United States Patent

Bremmer et al.

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[54] AGITATOR APPARATUS

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[21] Appl. No.: **84,855**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 812,565, March 25, 1969, abandoned.

[52] **U.S. Cl.** **259/108,** 259/44

[51] **Int. Cl.** **B01f 7/24**

[58] **Field of Search** 259/7, 8, 9, 10, 24, 44, 67, 259/74, 78, 85, 93, 97, 107, 108

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[57] **ABSTRACT**

The agitator apparatus of this invention is designed primarily for use in mixing suspension liquids, such as suspension fertilizers and feeds, and comprises an agitator having a shaft with a first helicoid layer surrounding the shaft, and a second unsymmetrical helicoid layer, pitched greater than and opposite to the first, mounted around the periphery of the first helicoid layer. Means are provided for rotatably mounting the agitator vertically disposed in the material to be mixed, the material being contained in a tank having a diameter substantially greater than the diameter of the agitator, and for rotating the shaft in a direction such that the first helicoid layer produces a movement of the material in the downward direction, and the second helicoid layer produces a movement of the material in the upward direction.

20 Claims, 6 Drawing Figures

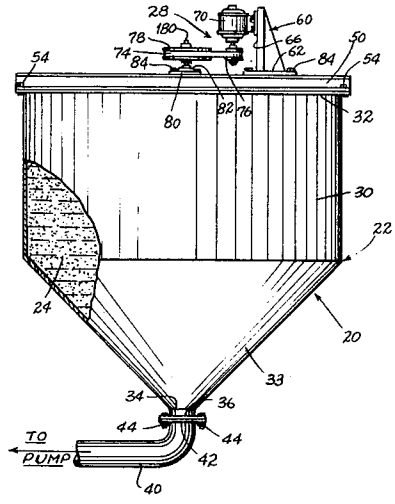

Fig. 1.

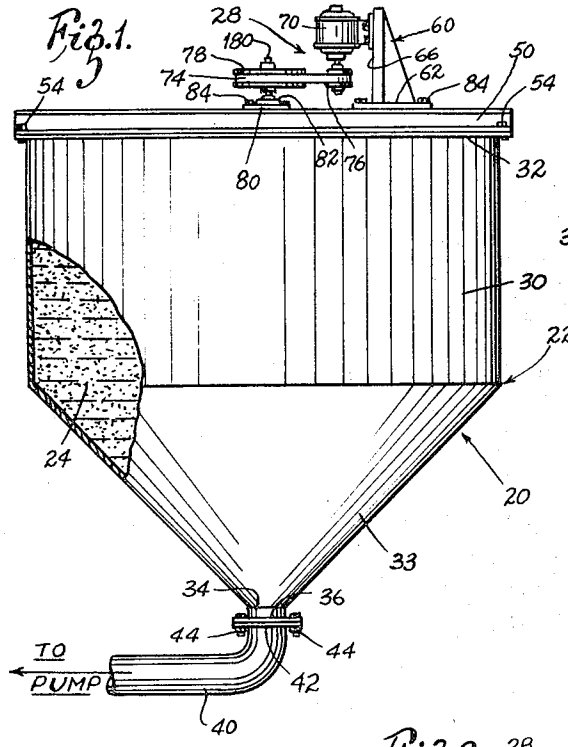

Fig. 2.

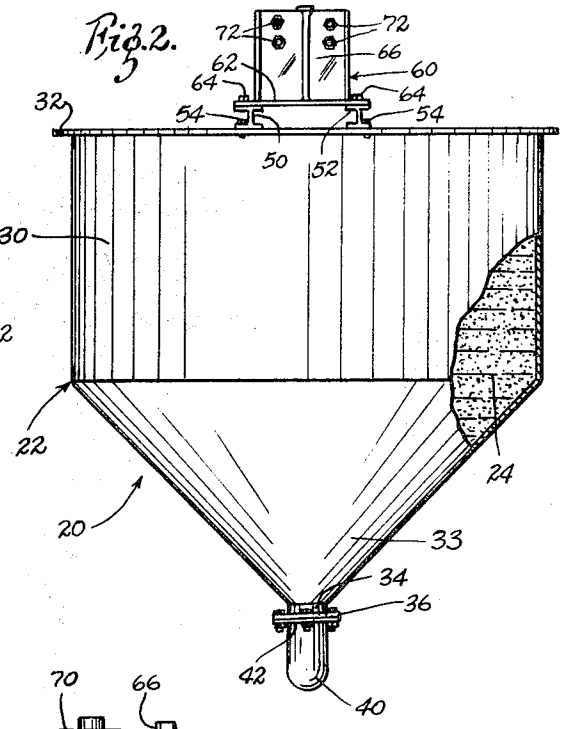

Fig. 3.

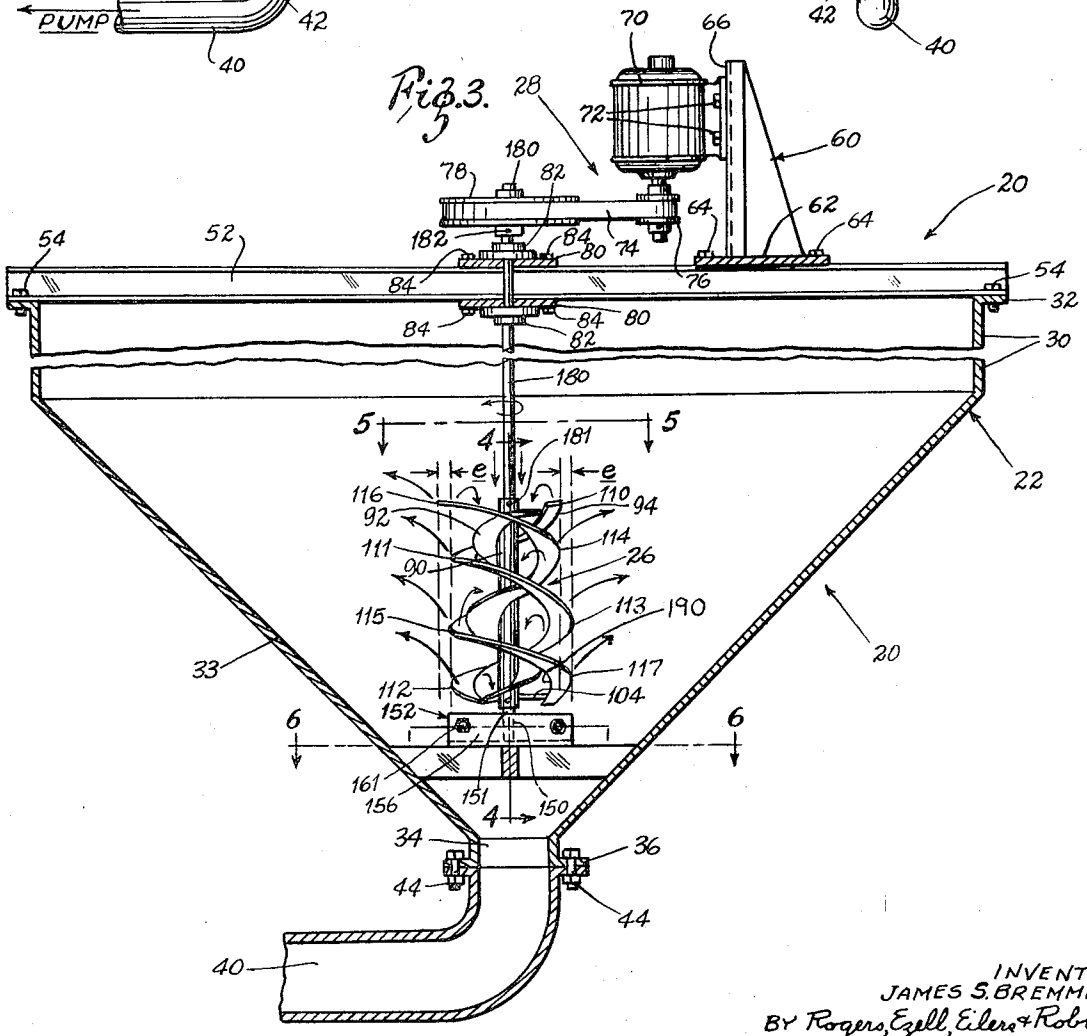

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Fig. 4.

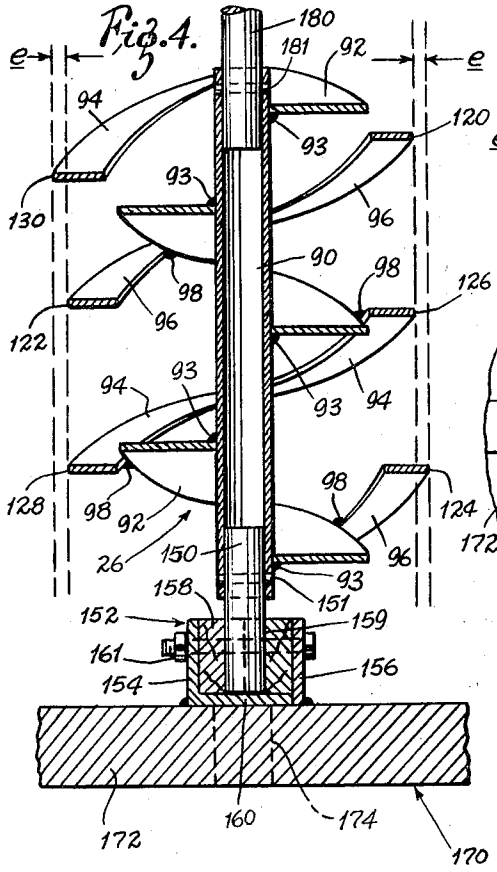


Fig. 5.

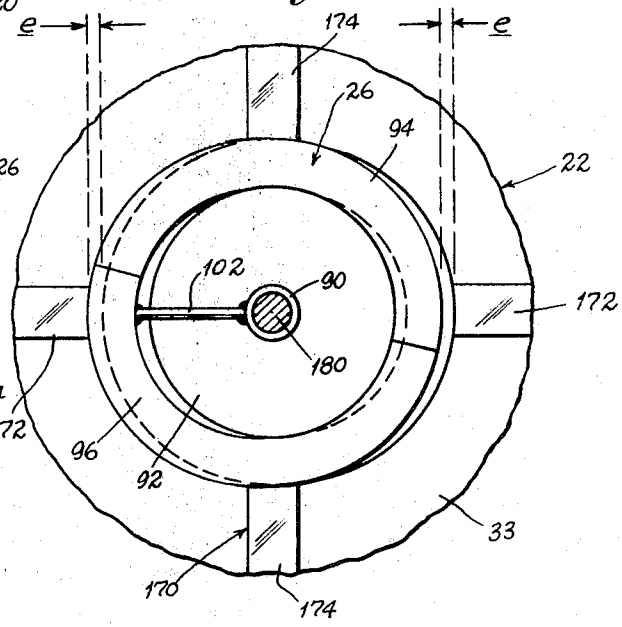
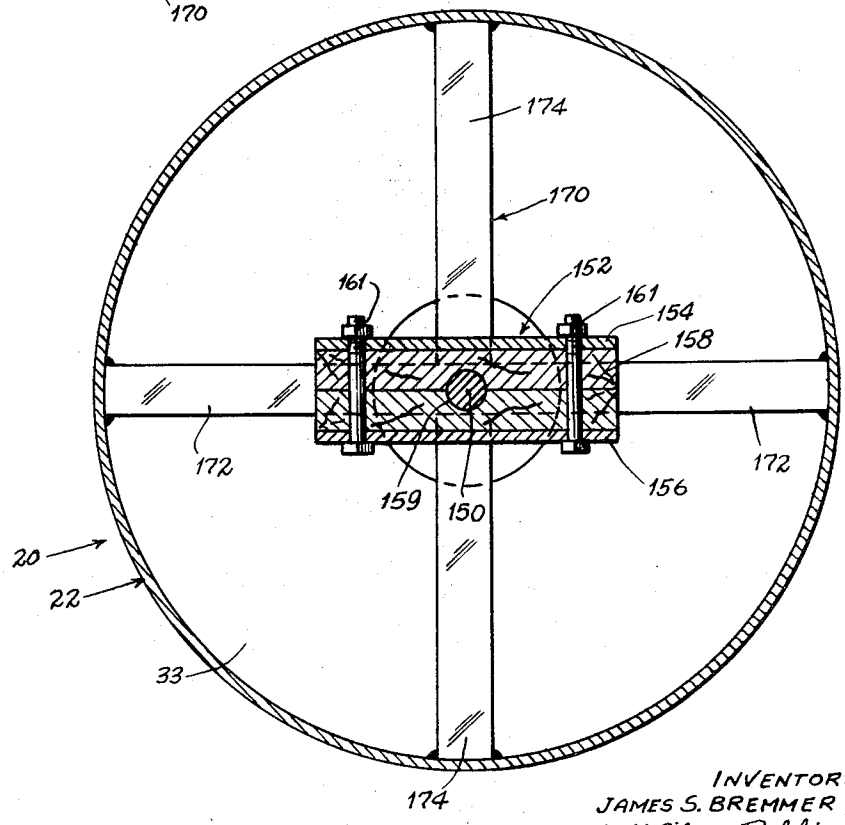


Fig. 6.



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AGITATOR APPARATUS

The present application is a continuation-in-part of copending application Ser. No. 812,555, now abandoned, filed Mar. 25, 1969.

BACKGROUND OF THE INVENTION

By their very nature the mixing of suspension liquids, that is, liquids having solid particles in suspension, such as suspension fertilizers and feeds, has long been a problem. For example, the solid phase of some suspension fertilizers might constitute as much as 65 percent of the total mass and include such materials as Attapulgite clay and potash. The mixing of these solids with the liquid to form the suspended mass is extremely difficult, particularly when mixed in large quantities, e.g., in 20-ton batches. Furthermore, the resultant mix must be perfectly homogenous with all solid particles in suspension, and must thereafter maintain these properties.

The mixing of feeds is particularly critical in that often extremely small amounts of nutrients are mixed with large quantities of other ingredients, making it difficult to uniformly disperse the nutrients.

Prior art devices for mixing suspension liquids generally consist of propellers, paddle wheels, air jets, screws, and pumps, or a combination of two or more of these mixing elements. However, each requires more time than is desirable to thoroughly mix the suspension liquids, leaves lumps in the suspended material, and/or produces a non-homogenous mass. For example, a propeller affects only a small volume of the mass while the greater part is unmoved or moved only slightly. To assist the propeller, it is common to use pumps to circulate the material into the path of the propeller. However, the suspended material circulating through the pumps and acting as an abrasive causes the pumps to wear very quickly.

To produce a perfectly homogenous mixture and to produce it quickly requires an extremely violent and turbulent movement of the entire mass. This invention produces such movement and, hence, a perfectly homogenous suspension liquid of superior quality and in only a small fraction of the time required by the prior art devices.

SUMMARY OF THE INVENTION

The agitator apparatus of this invention includes a shaft extending into the material to be mixed, the shaft having an inner helicoid mounted around its periphery. A double flight of outer helicoids are mounted around the periphery of the inner helicoid, and each pitched opposite to the inner helicoid. The outer helicoids each have a pitch greater than the pitch of the inner helicoid, and are mounted eccentrically about the inner helicoid in such a way as to create an unsymmetrical configuration at at least some of the points along the shaft so that rotation of the shaft produces eccentric rotation of the outer helicoids.

Means are provided for rotatably mounting the agitator shaft within a mixing tank with the helicoids vertically disposed in the material. Means are also provided for rotating the shaft at a selected speed and in a direction whereby the outer helicoids move the material upward and the inner helicoid downward, creating violent disturbance and shearing of the mass to produce mixing results far superior to the prior art devices.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is front elevational view of the tank and driving means portions of this invention with part of the tank broken away to show the suspension liquid;

FIG. 2 is a right-side elevational view of the apparatus of FIG. 1;

FIG. 3 is an enlarged view of FIG. 1 with the tank shown in section to illustrate the agitator and agitator mount of this invention.

FIG. 4 is a sectional view on an enlarged scale taken along the line 4—4 of FIG. 3;

FIG. 5 is a sectional view on an enlarged scale taken along the line 5—5 of FIG. 3; and

FIG. 6 is a sectional view on an enlarged scale taken along the line 6—6 of FIG. 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT:

Referring to FIGS. 1, 2 and 3, the mixing apparatus 20 of this invention generally includes a tank 22 for holding the ingredients 24 to be mixed, an agitator 26, and a motor and belt drive assembly 28.

The tank 22 has an upper cylindrical portion 30 with a flange 32 at its top, and a lower frusto-conical portion 33 with a neck portion 34 formed at its bottom, the neck portion 34 having a flange 36 at its bottom edge. A drain pipe 40, having a flange 42 that mates with the flange 36, is connected at the neck portion 34 by any suitable means such as nut and bolt assemblies 44. A suitable pump (not shown) pumps the material from the tank by way of the drainpipe 40 after mixing is completed.

Because of the great turbulence created in the liquid 24 by the agitator 26, a ratio of tank diameter to agitator diameter of at least three to one is preferred, and ratios of approximately 10 and 15 to one are ordinarily used. For example, with an agitator diameter of 18 inches and a tank diameter of 20 feet, 20 tons of suspension liquid can be thoroughly mixed in 15 to 20 minutes.

As best shown in FIG. 2, a pair of parallel H-beams 50 and 52 extend across the top of the tank, positioned an equal distance from the center of the tank, and are mounted to the flange 32 by any suitable means such as stud bolts 54.

An angle bracket 60 is secured at its base 62 to the H-beams 50 and 52 by any suitable means such as stud bolts 64. The angle bracket 60 has a vertical face plate 66 perpendicular to the H-beams 50 and 52.

The motor 70 of the motor and belt drive assembly 28 is mounted to the vertical face plate 66 by any suitable means such as nut and bolt assemblies 72. The assembly 28 further includes a belt 74 connecting a pulley 76, attached to the shaft of the motor 70, and a pulley 78. Bearing mounting plates 80, which bridge the H-beams 50 and 52, and bearings 82 are mounted to the top and bottom of the H-beams 50 and 52 directly over the center of the tank by any suitable means such as stud bolts 84.

The agitator 26 is best illustrated in FIGS. 3, 4 and 5 and includes a tubular shaft 90 surrounded by an inner helical blade 92 welded all along its inside edge, as at 93, to the shaft 90 with the blade being substantially normal to the shaft at all points along its inside edge. The blade 92 is preferably full pitch, that is, the distance between corresponding points on adjacent threads is approximately equal to its outside diameter. The importance of the various pitch relationships will be hereinafter explained.

Surrounding the inner helical blade 92 are two outer helical blades 94 and 96, each pitched opposite to the inner blade 92 and welded at its inner edge to the outer edge of the blade 92 at the various points of contact, such as the points 98. Hence, referring to FIG. 3, the inner and outer edges, respectively, of the outer and inner helical blades 92 and 94 are welded at their upper and lower ends and at those points therebetween where they contact. The outer helical blade 96 is wound approximately 180° out of phase with the outer blade 94 and is likewise welded at its inner edge to the outer edge of the inner blade 92 where they contact. However, because the top and bottom ends of the blade 96 are on the opposite side of the shaft 90 from the top and bottom ends, respectively, of the inner blade 92, and therefore cannot be supported by the blade 92, a supporting bar 102, extending horizontally from the upper end of the shaft 90, supports the upper end of the blade 96, and a supporting bar 104, extending horizontally from the lower end of the shaft 90, supports the lower end of the blade 96.

The pitch of each of the outer helical blades 94 and 96 is substantially greater than the inner blade 92. For example, as shown in FIG. 3, while the inner blade 92 has approximately 2

½ turns, each of the outer blades **94** and **96** has only approximately 1 ½ turns giving a pitch ratio of about **1.7** to **1**. This pitch relationship is believed to be an important factor in producing the superior mixing results of this invention, as will be hereinafter explained. Also, as shown in FIGS. **3**, **4**, and **5**, the widths of the outer blades **94** and **96** are substantial (about half the width of the inner blade **92**) to provide a substantial surface for moving the material in the opposite direction to that of the inner blade for producing a violent shearing action between the inner and outer blades.

It will be noted in referring to FIGS. **3**, **4** and **5** that, while the inner helical blade **92** is mounted symmetrically about the shaft **90**, each of the outer blades **94** and **96** is mounted with a slight eccentricity generally designated in the drawing as *e*. For example, the distances from the center of the shaft **90** to the outer edge of the blade **94** at the points **110**, **111** and **112** are less than the distance from the center of the shaft **90** to the outer edge of the blade **94** at the point **113**; and the distances from the center of the shaft **90** to the outer edge of the blade **96** at the points **114** and **115** are less than the distances from the center of the shaft **90** to the outer edge of the blade **96** at the points **116** and **117**. Likewise, referring to FIG. **4**, the distances from the center of the shaft **90** to the outer edge of the blade **96** at the points **120** and **122** are less than the distance from the center of the shaft **90** to the outer edge of the blade **96** at the point **124**; and the distances from the center of the shaft **90** to the outer edge of the blade **94** at the points **126** and **128** are less than the distance from the center of the shaft **90** to the outer edge of the blade **94** at the point **130**.

Furthermore, not only are each of the outer blades **94** and **96** eccentric, but the eccentricity is such that the agitator is unsymmetrical at certain points along the shaft **90**. For example, the distance between the shaft **90** and the point **110** is less than the distance between the shaft **90** and the point **116**, directly opposite the point **110**; and the distance between the shaft **90** and the point **112** is less than the distance between the shaft **90** and the point **117**, directly opposite the point **112**.

Hence, due to the unsymmetrical configuration, rotation of the shaft creates eccentric rotation in the agitator, believed to be an important factor in producing the exceptional mixing results of this invention, as hereinafter explained.

A solid shaft **150** is mounted in the lower end of the shaft **90** by a pin **151** as best shown in FIGS. **3** and **4**, and extends downward into a bearing **152**. The bearing **152** is best shown in FIGS. **4** and **6** and includes a metal angle member **154** and a front plate **156** to form the bearing housing. Within the bearing housing is mounted a wooden block **158**, such as a pair of 2 × 4's, having a vertical bore **159** extending completely therethrough to the base **160** of the bearing housing. The angle member **154**, the front plate **156**, and wooden block **158** are held together by nut and bolt assemblies **161**. The diameter of the bore **159** is such as to form a relatively close fit with the shaft **150**. The agitator **26** is mounted with the shaft **150** extending into the bore **159** with the bottom end of the shaft **150** resting on the base **160** of the angle member **154**.

A mounting stand **170** having a pair of horizontal cross members **172** and **174** is mounted in the bottom of the tank **22** just above the neck portion **34**. The ends of the cross members **172** and **174** are formed to fit the contour of the bottom portion **33** of the tank. Hence, with the tank having a frusto-conical lower portion as described in this embodiment, the ends of the cross members **172** and **174** are tapered for welding to the tank wall. The base of the bearing **152** is welded to the top of the mounting stand **170**.

The lower end of another solid vertical shaft **180** is mounted in the upper end of the shaft **90** by a pin **181** as best shown in FIGS. **3** and **4**. Its upper end is extended through the bearings **82** and bearing mounts **80** and secured to the hub of the pulley **78** by a set screw **182**.

OPERATION

With the inner helical blade **92** forming a right-hand screw and the outer helical blades **94** and **96** forming left-hand screws, the preferred direction of rotation is counterclockwise producing a violent movement of the material in the tank as shown by the arrows in FIG. **3**. The same movement can be produced with a clockwise rotation by reversing the pitches of the inner and outer blades **92**, **94** and **96**. Hence, with a counterclockwise rotation produced by the motor and belt drive assembly **28**, the outer helical blades **94** and **96** move the material primarily upward and outward as shown by the arrows with the inside portion of the blades producing some movement of the material in a generally upward and inward direction where it is picked up by the inner blade **92**. The inner blade **92** moves the material primarily in a downward direction. Also, it is believed that due to the turbulence, a substantial portion of the material between the agitator and tank wall penetrates between the outer helical blade to the inner helical blade **92**, where it is forced downward.

For mixing suspension liquids, a speed of rotation of approximately 350 rpm is recommended. At this speed, the violent downward movement of the material by the inner blade directly adjacent to the violent upward movement of the material by the outer blades produces high shear forces between the inner and outer blades which are believed to be a major factor in producing the superior mixing results. These shearing forces are evidenced by the fact that the greatest wear occurs at the outer edge of the inner blade and particularly where the inner and outer blades contact. For this reason, it is recommended that the thickness of the inner blade, particularly, at its outer edge, be approximately three-eights of an inch.

With the inner blade approximately full pitch, the outer blades are each made substantially greater than full pitch. This greater pitch provides greater spacing between adjacent surfaces of the outer blades for material to penetrate to the inner blade, and a more rapid upward movement of the material for a given rate of rotation. It also allows for the use of a double flight of outer blades to provide greater surface area for moving the material, while at the same time providing a stronger structure with more contact points between the inner and outer blades for each turn of the outer blades.

The eccentric rotation of the agitator caused by the eccentricity of the outer blades is important in moving the material in contact with the inner blade. As the agitator rotates, certain portions of its outer blades reach further outward toward the walls of the tank than do other portions to force material into contact with the inner blade **92**. For example, material which would contact only the outer portion of the blade **94** at the point **112** for movement upward, contacts the inner portion of the blade **96** at the point **190** for movement inward and downward.

Various changes and modifications may be made within this invention as will be readily apparent to those skilled in the art. Such changes and modifications are within the scope and teaching of this invention as defined by the claims appended hereto.

What is claimed is:

1. An agitator apparatus for mixing a suspension liquid comprising a tank for containing the ingredients of the liquid to be mixed, agitator means, means for rotatably mounting the agitator means vertically disposed in the ingredients, and means for rotating the agitator means, the agitator means further comprising a shaft, a first helical blade mounted around the periphery of the shaft for rotation therewith, the first helical blade being approximately full pitch and mounted substantially normal to the shaft at all points along the blade, and at least one second helical blade mounted around the periphery of the first helical blade substantially normal to the shaft at all points along the blade, the pitch of the second helical blade being less than approximately two times the pitch of the first helical blade, and the width of the second helical

blade being at least about half the width of the first helical blade to provide substantial surface for movement of the liquid in a direction opposite to that produced by the first helical blade.

2. The agitator apparatus of claim 1 wherein the direction of rotation is such that the first helical blade produces movement of the material in the downward direction, and the second helical blade produces movement of the material in the upward direction.

3. The agitator apparatus of claim 1 wherein the second helical blade is mounted eccentrically around the first helical blade in such a way that the agitator is unsymmetrical at at least some points along the shaft to produce an eccentric motion as the shaft rotates.

4. An agitator apparatus for mixing a suspension liquid comprising a tank for containing the ingredients of the liquid to be mixed, agitator means, means for rotatably mounting the agitator means vertically disposed in the ingredients, and means for rotating the agitator means, the agitator means further comprising a shaft, a first helicoid blade mounted around the periphery of the shaft for rotation therewith, at least one second helicoid blade mounted around the periphery of the first helicoid blade and pitched opposite to the first helicoid blade for rotation therewith, the second helicoid blade being mounted eccentrically around the first helicoid blade in such a way that the agitator is unsymmetrical at at least some points along the shaft to produce an eccentric motion as the shaft rotates.

5. The agitator apparatus of claim 4 wherein the direction of rotation is such that the first helicoid blade produces movement of the material in the downward direction and the second helicoid blade produces movement of the material in the upward direction.

6. The agitator apparatus of claim 4 including a plurality of second helical blades each out of phase with the other and each having a pitch of approximately 1.5 – 2 times the pitch of the first helical blade.

7. An agitator apparatus for mixing suspension liquids such as suspension fertilizers and feeds comprising a tank for containing the ingredients of the suspension liquid to be mixed, agitator means, the inside diameter of the tank being large relative to the outside diameter of the agitator means to provide space therebetween for large quantities of the ingredients, means for rotatably mounting the agitator means vertically disposed in the liquid to be mixed, and means for rotating the agitator means, the agitator means further comprising a shaft, a first helical blade mounted around the periphery of the shaft for rotation therewith, a plurality of second helical blades, each mounted around the periphery of the first helical blade out of phase with the other for rotation with the shaft, each of the second helical blades being pitched opposite to the first helical blade and having a pitch of approximately 1.5 – 2 times the pitch of the first helical blade, each second helical blade being mounted eccentrically around the first helical blade in such a way that the agitator is unsymmetrical at at least some points along the shaft to produce an eccentric motion as the shaft rotates.

8. The agitator apparatus of claim 7 wherein the first helical blade is approximately full pitch.

9. The agitator apparatus of claim 7 wherein the direction of rotation is such that the first helical blade produces a movement of the material in the downward direction, and the second helical blades produce a movement of the material in the upward direction.

10. The agitator apparatus of claim 7 wherein the plurality of second helical blades comprises two helical blades mounted approximately 180° out of phase.

11. An agitator for mixing suspension liquids such as suspension fertilizers and feeds comprising a shaft, a first helical blade mounted around the periphery of the shaft for rotation therewith, the first helical blade being approximately full pitch, a plurality of second helical blades, each mounted around the periphery of the first helical blade out of phase with the other for rotation with the shaft, each of the second helical blades being pitched opposite to the first helical blade and having a pitch of approximately 1.5 – 2 times the pitch of the first helical blade, each second helical blade being mounted eccentrically around the first helical blade in such a way that the agitator is unsymmetrical at at least some points along the shaft to produce an eccentric motion as the shaft rotates.

12. The agitator apparatus of claim 1 wherein there are a plurality of second helical blades, each mounted around the periphery of the first helical blade out of phase with each other and extending substantially the full length of the first helical blade.

13. The agitator apparatus of claim 12 wherein the pitch of each second helical blade is greater than the pitch of the first helical blade.

14. The agitator apparatus of claim 13 wherein the outer helical blades are of approximately equal pitch and width.

15. The agitator apparatus of claim 14 wherein there are two second helical blades mounted approximately 180° out of phase.

16. The agitator apparatus of claim 12 wherein the second helical blades are narrower than the first helical blades.

17. The agitator apparatus of claim 1 wherein the inside diameter of the tank is large relative to the outside diameter of the agitator means to provide space therebetween for large quantities of the ingredients.

18. The agitator apparatus of claim 17 wherein the inside diameter of the tank is at least three times the outside diameter of the agitator means.

19. The agitator apparatus of claim 1 wherein the thickness of the first helical blade at its outside edge is between approximately three-sixteenths and three-eights inch.

20. The agitator apparatus of claim 1 wherein the shaft is rotated at a speed of between approximately 250 and 450 r.p.m.

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