

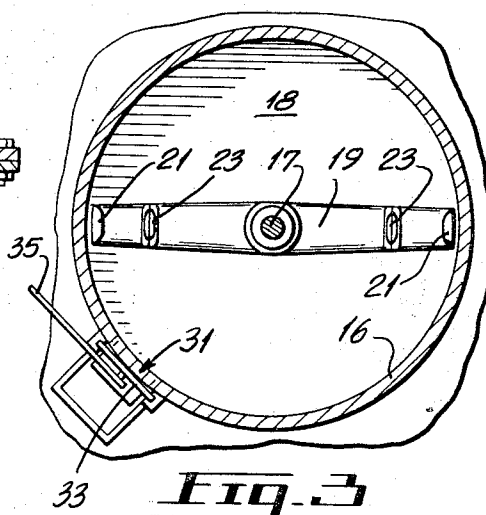
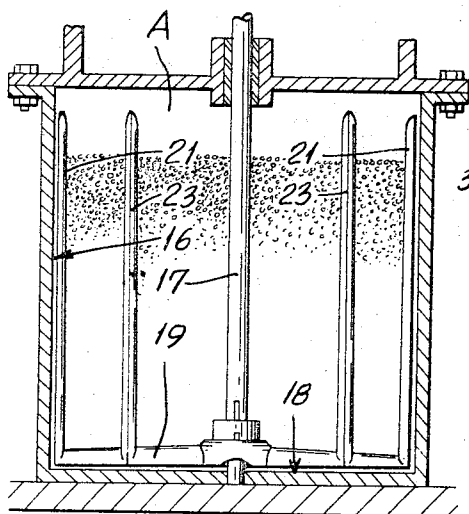
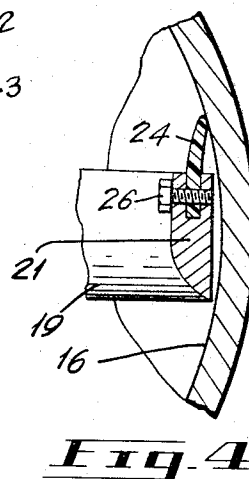
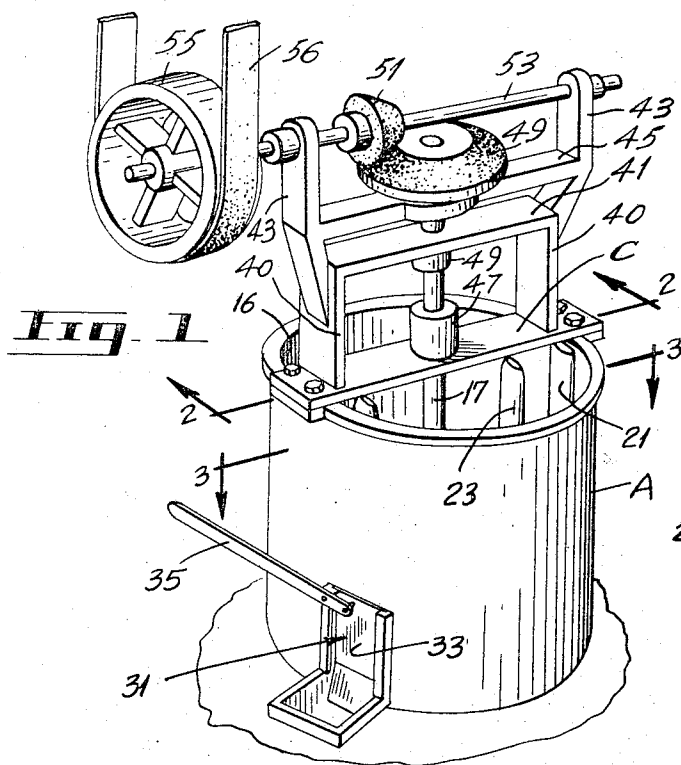
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PIGMENT GRINDING MILL

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2 Sheets-Sheet 1



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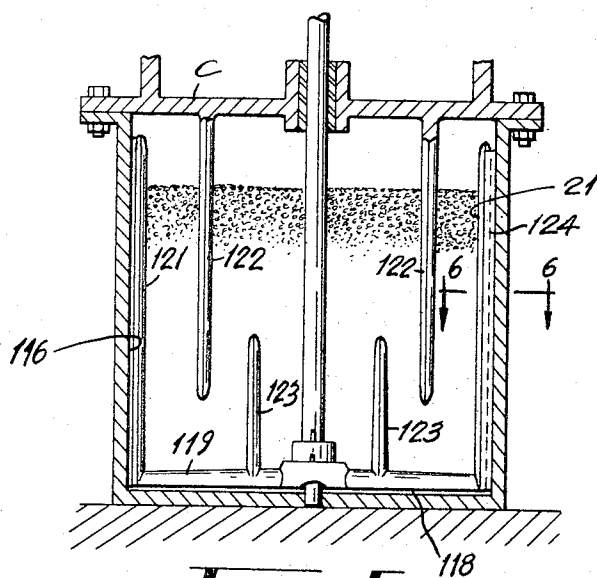


Fig. 5

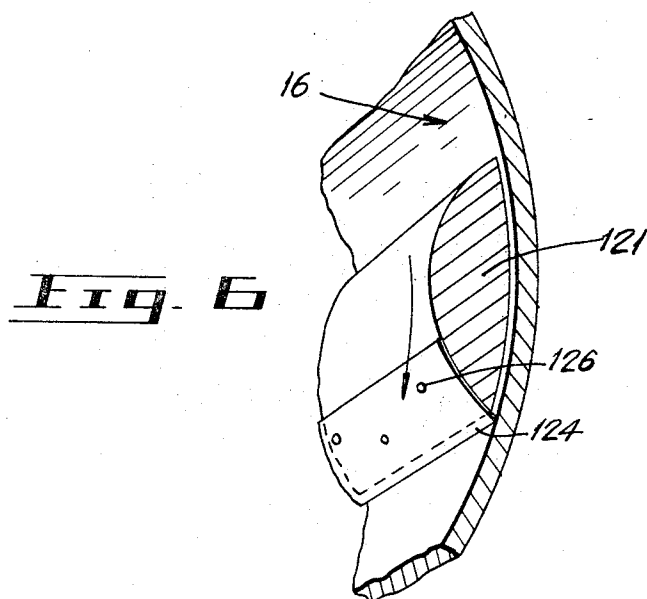


Fig. 6

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PIGMENT GRINDING MILL

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This invention relates to a method of finely dividing grinding or dispersing solids and to apparatus for carrying out this method which may be referred to as attritors.

The invention has particular application to grinding pigments, fillers, extenders, additives and other components. One use for example, is in the grinding of pigments, and extenders in the manufacture of paints, and coatings, another in the grinding of iron compositions for coating magnetic tapes.

Various methods have been suggested for analogous purposes. Examples are shown in U.S. Patents 1,956,293, Kline et al., Apr. 24, 1934; 2,719,009, Szegvari, Sept. 27, 1955; 2,764,359, Szegvari et al., Sept. 25, 1956, and Canadian Patent 603,756, Szegvari, Aug. 23, 1960, the disclosures of which are incorporated by reference. These methods use attritors which include a stationary vessel containing a mass of spherical grinding balls and agitate the elements by an agitator passing through the middle of the mass.

The devices of the prior art and the methods which they perform while effective for the purposes they describe, suffer from various disadvantages which will become clear from the following description which compares them with the applicant's method.

The present invention is based on a different type of agitation of the grinding elements, which reduces the energy required, eliminates dead areas and reduces attrition of the vessel and grinding elements. Briefly, in the applicant's method, agitating means is moved through the periphery of the system close to the wall of the vessel at a speed sufficient to impart flow substantially throughout the system and a flow pattern characteristic of the peripheral agitation. Depending upon the size of the vessel, its shape, and the nature of the grinding problem, the agitating means may operate only at the periphery of the system or it may also operate within the mass. The agitation may also be modified by providing stator means which makes contact with the agitated grinding elements within the mass. It is also within the scope of the invention to provide auxiliary agitating means, contacting the middle of the mass of the grinding elements, which moves either in a counter direction or in the same direction at a different speed to the peripheral agitating means.

A preferred form of vessel is cylindrical with vertical walls and either a flat or a dished floor. In this case, the agitator may take the form of an agitating shaft extending axially of the vessel with a horizontal arm extending from the bottom of the shaft substantially flush with the floor and a vertically extending arm connected to the end of the horizontally extending arm and just clearing the side wall. A cover may be applied about the shaft to help prevent losses of volatile materials in the charge, and to reduce noise.

Other features will appear from the following detailed description which will be illustrated by reference to a preferred embodiment of the invention which is shown in the accompanying drawings. In the drawings:

FIGURE 1 is a perspective view showing an attritor according to the invention.

FIGURE 2 is a vertical cross-section as along the line 2—2 of FIGURE 1.

FIGURE 3 is a horizontal cross-section through the vessel as along the line 3—3.

FIGURE 4 is an enlarged fragmentary horizontal cross-

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section partly in plan through the wall of the attritor vessel just above the horizontal arm.

FIGURE 5 is a vertical cross-section to another form of attritor according to the invention.

FIGURE 6 is a fragmentary horizontal cross-section perspective view, as along the line 6—6 of FIGURE 5.

Referring more particularly to the drawings, the attritor, in the preferred form of the invention shown, is constructed as follows. It is made up of an upright vessel of mild steel, having a cylindrical wall 16, and a flat bottom or floor 18. Downwardly extending axially into the vessel A is an agitator shaft 17, on the lower end of which is mounted an agitator made up of a flat horizontal bar 19 of D cross-section. This bar just clears the bottom of the floor 18. This clearance is less than the radius of the smallest grinding element to be used. Upwardly extending from the outer ends of the bar 19 are agitator blades 21 of substantially the cross-section shown, which also operate just clear of the wall 16. Extending upwardly from the bar 19 beside the respective blades 21 are optional auxiliary blades 23 of rectangular cross-section. The vessel A is provided with a discharge opening 31, which is controlled by a gate valve 33, operated by an arm 35. The container A is filled with grinding balls, which reach substantially the level shown. Variations in the specific characteristics of the various parts will be described later.

The blade 21 is provided at its trailing edge with a flexible sweeping member or brush 24, held in a groove in the rear of the blade 121 by a screw 26. The member 24 projects downwards beyond the lower surface of the blade 21 to engage the wall 16 and thus to sweep this wall continually, as the blade 121 rotates close to it. The end of the member 24 is in the nature of a flap or scraper. It can be a flexible metal sheet or of resilient material, say rubber or plastic.

FIGURE 6 is a cross-section perspective view somewhat similar to FIGURE 4, showing an alternative arrangement of a scraping device for the agitator member 121. This scraping device is a strip 124 of flexible material (similar to the member 24 of FIGURE 4), which is held to the upper surface of the leading face of the agitator member 121 by screws 126. The scraper member 124 is arranged so that its edge projects slightly beyond the lower surface of the agitator blade 121, so as to engage the wall 116 of the vessel and to sweep off any material adhering to the wall.

A crossbar C is shown extending across the top of the vessel A, although there may be a cover, covering the entire top of the vessel, if desired. Mounted on the crossbars C is a superstructure which includes upwardly extending arms 40 carrying a crossbeam 41 and further upwardly extending arms 43 carrying a crossbeam 45. The agitator shaft extends up through the crossbar C and is provided with collars 47 and 49, adapted to bear against the crossbars C and 41 respectively. On its upper end, the shaft 17 carries a bevel gear 49 meshing with a bevel gear 51, mounted on a cross shaft 53, journaled in the arms 43. The shaft 53 is driven by a pulley 55 through a belt 56, which is in turn driven by a suitable motor which is not shown. This driving arrangement is calibrated to provide the necessary power and speed in keeping with the desired grinding effect, as described herein, as will be understood by one skilled in the art.

OPERATION

In operation, the material to be ground is fed into the top of the vessel A and the agitator 17 set into motion so that the blades 21 sweep just clear of the walls 16 at the periphery of the mass of grinding balls. This motion by

the blades 21 and the bar 19 sets up a characteristic form of peripheral agitation.

AGITATING MEMBER

An attritor according to the invention will have at least one agitating member of the following description. It will extend radially from the centre as a rigid bar along the bottom and the wall. It will match the inside shape of the vessel which will thus be shaped as if engendered by a parallel member. This member will clear the vessel's inner surface by less than the smallest radius of any grinding element contained in the vessel so that no wedging occurs. It need not extend above the vessel wall. It should reach the highest level of the attritor charge under operating conditions. In this respect, it should be noted that the level tends to rise at the periphery under centrifugal force. In practice, to accommodate maximum charges, the member will be so constructed as to be about level with the top of the vessel wall. These overall dimensions of an agitating member of the main type may be expressed as follows:

Internal radius of vessel—radius of smallest grinding element < radial length < internal radius of vessel.

Level of charge when in operation $\leq$ height $\leq$ height of vessel wall.

The motion of the main agitator member will be circular along the periphery of the vessel. The rotational speed is preferably from about 300 to about 900 feet per minute at the periphery. This represents for a vessel of one foot diameter, an axial speed of about 100–300 r.p.m., or for a vessel ten feet in diameter, an axial speed of about 10–30 r.p.m. The speed is actually not critical as in prior devices. In the patented devices mentioned, a minimum speed is needed for dynamic movement. Contrary to the devices based on so-called "dynamic movement" of the grinding elements, which must operate above a certain speed threshold, any movement at all of the agitating elements in this invention sets up movement and performs work throughout the charge.

An alternative form of attritor is shown in FIGURE 5. The same numbers have been used to denote similar parts, as in the previous figures, but they have been raised by 100. In the device shown in FIGURE 5, a cover C has been applied, or this can be merely a crossbar, as shown in FIGURE 1. On the cover or crossbar C are mounted downwardly extending rods 122 in a position to lie between the upwardly extending peripheral agitator members 121 and the intermediate agitator members 123. The members 121 are static and intercept the mass which is being moved by the members 121 and 123. The members 121 tend to prevent the mass of grinding balls and material being ground to move as a whole, and cause it to be agitated internally, as it is brought into contact with the members 121/122. In the form shown, the upwardly extending intermediate agitator members 123 are shorter than in the form of the invention shown in the previous figures, although this is not a necessary limitation.

The agitating members must be of rigid material suited to the product to be ground. Mild steel, or mild steel clad with tetrafluoroethylene resin, sold under the name "Teflon" or other materials for special purposes are suitable. The shape of the bars themselves in cross-section may be rectangular or rounded. A substantially D-shaped cross-section of the main agitating member with its flat surface facing the inside of the vessel along the bottom and against the wall, has been found helpful in promoting additional desirable oscillating motions among the grinding elements. This type of cross-section is also more suitable than a rectangular section from a hydrodynamic point of view, and reduces drag. The agitating members of the main type may be fitted with a "feather edge" or scraper, for example, heavy gauge nylon or "Teflon" trailing or leading in order to remove from the wall any material accidentally or continuously being splashed above the normal level. This scraper arrangement has been found to work best

when fitted as a trailing edge, between the level of the charge and the top of the vessel wall, onto the arm of the main agitating member. A stator member is useful to reduce the tendency of a very thixotropic mass from being pushed around, as a whole and without internal agitation. The stator member tends to cause additional internal agitation.

GRINDING ELEMENTS

The grinding elements should be spherical and between about $\frac{1}{8}$ " and 2" in diameter. In a given vessel, they should all be substantially of the same size. This size will be determined by the viscosity of the charge and the speed of rotation. A large size acquires more momentum than a smaller size and thus contacts between large size grinding elements are best able to shatter the particles to be ground, or dispersed, particularly at relatively high viscosities. On the other hand, small grinding elements provide a greater number of contacts per unit of time and per revolution of the agitating members. The smallest size that will suit the work to be done is to be preferred. Enough elements should be used to fill the material to be ground. The grinding elements should be of a material at least as hard as the hardest material to be ground. The more dense the better in order to preserve momentum. They must not be prone to shatter. Typical ball-mill elements may be used, for example, flint, stainless steel, porcelain or other ceramics.

NATURE OF THE AGITATION

The agitation set up is what the applicant calls "peripheral agitation." The term "peripheral agitation" as used in this application, means the imparting of movement to a peripheral zone of the charge of grinding balls and materials being ground (which is defined by the wall of the containing vessel) whereby the grinding balls in that zone are acted on by the agitating member. In the case of a cylindrical vessel the agitating member sweeps the side wall and floor and thus acts directly on the parts of the mass most difficult to energize. The horizontal parts cause an upward and outward movement which, in addition to providing grinding agitation, is most useful in sweeping the ground materials through the outlet. The vertical agitating parts cause oscillation of grinding elements in a horizontal plane which transmits itself throughout the mass, the leading edge pushing the grinding elements towards the center and the trailing edge withdrawing them into its wake. In vessels of large diameter, intermediate vertical agitating parts reinforce the peripheral agitation. Stator parts, if used, will increase attrition within the mass.

A circular pattern, in a horizontal plane, is set up by the main type of agitating member. In addition, centrifugal action of the bar along the bottom drives material from the centre along the bottom towards the wall. This produces a continuous flow in a vertical circular pattern within the "peripheral" agitation. Superimposed on this general movement of the charge is an oscillatory movement of the grinding elements perpendicular to the surfaces of the agitating members which continuously lift and push the grinding elements they contact. There are no dead spots. And, unlike the devices described in the above-mentioned patents, the viscosity of the charge being worked does not reduce the range at which the agitators can impart motion to the grinding elements. The type of "attritor" in which the agitators do not reach the periphery of the vessel suffer from severe limitations, since, as the viscosity of the charge goes up, the energy imparted to the grinding elements fails to reach the bottom or the walls. A recirculating pump is thus required in order to ensure even grinding in these devices. Another feature of the agitation set up by the applicant's device is that the centrifugal force along the bottom is sufficient to discharge the finished product, rendering dumping and pumping arrangements unnecessary.

ADVANTAGES

Among the advantages of the present invention are the following.

(1) Dead spots are less likely.
 (2) In some of the prior art grinding methods, there are a number of critical factors which require special adjustment of the apparatus. For example, viscosity of the charge being ground, the movement of the agitators, the depth of the bed, and the clearance between the arms of the walls, all have to be coordinated. In the applicant's type of agitation, these factors are not critical because of the nature of the agitation and design of the agitator.

(3) In the prior art devices the agitators do not reach the periphery of the vessel. So as the viscosity of the charge goes up, the energy imparted to the grinding elements fails to reach the bottom or the walls of the vessel. A recirculating pump is thus required to insure even grinding or dispersion.

(4) In the applicant's device, the centrifugal force along the bottom is sufficient to discharge the finished product. This does away with the necessity for special arrangements for pumping out the ground product.

(5) Some of the prior patents recommend that the drive shaft be operated from worm gear so as to get a positive drive, necessary in order to move the agitator against the heavy resistance encountered from the particular agitating arrangement. This makes it impossible to turn the shaft manually and it is necessary to resort to complicated and expensive coupling devices.

(6) In other devices, extreme wear occurs at the extremities of the agitating arms because of their high speed through the grinding elements. This requires expensive hard alloys for the agitators. In the applicant's device, the speed of the agitating elements is lower relative to the grinding elements. Remarkably little wear occurs. In a cylindrical vessel, it affects mainly the vertical arms. No wear of a mild steel vessel wall was noticed after hundreds of hours of operation.

(7) Since discharge in the applicant's device is effected or facilitated by the manner of agitation, the apparatus does not have to be uncoupled from the drive for dumping. The device may be fixed to the floor permanently.

(8) The method of the invention can handle paint materials in the wet, for example, alkyd resin with a vehicle and pigments in it, water and pigments, solvents and vehicles, pigments and/or fillers, or any other grinding job within the paint industry.

EXAMPLES

The invention will be further explained by reference to the following examples. These examples are carried out on a typical attritor including a vessel of the type shown on the drawings, of about 4½ feet in diameter and 2½ feet high. In this device, the bar 19 was about 4 inches in width by about 2 inches thick. Blades 23 were about 3½ inches wide and 1½ inches thick. The range of rotational speed for the shaft 17 which is found effective, was from about 20 to about 80 r.p.m. or a linear speed the periphery of around 700 feet per minute. The apparatus had a capacity of about 60 gallons. It was driven by a 5 H.P. electric motor through a belt drive.

Example 1

A run was carried out in a vessel of the type described in the previous paragraph and it is of the nature of the agitating elements and of the charge, as shown. The amount of the charge, temperature and time of grinding as well as the fineness after various grinding periods is indicated.

Charge	Lbs.	Temp.	Time	Hegman, N.S. Fineness
1" Selected Flint Pebbles.	300	-----	-----	-----
Iron Oxide N.P. 300.	75	-----	-----	-----
Polyurethane Soln. 60%.	75	-----	1 hr.	3
Pb Naphthenate 24%.	1	-----	2 hrs.	5½
Soya Lecithin.	1	-----	3 hrs.	7
	-----	89% F.	4 hrs.	7

Example 2

A similar grinding operation as in Example 1, was carried out, according to the following criteria.

Charge	Lbs.	Temp.	Time	Hegman, N.S. Fineness
1" Selected Flint Pebbles.	300	-----	-----	-----
Carbon Black Witco F1.	30	-----	1 hr.	2
Epoxy Ester Soln., 60%.	200	-----	2 hrs.	4
Ca Naphthenate 6%.	1	-----	3 hrs.	53/
Pb Naphthenate 24%.	1	89% F.	4 hrs.	53/

Example 3

A still further grinding operation is carried out as follows, with the results shown.

Charge	Lbs.	Temp.	Time	Hegman, N.S. Fineness
1½" Steel Balls.	1,000	-----	1 hr.	4
Carbon Black Witco F1 as above.	30	-----	2 hrs.	6
Epoxy Ester as above.	-----	-----	3 hrs.	7
Ca and Pb as above.	-----	109% F.	-----	-----

Example 4

A grinding operation which is carried out using the following amounts and with the following results.

Charge	Lbs.	Temp.	Time	Hegman, N.S. Fineness
Chrome Yellow Deep, McArthur Irwin.	320	-----	-----	-----
Toluidine Red Medium, Dominion Col.	40	-----	-----	-----
Alkyd, 65% Soya, 70% in Min. Spirits.	300	-----	-----	-----
Using Pebbles, 1" Chlorinated Rubber, 10 cps.	300	-----	8 hrs.	4
Xylene.	150	-----	8 hrs.	3½

Latter film was weak, possibly due to polymer breakdown under attrition. Recommend grinding in plasticizer and solvent instead of in the chlorinated rubber.

VESSEL

The vessel may be of various shapes. For example, in the preferred form shown, it has a cylindrical wall and a floor symmetrically related thereto. The floor can be flat or dished. Likewise, the vessel can have a hemispherical wall or a wall of some other shape whose surface always lies on a circle of which the agitating member shaft is at the centre so that an agitating member mounted on the shaft is always equidistant from the wall.

I claim:

1. A method of grinding and of dispersing by means of an attritor in which a mass of substantially spherical attritive grinding elements is contained to a substantial depth along with a material to be ground in a vessel having a confining wall, comprising moving an agitating blade in a peripheral direction and close to said wall throughout the depth of said grinding elements through a major part of the periphery of the mass at a distance from the wall less than the radius of the smallest grind-

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ing element at a speed effective to impart flow throughout the mass while leaving radially inward portions of the mass free from contact with said agitating blade.

2. A method of grinding, as defined in claim 1, in which the agitating blade is moved at a linear speed at the periphery of the mass within the range from about 300 to about 900 feet per minute.

3. A method of grinding, as defined in claim 1, in which the mass is also subjected to the action of a blade acting on the mass in a relative direction counter to that in which the said agitator is moving.

4. A method, as defined in claim 1, in which an agitating blade is moved through a middle part of the mass in a direction counter to the movement of said peripheral agitator.

5. In a device of the type described, a vessel adapted to contain a mass of grinding balls and material to be ground and a blade adapted to pass about the surface of said vessel thereby to provide peripheral agitation for the mass, said blade being spaced from the wall a diameter less than the distance of the grinding balls to be

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used and provided at one edge thereof with a flexible sweeping member projecting beyond the surface of the blade into contact with the wall of the vessel.

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