Nov. 12, 1968 | L. L. BALASSA | 3,410,535

MIXING DEVICE

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FIG. 1

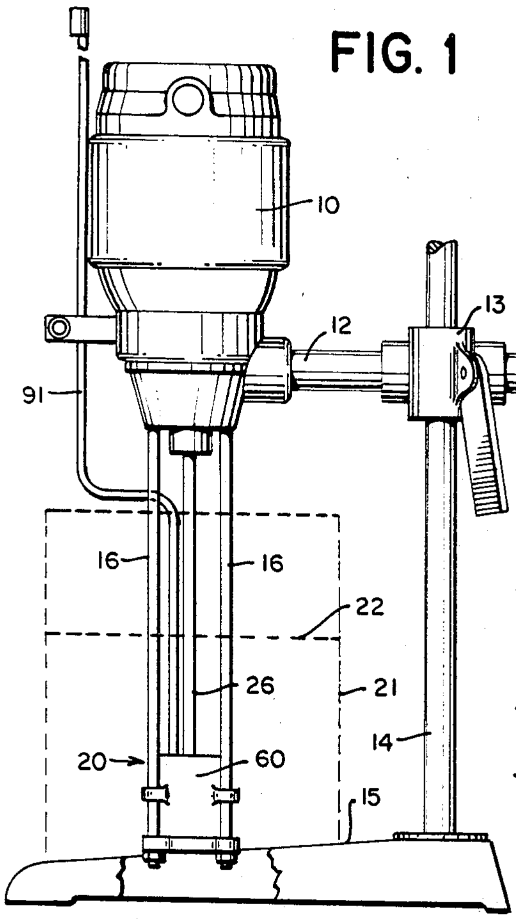



FIG. 2

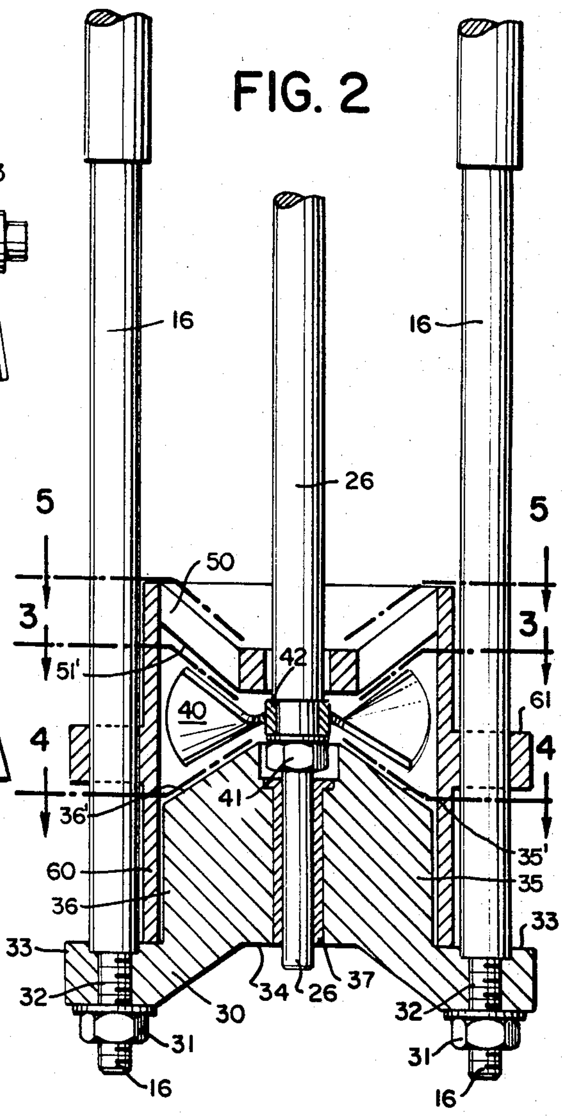
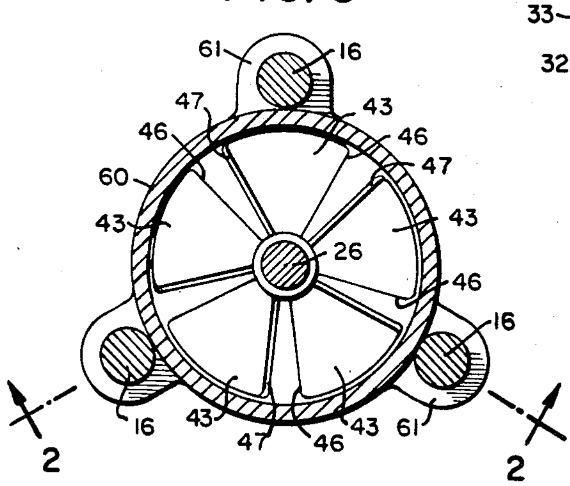



FIG. 3




INVENTOR
LESLIE L. BALASSA

BY Darby & Darby

ATTORNEYS

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FIG. 4

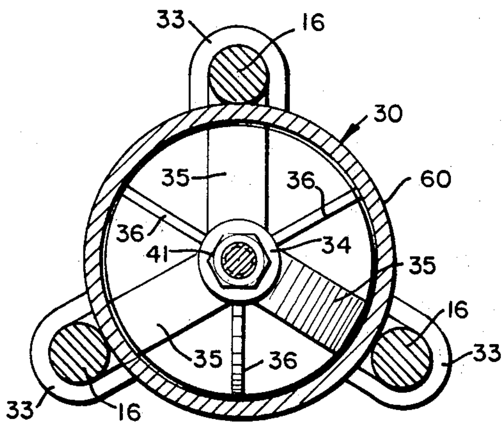



FIG. 5

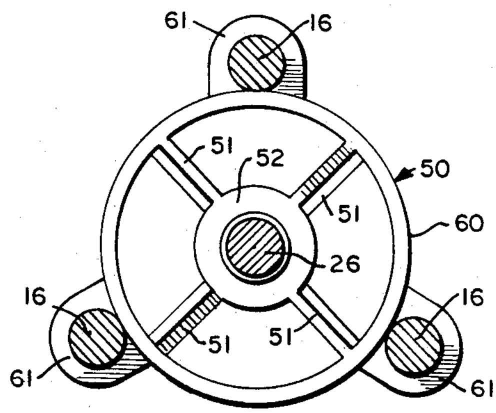
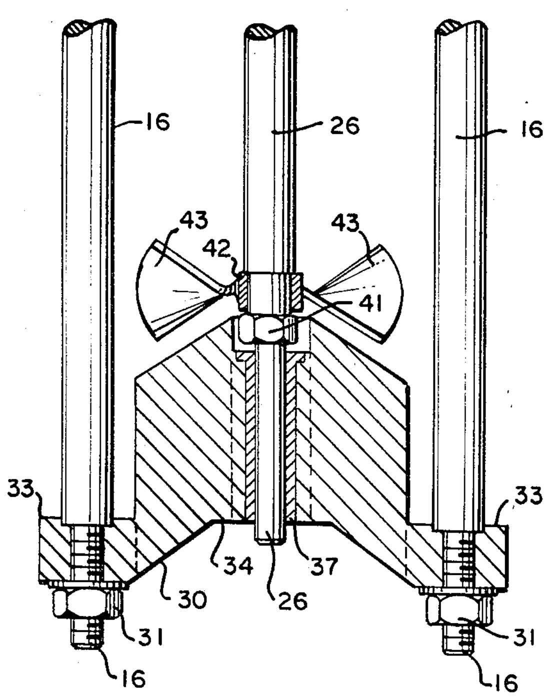



FIG. 6



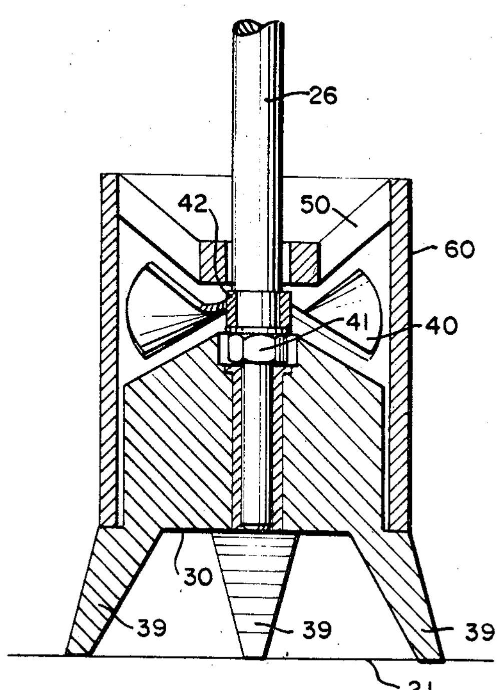




FIG. 7

INVENTOR
LESLIE L. BALASSA

BY Darby & Darby

ATTORNEYS

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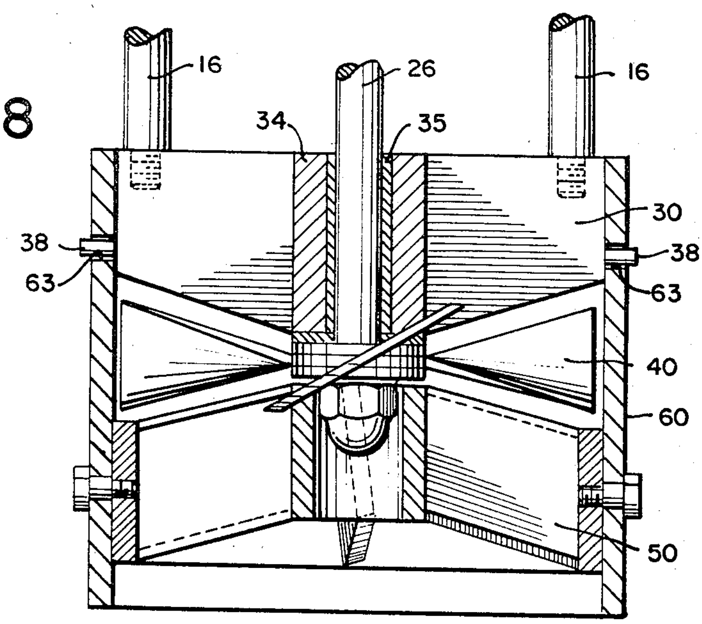
FIG. 8



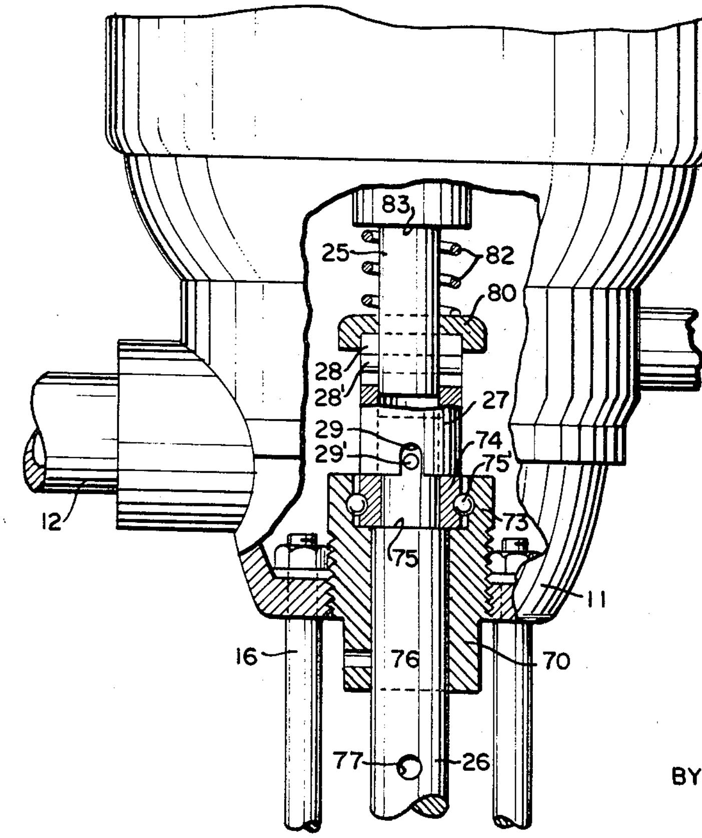




FIG. 9

INVENTOR
LESLIE L. BALASSA

BY Darby & Darby

ATTORNEYS

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3,410,535

Patented Nov. 12, 1968



# 3,410,535
# MIXING DEVICE

Leslie L. Balassa, Creighton Lane, Scarborough, N.Y. 10582

Filed Jan. 23, 1967, Ser. No. 611,034
18 Claims. (Cl. 259—95)

## ABSTRACT OF THE DISCLOSURE

This disclosure describes a reversible mixing device of the turbine type in which the mixing action is produced by the coaction of a revolving rotor element and a fixed stator element mounted below and in hydraulic shear relation with the rotor element, and in which the flow of the material to be mixed is normally in downward direction. This mixing device is suitable for many purposes such as mixing, blending, homogenizing, dispersing and pumping.

*Background of the invention*

In general, turbine type mixing devices are well known in the prior art, but have been predominantly of the upward-flow variety. Examples of such mixing devices are shown, for example, in U.S. Patents Nos. 2,801,083, 3,154,296 and 3,163, 405, issued to the present inventor. Such mixing devices are suitable for use either in the laboratory or in production for the preparation of emulsions vegetable gum and starch dispersions, and for the dispersion of finely divided solids in liquids, such as pigment dispersions.

In the normal operation of the prior art turbine type mixers, the rotor element, which generally comprises a plurality of angled blades, impels or forces the material to be mixed upward through the stator element, which generally comprises a plurality of vanes oriented so as to constrain the material to flow in a substantially axial direction. Because of the close spacing between the blades of the rotor and the vanes of the stator, the coaction of these elements causes hydraulic shearing and consequent homogenization of the material to be mixed. By decreasing the spacing between the rotor and stator, their homogenizing and dispersing action can be increased. Conversely, by increasing the spacing between these elements, their pumping, blending, and mixing action can be increased with a resulting increase in the processing capacity of the mixing device. The use of a sleeve surrounding the rotor and stator so as to form a closed turbine promotes the axial flow of the material and enhances the homogenizing and dispersing action of the device. Removal of the sleeve and operation of the mixing device as an open turbine enhances the mixing action by causing the rotation of the entire mass of the material in the mixing vessel, thus creating a vortex.

Although the prior art upward-flow turbine type mixing devices possess many advantages, they are, nevertheless, subject to certain problems. For example, in the upward-flow device of the prior art, "dead spaces" are likely to occur immediately below the mixing head and around the edges of the bottom of the mixing vessel. The material in such "dead spaces" would tend to remain stationary rather than flow through the mixing head to be uniformly homogenized with rest of the material. In order to insure the circulation of the material in such "dead spots" it was necessary to periodically suspend the homogenizing action and reverse the direction of flow of the material by reversing the direction of rotation of the rotor.

Another problem of the prior art upward-flow turbine type mixing devices is the difficulty of removing or replacing the sleeve so as to convert the device from a



closed turbine configuration to an open turbine configuration or vice versa. In the prior art upward-flow devices it was generally necessary to remove the sleeve in a downward direction. This could not be accomplished without removing the mixing head from the mixing vessel. Alternatively, in order to provide for conversion between the open and closed turbine configurations without removing the mixing head from the material to be mixed, it was necessary to resort to a rather complicated arrangement of the type shown in the above-mentioned U.S. Patent No. 3,163,405.

Still another problem of the prior art turbine type mixing devices involves the difficulty of dispersing ingredients added to the material to be mixed. If such ingredients were simply scattered on the surface of the material to be mixed, the upward flow of material created by the mixing head would cause the added ingredients to be carried outward to the sidewalls of the mixing vessel, downward along the sides of the vessel, and then inward along the bottom of the vessel to the mixing head. This flow pattern permitted the added ingredients to stick to the side walls or bottom of the mixing vessel or become trapped in one of the above-mentioned "dead spaces." In order to avoid this problem of the prior art devices, and provide for the immediate dispersion of added ingredients, it was necessary to provide some means such as shown in the above-mentioned U.S. Patent No. 2,801,083 for introducing the ingredients below the rotor element so that they would be immediately carried upward and dispersed by the coaction of the rotor blades and the stator vanes.

*Summary of the invention*

It is therefore an object of this invention to provide an improved mixing device which obviates or overcomes the problems of the prior art upward-flow turbine type mixing devices.

More particularly, it is an object of this invention to provide an improved turbine type mixing device which does not permit "dead spaces" to occur in the mixing vessel.

It is also an object of this invention to provide an improved mixing device which may be easily converted from the open turbine to the closed turbine configuration and vice versa.

It is still another object of this invention to provide an improved turbine type mixing device by means of which added ingredients are immediately dispersed in the material to be mixed.

In accordance with the above and other objects, this invention provides a mixing device of the turbine type wherein the stator is located below the rotor and wherein the normal flow of the material to be mixed is in a downward direction through the combination of rotor and sator. The rotor is mounted at the end of a shaft which projects downward into the mixing vessel from a drive motor which is mounted above the vessel. The stator may be either mounted on the bottom of the mixing vessel or suspended from the drive motor. In either case, means are provided for adjusting the spacing between the rotor and stator. In order to provide closed turbine operation, there is provided a removable sleeve which surrounds the rotor and stator, and which may be supported at its lower end by suitable projections from the lower end of the stator. In order to provide an open turbine operation, the sleeve may be simply drawn upward by means of a control rod or handle attached thereto without removing the mixing head from the material to be mixed. Optionally, there may be provided a second stator located above the rotor and enclosed within the sleeve during closed turbine operation. The coaction of the second stator with the rotor would provide an additional measure of homogenization, particularly when the flow of material is reversed. The angles of the vanes of either or both stators may be adjusted in order to provide a slight, controlled vortex motion to the entire mass of the material to be mixed, thus enhancing the overall effectiveness of the mixing device.

The downward-flow mixing device of the present invention possesses an advantage over the prior art devices with regard to the processing of extremely viscous materials in that the feeding of the material through the mixing head is aided by gravitational force in the downward-flow device.

Another advantage of the improved mixing device of the present invention is that in the configuration including a second stator, the vanes of the second stator serve to block lumps of material thus protecting the rotor from damage.

Other objects and advantages of the present invention will be apparent from the following detailed description and accompanying drawings which set forth the principles of the invention and, by way of example, the best modes contemplated for applying those principles.

*Brief description of the drawings*

FIG. 1 shows a mixing device embodying the present invention.

FIG. 2 is a detailed cross-sectional view of the mixing head of the mixing device shown in FIG. 1.

FIG. 3 is a cross-sectional view taken along the line 3—3 of the rotor of the mixing head shown in FIG. 2.

FIG. 4 is a cross-sectional view taken along the line 4—4 of the lower stator of the mixing head shown in FIG. 2.

FIG. 5 is a cross-sectional view taken along the line 5—5 of the upper stator of the mixing head shown in FIG. 2.

FIG. 6 is a view of the mixing head shown in Fig. 2 with the sleve and upper stator removed for open turbine operation.

FIG. 7 is a cross-sectional view of a modified mixing head embodying the principles of the invention.

FIG. 8 is a cross-sectional view of another modified mixing head embodying the principles of the present invention.

FIG. 9 is a cross-sectional view of the longitudinally adjustable coupling connecting the motor shaft and the mixer saft of the mixing device shown in FIG. 1.

*Description of the preferred embodiment*

Referring to the drawings for a more detailed description of the structure and operation of the mixing device of the present invention, FIG. 1 shows a mixing machine comprising a motor **10** mounted in an upright position with its lower end attached to a motor support **11** having a tubular rod **12** extending horizontally therefrom. Rod **12** is secured in a bracket **13** which is adapted to be clamped to a fixed vertical post **14** extending upwardly from a bifurcated pedestal **15**. Tubular rod **12** may also serve as a conduit through which cooling air may reach the motor **10** for ventilation purposes. Tubular guide rods **16** are secured to and project downward from motor support **11**. The lower ends of guide rods **16** are secured to and serve to support mixing head **20** relatively remote from motor **10** and in vertical alignment therewith. Mixer shaft **26** is connected to the drive shaft of motor **10** by means of adjustable coupling device **70** which enables the position of mixer shaft **26** to be vertically adjusted. At the lower end of mixer shaft **20**, there is mounted a rotor which, in FIG. 1, is concealed by sleeve **60** of mixing head **20**.

By sliding bracket **13** up or down post **14**, motor support **11** together with motor **10** and mixing head **20** may be raised or lowered with respect to mixing vessel **21** shown in dotted lines in FIG. 1. In its operative position, mixing head **20** extends into mixing vessel **21** beneath the level indicated by dotted line **22** of the material to be mixed.

Referring now to FIG. 2 for a more detailed description of the preferred embodiment of the mixing head of the present invention, there is shown a cross-sectional view of mixing head **20** shown in FIG. 1. Basically, mixing head **20** comprises a rotor **40** mounted on mixer shaft **26**, a lower stator **30** journaled on mixer shaft **26**, an upper stator **50** also journaled on mixer shaft **26**, and a cylindrical sleeve **60** which normally encloses rotor **40** and stators **30** and **50**.

Rotor **40** is the heart of mixing head **20**. It is preferably made of stainless steel and precision engineered, tempered and balanced for high speed operation. Rotor **40** is mounted on mixer shaft **26** by means of nut **41** which acts against shoulder **42** of shaft **26**.

As is more clearly shown in FIG. 3 which is a cross-section taken along the line **3—3** of FIG. 2, rotor **40** consists of a plurality of flat electric-fan-type blades **43** which radiate outwardly from a central disc **44**. Although the preferred form of rotor **40** has five blades **43**, there may be more or fewer blades within the scope and spirit of the invention. Blades **43** have a pitch between **10** and 35 degrees, their trailing edges **46** being more remote from motor **10**, shown in FIG. 1, than are leading edges **47**. In rotation, leading edges **47** and trailing edges **46** of blades **43** produce conical surfaces of revolution arranged in back-to-back relation co-axially with mixer shaft **26**.

Lower stator **30** is secured to guide rods **16** by means of nuts **31** which threadedly engage the tips of guide rods **16** which extend through suitable holes **32** in projections **33** which extend horizontally from stator **30** for that purpose. The lower end of mixer shaft **26** is slidably journaled in hub **34** of stator **30**. If desired, hub **34** of stator **30** may be provided with an anti-friction sleeve **37** for the purpose of facilitating the rotation of mixer shaft **26** and to reduce problems due to the heat resulting from the friction of rotation. In addition, hub **34** of the stator **30** is provided with an enlarged recess in order to accommodate retaining nut **41** of rotor **40**. The journaling of the lower end of mixer shaft **26** in hub **34** of stator **30** serves to stabilize rotor **40** during high-speed operation.

As shown in FIG. 4, stator **30** comprises a plurality of vanes **35** and **36** radiating from a central hub **34**. Although there are six vanes **35** and **36** in the preferred form of stator **30**, it will be understood that a greater or lesser number of vanes may be employed within the scope and spirit of the invention. The lower ends of the three vanes **35** are extended horizontally to form projections **33** having holes therein for receiving the threaded tips of guide rods **16** as explained above.

The flat upper surfaces **35'** and **36'** of vanes **35** and **36** are inclined downwardly and outwardly at an angle between 10 and 35 degrees to the horizontal. As shown in FIG. 2, this angle conforms to the angle of the trailing edges **46** of blades **43** of rotor **40**. As a result of the close relation between trailing edges **46** and upper surfaces **35'** and **36'**, the co-action of rotor **40** with stator **30** produces a hydraulic shearing of the material to be mixed. More particularly, the configuration of blades **43** is such that a wedge-like area is formed between trailing edges **46** and upper surfaces **35'** and **36'**. This area diminishes progressively and rapidly as the whirling of rotor **40** causes trailing edges **46** to sweep across surfaces **35'** and **36'** thereby producing a smooth and effective shearing action.

As shown in FIG. 5, upper stator **50** comprises a plurality of vanes **51** radiating from hub **52**, Hub **52** is journaled on mixer shaft **26** as shown in FIG. 2. Although there are four vanes in the preferred form of stator **50**, it will be understood that a greater or lesser number of vanes may be employed within the spirit and scope of the invention. The lower surfaces **51'** of vanes **51** are inclined upwardly and outwardly at an angle at approximately 15 degrees to the horizontal. This angle conforms to the angle of the leading edges **47** of blades **43** of rotor **40**. If desired, the lower surfaces **51'** of vanes **51** may be flat so as to provide a hydraulic shearing action with edges **47** of blades **43** especially when the direction of rotation of rotor **40** is reversed. Alternatively, the upper or leading edges **54** of vanes **51** may be rounded and the lower or trailing edges **51'** may be tapered so as to streamline vanes **51** in order to reduce the resistance of vanes **51** to the flow of the material through mixing head **20**. In order to further reduce the resistance of vanes **51** to the flow of material through mixing head **20**, vanes **51** may be slightly canted so as to conform to the direction of rotation of the material to be mixed as imparted by the action of rotor **40**. In addition, to reducing the resistance to the flow of material, the canting of vanes **51** promotes a slight rotary motion of the entire mass of the material within mixing vessel **21** shown in FIG. 1, thus enhancing the overall mixing action of the apparatus. On the other hand, in some applications, a vertical orientation of vanes **51** or perhaps even a slight canting in the opposite direction may be preferred in order to prevent the rotation of the mass of material to be mixed and thus prevent the possible formation of a vortex with the consequent and, in some applications, disadvantageous, entrainment of air into the mixture.

In the preferred form of the mixing machine of the present invention, the outer extremities of vanes **51** of stator **50** are rigidly connected, as by welding, to the inner surface of cylindrical sleeve **60** the lower end of which is supported by the horizontal projections **33** of vanes **35**. Sleeve **60** closely encloses rotor **40** and stators **30** and **50** thus causing mixing head **20** to operate as a closed turbine. In this manner, sleeve **60** promotes the smooth axial flow of the material to be mixed and prevents the action of rotor **40** from imparting vortex motion to the mass of material in the mixing vessel. It is noted that during the normal operation of the machine, the downward flow of the material to be mixed forces sleeve **60** firmly into contact with projections **33** thereby obviating the need for any locking devices in order to maintain sleeve **60** in its correct operational position.

In order to convert the mixing machine of FIG. 1 to open turbine operation, all that is necessary is to draw sleeve **60** upward by means of handle or control rod **91** which is attached thereto and which extends upward adjacent to motor **10** for easy access by the operator. The vertical motion of sleeve **60** is guided by means of guide rings **61** which project from the outer surface of sleeve **60** and engage guide rods **16**. FIG. 6 shows the mixing head **20** of FIG. 2 open during turbine operation.

It is noted that because of the construction of the mixing machine of the present invention, sleeve **60** may be drawn upward without otherwise moving mixing head **20** from its position in mixing vessel **21**. Further, it is noted that sleeve **60** may be lowered again into position by control rod **91** and firmly seated against projections **33** by means of the downward flow action described above similarly without moving mixing head **20** from its position. Hence, it is seen that the mixing machine of the present invention may be converted from closed turbine to open turbine operation and vice-versa without removing the mixing head from the mixing vessel. This feature provides a substantial advantage over the prior art upward flow mixing machines which had to be withdrawn from the mixing vessel in order to permit the removal of the sleeve which was commonly fastened in position by means of bayonet locks or the like and was removable only in a downward direction.

FIG. 7 shows a modified form of the mixing machine of the present invention. More particularly, FIG. 7 shows a modified form of the mixing head **20** shown in FIG. 2 in which guide rods **16** have been eliminated and stator is supported instead of means of legs **39** which rest on are rigidly connected to the bottom of mixing vessel **21**. This arrangement simplifies somewhat the disassembly and cleaning of the mixing head.

FIG. 8 shows another modification of the mixing machine of the present invention. More particularly, FIG. 8 shows a modification of the mixing head **20** of FIG. 2 wherein stator **30** is located above and stator **50** below rotor **40**. As in FIG. 2, stators **30** and **50** are journaled on mixer shaft **26**. Stator **30** is supported by guide rods **16** to which it is connected by any suitable means such as, for example, by means of recesses tapped into vanes **35** of stator **30** which threadedly engage the tips of guide rods **16**. But, in the modification of FIG. 8, sleeve **60** and stator **50** are locked into position for closed turbine operation by means of bayonet locks comprising slots **63** in sleeve **60** and lugs **38** projecting from vanes **35** of stator **30**. Hence, it is noted that in the modification of FIG. 8, sleeve **60** must be removed in a downward direction in order to convert the mixing machine from closed turbine to open turbine operation.

FIG. 9 is an enlarged fragmentary view, partly in section, of the adjustable coupling device **70** shown in FIG. 1. Adjustable coupling device **70** permits mixer shaft **26** to be adjusted in an axial direction thereby providing adjustment of the clearance between the trailing edges **46** of rotor blades **43** and the cooperating surfaces **35'** and **36'** of stator vanes **35** and **36**. Decreasing the clearance between these operating elements serves to increase the homogenizing and dispersing action of the mixer. Increasing the clearance between the operating elements serves to increase the pumping, blending, and mixing action as well as the capacity of the machine. Referring to FIG. 9, drive shaft **25** of motor **10** is shown in vertical alignment with mixer shaft **26**. The driving force of motor **10** is transmitted from drive shaft **25** to mixer shaft **26** by means of crenelated coupling consisting of sleeve **27**, the opposite ends of which enclose the opposed ends of shafts **25** and **26**. In the embodiment shown in FIG. 7, the crenelation consists of diametrically opposed pairs of slots **28** and **29** formed in the ends of sleeve **27**. Pairs of slots **28** and **29** cooperate with pins **28'** and **29'** which project diametrically outward from the sides of the ends of shafts **25** and **26**. Slots **28** and **29** extend sufficiently far in the axial direction to allow the axial adjustment of mixer shaft **26** as described below.

The mechanism for raising or lowering mixer shaft **26** and, consequently changing the relative spacing of the rotor end of the stator, includes cylindrical adjusting unit **70**. The upper end of adjusting unit **70** is externally threaded to engage internal threads formed within the lower end of motor support **11**. The upper end of unit **70** is internally formed to provide the outer race **73** of a ball bearing the other race **74** of which is tightly fitted to the upper end of mixer shaft **26** which, for this purpose, is reduced in diameter to form a shoulder **75** against which the inner race **74** is seated. A series of balls **75'** between the races provide an anti-friction bearing for this end of shaft **26**. The outer race of this bearing need not necessarily be an integral part of unit **70** since the bearing may instead be a conventional one mounted in the unit as an insert.

The coupling sleeve **27** in FIG. 7 is positioned above race member **74**, and its upper end is closed by a cover **80** through which shaft **25** passes. A spring **82** surrounds shaft **25** between the cover and a shoulder **83** so as to not only keep the cover seated as a grease shield, but to urge the sleeve downwardly against race member **74**. The unit **70** may be conveniently turned by engaging a hole **76** in its lower end, while at the same time holding shaft **26** against rotation by inserting a tool in a hole **77** through shaft **26**. For example, if unit **70** is turned to ride the threads upwardly it will rise and carry the ball races with it lifting sleeve **27** and, since shaft **25** is in a fixed position its pin **28'** will also remain stationary, so that sleeve **27** in rising will compress spring **82** because of the aforesaid clearances between pin **28'** and associated slots **28**. Shaft **26** will thus be moved upwardly, due to its connection to race **74**, resulting in decreasing the distance separating the opposed ends of the shafts and lifting the rotor **40** with respect to the stator **30**. In this manner, or by reversing the procedure, a close or coarser relationship of the stator and rotor parts of the operating head may be accomplished to selectively obtain a fine or coarser granulation of the particles in suspension in the emulsion in container **21**.

Although the preferred form of the present downward flow mixer has been described with reference to both closed turbine and open turbine operation, it will be recognized that other changes may be made in the operational structure of mixing head **20** without departing from the principles of the invention. For example, the present invention contemplates a mixing machine having a mixing head similar to the mixing head **20** shown in FIG. 2 except that upper stator **50** is omitted.

Further, it is noted that because the mixing machine of the present invention combines an upper and a lower stator with an axially adjustable rotor, it is particularly well suited to reversible operation. When the present mixing machine is operated in the downward flow direction, there is a hydraulic shearing action between the rotor and the lower stator. When the machine is operated in the upward flow direction, there is a hydraulic shearing action between the rotor and the upper stator. In both cases the shearing action, and consequent homogenization of the material to be mixed, is determined by the axial position of the rotor under control of the adjustable coupling device which connects the motor shaft to the mixer shaft.

As mentioned above, the downward flow mixing machine of the present invention possesses an advantage over the prior art upward flow machines in that ingredients added to the mixture are carried toward the center of the mixing vessel and then downward through the mixing head for rapid dispersion into the mixture. If desired, there might be provided a small disc mounted on the mixer shaft immediately above the mixing head in order to break up lumps of material before they reach the mixing head thus avoiding possible damage to the rotor. Such a disc may have a diameter two or three times the diameter of the mixer shaft but much smaller than the diameter of the rotor. The effectiveness of such a disc may be enhanced by providing it with small vanes or wavy edges.

Additionally, in order to achieve a more immedite dispersion of added ingredients there might be provided a simple pipe or conduit for introducing ingredients directly above the mixing head or the rotor itself. Such a conduit might extend downward parallel to the mixer shaft from a suitable position adjacent the motor **10** shown in FIG. 1 to a position immediately above the mixing head.

Alternatively, ingredients may be introduced into the mixture by means of a hollow mixer shaft having a plurality of exit ports spaced about the periphery of the shaft immediately above the mixing head for the rotor itself. Such an arrangement is described in conjunction with an upward flow mixer in U.S. Patent No. 2,891,083, issued July 30, 1957 to the present inventor.

Although the preferred embodiment and several modifications of he mixing machine of the present invention have been described as having unitary cylindrical sleeves **60** which must be removed in an axial direction, it will be understood that the principles of the present invention embrace other types of sleeves. For example, a sleeve comprising several segments adapted to swing outward in order to convert the mixing machine from closed turbine to opened turbine operation might be employed. Such an arrangement is described in U.S. Patent No. 3,163,405 issued Dec. 29, 1964 to the present inventor.

While the preferred embodiment has been described as oriented in a vertical direction, it will be appreciated that the mixing device of the present invention can be operated in any orientation with good results. For example, the mixing device of the present invention may be operated as a side entering unit or may be mounted on the bottom of the mixing vessel and driven by a shaft entering the vessel from below.



It will further be apparent to those skilled in the art that other modifications and adaptions of the apparatus may be made without departing from the spirit and scope of the invention as set forth with particularity in the appended claims.

What is claimed is:

1. A mixing device for mixing material within a vessel comprising:
   - a mixing head for operation within said vessel, said mixing head comprising a stator and a rotor, said stator comprising a central hub with a plurality of vanes radiating therefrom, each of said vanes having a flat upper surface which is inclined downwardly and outwardly and defines a substantial angle to the horizontal, said rotor having a plurality of fan-like blades having a pitch of from 10° to 35°, the leading and the trailing edges of said blades producing conical surfaces of revolution arranged in back-to-back relation, with the leading edges of said blades being more remote from the upper surfaces of said vanes than said trailing edges, said trailing edges being in hydraulic shearing relation to said upper surfaces,
   - remote drive means for said rotor, and
   - a shaft connecting said drive means to said rotor.

2. A mixing device for mixing material within a vessel comprising:
   - a mixing head for operation within said vessel, said mixing head comprising a stator and a rotor, said stator comprising a central hub with a plurality of vanes radiating therefrom, each of said vanes having a smooth upper surface which is inclined downwardly and outwardly and defines a substantial angle to the horizontal, said rotor having a plurality of fan-like blades, the leading and the trailing edges of said blades producing conical surfaces of revolution arranged in back-to-back relation, with the leading edges of said blades being more remote from the upper surfaces of said vanes than said trailing edges, said trailing edges being in hydraulic shearing relation to said upper surfaces, remote drive means for said rotor, a shaft connecting said drive means to said rotor, and
   - an open-ended cylindrical sleeve coaxial with said shaft and surrounding said rotor and said stator for converting said mixing device to a closed turbine configuration.

3. A mixing device of the type described in claim **2**, further comprising:
   - means for removing said sleeve upward coaxially with said shaft so as to convert said mixing device to an open turbine configuration.

4. A mixing device of the type described in claim **3**, wherein the means for removing said sleeve comprises a control rod connected to said sleeve and extending upward substantilally parallel to said shaft to a position adjacent said drive means.

5. A mixing device of the type described in claim **3**, further comprising:
   - means coupled to said shaft for moving said shaft longitudinally with respect to said stator so as to vary the spacing between the blades of said rotor and the upper surfaces of the vanes of said stator.

6. A mixing device for mixing material within a vessel comprising:
   - a drive motor,
   - motor support means for supporting said drive motor above said vessel,

a mixer shaft connected to said drive motor and projecting downward into said vessel,
a rotor mounted at the lower end of said mixer shaft,
a first stator journaled on said mixer shaft above and in close proximity to said rotor, said first stator having a central hub and a plurality of vanes radiating therefrom,
a second stator mounted below and in close proximity to said rotor, said second stator having a central hub with a plurality of vanes radiating therefrom, said rotor having a plurality of fan-like blades, the upper edges of the blades being in hydraulic shearing relation with the undersurfaces of the vanes of said first stator, and the lower edges of said blades being in hydraulic shearing relation to the upper surfaces of the vanes of said second stator.

**7.** A mixing device for mixing material within a vessel comprising:
a drive motor,
motor support means for supporting said drive motor above said vessel,
a mixer shaft connected to said drive motor and projecting downward into said vessel,
a rotor mounted at the lower end of said mixer shaft,
a stator mounted below and in close proximity to said rotor, said stator having a central hub with a plurality of vanes radiating therefrom, each of said vanes having a smooth upper surface which is inclined downwardly and outwardly and defines a relatively sharp angle to the horizontal, said rotor having a plurality of fan-like blades, the leading and trailing edges of said blades producing conical surfaces of revolution arranged in back-to-back relation coaxially with said drive shaft with the leading edges of the blades being more remote from the upper surfaces of the vanes of said stator, the trailing edges of said blades being in hydraulic shearing relation to the upper surfaces of the vanes of said stator, and
adjustment means for raising and lowering said mixer shaft so as to vary the spacing between the blades of said rotor and the upper surface of the vanes of said stator.

**8.** A mixing device of the type described in claim **7**, wherein said adjustment means comprises:
coupling means coupling the drive shaft of said drive motor to said mixer shaft, and
a housing journaled on said mixer shaft adjacent its coupled end and threadedly engaging said motor supporting means so that rotating said housing with respect to said motor supporting means varies the distance separating said rotor and said stator so as to selectively provide fine and coarse granulation of the mateirals to be mixed.

**9.** A mixing device of the type described in claim **7**, further comprising:
an open-ended cylindrical sleeve coaxial with said shaft and surrounding said rotor and said stator for converting said mixing device to a closed turbine configuration.

**10.** A mixing device of the type described in claim **9**, further comprising:
means for removing said sleeve upward coaxially with said shaft so as to convert said mixing device to an open turbine configuration.

**11.** A mixing device for mixing material within a vessel comprising:
a drive motor having a drive shaft,
motor support means for supporting said drive motor above said vessel.
a mixer shaft projecting downward from said drive motor into said vessel,
coupling means coupling said mixer shaft to the drive shaft of said drive motor,
a first stator journaled on said mixer shaft,



a rotor mounted on said mixer shaft below said first stator and in close proximity thereto, and
a second stator located below said rotor and in close proximity thereto, said first stator having a central hub with a plurality of vanes radiating therefrom each of said vanes having a smooth undersurface which is inclined upwardly and outwardly and defines a relatively sharp angle to the horizontal, said second stator having a central hub with a plurality of vanes radiating therefrom, each of said vanes having a smooth upper surface which is inclined downwardly and outwardly and defines a relatively sharp angle to the horizontal, said rotor having a plurality of fan-like blades so pitched that in rotation the upper and lower edges of said blades produce conical surfaces of revolution arranged in back-to-back relation, with the upper edges of said blade being in hydraulic shearing relation to the undersurfaces of the vanes of said first stator and the lower edges of said blades being in hydraulic shearing relation to the upper surfaces of the vanes of said second stator.

**12.** A mixing device of the type described in claim **11**, further comprising:
an open-ended cylindrical sleeve coaxial with said mixer shaft and surrounding said rotor and said first and second stators so as to provide a closed turbine configuration.

**13.** A mixing device of the type described in claim **12**, wherein said sleeve is rigidly connected to said first stator and the combination of said sleeve and said first stator is removable upward coaxially with said mixer shaft so as to provide an open turbine configuration comprising said rotor and said second stator.

**14.** A mixing device of the type described in claim **12**, wherein said sleeve is rigidly connected to said second stator and the combination of said sleeve and said second stator is removable in a downward direction so as to provide an open turbine configuration comprising said rotor and said first stator.

**15.** A mixing device of the type described in claim **11**, further comprising:
adjustment means for raising and lowering said mixer shaft so as to vary the spacing between the blades of said rotor and the upper surface of the vanes of said stator.

**16.** A mixing device of the type described in claim **15**, wherein said adjustment means comprises:
coupling means coupling the drive shaft of said drive motor to said mixed shaft, and
a housing journaled on said mixer shaft adjacent its coupled end and threatedly engaging said motor supporting means so that rotating said housing with respect to said motor supporting means varies the distance separating said rotor and said stator so as to selectively provide fine and coarse granulation of the materials to be mixed.

**17.** A mixing device of the type described in claim **11**, wherein said stator is mounted within said vessel in spaced relation with the bottom and sides thereof.

**18.** A mixing device of the type described in claim **11**, wherein said stator is carried by a plurality of support rods extending downward from said motor support means in substantially parallel relation to said mixer shaft.

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ROBERT W. JENKINS, *Primary Examiner.*