it is desired to provide a multi-stage contacting system, a series of vessels such as the vessel 21 of Fig. 5 may be employed. A three-stage system is illustrated by Fig. 6, in which provision is made for countercurrent flow of two immiscible fluids to be contacted, the lighter fluid entering through an inlet conduit 22 at one end of the system and the heavier fluid entering by way of an inlet conduit 23 at the opposite end of the system. In such a countercurrent system, the outlet conduit means 41 from the first vessel in the series is connected to the inlet conduit means 22 of the second vessel, and each succeeding vessel is thus connected to another until the lighter fluid is discharged from the system by means of outlet conduit 41 opening from the last vessel. The heavier fluid enters the mixing chamber of the last vessel in the series by way of inlet conduit means 23 connected thereto, and is passed from the separation chamber of that vessel by way of outlet conduit means 42 opening therefrom and connected in turn to the next preceding chamber by way of the inlet conduit means 23. Such interconnection is continued through the series to the first vessel 21 thereof, from whence the heavier fluid is discharged by way of outlet conduit means 42 opening therefrom. In each of the vessels 21, the incoming

fluids are mixed in the mixing chamber 30 thereof, continuously withdrawn through the slotted portion of the interior partition 21b into the separation chamber 40, whence the separated materials are withdrawn respectively through the outlet conduit means 41 and 42.

What is claimed is:

1. A fluid mixing and contacting device comprising a container vessel, a rotatably driven shaft extended vertically into said vessel, a perforate plate member mounted on said shaft in angular relation thereto, an annular shield member interiorly of said vessel enclosing said plate peripherally thereof and in closely spaced lateral relation thereto and disposed longitudinally of the vessel at an intermediate level vertically thereof, said shield communicating with the interior of said vessel above and below said plate outlet conduit means opening from the vessel through said shield substantially at said intermediate level, and inlet conduit means opening into said vessel above and below said shield in vertically spaced relation to said outlet conduit means.

2. A fluid mixing and contacting device according to claim 1, in which the annular shield member consists of an intermediate spherical zone section having upper and lower base edge portions of equal radius, and upper and lower frustoconical rim portions each joined to a base edge portion of said intermediate section by its smaller end.

3. A fluid mixing and contacting device according to claim 1, in which the annular shield member consists of a tubular element supported in radially spaced relation to the vessel walls.

4. A fluid mixing and contacting device according to claim 1, in which said plate member is disposed so as to lie substantially in a plane extending diagonally across the shield from a point on the upper edge of one side to a diametrically opposite point on the lower edge of the opposite side.

5. A fluid mixing and contacting device comprising a container vessel; outlet conduit means opening from said vessel at an intermediate level vertically thereof, inlet conduit means opening into said vessel above and below said outlet conduit and in vertically spaced relation thereto, a rotatably driven shaft extending vertically into said vessel, a perforate plate member mounted substantially concentrically on said shaft in angular relation to a plane perpendicular to said shaft, and vertical baffle means extending radially outward from immediately adjacent the peripheral surface of said shaft into secured contact with the vessel walls, and vertically into spaced relation to said plate member.

6. A fluid mixing and contacting device according to claim 5, in which at least two of said baffle means are disposed in a line normal to said inlet and outlet conduit means.

7. A fluid mixing and contacting device according to claim 5, in which at least two of said baffle means are disposed in a line parallel to said inlet and outlet means.

8. A fluid mixing and contacting device according to claim 5, in which said baffle means are disposed in a line intermediate those which may be normal and parallel to said inlet and outlet means.

9. A fluid mixing and contacting device according to claim 5 in which said baffle means are disposed above and below said plate member in

vertically spaced relation thereto and to said inlet and outlet conduit means respectively.

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