

[54] MIXING APPARATUS AND METHOD

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[58] Field of Search 259/191, 5, 2, 21, 40, 192,
259/193, 64, 4

[56] **References Cited**

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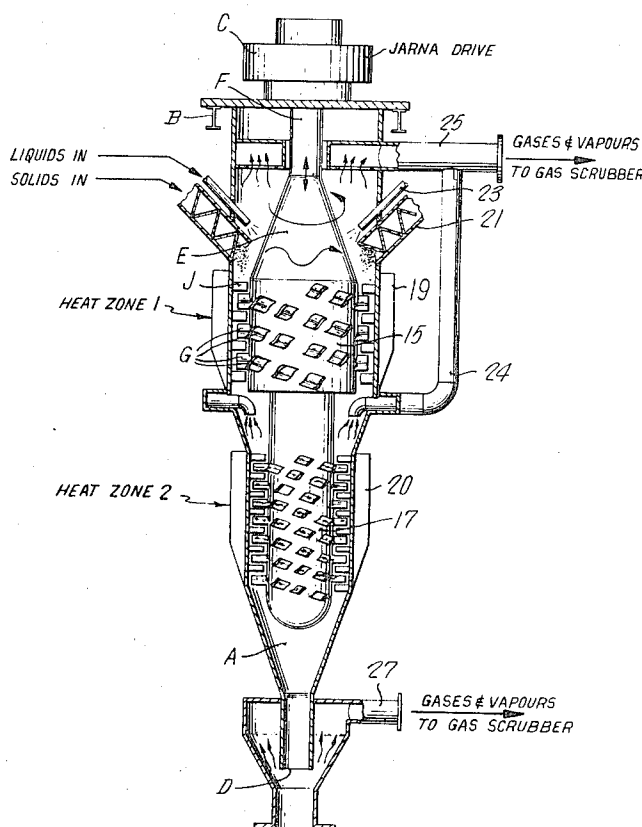
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[57] **ABSTRACT**

A mixing apparatus comprising a stator housing having a cylindrical inner wall defining a mixing chamber having an inlet and an outlet leading thereto. A rotor is supported for rotatable and reciprocal motion within the mixing chamber and defines a cylindrical rotor wall spaced from the stator inner wall. Drive means and coupling means are provided for transmitting rotatable and axial reciprocating motion to the rotor. The stator inner wall is provided with rows of spaced apart projections thereon protruding into the mixing chamber. The rotor is also provided with rows of spaced apart rotor blades which are arranged in a predetermined manner to pass between the stator projections on the inner wall of the stator. The coupling means is arranged to provide a cycloidal motion to the rotor whereby each rotor blade will pass between adjacent stator projections and wipe against them on the upward motion and pass between rows of projections on the downward motion.

8 Claims, 6 Drawing Figures



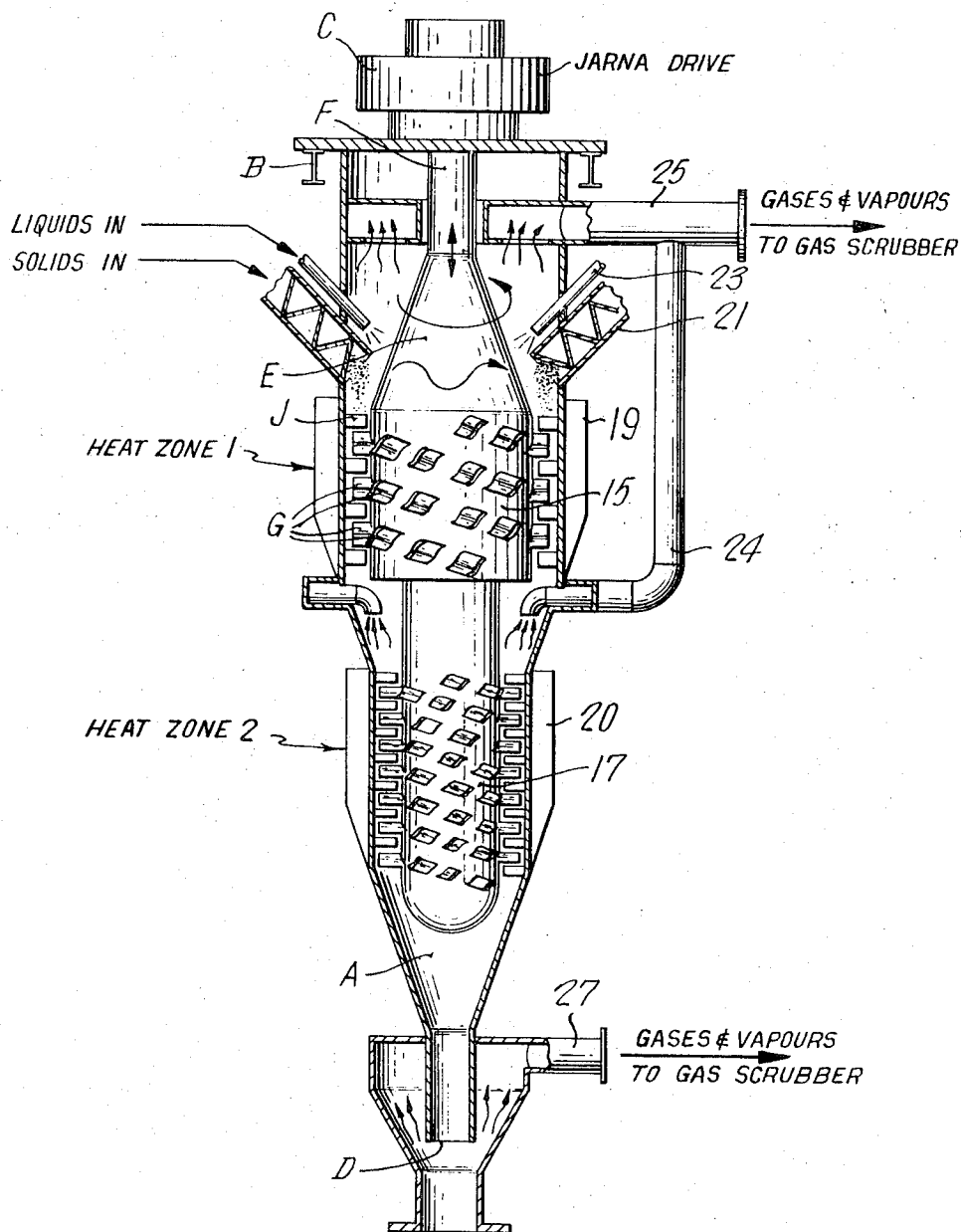


FIG. 1

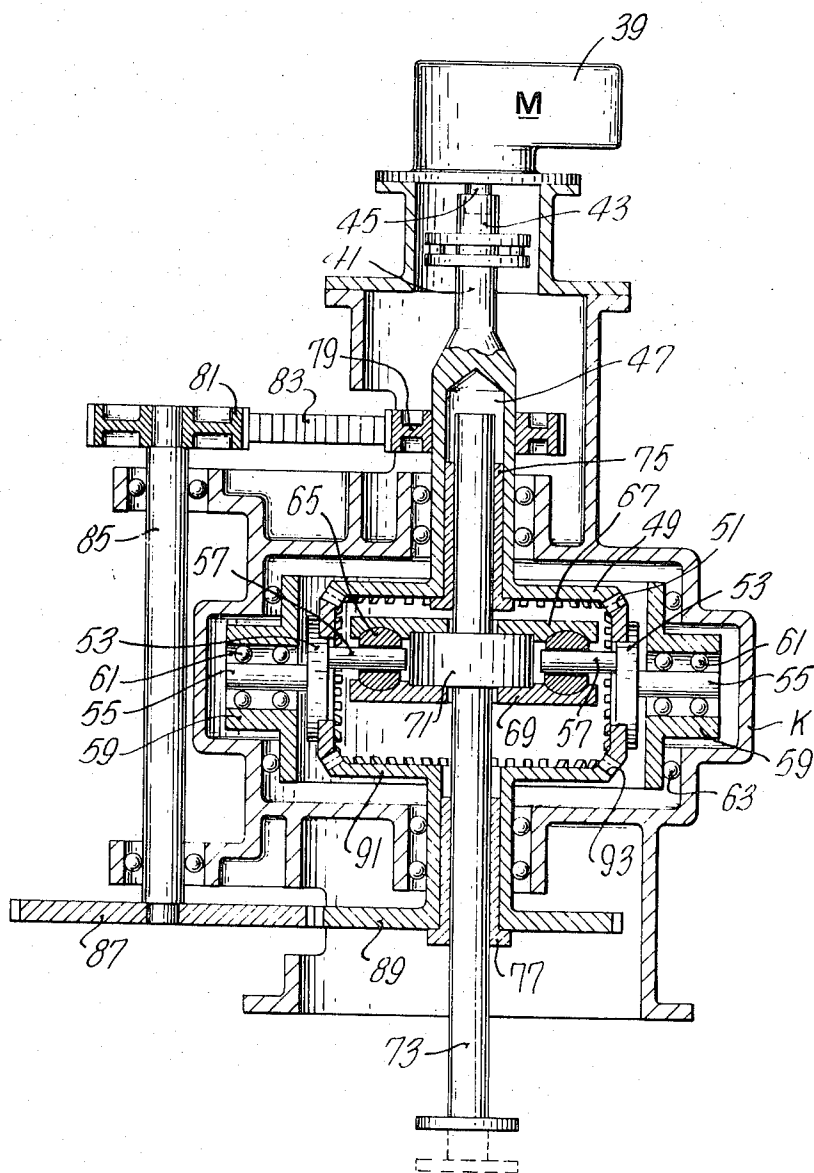


FIG. 2

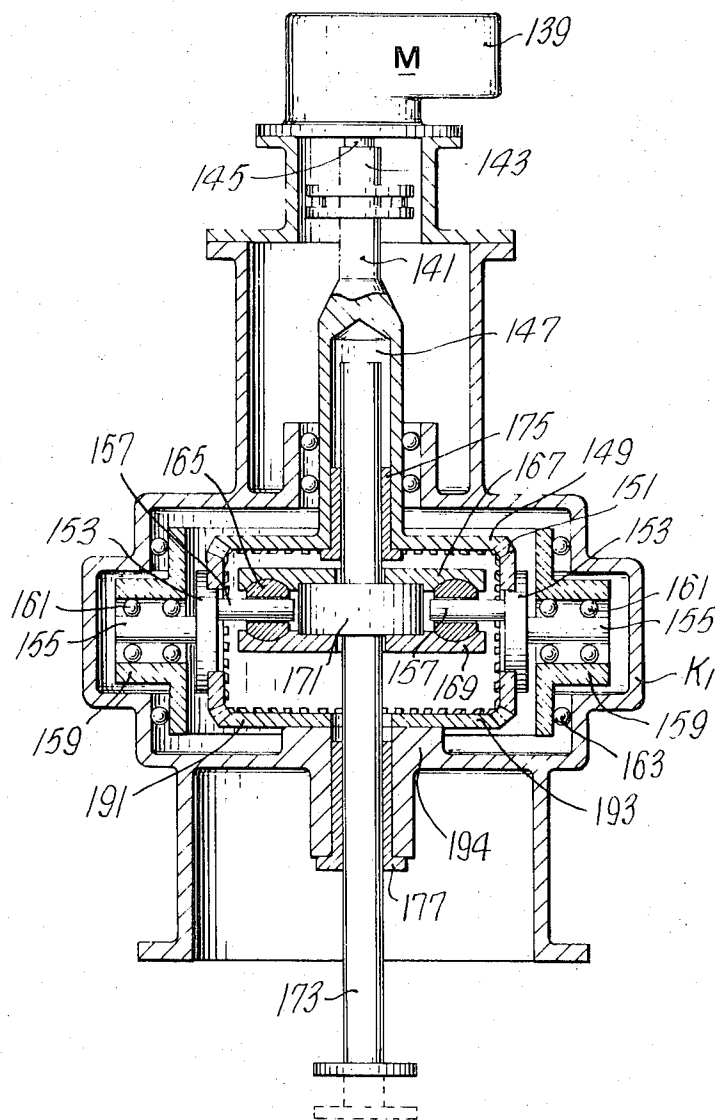
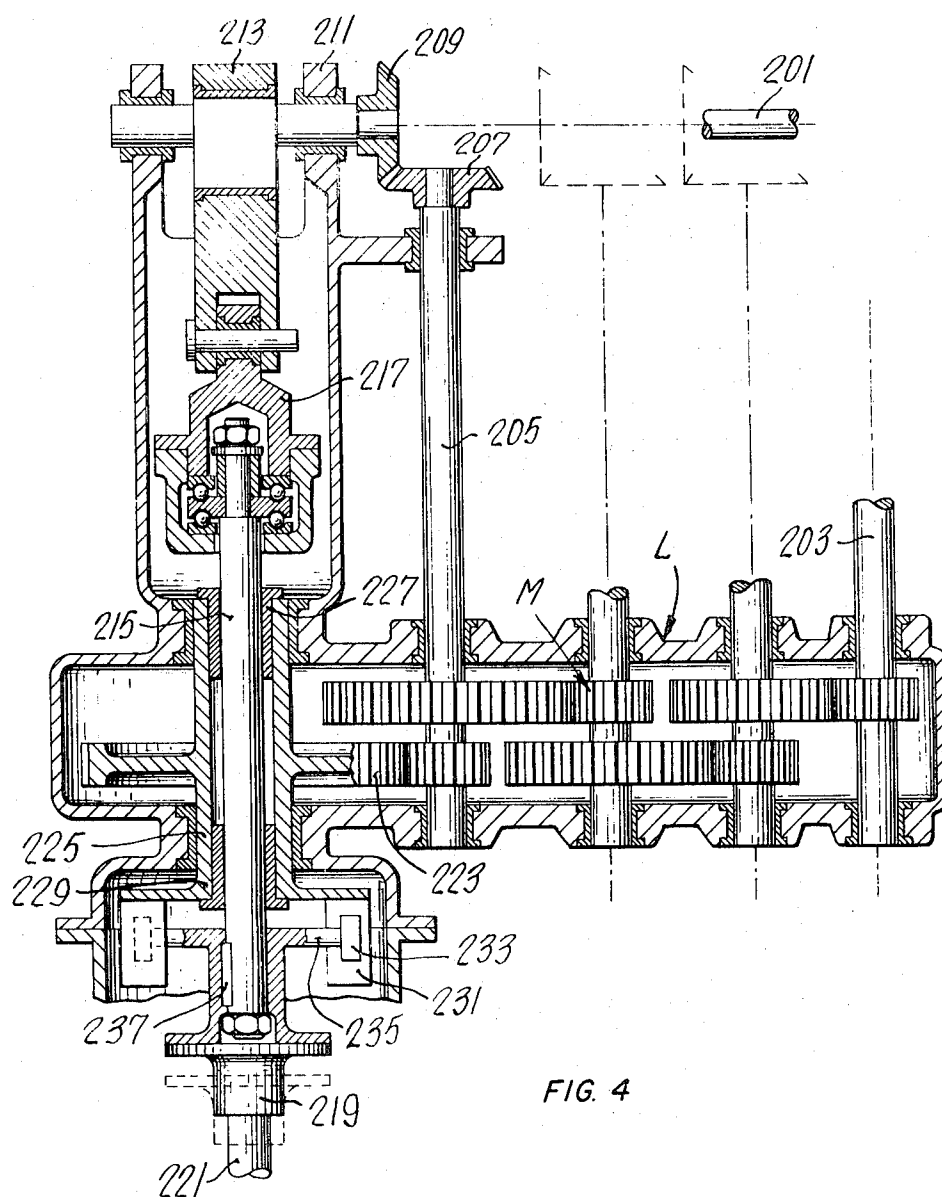
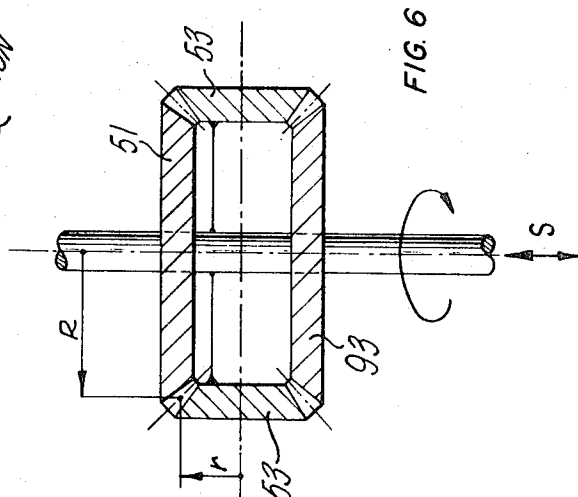
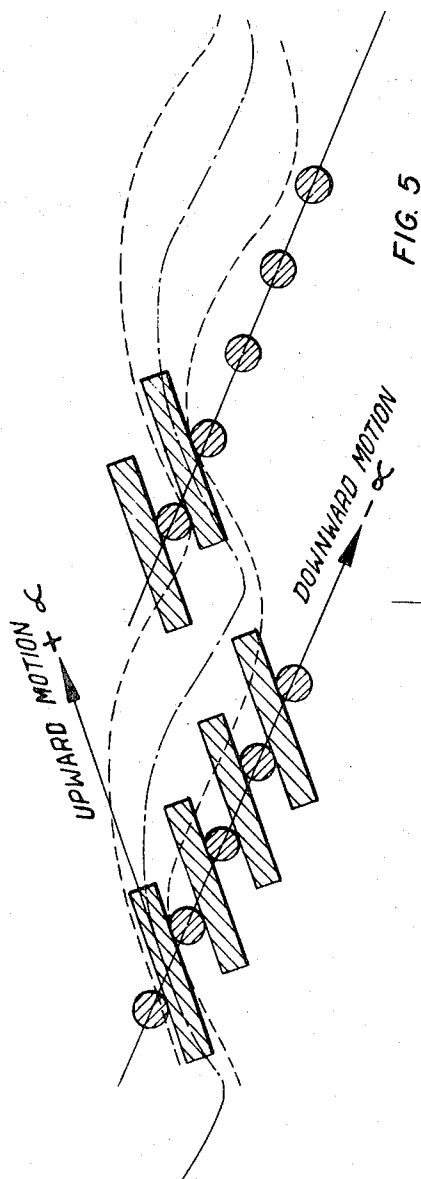


FIG. 3





MIXING APPARATUS AND METHOD

BACKGROUND OF INVENTION

1. Field of the Invention

This invention relates to a mixing apparatus and method.

In particular the apparatus of the invention is specially applicable to mechanical mixing, chemical reactions, kneading, crystallizing, drying, evaporating, homogenizing, degassing and feeding. The invention is useful for mixing liquids, plastic materials and solid materials and combinations of these.

2. Description of Prior Art

The prior art is replete with attempts to provide better mixing equipment. Most have shortcomings in that they fail to provide for mixing a homogeneous mass of components on a continuous process basis. Often lumps appear in the mixed product.

The action of mixing may best be compared with that of a person kneading flour and water to make dough for bread. The action of pushing, squeezing, pulling and overlapping occur within the person's hands.

The prior art attempts to reproduce this action to provide a rotor with blades rotating about a longitudinal axis and at the same time executing a reciprocating motion. This produces a sinusoidal motion of rotor blades between projections on the inside of a stator. Because of the rotor and stator blades geometric disposition, this action is limited to only one movement in either direction, that is one rotary and one reciprocating motion. Further, this design requires large clearances between the rotor blades and the stator projections, resulting in passing lumps without proper mixing. Further, the prior art lacks other aspects of control of the mixing process.

SUMMARY OF INVENTION

The present invention aims to overcome the disadvantages mentioned and to provide positive advantages as will be evident from the following description.

From a broad aspect, the present invention provides a mixing apparatus comprising a stator housing having a cylindrical inner wall defining a mixing chamber having an inlet and an outlet leading thereto. A rotor is supported for rotatable and reciprocal motion within the mixing chamber and defines a cylindrical rotor wall spaced from the stator inner wall. Drive means and coupling means are provided for transmitting rotatable and axial reciprocating motion to the rotor. The stator inner wall is provided with rows of spaced apart projections thereon protruding into the mixing chamber. The rotor is also provided with rows of spaced apart rotor blades which are arranged in a predetermined manner to pass between the stator projections on the inner wall of the stator. The coupling means is arranged to provide a cycloidal motion to the rotor whereby each rotor blade will pass between adjacent stator projections and wipe against them on the upward motion and pass between rows of projections on the downward motion.

BRIEF DESCRIPTION OF DRAWINGS

Having thus generally described the invention, it will be referred to in more detail by reference to the accompanying drawings, which show preferred embodiments and in which:

FIG. 1 is a vertical cross-section through a mixer according to the invention;

FIG. 2 is an enlarged vertical cross-section, partly in elevation, through a preferred drive used in a mixer, as shown in FIG. 1;

FIG. 3 is an enlarged vertical cross-section, similar to that of FIG. 2, an alternative preferred drive assembly;

FIG. 4 is an enlarged vertical cross-section through a further alternative form of drive;

FIG. 5 is a diagram illustrating the motion of the blades produced by the drive of FIGS. 2 or 3;

FIG. 6 is a diagram showing the general arrangement of the drive gears of FIGS. 2 and 3 specially illustrating their motion.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring more particularly to FIG. 1, the mixer is made up of the following main parts. An elongated vertically disposed stator body A is supported in a conventional manner, in this case hung from a floor or ceiling beam B to enclose a mixing chamber. The body A extends from a special drive C, as will be described later in more detail to an outlet D. Within the body is a rotor E connected to a shaft F from the drive C.

In the particular form shown, the rotor E is in the form of a hollow shell having an upper part 15 and a lower part 17 of reduced diameter. The parts 15 and 17 are adapted to receive heating or cooling fluid.

The rotor E carries external mixing blades G. The body A is provided with heating jackets 19 and 20 and with inward projections which may be bolts or blades J.

At a convenient location towards the upper part of the body A are provided inlets 21 and 23 for solids and liquids respectively. Gas and vapor outlets are shown at 24 and 25 and 27.

GENERAL OPERATION

In general operation the liquid and/or solid materials to be mixed are fed into the inlets 21 and 23. A typical example would be an aqueous sulfuric acid and fluor spar. The materials gravitate within the mixing chamber in the stator A as the rotor E is in motion by the drive C. The material is acted on by the blades G in conjunction with the projections J and is propelled downwards by the action of the blades through the outlet D.

The rotor E is rotated and at the same time reciprocated in an up-and-down direction, in a special manner, made possible by the drive C, as will be described in detail. This imparts to the blades a special path, as will be later described, and consequently produces the unique mixing action, characteristic of the invention.

DETAILED DESCRIPTION OF DRIVE

Referring to FIG. 2 which shows a preferred drive, this drive includes having a main housing K, a prime mover, which in this case, is an electric motor 39. The motor 39 is connected to a drive shaft 41 through a coupling 43 and a stub shaft 45. The drive shaft is of special design and has a hollow part 47 terminating in a flange 49 which has an annular toothed extremity or gear part 51. The gear part 51 meshes with secondary gears 53, each of which has an outwardly extending shaft 55 and an inwardly extending shaft 57. The shaft 55 is mounted in a cage 59 through ball bearings 61.

The cage is in turn mounted on bearings 63 within a part of the housing K.

Carried on the shaft 57 are bearings 65 mounted between plates 67 and 69, attached to a collar 71, mounted on a shaft 73. The shaft 73 extends within the hollow part 47 of the shaft 41 and is slidable up and down within this hollow shaft on bearings 75 and 77. The shaft 41 carries a gear 79 which drives a gear 81 through a belt or other transmission 83. In turn the gear 81 drives a shaft 85 mounted in bearings in the main housing K. The lower end of the shaft 85 carries a gear 87 which meshes with a gear 89 which has an outwardly extending flange 91 which has an annular toothed portion 93 which engages with the gear 53.

In operation the rotation of the shaft 41 by the motor 39, through the gearing arrangement, causes rotation of the gear 93 and the gear 51, so as to cause rotation of the gears 53 and the shaft 57.

The alternative construction shown in FIG. 3 is similar to that shown in FIG. 2 and similar numbers have been given to the parts except that they have been raised by one hundred and similar letters have been used for similar parts with the addition of a prime sign. The difference between the constructions is that in FIG. 3 there is no external drive through gears 79 which, in turn, drives the gear 93. But the gear 193 is fixed to a base formed by an annular boss 194 on the housing K₁.

The apparatus shown in FIG. 4 is adapted to generate a different curve through which a point on the stator would move as a result of the special motion imparted to the mixer by this drive. This construction will be described in terms of its operation.

A motor (not shown) drives shaft 201 which in turn drives a shaft 203 coupled through a train of gears M appropriately journaled on shafts in the gearbox L, which in turn drives an outward shaft 205, which drives the gear 207 meshing with the gear 209 on a shaft 211. The shaft 211 drives a crank 213 to impart to it a reciprocal motion. The crank 213 in turn imparts reciprocal motion to a shaft 215, through a yoke 217, which reciprocates a coupling 219 which in turn is connected to the mixer rotor (not shown) through a shaft 221.

Rotary motion to the shaft 215 is imparted as follows. From the gear train M is driven a gear 223, mounted on spider 225 which rotates on bearings 227 and 229 on the shaft 215. The spider 225 carries a yoke 231 which has channels which engage bearings 233 mounted on a spider 235 keyed to the shaft 215 with key 237.

It is thus seen that there is imparted to the shaft 215 both a reciprocal up-and-down motion as well as a rotary motion causing the rotor sections G to move in such a way that a point on its surface will describe a sinusoidal curve.

The arrangement as shown in FIG. 2 may be produced to give a combination of movements of gears 53 and by thus the shaft 73, namely, by:

1. Rotating gears 51 and 93 in the same direction and at the same peripheral speed, the gear 53 is locked between gears 51 and 93. The shaft 73 is only rotated at the speed of the shaft 41 with no up-and-down movement.

2. Rotating gears 51 and 93 in the opposite direction, but at equal peripheral speed, the gear 53 will rotate around the center of the shaft 55 but will not execute circular motion around the shaft 73.

The main motion imparted to the shaft 73 is the up-and-down motion.

3. Rotating gear 51 but holding gear 93, see FIG. 3, the gear 53 imparts the composite motion to the shaft 73 which rotates at the speed of the shaft 41 and slides up and down at the ratio of "R" and "r."

4. Rotating the gears 51 and 93 but varying the peripheral speed and direction from maximum speed in, for example, the left direction through zero speed to maximum speed in the opposite direction, right direction gives a variation of both movements from rotation only to predominantly sliding motion and all movements in between.

Through proper engagement, similar motions can be achieved with the drive arrangement shown in FIG. 4.

For drives to be used with the mixer where stator has teeth or blade arrangement, the motion of the rotor must be made to fit the relative movement of rotor and stator blades.

FIG. 5 shows the path of a rotor blade as described on the circumference of the stator. This path is a curve, as designed and controlled by the drive on FIGS. 1 to 3. The teeth on the stator are arranged in such a way that each rotor blade passes between individual pairs of teeth on the upward motion and between rows of teeth on the downward motion.

The mixing action is as follows. When the downward motion blades move in between two rows of teeth the material is kneaded between the rotor and stator teeth and pushed in the downward direction. At the same time the rotary motion is imparted. The rotary motion is composed with the downward motion into cycloidal motion. The downward stroke causes kneading action between the rotor blades and the stator blades. The upward stroke causes a shearing and wiping motion as the rotor blades move between two consecutive teeth.

FIG. 6 shows diagram of gears 51 and 53, as presented in FIG. 2. The ratio of radius "R" of gear 51, to the radius "r" of gear 53 in FIG. 2 (applies to FIG. 3) defines the number of sliding movements of the shaft 73 per one revolution. Because the rotor blades must always clear the blades or teeth of the stator, therefore the ratio of "R" to "r" must be so chosen that each rotor blade will exactly repeat its consecutive movement in space in relation to its previous movement. This condition can be met when the number of revolutions of small gear 53 per one revolution of the large gear 51 is a whole number.

I claim:

1. A mixing apparatus comprising a stator housing having a cylindrical inner wall defining a mixing chamber, said mixing chamber having an inlet and an outlet, a rotor supported for rotatable and reciprocal motion within said mixing chamber and having a cylindrical rotor wall spaced from said stator inner wall, drive means, coupling means connected between said drive means and rotor for transmitting a rotatable and axial reciprocating motion to said rotor, said stator inner wall having rows of spaced apart projections thereon protruding into said mixing chamber, said rotor having rows of spaced apart rotor blades arranged to pass between said stator projections, said coupling means being arranged to provide a cycloidal motion to said rotor whereby each rotor blade will pass between adjacent stator projections and wipe against them on the upward motion and pass between rows of projections

on the downward motion, said coupling means comprising a first and second annular toothed gear, said first and second gears being positioned in opposed spaced apart relationship on a common central axis and having identical radius and number of teeth, opposed circular secondary gears in toothed engagement between said first and second annular gears, a rotor shaft supported on said central axis and connected to said secondary gears, said first annular gear being rotatably driven by said drive means to impart rotary motion to said rotor shaft and upward and downward motion through said secondary gears.

2. A mixing apparatus as claimed in claim 1 wherein said stator projections are stator blades adapted to pass in close proximity to the surfaces of said rotor blade.

3. A mixing apparatus as claimed in claim 2 wherein a material is introduced to said mixing chamber in said inlet and removed through said outlet, said material being kneaded between said rotor and stator blades and pushed towards said outlet during said downward motion, said upward motion of said rotor imparting a shearing and wiping action to said material as each said rotor blades moves between adjacent stator blades.

4. A mixing apparatus as claimed in claim 1 wherein said second annular gear is fixed and said secondary gears impart said rotary and upward and downward motion to said rotor shaft as said secondary gears rotate about the circumference of said first and second annular gears.

5. A mixing apparatus as claimed in claim 1 wherein said second annular gear is driven by said drive means at the same peripheral speed and in opposite direction to said first annular gear causing said secondary gears to rotate about its central transverse axis and to thereby impart upward and downward motion to said rotor shaft.

6. A mixing apparatus as claimed in claim 1 wherein said first and second annular gears are driven at the same peripheral speed and in the same direction by said drive means, said secondary gears being locked within said first and second annular gears whereby said secondary gears impart a rotary motion to said rotor shaft.

7. A mixing apparatus as claimed in claim 1 wherein said first and second annular gears are rotated at varying peripheral speed in one direction and at varying speed in the opposite direction, said directions being reversed when said drive means is stopped.

8. A mixing apparatus as claimed in claim 1 wherein said secondary gears are each supported by a central transverse shaft supported in a cage disposed in a horizontal plane, a further shaft secured to said secondary gear offset from said central shaft and attached to a collar mounted on said rotor shaft, said secondary gears when rotating causing said further shaft to rotate about said central shaft to thereby impart said upward and downward motion to said rotor shaft.

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