

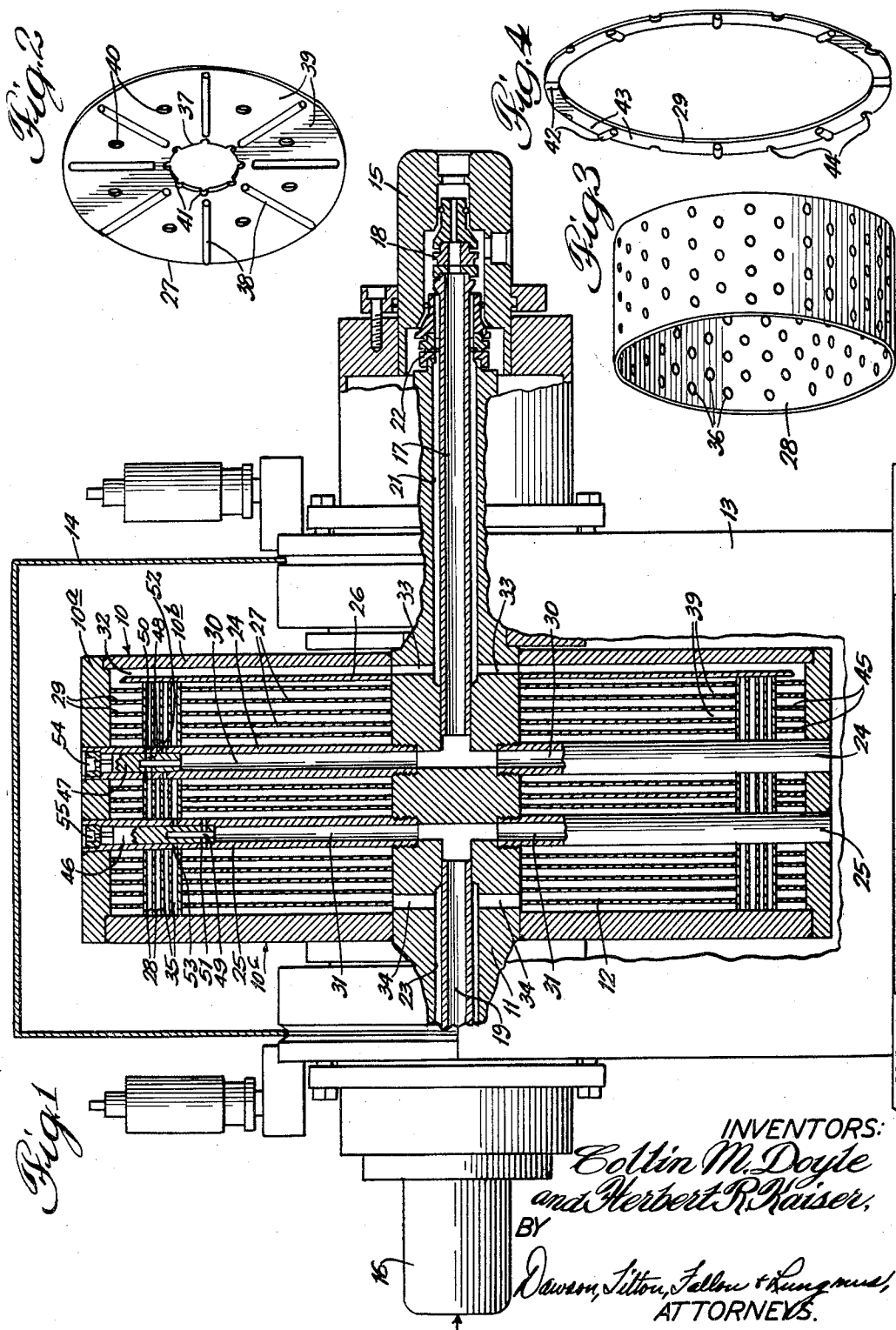
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ROTATING SEPARATOR WITH DISTRIBUTION AND MIXING MEANS

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3,053,440

ROTATING SEPARATOR WITH DISTRIBUTION AND MIXING MEANS

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This invention relates to a rotating separator with distribution and mixing means. The combination of the present invention has utility in connection with rotating contactors where the final clarification of one or both phases presents a problem. For example, the present invention is applicable to rotating contactors like those described in prior Patents 2,758,783 and 2,758,784.

In the design and operation of rotating devices of the kind described in the patents just cited, it has heretofore been assumed that the principal problem was to obtain adequate mixing of the phases being contacted, and that the separation or clarification of the phases would be readily taken care of by virtue of the very large centrifugal forces created by the high speeds of rotation. The high centrifugal forces created by the rotation of the devices does tend to produce a separation of the light and heavy phases as would be expected. However, there is an offsetting factor which heretofore has not been adequately taken into account. The rotation of the device tends to cause the liquids to swirl around in circumferential paths which leads to intermixing of the phases and opposes their separation. At the high speeds of rotation normally employed, the liquid phases may be brought into turbulent flow due to this rotary swirl action. Consequently, this type of action, which has not heretofore been fully understood or appreciated, may greatly complicate the problem of separating or clarifying the phases, and this problem is especially acute where the phases tend to emulsify, where solids are present in the liquid phases, or where the liquid phases are of relatively high viscosity.

It is therefore an object of the present invention to provide a device which has application as a combination contactor and separator wherein the rotary swirl action is taken advantage of for the purpose of distributing and/or mixing the liquids being processed while at the same time minimizing this action in connection with the separation or clarification of the liquid phases. Further objects and advantages will appear as the specification proceeds.

A typical application of the present invention is illustrated in the accompanying drawing, in which—

FIGURE 1 is a front elevational view of a rotating device embodying the present invention, portions of the rotor and shaft being broken away to more clearly show the construction of the internal elements;

FIGURE 2 a perspective view of one of the swirl-arresting disks employed in the device of FIGURE 1;

FIGURE 3 a perspective view of one of the perforated rings which function as mixing and distributing elements in the device of FIGURE 1; and

FIGURE 4, a perspective view of one of the swirl-arresting rings employed in the device of FIGURE 1.

In the device of FIGURE 1 there is shown a rotor casing 10 which is mounted co-axially on a shaft 11 and provides a radially-extending chamber 12 therein. Shaft 11 extends horizontally and is rotatably-mounted on a base 13 by means of suitable bearings (not shown in section). A case 14 extends above base 13 to complete the enclosure of the rotor 10. As is well-known in the art, means is provided for driving the shaft 11 at a controlled rotational speed, and conduits are connected to stationary shaft extensions 15 and 16 for the introduction and re-

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moval of liquids through passages in the shaft. In the illustration given, for example, the liquid phase of lighter density can be supplied to shaft passage 17 through a seal 18 which permits shaft 11 to rotate while extension 15 remains stationary. In a similar manner the heavy phase can be supplied to shaft passage 19 through a seal corresponding to seal 18 (not shown). The heavy phase can be removed through shaft 21 and seal 22, and the light phase through shaft passage 23 and a seal corresponding to seal 22 (not shown). Since this invention relates to the internal construction of the rotor and the rest of the device can be constructed in a manner previously known and described, it is not believed that it will be necessary to further discuss the details of construction of the device of FIGURE 1 other than those of the rotor itself. In this connection, reference is made to prior patents on similar devices which contain disclosures supplementing the foregoing brief description, such as the disclosures of Patents 2,578,783 and 2,578,784.

Turning now to the specific subject matter of the present invention, it can be seen in FIGURE 1 that the rotor 10 includes a number of elements within chamber 12. These elements include inlet tubes 24 and 25, a spill-over disk 26, a group of axially spaced-apart partition walls 28, and a second group of axially spaced-apart partition walls 29. In the illustration given, the inlet tubes 24 and 25 are arranged in oppositely-disposed pairs. The tubes 24 and 25 respectively provide internal passages 30 and 31 which communicate with passages within shaft 11, the passages 30 communicating with shaft passage 17 and the passages 31 with shaft passage 19. With this arrangement, the inlet tubes 24 can be used for supplying the light phase to rotor chamber 12 and the inlet tubes 25 for the heavy phase.

It will also be noted that in the embodiment shown in the drawing, casing 10 is of a cylindrical configuration, being formed of a cylindrical outer band or wall 10a and end plates 10b and 10c. The end plates 10b and 10c are received within recesses in the outer ends of band 10a and are welded thereto as well as to shaft 11, which in the illustration given extends through rotor chamber 12. It will be understood that this provides a sealed casing around chamber 12.

In the illustration given, spill-over disk 26 terminates short of the inside of band 10a and is spaced inwardly from end wall 10b to provide a passage 32 for the removal of the heavy phase, the passage 32 being arranged to communicate with shaft passage 21. In the illustration given, lateral passages 33 connect passage 32 with passage 21. Shaft passage 23 which can be used for the removal of the lighter phase communicates with the inwardmost portion of rotor chamber 12 through lateral passages 34.

In accordance with the present invention, the group of radially spaced partition walls 28 are arranged to occupy a zone outwardly of shaft 11 and inwardly of the radially outermost wall portion of casing 10. These partition walls provide passages 35 therebetween which extend axially and circumferentially. Partition walls 28 provide openings for the flow of liquids along radial paths, thereby permitting liquids to flow into the innermost and outermost of the spaces 35 between the walls, and then to traverse the zone occupied by the partition walls. In the illustration given, partition walls 28 are in the form of concentric cylinders which are arranged coaxially with shaft 11 and are provided with a plurality of perforations or holes 36, as shown in FIGURE 3. Rings 28 can be held in position by having their outer ends received within grooves in end plate 10c and spillover disk 26.

The zone occupied by the partition walls 28 constitutes the distributing and mixing section of the rotor chamber. In the illustration given, this section is de-

finished by five of the partition walls 28. However, it may be understood that more of the partition walls can be provided and that the zone can be enlarged. The design illustrated in FIGURE 1 is especially adapted for the processing of two liquid phases where the principal problem is the clarification of the light phase which is present in relatively large volume compared to the heavy phase. In the illustration given, the clarifying area for the light phase is the zone occupied by the partition walls 27, while the clarifying area for the heavy phase is the zone occupied by the partition walls 29. For the processing of liquid phases where the heavy phase was present in larger volume than the light phase, the extent of the zone occupied by partitions 29 would be correspondingly enlarged while the extent of the zone occupied by the partitions 27 would be diminished. Where additional mixing was required, as where a plurality of stages was needed, the extent of the zone occupied by the partition walls 28 would be increased. It will therefore be understood that the relative size of the various zones within the rotor chamber 12, as defined by the partition walls 27, 28, and 29, can be varied considerably without departing from the principles of the present invention.

In accordance with the present invention, axially-spaced partition walls, such as walls 27 and 29, are provided in combination with the radially spaced partition walls, such as partition walls 28. In other words, the present invention contemplates the use of axially-spaced partition walls within chamber 12 which are arranged to occupy a zone radially-spaced from the zone of the group of radially-spaced partition walls. Where it is desired to promote the complete and rapid clarification of both phases, this can be done by employing two groups of axially-spaced partition walls as in the illustration given, one group being positioned inwardly of the radially-spaced partition walls and the other group being positioned outwardly thereof. However, the inwardly positioned group of partition walls can be used independently of the outwardly positioned group. For example, where the heavy phase presents no problem with regard to its complete clarification, the partition walls 29 can be omitted, and the partition walls 27 used alone in combination with the partition walls 28.

For the purpose of the present invention there is associated with the axially-spaced partition walls, such as the walls 27 and 29, means, such as baffles or vanes, for at least partially blocking the circumferential flow of liquids between the partition walls while permitting the liquids to flow along radial paths. Preferably, a plurality of such vanes or baffles are positioned between each of the axially-spaced partition walls. In the illustration given, the partition walls 27 are in the form of disks which are coaxially received on shaft 11. As shown more clearly in FIGURE 2, the disks 27 have a central opening 37 through which the shaft 11 extends. A plurality of radially extending vanes 38 are mounted on one face of the disks 27 to define segments 39 therebetween. In the illustration given, the vanes 38 are in the form of straight rods which are welded to the disks 27. The vanes or rods 38 need not be straight, and can be curved in various arcuate shapes, such as a convolute shape, a spiral shape, etc. In order to prevent any unequal pressures from developing in the spaces 39 between the disks 27, the intermediate portions of the disks are provided with a few openings, such as openings 40 (FIGURE 2). Also, the disks 27 are provided with spaced serrations 41 around central opening 37. When the disks are arranged on shaft 11 in the manner shown in FIGURE 1, the serrations 41 provide ports through which the clarified light phase can flow along shaft 11 for discharge into the shaft passages 34 and thence into shaft passage 23.

The construction of the outer axially-spaced partition walls 29 is illustrated in FIGURE 4. In the illustration given, these partition walls are in the form of flat-sided

rings. A plurality of vanes 42 are mounted on one side of the rings. As with the partition walls 27, the vanes may be in the form of straight rods which are arranged to extend radially and are attached to the partition wall by welding. This is the construction shown in FIGURE 4 where the rod-like vanes 42 are welded to the rings 29. It will be understood from what has been previously said that the vanes 42 should extend outwardly so as to define partially enclosed segments therebetween, such as segments 43. The vanes themselves, however, do not need to be straight nor do they need to be arranged on precisely radial lines.

In the illustration given, the outer edge of partitions 29 are provided with spaced serrations 44. When the partitions 29 are arranged in the manner shown in FIGURE 1 with their outer edges abutting the outer wall of casing 10, the serrations 44 define ports through which the clarified heavy phase can flow axially from the spaces 45 between walls 29 to discharge passage 32 for removal through shaft passage 21.

In the construction of rotors like the one shown in FIGURE 1, the inner partition walls 27 can be slipped onto shaft 11 through an open end of the casing 10, that is, for example, before the attachment of end wall 10b. The partition walls center themselves on the shaft and are held in axially-spaced apart relation by the vanes 38, the vanes being attached to one side of each of the partition walls and extending into contact with the adjacent side of the next partition wall. The cylindrical partition walls 28 can next be slipped on over the partition walls 27. These cylindrical walls may be held in radially-spaced apart relation by having their ends received within the grooves of a master end plate until they are permanently secured by means of the radially extending rods and tubes, such as the tubes 24 and 25. If desired, other means can be provided for holding the cylindrical partition walls in concentrically spaced relation with respect to each other, such as projections extending from the rings, dimples formed in the rings, etc.

As a further step in the assembly procedure, the outer partition walls 29 can be slipped on over the outermost of the cylindrical partition walls 28. The vanes 42 will act as spacers between the walls, the vanes extending from the wall to which they are attached to the adjoining face of the next adjacent wall. In completing the assembly of the rotor, the spill-over disk 26 can be slipped onto the rotor shaft and moved inwardly to the position shown in FIGURE 1. Both sides of the spill-over disk can be provided with outwardly extending vanes, such as the vanes 38 and 42, and having a similar function to these vanes. For example, the vanes attached to disk 26 would extend into contact with the adjacent partition walls of the groups 27 and 29. Similarly, the vanes extending outwardly on the other side of spill-over disk 26 would engage the inner face of end wall 10b when it is applied to the rotor. It will be understood of course that these spacers would be arranged to permit the radial flow of liquids through outlet passage 32 while tending to restrict the circumferential flow of liquid therein.

It has been previously pointed out that the tubes 24 and 25 provide means for introducing the liquids to chamber 12. In the illustration given, the tubes 24 can be used for introducing the light phase, while the tubes 25 can be used for introducing the heavy phase. It will be understood that the liquid phase of lesser density (the light phase) should be introduced outwardly of the point of introduction of the liquid phase of greater density (the heavy phase). In accordance with the present invention, the inlet means should be arranged so that at least part of the radially-spaced partition walls, such as the walls 28, lie between the respective points of introduction of the light and heavy phases. Preferably, at least one of the phases is introduced within the zone defined by the radially spaced partition walls.

The inlet means shown in FIGURE 1 is described

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more particularly in copending application Serial No. 796,584 filed March 2, 1959, entitled "Liquid Feed Arrangement for Centrifugal Devices." Reference is therefore made to this application for a more detailed description. It is believed sufficient for the purpose of the present application to indicate that the tubes 24 and 25 have their inner ends threadedly secured to shaft 11 and their outer ends connected to casing band 10a by welding. Within the tubes there are rotatable sleeves, such as sleeves 46 and 47 which provide two or more groups of radially-spaced ports, the groups being selectively alignable with ports in the tubes 24 and 25. In the illustration given, the ports 48 of tubes 24 and the ports 49 of tubes 25 are in alignment with the ports 50 and 51 respectively of the tubes 24 and 25. As described in the above cited application, the sleeves 46 and 47 provide other ports, which are selectively alignable with radially spaced ports in the inlet tubes, such as ports 52 and 53. In the illustration given, the heavy phase would flow outwardly from tube passages 31 to ports 49 and 51 into the portion of rotor chamber 12 just inwardly of the innermost partition wall of the group of partition walls 28. Similarly, the light phase would flow outwardly from the passages 30 through the ports 48 and 50 into the outermost space 35 within the group of partition walls 28. If it is desired to vary the position of one or both inlets, this can be done by removing the threaded closure plugs 54 and 55, and manipulating the sleeves 46 and 47 to disalign the ports 49 and 48 with the ports with which they are now aligned and bring other ports into alignment with the two ports 52 and 53. If this were done, both the light and heavy phases would be introduced within the spaces 35 provided by the cylindrical partitions 28. Alternatively, the position of the heavy and light phases inlets can be varied independently, providing the heavy phase is not released outwardly of the light phase so that there is no contact therebetween. When it is desired to provide a plurality of stages, the points of introduction of the phases may be separated by a plurality of partition walls.

In the operation of the device, the mixing of the phases is promoted by the rotary swirl action which occurs within the spaces 35 between the cylindrical partition walls 28. On the other hand, this action is reduced to a minimum in the clarification zones. For example, the light phase moves toward shaft 11 by flowing inwardly through the spaces 39 between the disks 27. At the same time, portions of the liquid are captivated within the segmental spaces 39, thereby preventing circumferential flow of the liquids. Similarly, the heavy phase is captivated within the segmental spaces 43 provided by partitions 29 and vanes 42. In this way, the clarification of the light phase and the heavy phase, are both as promoted, and the tendency of the phases to be continually remixed due to rotational swirl is substantially overcome.

As an example of the two procedures just described, the water washing of alkali-refined vegetable oils can be mentioned. Following alkali-refining the vegetable oils contain a small proportion of soap and residual alkali, which is commonly removed by a procedure known as water washing. With the device shown in FIGURE 1, the vegetable oil to be treated could be introduced through the tubes 24, and the wash water through the tubes 25. The water would be thoroughly mixed with the oil within the zone defined by the cylindrical partitions 28, the soap and residual alkali being removed into the water phase, which would then flow outwardly into the zone defined by the outer partition walls 29, and after being clarified within this zone would be removed through the heavy phase outlet passage 32. The oil, being the larger volume phase, and the more difficult to clarify, flows inwardly through the relatively large zone defined by partition walls 27, and the clarified oil is removed from the innermost portion of the zone through the shaft passages 34. Flowing inwardly through the clarifying

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zone, the partitions 27 and the vanes 38 will act to arrest any tendency of the oil to remix with the water phase from which it is being separated, the partition walls and vanes functioning to prevent rotational swirl in the manner previously described. This has particular advantage in connection with the clarification of a light phase, such as the oil in the process just described. The centrifugal force created by the rotation of the device is considerably smaller within the light phase clarifying zone which adjoins the shaft than it is within the heavy phase clarifying zone which is at a considerable radial distance from the shaft. Consequently, it is more difficult for the centrifugal separating force to overcome a tendency toward remixing which is produced by a rotational swirl action.

While in the foregoing specification this invention has been described in relation to a specific embodiment thereof for purpose of clarity, it will be apparent to those skilled in the art that the invention described herein is of wide scope and is capable of application in many other specific embodiments. Furthermore, it will be apparent that many of the specific details hereinbefore described can be varied considerably without departing from the basic principles of the invention.

We claim:

1. In a centrifugal apparatus for countercurrently contacting and separating liquid phases of different densities, said apparatus being of the kind including a rotatably-mounted horizontally-extending shaft providing a plurality of liquid flow passages therein, liquid seals at each end of said shaft to permit liquids to be introduced into and removed from said shaft passages while said shaft is rotating, and a rotor casing mounted coaxially on said shaft between said seals and providing a cylindrical chamber therein, the combination comprising a group of concentric rings arranged in radially-spaced apart relation within said rotor chamber and coaxial to said shaft to provide a contacting and mixing section, said section occupying a zone outwardly of said shaft and inwardly of the radially outermost wall portion of said casing, said rings providing open cylindrical spaces between adjacent rings which extend axially across said contacting and mixing section and entirely around said rings so that liquids can flow freely across and around said spaces, thereby promoting the mixing and intimate contacting of said liquid phases within said section, said rings having openings therethrough for the flow of liquids along radial paths in passing between said cylindrical spaces, a group of outwardly-extending partition walls arranged within said rotor chamber in axially-spaced apart relation to provide a clarifying section, said clarifying section occupying a zone radially-spaced from said contacting and mixing section, said partition walls having a plurality of swirl arresting baffles extending therebetween, said baffles dividing the spaces between said partition walls into a plurality of radially-extending open-ended segments, thereby permitting the flow of liquids along radial paths while restricting the circumferential flow of liquids, said open-ended segments communicating at one end with the nearest cylindrical space of said contacting and mixing section, said rotor and shaft providing outlet means extending between the other ends of said open-ended segments and one of said passages within said shaft, said rotor and shaft having a second outlet means providing communication between a second of said shaft passages and the cylindrical space of said contacting and mixing section which is furthest away from said clarifying section, and said shaft and rotor also providing inlet means for separately supplying a light liquid phase and a heavy liquid phase from additional ones of said shaft passages to said rotor chamber, said inlet means introducing said heavy phase at a place outwardly of said shaft and radially inwardly of the place of introduction of said light phase, and said places of introduction for said light and heavy phases being separated by at least part of said rings.

2. The centrifugal apparatus of claim 1 wherein said group of partition walls occupies a zone between said shaft and said contacting and mixing section, said partition walls extending outwardly from said shaft toward said rings.

3. In a centrifugal apparatus for countercurrently contacting and separating liquid phases of different densities, said apparatus being of the kind including a rotatably-mounted horizontally-extending shaft providing a plurality of liquid flow passages therein, liquid seals at each end of said shaft to permit liquids to be introduced into and removed from said shaft passages while said shaft is rotating, and a rotor casing mounted coaxially on said shaft between said seals and providing a cylindrical chamber therein, the combination comprising a group of concentric rings arranged in radially-spaced apart relation within said rotor chamber and coaxial to said shaft to provide a contacting and mixing section, said section occupying a zone outwardly of said shaft and inwardly of the radially outermost wall portion of said casing, said rings providing open cylindrical spaces between adjacent rings which extend axially across said contacting and mixing section and entirely around said rings so that liquids can flow freely across and around said spaces, thereby promoting the mixing and intimate contacting of said liquid phases within said section, said rings having openings therethrough for the flow of liquids along radial paths in passing between said cylindrical spaces, a group of vertically-extending disks received on said shaft in axially-spaced apart relation to provide a clarifying section within said rotor chamber, said clarifying section occupying a zone between said shaft and said contacting and mixing section, said clarifying section also being provided with a

plurality of vanes supported within the spaces between said disks, said vanes extending outwardly from said shaft and dividing said disk spaces into a plurality of radially-extending open-ended segments, thereby permitting the flow of liquids along radial paths while restricting the circumferential flow of liquids, said open-ended segments communicating at one end with the nearest cylindrical space of said contacting and mixing section, said rotor and shaft providing outlet means extending between the other ends of said open-ended segments and one of said passages within said shaft, said rotor and shaft having a second outlet means providing communication between a second of said shaft passages and the cylindrical space of said contacting and mixing section which is furthest away from said clarifying section, and said shaft and rotor also providing inlet means for separately supplying a light liquid phase and a heavy liquid phase from additional ones of said shaft passages to said rotor chamber, said inlet means introducing said heavy phase at a place outwardly of said shaft and radially inwardly of the place of introduction of said light phase, and said places of introduction for said light and heavy phases being separated by a plurality of said rings.

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