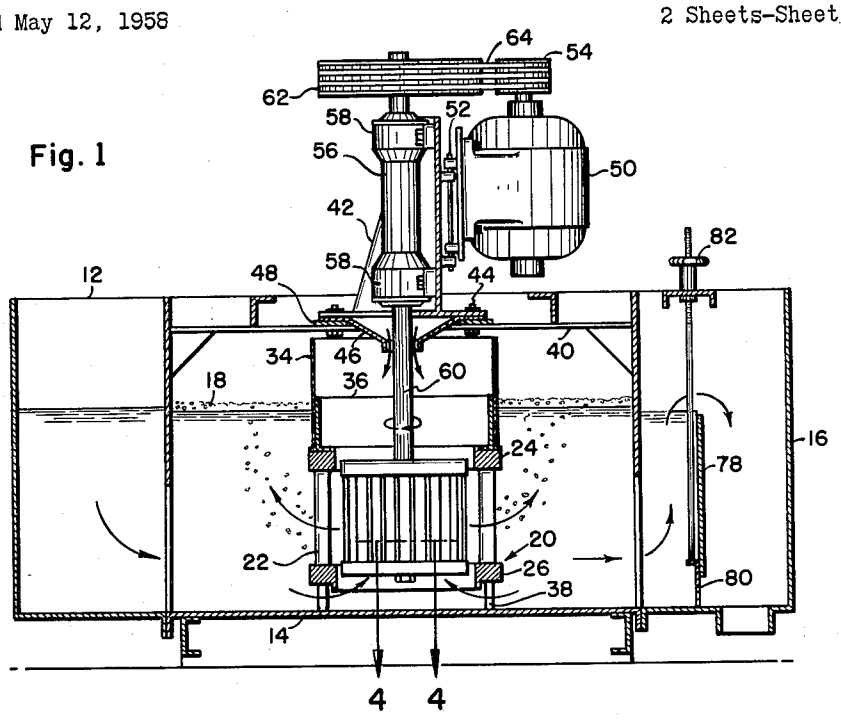
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ROTOR TUBE ASSEMBLY

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Fig. 1



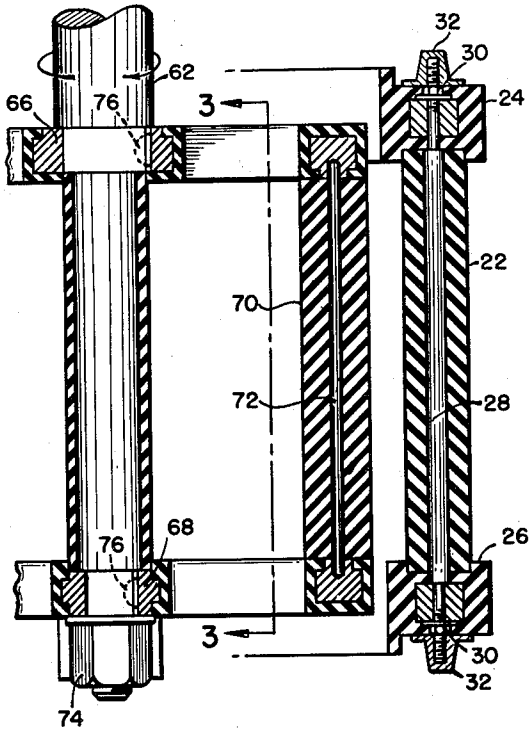


Fig. 2

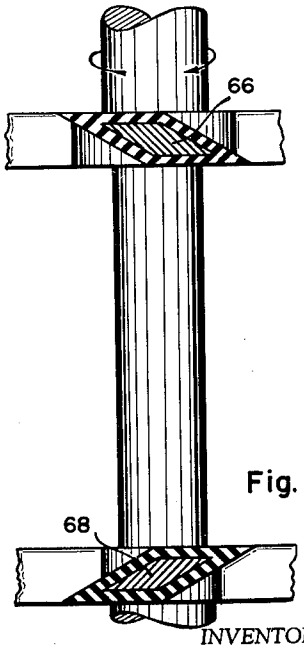


Fig. 3

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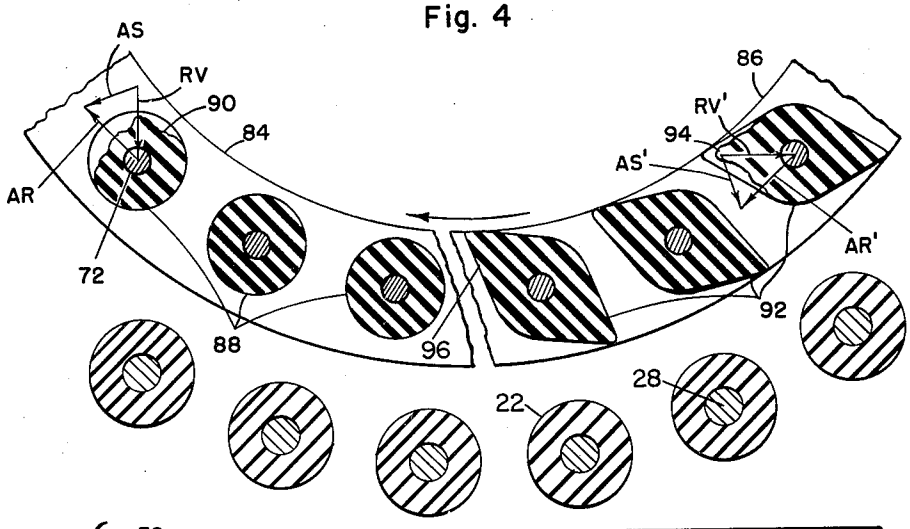
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Fig. 4



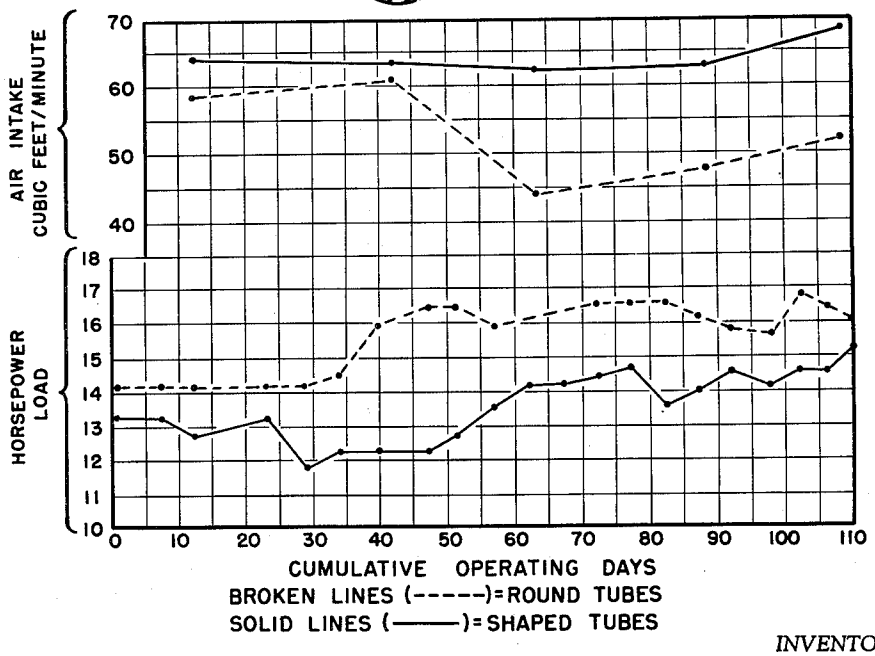


Fig. 5

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United States Patent Office

3,041,050
Patented June 26, 1962

3,041,050
ROTOR TUBE ASSEMBLY

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Filed May 12, 1958, Ser. No. 734,460
7 Claims. (Cl. 259—107)

The present invention relates generally to liquid agitating apparatus, and more particularly to an improved rotor tube assembly for combining and agitating fluids to mix them intimately.

The invention is particularly but not exclusively useful in flotation cells for separating minerals from ore or rock and comprises improvements upon a conventional mechanical action cell. This cell comprises a tank for a water slurry of the ore, a stator in the tank comprising a number of stationary vertical tubes spaced about an axis to form a "squirrel cage," and a rotor supported on the axis and comprising a number of tubes similarly arranged to form a "squirrel cage" within the circle of stator tubes. The rotor tubes are supported between end retaining plates which also serve as impellers, having sloping spokes forming vanes to draw in air through the upper plate and slurry through the bottom plate. The movement of the rotor in the conventional cell imparts rotational velocity to the liquid and subjects it to a centrifugal force which drives it outwardly between the tubes of the rotor and stator. At the same time air is mixed with the liquid, and the agitation of the liquid as it impinges on and passes through the rotor and stator tubes causes the air to mix intimately with the liquid in the form of masses of fine bubbles.

According to a well-known mineral concentrating technique, the mechanical action of this cell is utilized as described below. The mineral or minerals to be separated from ore or rock are ordinarily found in the form of small particles encased in the hard ore or rock material. The first step in the separation comprises crushing the ore or rock and then grinding it to progressive stages of fineness, the final grinding ordinarily taking place in a water slurry. The next step is to add to the slurry a chemical reagent or reagents which, through a well-known phenomenon, prevents wetting of a mineral to be separated. The slurry is then introduced to the flotation cell, wherein the non-wetted mineral particles attach themselves to the air bubbles and are floated to the surface as a layer of froth, the other mineral particles remaining in the liquid. The operation is ordinarily a continuous-flow process, with the froth layer being scraped off the surface of the cell over a weir board and recovered. It will be understood that the froth may be rich in a certain desired mineral or minerals and the mineral or minerals which do not rise in the froth may themselves be valuable as an enriched end product. The products from the flotation cell may be fed to a smelting furnace for substantially complete removal of impurities from a metallic end product.

It is conventional in apparatus of the foregoing type to employ rubber-coated parts in the construction of the rotor and stator members. The rubber material protects the parts from abrasive wear and chemical attack. In conventional practice, the rotor and stator tubes are thick rubber cylinders each having a central bore therethrough to receive a steel bolt or rod. The bolt or rod gives rigidity to the tube and affords means of securing it between the upper and lower retaining plates.

In practice, it is found that after a period of use conventional tubes gradually wear out in a somewhat predictable manner by the abrasive action of the slurry. Eventually, a wall of a rotor tube may wear completely through to the bolt, and the bolt itself may be corroded

and eroded until it breaks. To obtain maximum life from the tubes, they are ordinarily rotated at regular periods to expose unworn surfaces.

A principal object of this invention is to make a substantial improvement in the wearing qualities of the tubes, thereby reducing the cost of maintenance and the frequency of examination, replacement and rotation of the tubes.

A second object is to provide an improved form of rotor tube which will reduce the power consumption of the cell.

A third object is to provide an improved rotor tube which will give the cell greater air mixing capacity, thereby performing a more efficient mineral separation.

With the foregoing and other objects in view, a principal feature of this invention resides in the improved form of rotor tube described hereinafter. In contrast to the tubes found in the prior art, the improved tube has a cross-section with a larger dimension in the direction of impingement of the slurry thereon and a relatively smaller dimension laterally thereto.

Another feature resides in the orientation of the tubes with reference to the flow of slurry so that the slurry is impelled outwardly by combined centrifugal force and pumping action.

Still another feature resides in providing a rotor tube so shaped as to improve its wearing quality and to give it a longer useful life. Preferably, the shape is of a symmetrical form adapted for 180-degree reversal after a given period of use, thereby making possible a substantially equal additional period of use.

Other features of the invention reside in certain features of construction, arrangements and alignments of the parts, and in modes of operation which will become more evident from the following description of a preferred embodiment thereof, having reference to the appended drawings in which

FIG. 1 is a side elevation in section of a flotation cell adapted to employ the novel rotor tubes;

FIG. 2 is an enlarged partial side elevation in section showing details of the rotor and stator tube assemblies;

FIG. 3 is an elevation in section taken on line 3—3 of FIGURE 2;

FIG. 4 is a composite plan view in section taken on line 4—4 of FIG. 1 showing segments of "squirrel cage" rotor tube assemblies according to the prior art and according to this invention; and

FIG. 5 is a graph showing the performance of a flotation cell according to this invention, as compared with a similar cell according to the prior art.

Referring to FIG. 1, there is shown a flotation cell for separation of minerals of certain kinds from a water slurry of ore. In general, the cell is of well-known construction. The flow of slurry is continuous, passing into a feed end box 12, through a tank 14 and out through a discharge end box 16. The motion of the slurry through the assembly is gravitational. A froth 18 rich in a selected mineral passes over a weir board, not shown, at the illustrated liquid level on either or both sides of the tank 14.

The stator assembly designated generally at 20 comprises a plurality of elongated, mutually parallel stator tubes 22 evenly spaced about and generally parallel to a vertical axis and supported between steel-reinforced rubber stator rings 24 and 26. Thru bolts 28 (FIG. 2) pass through some of the tubes 22 and through the rings 24 and 26 at spaced positions about the stator, being secured by nuts 30 so as to hold the stator together as a rigid "squirrel cage" assembly. Rubber stator bolt protectors 32 are preferably provided to protect the protruding ends of the bolts. The remaining stator tubes 22 may have rods therethrough of the same diameter as the bolts

28, the rods being somewhat longer than the tubes but extending only part way into each of the rings 24 and 26. These rods are not threaded at their ends.

Secured to the stator ring 24 is a metal standpipe 34 which extends well above the surface of the slurry. A rubber liner 36 is provided for the portion of the standpipe below the surface of the slurry and extends over a portion slightly above the surface.

The stator assembly rest upon a number of stator support tubes 38. These tubes are rubber-covered metal rods having bores to receive the lower threaded ends of certain of the stator tube thru bolts 28.

The rotor assembly is supported upon a base plate 40 rigidly secured to the tank 14 and extending across the top thereof in spaced relation to the surface of the slurry. A bearing stand 42 is secured by bolts 44 to the plate 40, the bolts 44 passing through a metal splash cone 46 and washers 48. An electric motor 50 is supported on a motor mount 52 secured to the bearing stand, the shaft of the motor having a sheave 54 keyed thereto. A bearing support 56 is bolted to the stand 42 and houses thrust bearings 58 in which a drive shaft 60 is supported. The shaft 60 is keyed to a drive sheave 62. A number of flexible V-belts 64 extend between the sheaves 54 and 62.

Referring more particularly to FIG. 2, the shaft 62 has two portions of reduced diameter and a threaded end portion. A rubber-covered upper rotor retaining ring 66 is received over the upper of said portions against an upper shoulder of the shaft. A rubber-covered lower impeller ring 68 is received over the lower of said portions against a lower shoulder of the shaft. Between the upper and lower impeller rings are supported a plurality of elongated, mutually parallel rubber rotor tubes 70, evenly spaced about and generally parallel to the same axis as the stator tubes each tube having a steel support rod 72 extending into a hole in each of the impeller rings. The rotor assembly is completed by a lock nut 74 which is threaded on to the end of the shaft 62. Keys 76 prevent the rotor assembly from turning in relation to the shaft 62.

The upper and lower impeller rings 66 and 68, respectively, have spokes formed as impeller blades, as seen more clearly in FIG. 3. The upper impeller ring 66 draws air downwardly into the space within the rotor as indicated by the arrows in FIG. 1. The lower impeller ring 68 draws slurry upwardly into the space within the rotor.

In operation, the movement of the rotor within the stator imparts rotation to the liquid and consequently develops a centrifugal force which hurls it outwardly between the rotor tubes 70 and the stator tubes 22. The stator tubes 22 create turbulence in the slurry and produce masses of small air bumbbles. These air bubbles with attached mineral particles float upwardly to the surface of the liquid as shown by the arrows in FIG. 1. Liquid remaining at the bottom of the tank 14 flows toward the discharge end box 16 and may pass over a weir board 78 or through a gate 80 operated by a handwheel 82.

FIG. 4 is an elevation in section taken on line 4—4 of FIG. 1. It is a composite figure showing a segment 84 of a rotor tube assembly according to the prior art and a segment 86 of a rotor tube assembly according to this invention. In the prior art, the rotor tubes 88 are ordinarily of circular cross-section. With rotation in the direction indicated by the arrow, one may analyze the velocity of the rotor and slurry by vectors. The absolute velocity of the slurry AS has both radial and tangential components. The absolute velocity of the rotor AR is purely tangential. The relative velocity RV of the slurry and the rotor is the vectorial difference between the velocities AS and AR. As shown by the outline 90, the rotor tubes wear in a roughly symmetrical manner with reference to the axis defined by the vector RV. If

continued long enough, the tube wears through to the rod 72 and replacement is necessary. It will be seen that the life of a tube 88 may be prolonged by periodically rotating it through 90 degrees, thereby eventually producing a roughly diamond-shaped cross-section. However, this frequent turning of the rotor tubes is time consuming and is limited in the degree to which the life of a tube may be materially extended.

Referring next to the segment 86 showing a portion of the rotor according to this invention, the rotor tubes 92 are molded to a uniform, symmetrical, generally diamond-shaped cross-section. Preferably, this cross-section is a parallelogram with the angles terminating the shorter diagonal rounded to fit the largest included circle, this circle preferably being of the same diameter as the tubes 88 according to the prior art. The longer diagonal is a line of symmetry intersecting the path of the impeller members at an acute angle, said angle being oriented to the direction of rotation to impel fliud from the axis of the shaft 60. Also, this longer diagonal is aligned with the direction of the relative velocity between the slurry and the tubes 92, as represented by the vector RV', and it has a substantially greater dimension than any dimension in the cross-section normal thereto.

As shown by outline 94, the wear pattern of a tube constructed according to this invention is such that most of the wear occurs in the portion of the cross-section outside the radius of the largest included circle. It is only after considerable wear that the tube is reduced to a minimum thickness substantially less than its initial minimum thickness across the axis at right angles to the vector RV'.

It will be apparent that the wear occurs primarily at the leading edge of the rotor tube, the trailing edge remaining substantially protected. Preferably, the trailing edge is symmetrical with the leading edge to permit the rotor tube to be turned 180 degrees after the initial wearing period has advanced to the limit tolerated. Thereafter, it is found that the rotor tube may be used for an additional substantially equal period of time, and that its performance will remain substantially undiminished.

It will be noted that in spite of the increased cross-sectional area of the rotor tubes according to this invention, the narrowest space between the tubes 92 is a large fraction of the narrowest space between adjacent rotor tubes 88 according to the prior art. The streamlined shape of the tubes 92 offers less resistance to fluid flow than the prior art tubes 88.

It will be observed that the orientation of the rotor tubes 92 is such as to form a pump. The slurry is propelled outwardly with additional radial acceleration imparted by the inclined surfaces 96 of the elements 92. Thus the rotor serves a dual purpose: first, imparting rotational velocity to the slurry within the rotor which results in centrifugal force, and second, acting as a vane pump to further accelerate the slurry outwardly against and through the stator tubes.

The advantages of the tubes 92 over the prior art tubes 88 are illustrated by FIG. 5 which shows the results of an actual comparison taken over a period of 110 operating days. The solid lines represent observations made on a machine having round stator tubes and new rotor tubes shaped like the tubes 92 of FIG. 4. The broken lines represent the same tests taken on an identical machine handling substantially identical slurry at identical flow rates over the given period, this machine having standard new rotor tubes according to the prior art as indicated at 88 in FIG. 4.

It will be observed that the air intake in cubic feet per minute was greater with the improved tubes 92, and that the difference in air intake increased markedly over the operating test period. The rate of air intake is a measure of the rate of mixing air with the slurry. Also, less horsepower was required to operate the flotation machine equipped with the new rotor tubes 92.

After the test period, the minimum thickness of the tubes **92** was much greater than that of the tubes **88**. Thus the tubes **92** were found to have a much greater life expectancy than the tubes **88**.

With the improved rotor tubes, the rotor itself comprises three impellers, namely, a downwardly-directed air impeller ring **66**, an upwardly directed slurry impeller ring **68**, and the assembly of rotor tubes **92** comprising a radially directed "squirrel cage" impeller or vane pump for the mixture.

It will be understood that, while the invention has been shown as applied to flotation cells for separation of minerals from ore or rock, the structure of the rotor is well suited for other types of liquid agitating apparatus, for example, mixers and agitators of various kinds. It will be further understood that various modifications in the construction of the parts and in the shape of the rotor tubes may be made in accordance with considerations familiar to those skilled in the art, without departing from the spirit or scope of this invention.

It will be seen that there has been provided according to this invention an improved apparatus for agitating liquids, and more particularly apparatus of the kind in which a liquid is mixed with air to produce masses of tiny air bubbles throughout the liquid. This apparatus with the improved rotor tubes **92** produces a beneficial mixture at a lower power consumption than with the prior art tubes, this improved power performance being concurrent with an increased air intake capacity and longer life of the parts.

Having thus described the invention, we claim:

1. An agitator for mixing fluid systems having, in combination, a pair of spaced end impeller members adapted for mounting on a common rotatable shaft, each of said members including radial spokes sloped to produce a fluid flow toward the space between said members, and a plurality of mutually parallel impeller members each supported by and between said end impeller members, said parallel impeller members being spaced at uniform distances from and substantially parallel to the axis of said shaft and having a cross-section conforming to a parallelogram having a shorter diagonal rounded to fit the largest inscribed circle, the longer diagonal of said parallelogram being oriented to the direction of rotation of said shaft to impel fluid outwardly from said space.

2. In apparatus for agitating a fluid, a rotor supported in a tank for said fluid rotation about a predetermined axis and comprising a plurality of elongated, mutually parallel rotor members and end retaining means to secure said rotor members in evenly spaced relationship about and generally parallel to said axis, each rotor member having a cross-section in the general form of a parallelogram with a longer diagonal thereof being aligned with the direction of the relative velocity between said fluid and said rotor member.

3. The combination according to claim 2, in which each rotor member is adapted to be mounted by the retaining means with said longer diagonal of its cross-section in either of two positions mutually angularly displaced by 180 degrees.

4. In apparatus for agitating a fluid, the combination of a stator supported in a tank for said fluid and having a plurality of elongated stator members evenly spaced about and generally parallel to a common axis, and a rotor supported within the stator for rotation about said axis and comprising a plurality of elongated, mutually parallel rotor members and end retaining means to secure said rotor members in evenly spaced relationship about and generally parallel to said axis, each rotor member having a cross-section in the general form of a parallelogram with a longer diagonal thereof being aligned with the direction of the relative velocity between said fluid and said rotor member.

5. The combination according to claim 4, in which the end retaining means comprise a pair of impeller rings having spokes formed as impeller blades respectively oriented to draw air and fluid into the space within the rotor members.

6. The combination according to claim 4, with means to introduce said fluid to the space within the rotor.

7. The combination according to claim 2, in which the cross-section of each rotor member is tapered to a point at both ends of the longer diagonal thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

1,816,562	Beers	July 28, 1931
1,963,122	Tagergren	June 19, 1934
2,191,739	Bean	Feb. 27, 1940
2,235,604	Brumagin	Mar. 18, 1941
2,648,529	Wigton	Aug. 11, 1953
2,767,965	Daman	Oct. 23, 1956
2,769,623	Cawood	Nov. 6, 1956