Jan. 23, 1968 D. C. CHRISTENSEN 3,365,176

AGITATOR APPARATUS

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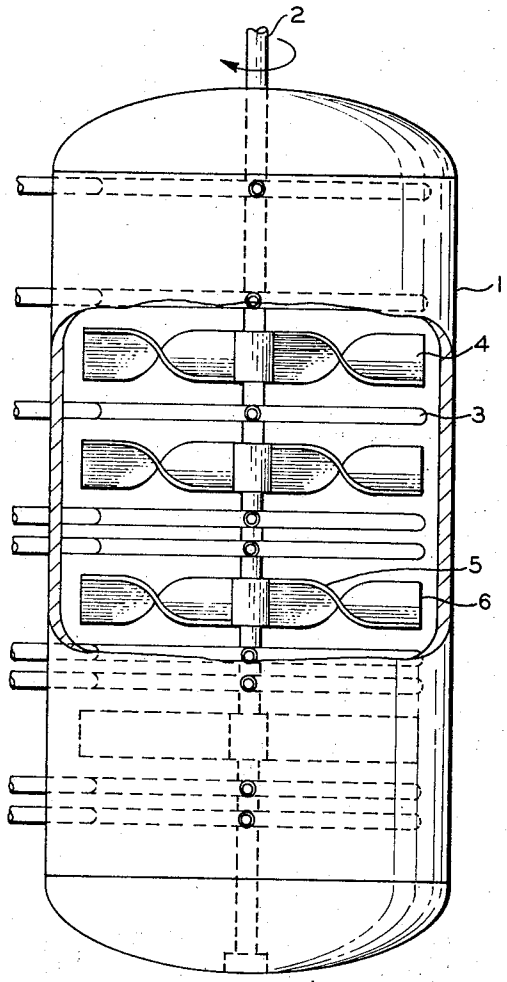


FIG. 1

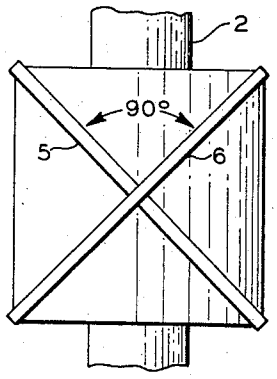


FIG. 2

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# AGITATOR APPARATUS

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## ABSTRACT OF THE DISCLOSURE

Agitator comprising a shell means and at least one impelling means rotatably mounted therein which is adapted to produce laminar flow along the inner surface of the shell means in one direction and through a central portion of the shell means in the opposite direction.

This invention relates to an agitator apparatus.

In another aspect, the invention relates to an agitator apparatus comprising, in combination, a shell means, and at least one impelling means rotatably mounted therein which is adapted to produce laminar flow along the inner surface of the shell means in one direction, and through a central portion of the shell means in the opposite direction.

In another aspect, the invention relates to the agitator apparatus described above in which the impelling means has at least two blade portions having an angle of about 90° between them, the first of which is pitched 45° from the horizontal axis of the impelling means; the impelling means further comprises means adapted to receive rotating means for the impeller.

In still another aspect, the invention relates to the agitator apparatus described above, and comprises at least two impelling means having heat exchange means between them.

In another of its aspects, the invention relates to the agitator apparatus described above wherein the shell means is substantially cylindrical in shape, and is vertically disposed.

Agitator apparatus heretofore available have proven unsatisfactory because of the high turbulence produced in such devices. This problem is particularly acute when the material being mixed is highly viscous because much power is wasted in driving impelling means which produce turbulent mixing in such systems. It is an object of this invention to provide an apparatus which produces thorough, non-turbulent mixing. It is also an object of this invention to provide a mixing apparatus which produces laminar flow therewithin, thus reducing turbulence and concomitant power wastage. A further object of the invention is to provide an agitator apparatus especially suitable for mixing viscous mixtures uniformly, while subjecting the mixtures to heat exchange at a high rate of efficiency. It is a particular object of the invention to provide an agitator apparatus that is especially suitable for viscous systems having viscosity of 1000 cps. and higher uniformly and at a high rate of heat exchange.

Other aspects, objects, and the several advantages of the invention will be apparent to one skilled in the art upon studying the specification, claims, and drawings.

According to the invention, an agitator apparatus is provided which comprises, in combination, a shell means, and at least one impelling means rotatably mounted therein which is adapted to produce laminar flow on the inner surface of the shell means in one direction, and through a central portion of the shell means in the opposite direction.

The agitator apparatus of this invention can be used to mix any system, but is particularly suitable for mixing viscous materials having viscosities in excess, for example, of 1000 cps. The laminar flow produced in the apparatus



permits highly efficient heat exchange when the heat exchange means are incorporated into the apparatus. Such means can be mounted in the apparatus in any suitable fashion such as, for example, by mounting heating or cooling coil between the impelling means normal to the flow of material in the apparatus. In a presently preferred embodiment, as shown in FIGURE 1 of the drawings, cooling or heating coils in the shape of a spiral are mounted between the impelling means. Such coils insure efficient heat exchange without disturbing the laminar flow of the material through the apparatus.

The shell means of the invention can be of any desired shape and dimensions, and can be disposed at any desired angle of orientation. For example, the shell means can be spherical, cylindrical, conical, etc., and can be disposed vertically, horizontally, or at any suitable angle with the horizontal or vertical.

As described above, the impelling means is adapted to produce laminar flow within the shell means along the inner surface thereof in one direction, and through a central portion of the shell means in the opposite direction. In one embodiment, the impelling means has at least two blade portions having an angle of about 90° therebetween, the first of said portions being pitched 45° from the horizontal axis of the impeller. Further, the impeller further comprises means adapted to receive rotating means therein. As shown in FIGURE 1, a suitable impeller has at least two blade portions having a 90° angle between them on both sides of the means adapted to receive the rotating means, and the blade portions and means adapted to receive rotating means are integral. However, it is apparent that there can be any number of groups of two blade portions having a 90° angle therebetween, and that these portions need not be integral with one another. Generally, the surface of each blade portion will be planar, and the length, width, and pitch of each portion can be suitably varied in accordance with the type of material to be mixed, shape and dimensions of the shell means, the presence or absence of heat exchange means, and so on. Thus, it is apparent that the first of each group of two blade portions can be pitched 45° from the horizontal axis in all four quadrants.

The impelling means of this apparatus are rotatably mounted therein in a central portion thereof. As shown in FIGURE 1 of the drawings, the impelling means can be fixedly attached to a shaft which extends through the shell means, and is driven by any suitable means such as a motor. However, depending upon the shape of the shell means, the dimensions thereof, the composition of the system to be mixed, presence or absence of heat exchange means and the type used and so on, the impelling means can be offset from the center of the shell means, and need not be fixedly attached to a shaft. For the apparatus shown in FIGURE 1, speeds of from about 5 to about 50 revolutions per minute are satisfactory.

Among the applications for which the apparatus of my invention has advantages are: polymerization reactions wherein a monomer is polymerized to form a viscous solution of polymer in a solvent such as polybutadiene, polyethylene, polypropylene, polystyrene, etc.; heating or cooling viscous solutions such as molasses, heavy oils, the polymer solutions mentioned previously, etc.

Referring now to the drawings:

FIGURE 1 shows one embodiment of the apparatus of this invention, and

FIGURE 2 shows an end view of a single impelling means used in the apparatus of FIGURE 1.

In FIGURE 1, substantially cylindrical shell means **1** houses drive shaft **2**, to which a plurality of impeller means **4** are fixedly attached. Above, below, and between the impelling means **4** are heat exchange coils **3**. Each impelling means has two portions on both sides of the

shaft; the first of the portions is pitched 45° from the horizontal axis of the impeller, and the second portion is pitched 90° from the first portion. Rotation of shaft 2 and impelling means 4, which are driven by driving means 7, promotes flow of a mixture upward along the inner surface of the shell means, and downward through the central portion thereof. Rotation of shaft 2 in the opposite direction promotes flow upward in the central portion of the vessel and downward along the inner surface of the shell. While the blades are shown pitched 45° from the horizontal, other angles of pitch may be used. For example, each blade may be pitched 30° from the horizontal in which case the angle between the two blades wil be 120°. It might also be desirable to pitch the two portions of a blade at different angles from the horizontal. This is the case in very large vessels where the peripheral speed of the outer portion of the blade is considerably higher than that of the inner portion. In order to balance the flows in such large vessels, it may be desirable to pitch the outer portion of the blade at an angle of 30° from the horizontal and to pitch the inner portion at an angle of 45° from the horizontal.

FIGURE 2 shows, from an end view, the pitch of two blade portions 5 and 6. Blade portion 5 is pitched 45° from the horizontal axis of the impeller, and blade portion 6 is pitched 90° from the blade portion 5. As mentioned above, rotation of such impelling means within a shell means tends to promote flow along the inner surface of the shell means in one direction, and through a central portion of the shell means in the opposite direction.

Reasonable modification and variation are possible within the spirit and scope of the invention, the essence of which is an agitator apparatus comprising a shell means and at least one impelling means rotatably mounted therein, and adapted to produce laminar flow along the inner surface of the shell means in one direction, and through a central portion thereof in the opposite direction.

I claim:

1. An agitator comprising, in combination,

(a) a shell means free of internal appurtenances, including baffles and other flow guiding means,

(b) a drive shaft extending substantially the length of said shell means,



(c) a plurality of spaced impelling means attached to said shaft adapted upon rotation of said shaft to produce laminar flow along the inner surface of said shell means in one direction and through a central portion of said shell means in the opposite direction, each of said impelling means extending from said shaft into close proximity to the inner wall of said shell and wherein the impelling means have at least two blade portions having an angle of about 90 degrees therebetween, the first of said portions being pitched at an acute angle from the horizontal axis of said impelling means, and

(d) heat exchange means extending into said shell means between at least two of said spaced impelling means, said heat exchange means being so shaped and arranged as to not impair the laminar flow produced by the impelling means.

2. An apparatus in accordance with claim 1 further characterized in that the first of said portions is pitched 45 degrees from the original axis of said impelling means and wherein said spaced impelling means are arranged in pairs and extend in diametrically opposite directions from one another toward the shell.

3. An apparatus according to claim 1 further characterized in that (a) is a vertically disposed enclosed cylindrical shell means and (b) is a coaxial drive shaft.

4. An apparatus according to claim 1 further characterized in that (d) is a tubular heat exchange coil mounted between the impelling means normal to the flow of material in the apparatus.


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