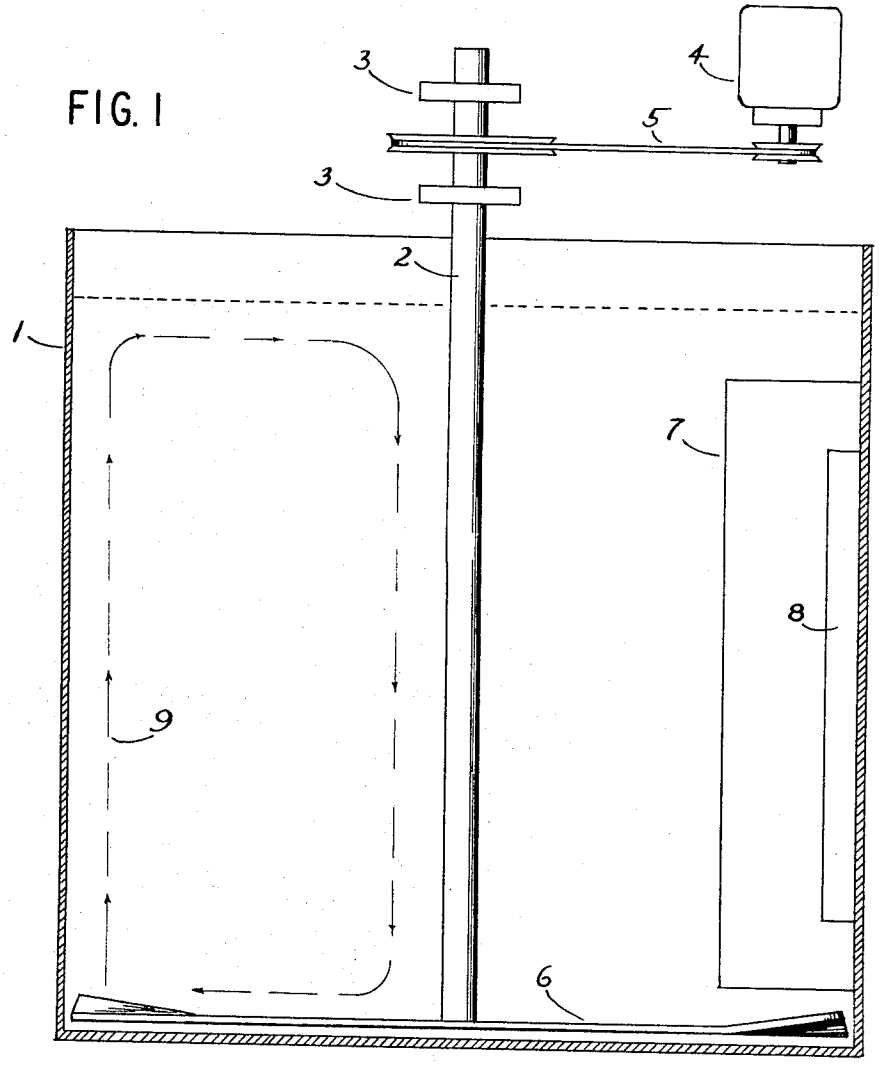
Oct. 8, 1968 R. K. MULTER 3,404,870

AGITATOR

Filed Sept. 23, 1965

5 Sheets-Sheet 1

FIG. 1



INVENTOR
Robert K. Multer

Oct. 8, 1968

R. K. MULTER

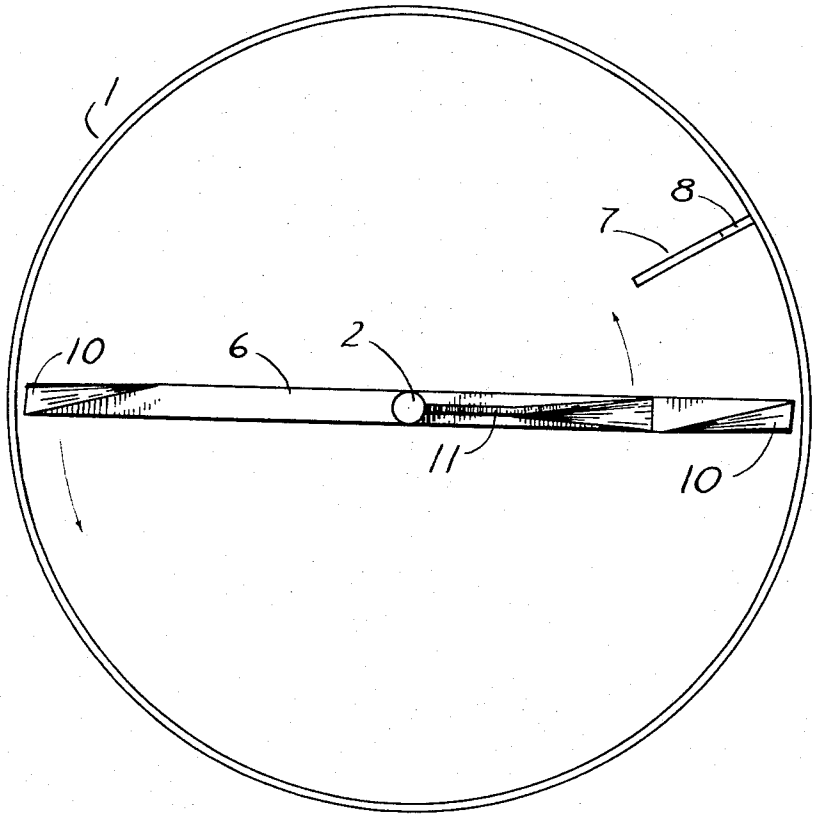
AGITATOR

3,404,870

Filed Sept. 23, 1965

5 Sheets-Sheet 2

FIG. 2



INVENTOR

Robert K. Multer

Oct. 8, 1968 R. K. MULTER 3,404,870

AGITATOR

Filed Sept. 23, 1965 5 Sheets-Sheet 3

FIG. 3

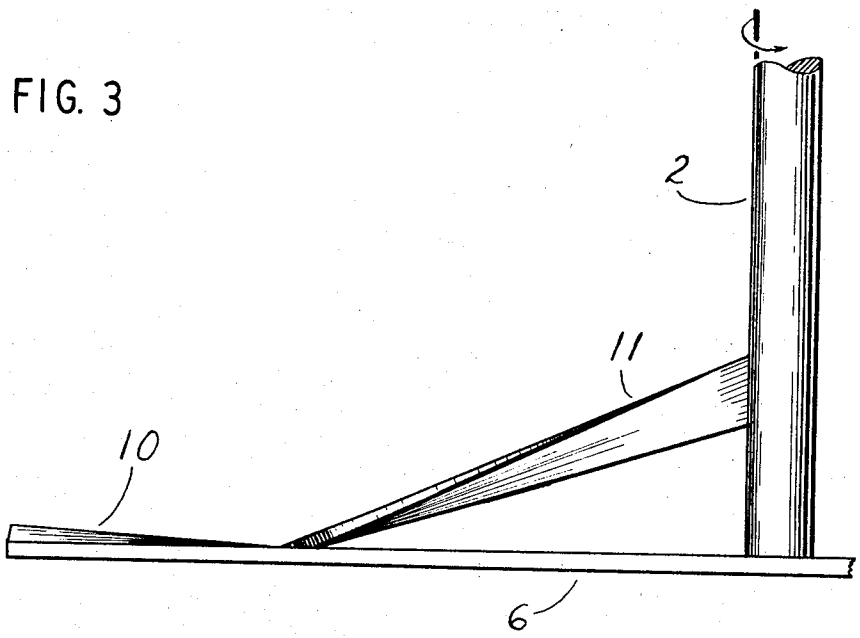
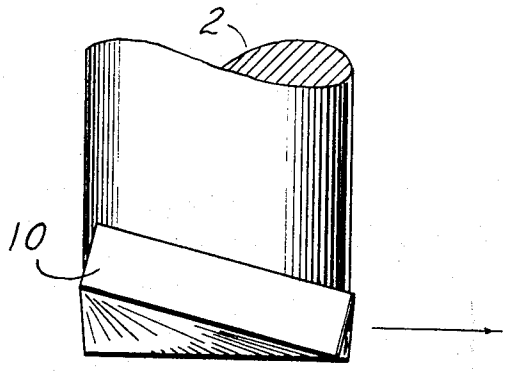


FIG. 4



INVENTOR

Robert K. Multer

Oct. 8, 1968 R. K. MULTER 3,404,870

AGITATOR

Filed Sept. 23, 1965 5 Sheets-Sheet 4

FIG. 5

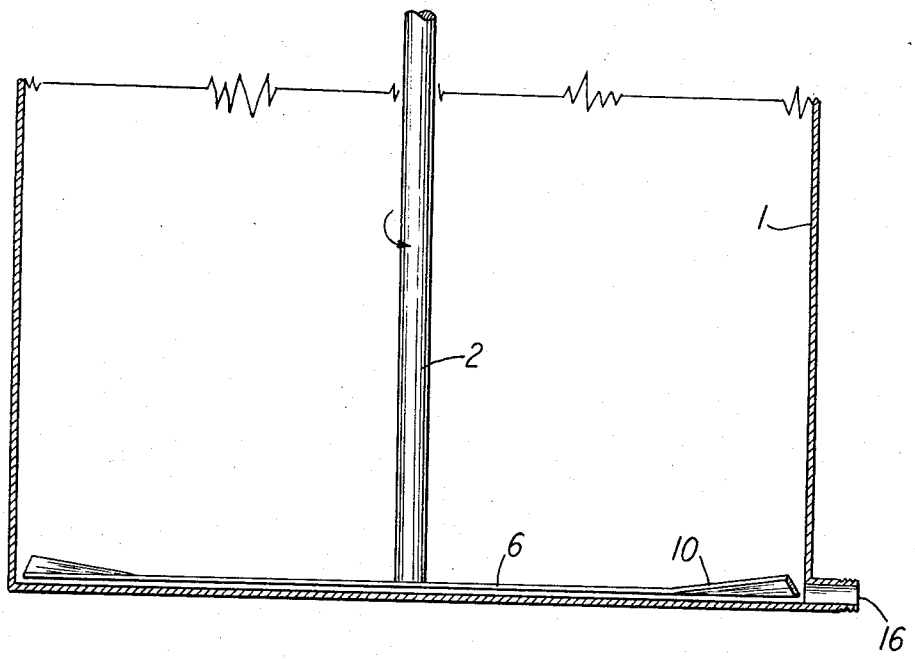


FIG. 7

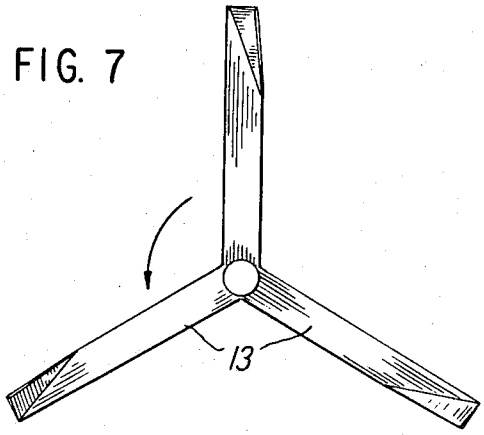
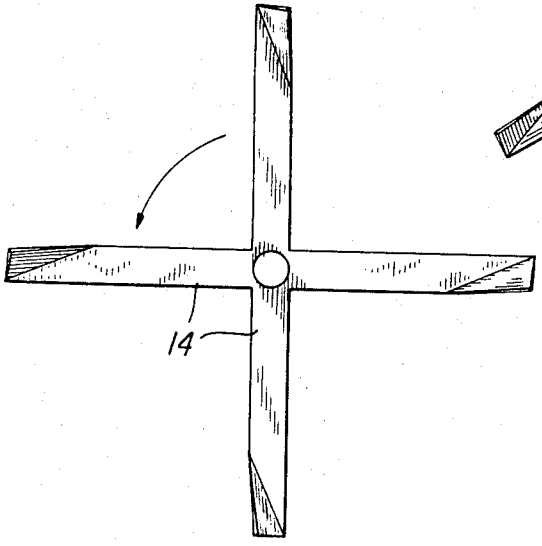


FIG. 8



INVENTOR.

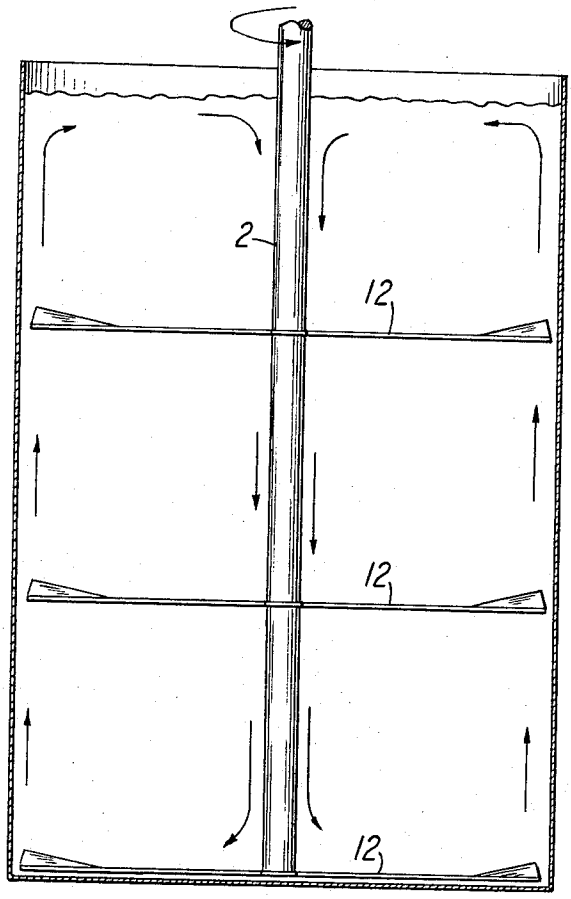
ROBERT K. MULTER

Oct. 8, 1968 R. K. MULTER 3,404,870

AGITATOR

Filed Sept. 23, 1965 5 Sheets-Sheet 5

FIG. 6



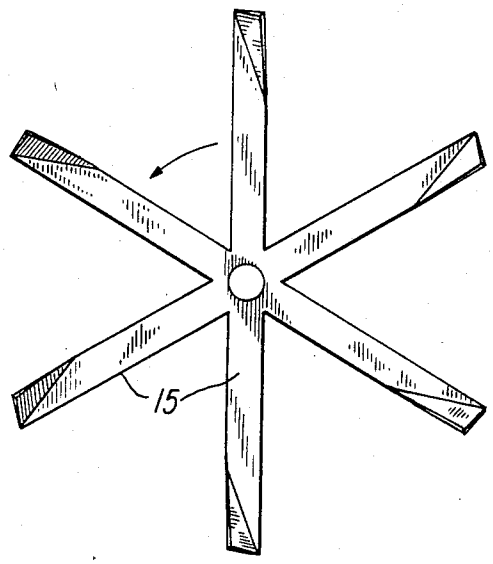


FIG. 9

INVENTOR.
ROBERT K. MULTER

United States Patent Office 3,404,870 Patented Oct. 8, 1968

3,404,870

AGITATOR

Robert K. Multer, R.F.D 1, Colts Neck, N.J. 07722

Filed Sept. 23, 1965, Ser. No. 489,632
8 Claims. (Cl. 259—43)

This invention relates to apparatus for agitating a liquid mixture, and more particularly to an impeller for such apparatus, especially suited for blending liquids, and for mixing and suspending particles and fluids in a liquid material, and for maintaining such mixtures in a state of uniform dispersion.

A great variety of apparatus for the agitation of liquids has been developed over the years, because this operation has been required in almost every industry. Many kinds continue in use today, but most have certain features in common.

The liquids under agitation are usually driven by one or more powered, rotating impellers, and the operation is usually carried out in a vessel with a circular cross-section and a vertical axis.

Extensive engineering literature on the subject classifies the liquid agitating systems according to the type of flow developed by the impeller: rotational, axial, or radial.

Among the oldest agitators are many rotational impeller systems. The impeller generally comprises one or more flat, vertically-surfaced paddles, radiating from a central driving shaft, which drives the liquid around horizontally. Vertical and radial flow, and liquid shear, are minimal unless the basic design is modified with stationary or contra-rotating surfaces inserted in the liquid flow path.

Probably today's most common agitator for smaller vessels is the vertical-shaft screw propeller system, in which the liquid is driven downward in a narrow, cylindrical path near the central axis of the vessel. The flow is diverted radially by the bottom of the vessel, and then upward by the wall of the vessel, eventually to return radially inward at the upper surface of the agitated liquid. This vertical and radial motion is generated only when rotation of the liquid is inhibited by stationary baffles, or counteracted by tilting of the impeller shaft so that the axial flow from the propeller opposes the rotational flow.

In larger vessels, liquids are often agitated with horizontal-shaft screw propellers, which drive the liquid along straight, approximately radial paths. Usually after being driven across the bottom of the vessel the liquid is diverted upward and tangentially by the wall of the vessel, to return across the surface of the liquid and downward to the propeller.

The most common agitators for generating radial flow are the centrifugal type, including blade turbines, discs, cones, cylinders, etc., which drive the liquid outward by friction and centrifugal force, near the bottom of the vessel, when rotated rapidly on a vertical shaft. The liquid is diverted upward by the wall, eventually to return inward and downward to the impeller. As with the vertical-shaft propellers, vertical and radial flow does not persist strongly unless rotation of the liquid is inhibited by stationary baffles.

Another well-known agitator for generating radial flow is the radial propeller, in which a vertical shaft has horizontal arms at the ends of which are flat, vertical pumping blades which are pitched so as to drive the liquid outward. The flow path is like that for the centrifugal impellers.

A good apparatus for agitating a liquid mixture will set the entire mass of liquid in continuous motion, with a uniform distribution of velocity throughout. The impeller must be designed to generate the required mixing, dispersing, and suspending action with minimum power consumption. For uniformity in the product and for high

rate of production, the impeller-vessel system must be designed so that everywhere the velocity, shear, and turbulence are great enough to prevent separation of the components in the mixture. The minimum necessary velocity, shear, and turbulence must be attained everywhere without the necessity of generating excessive, power-wasting agitation anywhere.

Advantages sought in an agitator design include ability to produce the desired mixture quickly and to maintain it perpetually, low power consumption, durability, ease of cleaning and machine maintenance, feasibility of construction from a wide variety of materials, low cost of construction, and flexibility in major operating variables such as type of liquid and height of liquid in the vessel.

My invention provides an improved balance of these advantages by impelling the liquid in a different manner.

My impeller drives the liquid upward, adjacent to and parallel to the wall of the vessel, from all points in an area around the circumference of the bottom of the vessel, while sweeping closely over the remaining area of the bottom. The impeller is slow-turning, dynamically-stable, light in weight, easily constructed, efficient in use of power, and versatile.

This impeller comprises any number of flat, horizontal arms that rotate in a single horizontal plane, each arm bearing at its outer end an upward-pitched blade, the whole being supported and rotated by a single, vertical shaft at the axis of a cylindrical vessel.

Two blades, on the ends of a pair of in-line arms, are often adequate. These would be installed as close as possible to the bottom of the vessel, with the blade tips as close as possible to the wall.

Additional arms and blades may be placed in this same plane. Additional impeller sets may be attached to the shaft at higher locations.

Like conventional agitators, mine often requires stationary baffles that inhibit rotation of the liquid.

The large diameter of the impeller results in high tip speeds at low rates of rotation. The combination of large diameter with low rates of rotation produces great dynamic stability. The high tip speeds make possible transfer of large amounts of energy to the liquid with only a slight pitch to the blades. This low pitch angle yields high power efficiency and reduces shock loads and damage to fragile solid particles.

Outboard bearings, submerged in the liquid, are usually not needed, even in very large systems.

In the drawings, FIG. 1 is a side elevational view, in section, showing a typical agitating system incorporating my impeller. FIG. 2 is a plan view of a double-blade impeller, with a pair of in-line arms, in a typical impeller-vessel configuration, including optional baffle and bracing.

FIG. 3 is a fragmentary side elevational view of the impeller of FIG. 2, including an optional brace.

FIG. 4 is an end view of a typical impeller blade and arm on a shaft.

FIG. 5 is a fragmentary side elevational view, in section, showing a typical side-outlet drain mounted in the wall of a cylindrical vessel.

FIG. 6 is a side elevational view, in section, showing an example of an agitating system incorporating numerous sets of blade-bearing arms at various elevations along the shaft.

FIGS. 7, 8, and 9 are plan views showing three of the many possible multi-blade impeller designs that can be employed when a two-blade impeller is inadequate.

In FIG. 1 the impeller shaft 2 is supported by bearings 3 and driven by a motor or motor-transmission combination 4, through a power train 5 comprising a V-belt with sheaves, or a set of gears, or other suitable system. The impeller arm or arms 6 are attached to the lower end of

the shaft **2**, with the minimum feasible clearance above the bottom of the vessel **1**.

The pitched tips or blades at the ends of these arms are brought as close as feasible to the wall of the vessel. Dimensions of one or two inches for bottom and end clearance are typical, but these may be varied.

One or more baffles **7** may be mounted rigidly inside the vessel, with three or four being typical. These baffles ordinarily should be set as close as possible to the bottom of the vessel, and should usually extend upward to a height close to the liquid surface, but not so high as to cause the liquid to splash over the vessel wall. An opening **8** in the baffle is generally desirable to eliminate stagnant pockets and to prevent solid material from adhering to the wall and baffle. A good width for the baffle in the radial direction is about one-third of the vessel radius, but this, and all other baffle dimensions, and the number and shape of baffles, may be varied without changing the kind of agitation generated by my impeller.

The vessel **1** shown in FIG. 1 is a conventional, vertical, cylindrical tank, with diameter about equal to the height. The dimensions of this vessel may be varied according to ordinary engineering practice, which generally prescribes a diameter equal to between one-third and three times the height. The advantages that derive from the use of my impeller and the agitating systems which utilize my impeller are generally maintained regardless of variations in size and shape of the vessel.

When the impeller is rotated, the liquid follows a path **9** like that shown in FIG. 1: rising near the wall, radially inward at the surface, sinking near the shaft, and radially outward along the bottom. There may also be some rotation of the liquid, depending on the type of fluid, the nature of the baffling, the impeller speed, the depth of liquid, and other factors.

This pattern of liquid motion will not ordinarily change much, in a well-proportioned system, as the depth of liquid changes. However in very flat, shallow vessels, or when the liquid level is extremely low in any vessel, the flow will not strictly follow the pattern shown; in these cases there will be an exceptional amount of turbulence, rotation, and centrifugal action because of the close proximity of the impeller arms to the liquid surface.

In very tall, narrow vessels it may be desirable to place additional impeller arms with blades at various heights along the shaft. For most applications, only one, double-bladed pair of arms is required at any level.

In FIG. 6, three sets of blade-bearing arms **12** are shown at various elevations along the shaft **2**.

For some applications, as in vessels with very large diameters, additional bladed arms in the same horizontal plane may be desirable.

In FIG. 7, a three-blade impeller set **13** is shown. In FIGS. 8 and 9 are shown a four-blade impeller set **14**, and a six-blade impeller set **15**, respectively. In each of these three examples, all of the blades and arms in a set are in a single plane.

It should be emphasized that many of the benefits of my impeller and agitating system derive from the fact that in most vessels, with most fluids, and regardless of variations in operating depth, only two blades on a pair of in-line arms are needed.

FIG. 2 shows how arm **6**, shaft **2**, and blades **10** appear when typically installed in a vessel **1** which includes one optional baffle **7** with a wall-side opening **8**. Optional brace **11** is desirable for stiffening arms made of thin material. Two arms can be formed from a single, flat strip, with its narrow edge facing in the direction of motion; the blades **10** can then be formed by twisting or bending the outer extremities of the arms as shown in the drawings, or separate blades can be attached.

Bracing of the arms is desirable, because this permits the use of thinner material, not only reducing weight, but also reducing rotation of the liquid and improving the effectiveness of the arms in cutting through solids or viscous fluids at the bottom of the vessel.

The particular brace **11** shown also improves the agitation. This brace is made from a flat strip, approximately the same in cross-section as the arm **6**. The brace is twisted through 90°, so that its inner end may be fastened to the shaft in a vertical plane, while its outer end may be fastened in a horizontal plane to the arm **6** next to the blade **10**. If twisted in the correct direction, the brace will impel liquid downward near the shaft during normal rotation, and will also generate some radial flow by centrifugal action near the shaft.

FIG. 3 shows in detail a typical assembly of shaft **2**, arm **6**, blade **10**, and twisted brace **11**. The normal direction of rotation would be toward the viewer.

FIG. 4 shows an end view of an impeller blade **10** formed by twisting an arm made of a flat strip. The blade is bent upward, so that the entire length of the arm and blade may closely follow the flat bottom of a tank. The pitch should normally be about 10° to 15° from the horizontal, but this can be varied.

In general, the pitched blade of the impeller should extend over about the outer one-third of the radius of the vessel. The width of the flat side of the arm and blade can be about one-thirtieth of the vessel diameter.

Rotational speed depends on the kind of agitation desired, the kind of fluid, the size of the vessel, and the exact impeller configuration, among other variables. I have found that a speed of about 40 to 50 revolutions per minute gives good agitation of the aqueous dispersions in tanks whose diameters are 5 to 7 feet, when all other proportions are about as described in the foregoing.

All of the dimensions, proportions and speeds described herein may be altered considerably, without departing from the essential concept of this invention, which is to use a simply-formed, large-diameter, rotating blade impeller, pitched upward at its outer extremities, so as to impart upward motion to a liquid from points near the bottom of the wall of a vertical, cylindrical vessel, for the chief purpose of mixing, dispersing, suspending, and otherwise agitating fluids and fluid mixtures in vessels of all sizes.

My impeller and agitating system have numerous advantages over previous designs, which will affect the way my invention will be used, and will govern the specific details of its construction in actual applications.

The impeller performs well in simply-built, flat-bottomed tanks, with straight, vertical sides, and plain, sharp corners at the junction of wall with bottom. These tanks are usually the easiest and cheapest to build, but conventional agitators do not perform well in them. Not only does my impeller agitate all parts of such vessels, but it also promotes enhanced drainage despite the lack of slope. Furthermore, well-mounted, side-outlet drains may be used with my agitation system, eliminating the need for supports which raise the tank above the floor to provide for the usual, center-mounted drains.

FIG. 5 shows the tip of the impeller blade heretofore described sweeping closely past the mouth of a typical side-outlet drain **16**, so that the drainage from a flat-bottomed vessel through such a drain is facilitated and made more complete than with other impeller designs.

Despite its suitability for flat-bottomed vessels, the impeller described here is easily modified to fit closely to a bottom of almost any shape.

The simple shape of this impeller, the lack of precision needed in its fabrication, and its dynamically stable shape, make possible the construction of units of any size, without complex tools or highly skilled labor, using standard shapes of almost any construction material, and applying protective coatings when required.

The T shape can be inserted through small openings in a vessel, or the arms can be attached to the shaft after both have been inserted separately into the vessel.

Bearing and support requirements are not severe, even when shafts are long, diameters large, and power high.

Outboard bearings submerged in the liquid are not needed.

Power consumption is low.

The impeller generates such uniform motion throughout the entire vessel, even while the speed is varied through a wide range, that the degree of agitation is easily adjusted without sacrifice in completeness of agitation throughout the vessel.

Because the impeller sweeps the entire bottom of the vessel, heavy materials cannot remain there undisturbed. Materials that settle are continually lifted, fluidized, and carried radially to the blades for elevation.

Since the liquid is initially placed in motion by being driven directly upward, adjacent to the smooth side wall of the vessel, it easily continues in motion all the way to the upper surface, even in tall vessels. The fluid is not forced through right-angle turns before being lifted, as it is with other agitators.

Heavy materials which fall prematurely out of the rising stream are quickly relifted, while well-suspended materials follow the longest possible path.

Adhesion of suspended materials to the vessel is minimized, because flow is largely directed parallel to vessel surfaces, rather than perpendicular as with conventional agitators.

The impeller is uniquely effective when the depth of liquid is very low, because centrifugal action drives most of the liquid to the outer rim, where the blades and baffles can function. Splashing and foaming are minimized under such conditions because the arms are so close to the bottom. Conventional agitators cease to function, and may cause excessive splashing and foaming at very low levels, because they operate near the center of the vessel, and usually not as close to the bottom as mine.

The small cross-section of my impeller in the direction of motion helps reduce the size of large particles which are to be dispersed, and reduces shock loads on the apparatus.

This small cross-section, and the sweeping action over the entire bottom, make my system effective in resuspending materials which have settled to the bottom, as for instance during a power failure. If the agitator has sufficient power to cut a path through the settled material, it will eventually redisperse it. On the other hand, if it lacks such power, but has been properly designed to withstand the torque of its drive and support apparatus, it will not rotate and will not be damaged. Most conventional designs either will not re-disperse materials under such condiitons, or else may be damaged during startup.

The plain shape of the impeller, with its smooth, flat surfaces and a lack of undercuts, promotes easy cleaning, and minimizes adhesion of materials during use. Close proximity of the bottom of the vessel minimizes buildup beneath the impeller.

The low velocity of the liquid at the surface, and its predominantly inward direction, minimizes splashing when the vessel is full. The lack of rotation also minimizes vortex action, which can draw undesired air into the liquid, but downward flow of liquid at the center is strong despite the absence of vortex.

The impeller can tolerate much wear and damage without loss in effectiveness.

Power consumption declines as the liquid depth falls in any vessel, so operating costs remain in proportion to the productive work performed, and the degree of agitation remains fairly constant.

A single piece of equipment can accommodate a wide variety of fluids and agitation requirements, with no more than a change in speed. Since the drive and bearing requirements are so mild, the system can be powered by V-belt and other simple types of apparatus which permit easy speed changes.

I claim:

1. An agitator for liquids comprising a vessel and an axial impeller suspended concentrically therein, the impeller comprising a vertical rotatable shaft with two in-line opposed arms carried radially by this shaft and an impeller blade affixed radially and substantially horizontally to the outer end of each of these supporting arms,

(a) the vessel being a right circular cylinder whose axis is vertical and whose bottom is flat and horizontal, and

(b) the length of each arm being about two-thirds of the radius of the vessel, each arm being made of a thin strip of flat material whose greater width lies in the horizontal plane of rotation and whose thickness in the vertical direction is so small that the hydraulic resistance in the direction of rotation is too slight to generate substantial rotary motion of the fluid under treatment, and the plane of rotation of the arms being adjacent to the bottom of the vessel so that sediment cannot accumulate to any significant depth beneath the rotating arms, and

(c) the length of each blade being about one-third of the radius of the vessel so that the outer tips of the blades rotate in close proximity to the wall of the vessel, the blades being made of flat material similar in shape to that of which the arms are made, with their thin leading edges rotating in the plane of the arms adjacent to the bottom of the vessel, and with their trailing portions twisted upward behind a line connecting the leading outer corner of the blade with the trailing inner corner of the blade so that the rearward surface of the blade comprises an approximately triangular plane inclined upward at an angle of about 10° to 15° from the horizontal plane of rotation of the arms while the forward surface of each blade comprises an approximately triangular plane in the plane of rotation of the arms.

2. The agitator of claim 1 wherein additional identical blades and arms are carried by the shaft in the horizontal plane of rotation adjacent to the bottom of the vessel.

3. The agitator of claim 1 wherein additional identical sets of blades and arms are carried by the shaft in horizontal planes of rotation above the set of blades and arms described.

4. The agitator of claim 1 wherein no foot bearing is employed to stabilize the lower end of the shaft in relation to the bottom of the vessel.

5. The agitator of claim 1 wherein stationary, vertical baffle surfaces are mounted radially inside the wall of the vessel.

6. The agitator of claim 1, wherein a diagonal brace connects each arm-blade pair with the shaft, the brace comprising a flat strip whose ends have been twisted perpendicular to each other, with a smoothly-curving surface between the two ends, and so affixed to the impeller that the widest surface of the brace is vertical at the shaft and horizontal where it joins the arm at the junction of arm and blade, and being twisted in such direction that the brace has its downward-driving face in the forward direction during rotation of the impeller.

7. The agitator of claim 1 wherein the rotational speed is about 40 to 50 revolutions per minute in vessels whose diameters are about 5 to 7 feet.

8. The agitator of claim 1 wherein a side-outlet drain is mounted in the wall of the vessel.

References Cited

UNITED STATES PATENTS

683,474	10/1901	MacKinzie	259—44
754,931	3/1904	Meyrick	259—24
1,803,446	5/1931	Warrick	259—108
2,235,604	3/1941	Brumagin	259—107
78,398	5/1869	Schuffert et al.	259—135
583,572	1/1867	Gordon et al.	259—108

FOREIGN PATENTS

13,784	1893	Great Britain.
590,635	4/1959	Italy.

WILLIAM I. PRICE, *Primary Examiner.*