March 6, 1962 R. M. NORTON ETAL 3,023,903

HEAVY MEDIA PROCESS AND APPARATUS

Filed Dec. 1, 1959

4 Sheets-Sheet 1

Fig. 1.

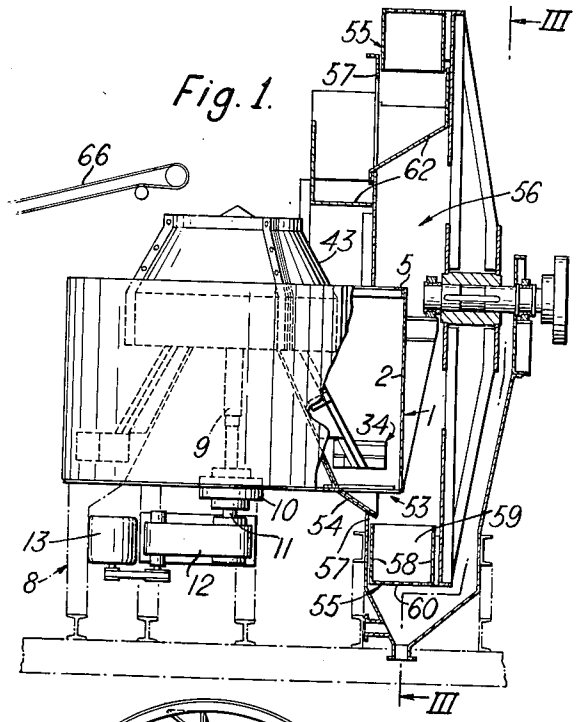
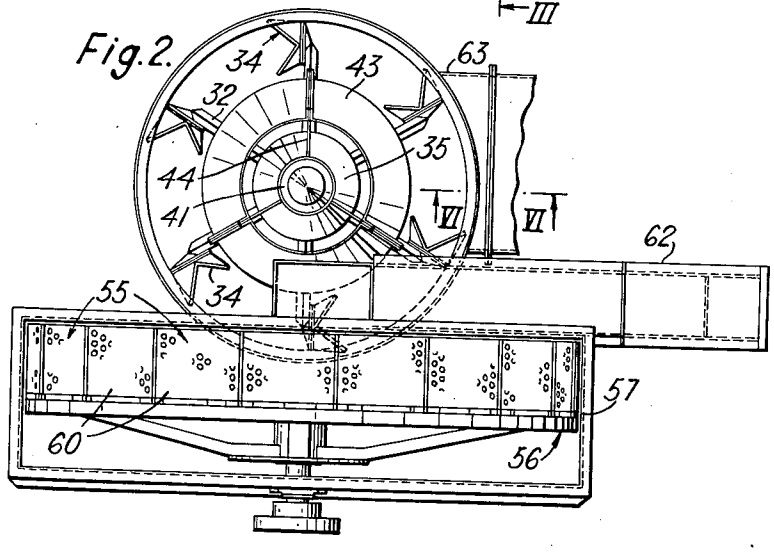


Fig. 2.



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4 Sheets-Sheet 2

Fig. 3.

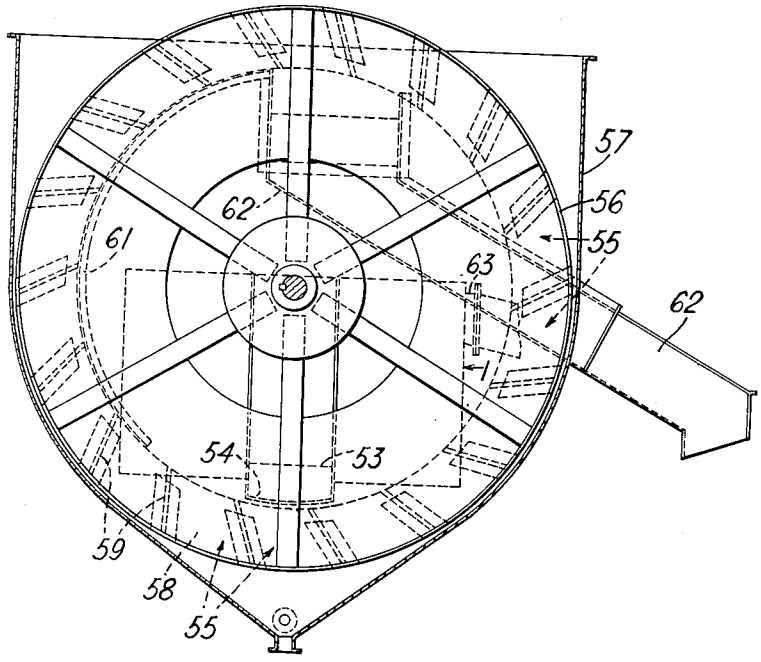
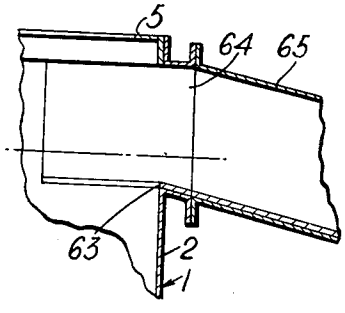


Fig. 6.



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4 Sheets-Sheet 3

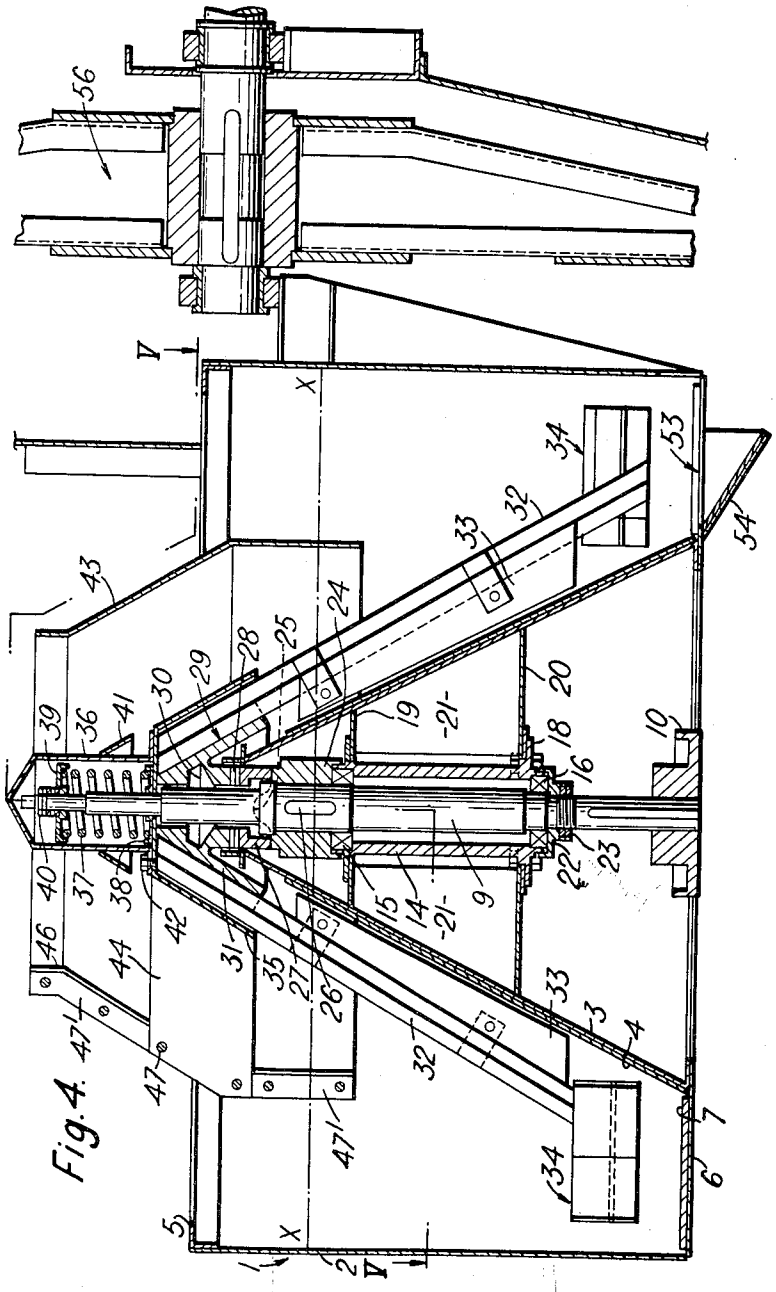


Fig. 4.

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4 Sheets-Sheet 4

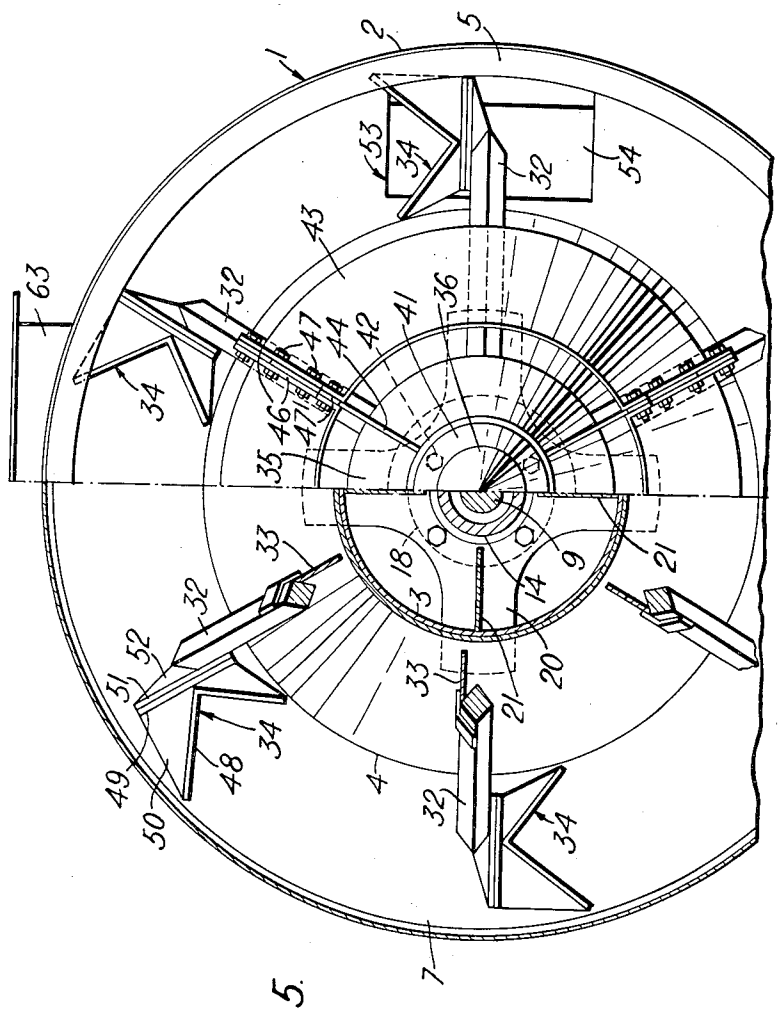


Fig. 5.

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HEAVY MEDIA PROCESS AND APPARATUS

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11 Claims. (Cl. 209—172.5)

This invention relates to the float-and-sink separation of solid materials into two or more fractions with the aid of a dense medium suspension, for example, the separation of coal from shale in an aqueous suspension of magnetite.

Two of the problems that arise in practice when a dense medium suspension is used are to maintain the particles of the medium in suspension and to reduce to a minimum the wear caused by the abrasive characteristics of the suspension. Furthermore, it is necessary to provide both a certain minimum depth of suspension if effective float-and-sink separation is to take place and a surface area that depends upon the quantity of material to be treated in unit time.

Apparatus commonly used for this purpose can be divided into two main types, namely shallow vessels and deep vessels. In a shallow vessel, which is commonly a tank with vertical sides, the difference between the levels at which the float and sink fractions are respectively collected for removal from the vessel is in practice from 3 to 4 feet, this being the depth of suspension required for effective separation. Since the capacity of the vessel, measured in quantity of material treated in unit time, is a function of the surface area, a shallow vessel of large capacity must also be of large area. The area of the bottom of the vessel into which the sink fraction falls is therefore large, even though the sink fraction may be small in relation to the float fraction, and the mechanism for recovering the sink fraction becomes large and complicated.

In a deep vessel, which is usually a conical tank, the sink fraction falls to the apex of the cone with the advantage that the surface area of the discharge outlet from which it must be removed is not large and the lateral dimensions of the elevator necessarily provided to carry the sink fraction above the level of the suspension can be related to the maximum quantity of sink material to be removed in unit time. The lateral dimensions, and therefore the capacity of the elevator, are independent of the surface area of the suspension. However, since the length of the elevator must necessarily be greater than the depth of the liquid in the vessel, it must increase with any increase in the size of the vessel, and since the maintenance of the complete mechanism including the elevator is one of the most important matters any increase in the length of the elevator is a serious disadvantage. A deep vessel presents another disadvantage also. The most commonly used dense medium suspensions are unstable and require mechanical agitation to maintain them. In a shallow vessel the agitation is usually no more than is required to impart a directional flow by which the float fraction is conveyed across the surface of the suspension to an outlet. But in a deep vessel if no greater agitation were imparted to the suspension than that required to convey the float fraction the settlement of the solids of the medium would result in a progressively increasing concentration of solids towards the bottom of the vessel and consequently a progressively increasing density of suspension throughout its depth. The result would be that any particle of the treated mineral of a density between that of the suspension in the separating zone in the upper part of the vessel and the higher density of the suspension at the bottom of the vessel would cease to sink when that particle reached a level in the suspension where the density of the suspension corresponded with that of the particle. In these circumstances the continuous operation of the float-and-sink process would become impossible. In deep vessels it is essential therefore to impart a greater mechanical agitation to the suspension than is required to impart the directional flow to the float fraction. Any pronounced mechanical agitation of the suspension will tend to interfere with the proper separation of the material under treatment. The deeper the vessel, the greater will be the agitation required. Therefore, in a deep vessel, the larger the vessel the more difficult it will be to approach the desired efficiency of separation.

Our main object in this invention is to provide an apparatus in which the advantages of both deep and shallow vessels are obtained without their disadvantages. Another object is to operate a process of float-and-sink separation more efficiently than hitherto.

Broadly an apparatus according to the invention comprises an annular vessel in which float-and-sink separation is carried out and which has one or more bottom outlets for the sink fraction, a central vertical shaft, and means carried by the shaft for moving the sink fraction around the bottom of the vessel to the outlet or outlets.

The invention and its advantages will be more clearly understood from the following description of the preferred form of apparatus which will now be described by way of example with reference to the accompanying drawings, in which:

FIGURE 1 is an elevation of the apparatus and an elevator shown somewhat diagrammatically;

FIGURE 2 is a plan of the apparatus and elevator;

FIGURE 3 is a section on the line III—III in FIGURE 2;

FIGURE 4 is a central vertical section through the apparatus on a larger scale;

FIGURE 5 is in part a section and in part a plan and is taken on the line V—V in FIGURE 4; and

FIGURE 6 shows the outlet for the float fraction on a still larger scale.

The apparatus shown comprises an annular vessel 1 having a cylindrical outer wall 2 and a frusto-conical inner wall 3 lined by wearing plates 4. The upper outer edge of the vessel is reinforced by a circular angle iron 5 and the bottom 6 of the vessel is lined by wearing plates 7. The vessel is carried by a supporting structure indicated generally at 8.

Because the inner wall of the annular vessel is frusto-conical and the outer wall cylindrical, the surface of the pool of dense medium suspension in the vessel is relatively large and the area on which the dense fraction is precipitated is relatively small.

The conical space within the inner wall 3 houses a shaft 9 driven through a coupling 10 by a driving shaft 11 itself driven through a speed reducer 12 by a motor 13. The lower part of the shaft 9 passes through a tube 14 which houses bearings 15 and 16 for the shaft. The lower end of the tube has a flange 18 which is bolted through a reinforcing ring to a cross-shaped plate 20. This plate and an upper annular plate 19 are both secured to radial webs 21 welded to the wall 3. The upper end of the tube 14 makes a friction fit in both the plate 19 and a reinforcing ring that is welded to this plate. Thus the tube 14 is rigid with the inner wall 3 of the vessel 1. The bearings 16 are supported by a flange thrust plate 22 which is urged upwards by locking nuts 23.

The upper end of the shaft 9 is surrounded by a sleeve 24 having an upper face shaped as a cam 25 and keyed at 26 to the shaft. A mating cam 27 surrounds the shaft

and has radial dogs or keys 28 by which it is keyed to a structure 29 also surrounding the upper part of the shaft 9 and keyed to it.

The structure 29 comprises an external conical casting 31 with V-shaped grooves extending along its conical surface. Bars 32 of square section enter and are held by bolts in these grooves. These bars carry paddles of two kinds, namely paddles 33 extending nearly into contact with the plates 4 and paddle assemblies 34 which are at a little distance from and sweep over the annular bottom of the vessel.

The maintenance of the dense medium in suspension involves constant stirring. This is effected by the rotation of the arms and the paddles.

The rotary structure 29 also includes a frusto-conical cap 35 which extends over the upper ends of the bars 32 and is bolted to them. This cap 35 carries a hood 36 which surrounds the upper end of the shaft and also a spring 37 which bears at its lower end on a disc 38 which rests on the cap 35 and at its upper end on a disc 39 which is held in position by lock nuts 40. The outside of the hood 36 carries a deflector 41 to prevent material delivered into the vessel from striking bolts 42 by which a flange on the hood 36 is secured to the cap 35.

The cap 35 also supports a sleeve 43 which surrounds the whole of the upper part of the rotary structure. The support is provided by radial webs 44 which are welded to the cap 35 and extend between flanges 46 on the sleeve 43, bolts 47 passing through the flanges and the webs. Above and below the webs 44 packing pieces 47' are inserted between the flanges 46.

Each paddle assembly 34 consists of a V-shaped paddle member 48 welded to a radial plate 49 and supported by stiffening plates 50, the plate 49 being in turn bolted to a plate 51 that is welded to the corresponding bar 32 and stiffened by fillet members 52.

There is a single discharge opening 53 in the bottom and lower part of the wall 2 of the vessel for the sink fraction. A chute 54 extends beneath part of this discharge opening so as to guide the sink fraction into buckets 55 of a bucket wheel of an elevator 56 working in a casing 57.

The buckets 55 are all spaces bounded by continuous circular walls 58, webs 59 spanning these walls and perforated plates 60 that form the bottoms of the buckets and are each inclined to the radius. An arcuate plate 61 extends over an arc from close to the bottom of the upwardly moving side of the wheel to a point near the top of that side, so that material entering the buckets at the bottom is prevented by the plate 61 from falling out until it nearly reaches the top; it is there discharged into a chute 62.

It is an advantage obtained by means of the invention that the elevator, which may take various forms in addition to that shown and which in itself is not part of the invention, does not have to be high.

The float fraction is discharged over a weir 63 through an opening 64 in the outer wall of the vessel together with some of the suspension, and flows along a chute 65.

In operation the material is fed from an endless conveyor to the sleeve 43, which acts as a chute. The separating medium may conveniently be delivered to the annular separating vessel from above and through tube or chute 43. Some of the material falls on the top of the casing and in moving down the sides of this is diverted outwards by the deflector 41.

The bottom of the sleeve 43 extends below the level of the surface of the suspension, indicated by the line x—x, and the material is discharged radially from the bottom of the sleeve. This has the important effect of eliminating an imperfection frequently apparent in normal dense medium vessels. This imperfection is that particles which ought to sink are entrained in floating rafts of material which tend to accumulate at the surface of the suspension in the vicinity of the feed point and which, if not broken up, may cause the entrained high density material to be discharged with the float fraction.

Because the raw material is introduced below the surface of the suspension particles that ought to sink are much less likely to become entrained in the floating rafts, and because the float material moves radially outwards on a continuously increasing front any floating rafts which may form near the central feed point disintegrate as the material spreads over the increasing front.

An important feature of the invention is thus the feeding of materials centrally to a dense medium separator in which the medium is moving in a circular path, the material moving radially outwards while, of course, partaking of the circular movement, and preferably being introduced below the surface of the medium.

It will be observed that the paddles 34 do not make close contact with the wearing plates 7 on the bottom of the vessel. The clearance between the lower sides of the paddles and the plates 7 may be from 1 to 4 inches, and the same clearance is provided at both the inner and outer vertical edges of the paddles 34. The result is that a bed of the sink fraction is formed on the plates 7, and when the paddles encounter large lumps or pieces of material the risk of jamming or damage is largely eliminated since the bed yields. Moreover, the wear on the bottom plates 7 is much reduced. If the sink fraction contains large pieces or lumps it is not necessary to increase the clearance, since so long as there is a bed or layer of sink material between the paddles and the adjacent surface of the vessel the risk of jamming is small.

The V-shape of the paddles 34 is advantageous. These paddles act as buckets and thrust the material towards the centre line of the paddle track, thus reducing the risk of sink material slipping past the paddles.

We find that in practice if we make the radial width of the annulus at the top of the vessel at least 4 feet and drive the central shaft and the arms at from 3 to 10 r.p.m. complete separation of coal from shale is effected before the coal reaches the outer wall. The pool of swirling dense medium should be at least 3 feet 6 inches deep. Although these figures are given as minima for complete success, nothing is gained by increasing either.

The apparatus may be modified in various ways. In particular the paddles may be replaced by a rotary bottom ring co-operating with one or more stationary ploughs and rigid with a frusto-conical sleeve carried by the upper part of the shaft. Lifters for removing the float fraction may be provided instead of a weir. The inner and outer walls of the vessel may be either cylindrical or conical or a combination of both. Again there may be an outlet at a suitable position in the outer wall between the medium surface and the bottom of the vessel for the removal of an intermediate fraction. Such a vessel would have two distinct zones of dense medium suspension, the lower one having a higher specific gravity than the upper.

Finally it should be understood that the dense medium may be a solution instead of a suspension, and that the invention is useful in separating materials other than coal from shale. Moreover in some such processes the sink fraction may be the valuable fraction to be recovered.

We claim:

1. An apparatus for use in the float-and-sink separation of solid materials into fractions comprising means forming an annular separating space upwardly increasing in cross-sectional area and having an outlet at the bottom thereof for discharging a sink fraction, a tubular feed member having its longitudinal axis in axial alignment with said annular separating space and with one end thereof extending below the surface of a separating medium contained within said separating space, means for delivering material to be separated into said feed member, means located above the lower edge of said feed member for discharging a float fraction, a shaft axially aligned with said annular separating space, radially spaced arm members carried by said shaft, paddle members carried

by said arms and adapted to sweep over a bed of sink fractions at the bottom of said space, and means for rotating said shaft to cause said paddle member to move sink material towards said outlet.

2. An apparatus for use in the float-and-sink separation of solid materials comprising a vessel having an outer wall circular in cross section, a generally conical partition in the vessel defining with the outer wall an annular separating space increasing upwards in cross-sectional area, said vessel also having an outlet at the bottom of said space, a tubular feed member disposed in said vessel and encircling the upper end of said partition, means for delivering material to be separated into said feed member, means located above the lower edge of feed member for discharging a float fraction, a shaft axially aligned with said annular separating space, radially spaced arm members carried by said shaft, paddle members carried by said arms and adapted to sweep over a bed of sink fraction at the bottom of said space, and means for rotating said shaft and said paddle members to move sink material towards said outlet.

3. A float-and-sink method of separating solid materials into fractions which comprises forming an annular pool of dense medium in an annular space which decreases downwardly in radial width, introducing a material to be separated centrally into the upper part of the pool and below the surface level of the dense medium, causing the material introduced into said pool to flow in a spiral path, removing the float fraction from the upper outer boundary of said annular space, concentrating the sink fraction over the relatively narrow bottom area of said space and removing the sink fraction from the lower part of said pool.

4. An apparatus for use in the float-and-sink separation of solid material into fractions comprising an annular vessel containing a dense separating medium, said annular vessel having at least one outlet at the bottom thereof for the sink fraction, said annular vessel decreasing in cross-sectional area in a downward direction, means extending below the surface level of the dense separating medium contained in said annular vessel for introducing raw material centrally therein, a central vertical shaft, means for rotating said shaft and means carried by the shaft for moving the sink fraction around the bottom of the vessel to said outlet, including paddles sweeping over the bottom area of the annular vessel and arms carrying said paddles.

5. Apparatus as defined in claim 4 wherein at least the inner wall of said annular vessel is conical.

6. Apparatus as defined in claim 5 wherein the conical space within the inner wall houses at least a part of the means for rotating said shaft.

7. Apparatus according to claim 4 wherein the arms carrying said paddles are fixed to a central structure carried by said shaft and said arms sweep along one wall of said annular vessel.

8. An apparatus according to claim 7 including a spring, means mounting said spring in compression between said central structure and said shaft so that said central structure can yield upwardly against said spring.

9. An apparatus according to claim 4 wherein said means for introducing raw material includes a central chute, and means connecting said chute to said shaft for rotation therewith.

10. A float-and-sink method of separating a solid material into fractions comprising establishing an annular pool of dense medium decreasing in cross-sectional area in a downward direction, moving said medium in a horizontal circular path substantially without vertical movement, feeding said material centrally to a zone at the inner edge of said path and below the surface level of said dense medium, whereby said material initially moves radially outwards while also partaking of the circular movement of said dense medium, removing a float fraction from the upper and outer part of said pool and removing a sink fraction from the lower part of said pool.

11. A method according to claim 10 in which a bed of sink fraction is maintained at the bottom of the pool and paddles by which the circular movement of the medium is produced are caused to sweep over this bed.

References Cited in the file of this patent

UNITED STATES PATENTS

492,720	Frey	Feb. 28, 1893
1,076,666	Dorr	Oct. 28, 1913
1,392,214	Peck	Sept. 27, 1921
1,895,504	Wuensch	Jan. 31, 1933
1,937,190	Chance	Nov. 28, 1933
1,966,609	Chance	July 17, 1934
2,777,577	McNeill	Jan. 15, 1957
2,783,887	Chisholm	Mar. 5, 1957
2,843,265	Rakowsky	July 15, 1958

FOREIGN PATENTS

727,441	Germany	Nov. 3, 1942