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[54] **ADJUSTABLE MIXING DEVICE**

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[51] **Int. Cl.**[2] **B01F 5/16**

[58] **Field of Search** 259/95, 96, 7, 8, 23, 24, 259/43, 44, 66, 67, 107, 108, 121, 122

[56] **References Cited**

UNITED STATES PATENTS

2,619,330	11/1952	Willems	259/96
2,738,174	3/1956	Magnant	259/96
3,326,532	6/1967	Lodge	259/96
3,339,897	9/1967	Davis	259/8
3,414,245	12/1968	Frazer	259/96

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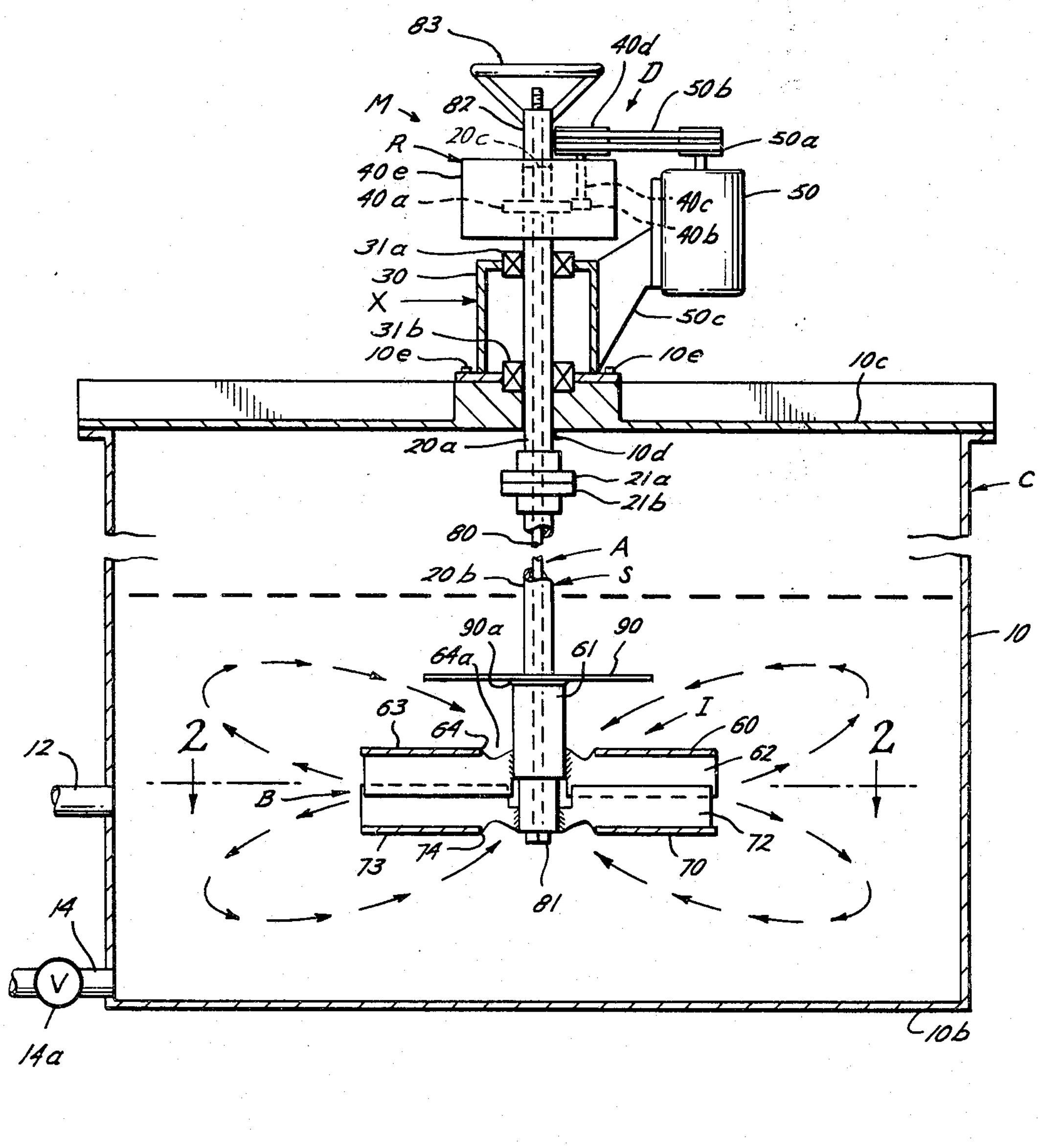
[57] **ABSTRACT**

An adjustable mixing device for mixing and blending fluids in a container which has a fluid impeller adapted for pumping the fluids substantially laterally in counter-rotating and circular continuous motion in the container that is area-adjustable for varying the volume of fluids pumped to adjust the torque load on the impeller to prevent overload on the mixing motor during start-up. The impeller of the mixing device can be adjusted from outside the container without impeller removal.

11 Claims, 3 Drawing Figures



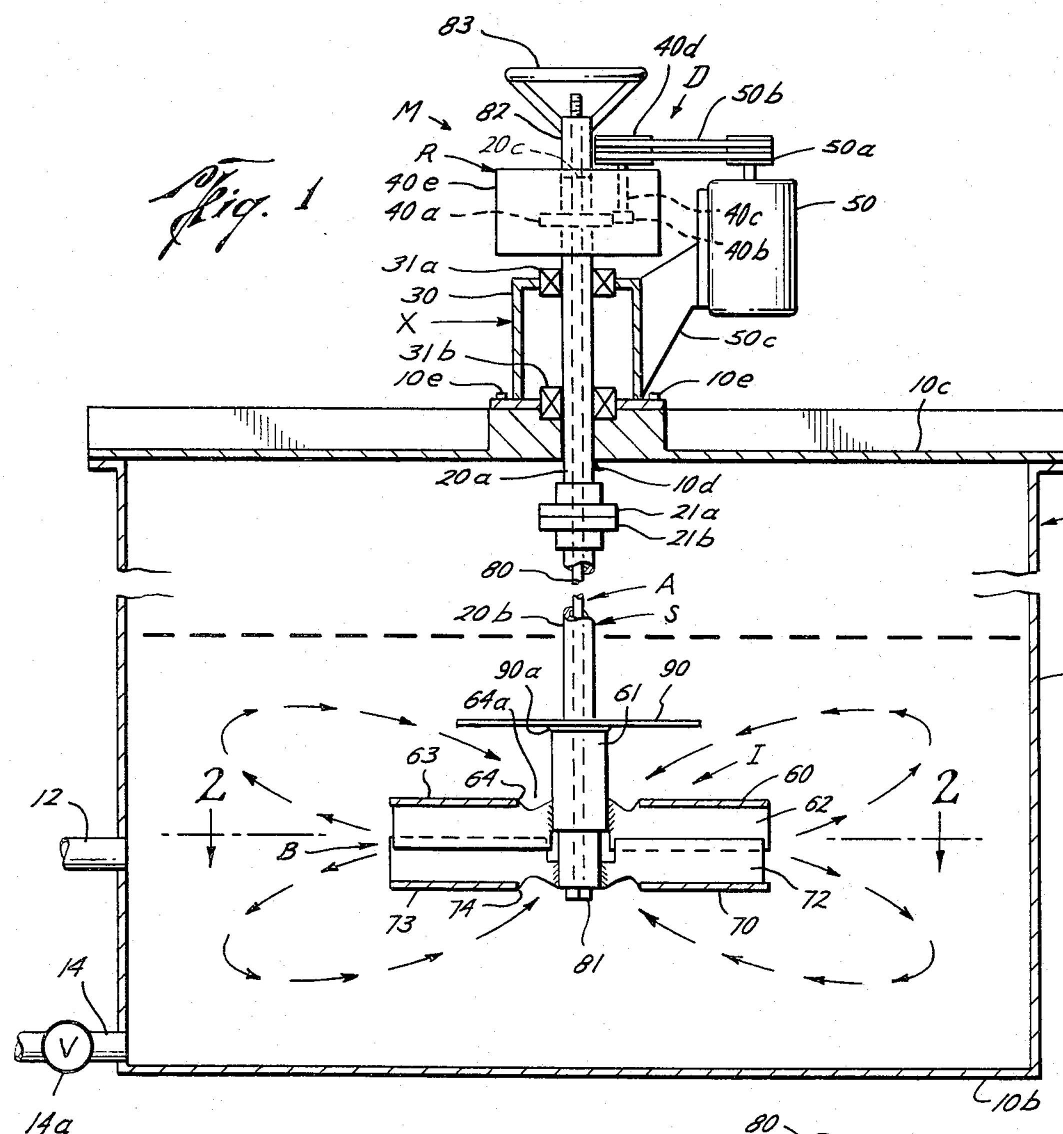


Fig. 1

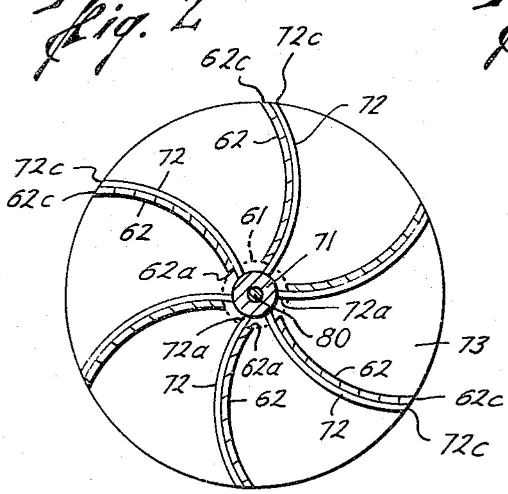


Fig. 2

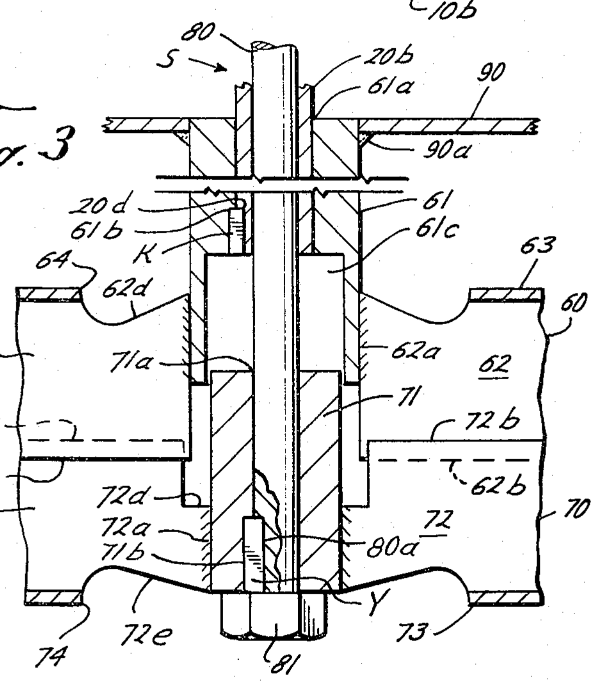


Fig. 3

ADJUSTABLE MIXING DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to mixing devices and more particularly pertains to apparatus for mixing and blending highly viscous fluids such as drilling fluids, concrete, petroleum crudes, aqueous oleaginous emulsions and the like.

Many viscous fluids, prepared by mixing or blending liquid and dry granular ingredients, substantially immiscible liquids and the like have tendencies to change viscosities and/or to separate into layers upon standing. For example, drilling fluids prepared from intimately mixed dry materials and liquids, gels and other special ingredients, tend to "settle out" or precipitate upon standing into thin liquid upper layers and heavy bottom residues or, in some instances, to form thixotropic gels. This occurs frequently at oil and gas well drilling sites due to constant interruptions in the drilling operation. Another example is petroleum crudes which have the tendency to form substantially undefined layers of differing viscosities during storage.

The separation and viscosity change properties of these highly viscous fluids create problems for conventional mixing devices employed to remix these fluids to consistent viscosities throughout. Due to these properties, large starting torques are required to restart agitation of the fluids. Such large starting torques place increased stress on the mixing device employed which can result in frequent breakdown and repair problems. For example, the required large starting torques can result in overloading the mixing device power source, thereby causing damage thereto. Moreover, increased energy is required to produce the large starting torques required which may be unavailable or in reduced supply in remote operating areas, such as the abovementioned remote drilling sites.

DESCRIPTION OF THE PRIOR ART

U.S. Pat. No. 3,339,897 issued to the present inventor on Sept. 5, 1967, discloses a continuous mixing device for drilling fluids which has a turbine-type impeller mounted with a driving shaft that is rotated by a power source. The mixing device is believed to be a substantial advance in the art of mixing devices useful for mixing and remixing viscous fluids. However, it has been found that the described mixing device can be overloaded during starting or opertating under heavy torque loads caused by highly viscous or dense fluids. The present invention is an improvement of the device described in the aforesaid U.S. Pat. No. 3,339,897.

SUMMARY OF THE INVENTION

The present invention is an improved mixing device for agitating fluids in a container that includes a mixing motor mounted with a drive shaft that extends into the fluid with an area-adjustable impeller mounted thereon. The area-adjustable impeller is adapted for positively displacing or pumping the fluid in the container outwardly substantially laterally from the drive shaft to provide counter-rotating and circular currents in the fluid throughout the container. The area-adjustable impeller is adapted for adjustment to vary the volume of fluid positively displaced during rotation so as to control the torque load on the motor during start-up and operation. The impeller is adjustable from the exterior of the container without removal of the impeller or mixing device from the container.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevational view, partially schematic and partially in section, of the mixing device of this invention with the improved area-adjustable impeller in partial cross-section;

FIG. **2** is a cross-sectional view of the area-adjustable impeller taken along line **2—2** of FIG. **1** which illustrates in detail the impeller blades of the invention; and

FIG. **3** is a fragmentary view, partially in cross-section, which illustrates certain details of the area-adjustable impeller of this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1** of the drawings, the improved mixing apparatus of the invention, generally M, is adapted for mounting with a container, generally C, which is preferably a large cylindrical structure of large capacity including a cylindrical wall **10** having an annular flange **10***a* attached to its upper edge, a bottom **10***b* and a circular roof **10***c* detachably mounted with the annular flange **10***a*. Container C is provided with an inlet means **12** for admitting fluids to be mixed into the container C and an outlet means **14** which includes a valve **14***a* to control the fluid flow from the container C.

The circular roof **10***c* is provided with an opening **10d** that is located substantially in its center and the mixing apparatus M is mounted with the roof **10***c* in vertical alignment with opening **10***d*. The mixing apparatus M includes a shaft means S extending vertically through the opening **10***d* into the container C and an impeller means I mounted at the lower end of the drive shaft means S and disposed within the container C for immersion in and agitation of a fluid in the container. The drive shaft means S extends through a support means X which is provided for supporting the drive shaft means S and impeller means I vertically within the container C for axial rotation. The support means X is attached to roof **10***c* about the roof opening **10***d* by any conventional means, such as bolts, **10***e*.

The mixing apparatus M further includes driving means D mounted with the upper end of the drive shaft means S for imparting a driving force for axially rotating the drive shaft means S and the impeller means I, and an area-adjusting means A for adjusting the surface area of the impeller means I coacting with the fluid during axial rotation for controlling the torque required from the driving means D to provide the axial rotation.

As shown in FIG. **1,** the drive shaft means S includes upper and lower hollow drive shaft members **20***a* and **20***b* attached in vertical axial alignment by means of rigid coupling members **21***a* and **21***b* which are disposed substantially immediately below roof **10***c* within the container C. Upper hollow shaft member **20***a* is mounted at substantially its upper end with the driving means D and extends through and is supportably mounted with the support means X. The lower shaft member **20***b* has mounted at its lower end the impeller means I which is located above the bottom **10***b* of the container C. Preferably, the rigid coupling members **21***a* and **21***b* are bolted together (not shown) so as to provide easy removal of the lower drive shaft member **20***b* and the impeller means I for cleaning, repair, storage, transfer and the like.

The upper hollow drive shaft member **20***a* extends vertically through the roof opening **10***d* and through the support means X which includes a support housing **30** mounted with the roof **10***c* and a plurality of bearing means **31***a* and **31***b* mounted therewith and rotatably mounted with the upper shaft **20***a*. The bearing means **31***a*, **31***b* are preferably located at the upper and lower ends of the support housing **30** and support the upper drive shaft means S and impeller means I for axial rotation.

The upper hollow drive shaft member **20***a* also is mounted at substantially its upper end with a speed control means R of the drive means D. The speed control means R can be any conventional type known in the art for varying the axial rotation speed and drive force of the drive shaft means S and the impeller means I under varying torque load conditions and is preferably a conventional gear reduction box **40**, as shown in FIG. **1** partially in phantom. As known, such a gear reduction box **40** has a plurality of driven gears **40***a* adapted for attachment with the upper drive shaft **20***a* and an equal plurality of driving gears **40***b* mounted with a driving gear shaft **40***c* which is further attached at its upper end with a driven pulley **40***d*. The driven gears **40***a* and the driving gears **40***b* are adapted for engagement to provide predetermined ratios between the speed of rotation of the drive shaft means S and the speed provided at the driven pulley **40***d*. Speed and driving force is provided at the driven pulley **40***d* by motor means such as an electric motor **50** having a driving pulley **50***a* at one end connected by a belt drive **50***b* to the driven pulley **40***b* of the gear reduction box **40**.

The gear reduction box **40** includes a gear housing **40***e* which can be supported by attachment to the support housing **30** (not shown) if desirable. The electric motor **50** can be supported by mounting with the support housing **30** such as by means of a stanchion **50***c*.

The impeller means I of the mixing apparatus M is of turbine-type construction including a plurality of area-adjustable impeller blade means, generally B, extending outwardly substantially laterally from the axial alignment of the impeller means I and the drive shaft means S for positively displacing a portion of the fluid in the container C outwardly and laterally in counter-rotating and circular turbulences or currents to accomplish the desired fluid mixing. The impeller blade means B are area-adjustable and coact with the fluid for varying the volume of fluid positively displaced during rotation so as to reduce the torque load required to axially rotate the impeller means I. More particularly, the impeller means I is illustrated in FIG. **1** as including an upper impeller **60** mounted with a driving hub **61** which is in turn mounted with the lower end of the hollow drive shaft member **20***b* and extends axially therewith. The upper impeller **60** includes a plurality of arcuate-shaped driving blades **62** attached at their respective inward tips **62***a* to the driving hub **61** that extend outwardly substantially laterally to the axis of the hub **61.** The driving blades **62** are disposed so as to provide vertical longitudinal fluid displacement surfaces relative to the vertical axis of driving hub **61** and drive shaft means S. An upper circular plate **63** is transversely attached to the upper edges of the driving blades **62** and has an axial opening **64** about the driving hub **61** which defines an axial intake means **64***a* for drawing a portion of the fluid to the impeller blade means B for positive outward displacement as more particularly described hereafter. The upper circular plate **63** has a radius substantially equal to the distance the arcuate driving blades **62** extend laterally from the driving hub **61.**

The impeller means I further includes a lower impeller **70** mounted with a driven hub **71** which is in axial alignment with driving hub **61** and is supportably mounted with the area-adjusting means A. The lower impeller **70** is adapted for axial rotation and for upward and downward longitudinal movement relative to the upper impeller **60.** The lower impeller **70** also includes a plurality of arcuate-shaped driven blades **72** attached at their respective inward tips **72***a* to the driven hub **71** and extend outwardly substantially laterally therefrom. Driven blades **72** are parallel relative to driving blades **62** and are thus disposed to provide vertical longitudinal fluid displacement surfaces relative to the axis of the drive shaft means S and impeller means I. A lower circular plate **73** is transversely attached to the lower edges of the driven blades **72** that is parallel to the upper circular plate **63** to provide a space therebetween through which the portion of fluid is outwardly positively displaced. Lower circular plate **73** has a radius substantially equal to the distance driven blades **72** extend laterally from driven hub **71** and has an axial opening **74** which defines an axial intake means **74***a* for drawing a portion of the fluid inwardly for positive outward displacement.

Upper impeller **60** and lower impeller **70** are positioned relative to each other so that the lower edges **62***b* of driving blades **62** and the upper edges **72***b* of driven blades **72** overlap to provide an interference fit. In operation, the rotational driving force provided by driving means D through drive shaft means S to the upper impeller **60** is imparted by driving blades **62** to the driven blades **72** so as to cause the upper impeller **60** to drive the lower impeller **70.** The interference fit of driving blades **62** and driven blades **72** also provide longitudinal areas between upper circular plate **64** and lower circular plate **74** which coact with the portion of the fluid to positively displace it outwardly from the impeller means I axis.

Referring now to FIG. **2,** which is a cross-sectional view of the impeller means I taken along line **2—2** of FIG. **1,** the plurality of impeller blades **62** are spaced equidistant apart. An equal plurality of driven blades **72** are spaced equidistant apart and positioned between the driving blades **62.** Each of the driving blades **62** and driven blades **72** have arcuate shapes and extend outwardly so that the respective outward tips **62***c*, **72***c* are behind the respective inward tips **62***a*, **72***a* attached to the respective driving hub **61** and driven hub **71.** FIG. **2** also specifically illustrates the overlapping relationship and interference fit of the lower edges of driving blades **62** with the upper edges of driven blades **72.**

Referring again to FIG. **1,** the lower impeller **70** and driven hub **71** are supported relative to the upper impeller **60** and driving hub **61** for upward and downward longitudinal movement by the area-adjusting means A which includes an adjusting rod **80** adaptable for supportable mounting at its lower end with the driven hub **71** and extending axially within the hollow drive shaft means S and through the speed control means R. The adjustment rod **80** is freely rotatable relative to the hollow drive shaft means S. The lower end of adjustment rod **80** is threadably mounted with a support nut **81** upon which the driven hub **71** rests. The upper end of adjustment rod **80** is threadably attached to an adjustment nut **82** which has a hand wheel **83** attached thereto. The adjustment nut **82** engages at its lower end the upper end **20c** of the upper hollow shaft member **20a** and is supported thereon. Axial rotation of adjustment nut **82** raises or lowers the adjustment rod **80** longitudinally which in turn raises or lowers the lower impeller **70.** This raising and lowering of lower impeller **70** accordingly increases and decreases the total longitudinal area of impeller blades **62** and **72** which coacts with the fluid so as to vary the volume of fluid positively displaced outwardly during rotation of the impeller means I.

Referring now to FIG. **3,** the cylindrical driving hub **61** is illustrated as having an axial bore **61a** through which the lower end of the hollow drive shaft member **20*b*** extends. The hollow shaft member **20*b*** and the hub **61** have respective grooves **20*d*** and **61*b*** aligned with each other so as to receive a key K which locks them together. A circular anticavitation plate **90** is attached by an annular weld **90*a*** to the upper end of the cylindrical driving hub **61** parallel to the upper and lower circular plates **63** and **72.** As shown in FIG. **1,** the circular anticavitation plate **90** is spaced above the axial intake means **64a.** In operation, the anticavitation plate **90** prevents vortexing of the fluid and thereby prevents the entrance of air into the intake means **64*a*.**

Referring now to FIG. **3,** the driving hub **61** is shown as also having an axial bore **61*c*** at its lower end that is adapted to receive the driving hub **71** for upward and downward longitudinal movement therein. Cylindrical driven hub **71** has a diameter slightly less than the axial bore **61*c*** and is disposed therein. Driven hub **71** also has an axial bore **71*a*** slightly in excess of the diameter of adjustment rod **80.** Adjustment rod **80,** extending axially through hollow drive shaft means S and being free to rotate relative thereto, such as during longitudinal adjustment, also extends through the bore **71*a*** of the driven shaft **71.** The adjustment rod **80** and the hub **71** have respective grooves **80*a*** and **71*b*** in alignment and adapted to receive a key Y which locks them together. The support nut **81** threadably attached to the lower end of adjustment rod **80** supports the driven hub **71** within the axial bore **61*c*** of the driving hub **61.**

The driving blades **62** of the upper impeller **60** are attached by welding, bolting or like attachment of their upward portions of their inward tips **62*a*** to the lower end of the driving hub **61** so that the lower edges **62*b*** extend below and beyond the driving hub **61** lower end. The driven blades **72** of the lower impeller **70** are likewise attached to the lower end of the driven hub **71** at their inward tips **72*a*.** However, the driven blades **72** have notches **72*d*** at the upper portions of their respective inward tips **72*a*** which are adapted to receive the lower end of driving hub **61** when the driven hub **71** is longitudinally raised in the driving hub axial bore **61*c*.** The driving blade lower edges **62*b*** and the driven blade upper edges **72*b*** are adapted to overlap in an interference fit while the driven hub **71** is disposed within the driving hub bore **61*c*** so as to impart the rotational driving force to the lower impeller **70** as mentioned hereinbefore.

As shown in FIG. **3,** each of the impeller blades **62** and **72** have respective curved leading edges **62*d*** and **72*e*** adjacent the respective axial openings **64** and **74** of the respective parallel circular plates **63** and **73.** These curved edges **62*d*** and **72*e*** bite portions of the fluid in the container C during rotation so as to draw portions of the fluid into the impeller means I for outward displacement during rotation.

In operation, the mixing apparatus M of this invention can be employed to intimately mix and agitate substantially any type of viscous fluid, to blend wet and dry ingredients, or to blend fluids capable of changing viscosity without the heretofore attendant dangers of motor damage due to excessive torque loads. Since torque loads and power requirements are usually the heaviest during start-up of the mixing device M when the impeller means I is immersed in a fluid in the container C, this description of operation will begin therewith. Prior to initial start-up, it is preferred to adjust the total longitudinal area provided by the blade means B which coact with the fluid for positive displacement thereof. This is accomplished by rotating the adjustment nut **82** in the proper direction to raise or lower the adjustment rod **80** which in turn longitudinally raises or lowers the lower impeller **70,** thereby decreasing or increasing the total longitudinal area of the blade means B to that desired. The volume of fluid which can be positively displaced outwardly during initial rotation is thus varied to the desired amount which will result in a reduced torque load required for rotation.

When power is supplied to the motor **50,** a driving force is imparted to the gear reduction box **40** which rotates the drive shaft means S and the upper impeller **70.** The rotational driving force is imparted through the interference fit of the driving blades **62** and the driven impeller blades **72** to rotate the lower impeller **70.** During rotation, a portion of the fluid is drawn through the intake means **64*a*** and **74*a*** and positively displaced outwardly substantially laterally by the blades **62** and **72** coacting with the parallel upper and lower plates **63** and **73.** Continuous rotation of the impeller means I causes continuous circular and counter- rotating turbulences of the fluid within the container as shown by arrows T in FIG. **1** whereby substantially all the fluid in the container C is intimately mixed. The anti- cavitation plate **90** prevents vortexing of the fluid, which thereby prevents excessive air bubbles during mixing. The anticavitation plate, accordingly, maintains the fluid in a substantially level position.

In the event it is determined that the torque load required for rotation of the impeller means I in the particular fluid to be mixed is too great, or in the alternative it is less than that which the motor **50** can handle without damage, the adjustment nut **82** can be rotated in the proper direction so as to increase or decrease the total longitudinal area of the blade means B coacting with the fluid as described hereinbefore. Thus, it can be readily appreciated that the adjustment can be made as desired to control the torque load required for rotation.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the size, shape, and materials as well as in the details of the illustrated construction may be made without departing from the spirit of the invention.

I claim:

1. A mixing apparatus for agitating fluids in a container comprising:

a. drive shaft means adapted to extend into a container,

b. support means for supporting said drive shaft means for axial rotation;

c. driving means mounted with one end of said drive shaft means for imparting a driving force thereto for axial rotation;
d. impeller means mounted with an opposite end of said drive shaft means for immersion in a fluid in a container having a surface coacting with the fluid for positively displacing a portion of said fluid outward substantially laterally from the axial alignment of said drive shaft means and into counter-rotating and circulating turbulences within said container; and
e. area-adjusting means for adjusting the surface area of said impeller means coacting with the fluid for varying the volume of fluid positively displaced during axial rotation for controlling the torque required from said driving means;
f. said impeller means comprising
1. a first impeller member having at least one blade member mounted therewith;
2. a second impeller member having at least one blade member mounted therewith;
3. said second impeller member being disposed in longitudinal spaced relationship with said first impeller member to provide an adjustable space therebetween and to provide a longitudinal overlapping arrangement of said blade members for engagement of said blade members to form an adjustable surface for said coacting with a portion of the fluid;
4. one of said impeller members mounted with said drive shaft for fixed axial rotation;
5. one of said impeller members rotatably mounted with said area-adjusting means for axial rotation and adapted for longitudinal movement relative to said other impeller member whereby the fixedly mounted impeller member drives the rotatably mounted impeller member during axial rotation; and
6. at least one of said impeller members having an axial opening to provide for fluid flow in the container into the space between said impeller members for positive displacement thereof substantially laterally through said space by said longitudinally overlapping blade members during axial rotation.

2. The mixing apparatus of claim **1,** including:
means mounting said area-adjusting means for adjusting said impeller meeans from the exterior of the container.

3. The mixing apparatus of claim **1,** including:
anticavitation means adapted for mounting with said impeller means for maintaining said fluid in the container substantially level during said axial rotation.

4. The mixing apparatus of claim **1,** wherein said driving means includes:
a. speed control means mounted with said drive shaft means, and
b. motor means connected therewith for imparting a driving force and rotation to said speed control means and drive shaft means.

5. The mixing apparatus of claim **1** wherein:
a. said first impeller member includes a first hub member mounted with said drive shaft means and disposed in axial alignment relative thereto, said first hub member having at least one blade member mounted therewith; and
b. said second impeller member includes a second hub member rotatably mounted with said area-adjusting means and disposed in axial alignment relative to said drive shaft means and longitudinally movable relative to said first hub member upon actuation of said adjusting means, said second hub member having at least one blade member mounted therewith.

6. The apparatus of claim **5** wherein said adjusting means includes:
a. an adjustment rod having one end adapted for mounting with said second impeller hub member and having an opposite end extending exteriorly of said container, the longitudinal axis of said adjustment rod being in substantial alignment with the longitudinal axis of said drive shaft means; and
b. means mounted with said opposite end of said adjustment rod for adjusting said adjustment rod upwardly and downwardly about its longitudinal axis whereby said second impeller member is also adjusted upwardly and downwardly relative to said first impeller member to provide an increase or decrease in the total longitudinal area of said blade members which coact with the fluid positively displaced through the space between said impeller members.

7. The mixing apparatus of claim **6** wherein said means for adjusting the adjustment rod includes:
an actuating member threadably mounted with said opposite end of said adjustment rod and rotatable for axial adjustment of said adjustment rod.

8. The mixing apparatus of claim **1** including:
a. an upper circular plate attached to the upper edge of said blade member of said first impeller member; and
b. a lower circular plate attached to the bottom edge of said blade member of said second impeller member and parallel to said upper circular plate;
said blade members being longitudinally adjustable relative to each other for positioning the lower edge of the first impeller blade member and the upper edge of the second impeller blade member so as to overlap each other in variable amounts upon adjustment thereof by said adjusting means to transmit a driving force from one of said impeller blade members to said other impeller blade member during said axial rotation; and
at least one of said circular plates having said axial opening to provide for said fluid flow into said space between said impeller members.

9. The mixing apparatus of claim **8** wherein:
a. said first impeller member includes a first hub member mounted with said drive shaft means and disposed in axial alignment relative thereto, said first hub member having said blade member mounted therewith; and
b. said second impeller member including a second hub member rotatably mounted with said area-adjusting means and disposed in axial alignment relative to said drive shaft means and longitudinally movable relative to said first hub member upon actuation of said adjusting means, said second hub member having said second impeller blade member mounted therewith.

10. The mixing apparatus of claim **9** wherein said blade members of each of said impeller members are respectively mounted with said first and second hub members, each of said blade members having a substantially arcuate shape and extending substantially laterally from the respective axial alignments of each of said hub members to the respective peripheries of said upper and lower circular plates.

11. The mixing apparatus of claim **8** wherein:

said first impeller member includes a plurality of blade members; and

said second impeller member includes a plurality of blade members.

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