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S. A. FALCONER

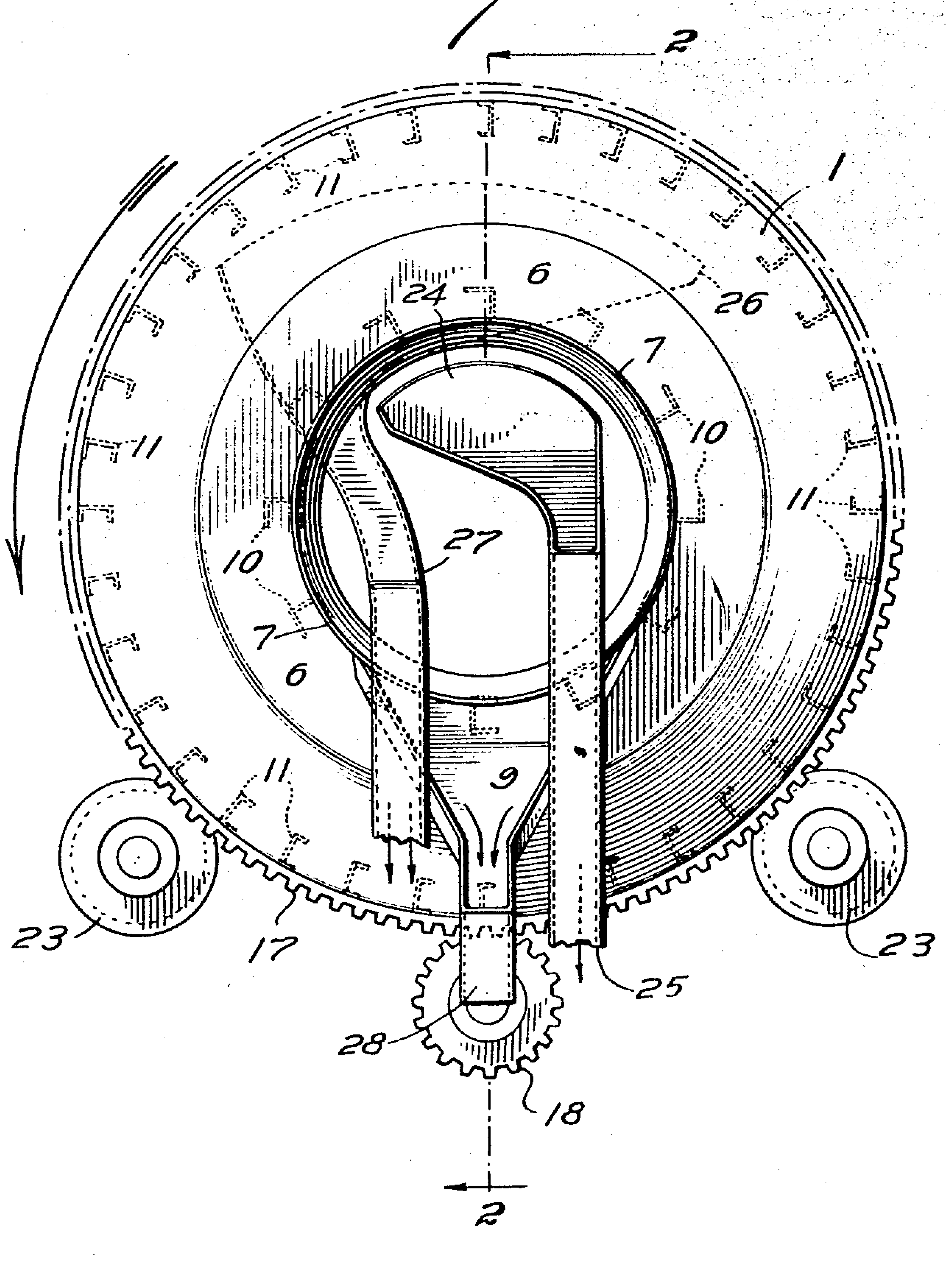
FLOAT REMOVAL DEVICE FOR ROTATABLE TYPE HEAVY-MEDIA SEPARATORS

2,624,461

Filed Aug. 13, 1949

3 Sheets-Sheet 1

Fig. 1.



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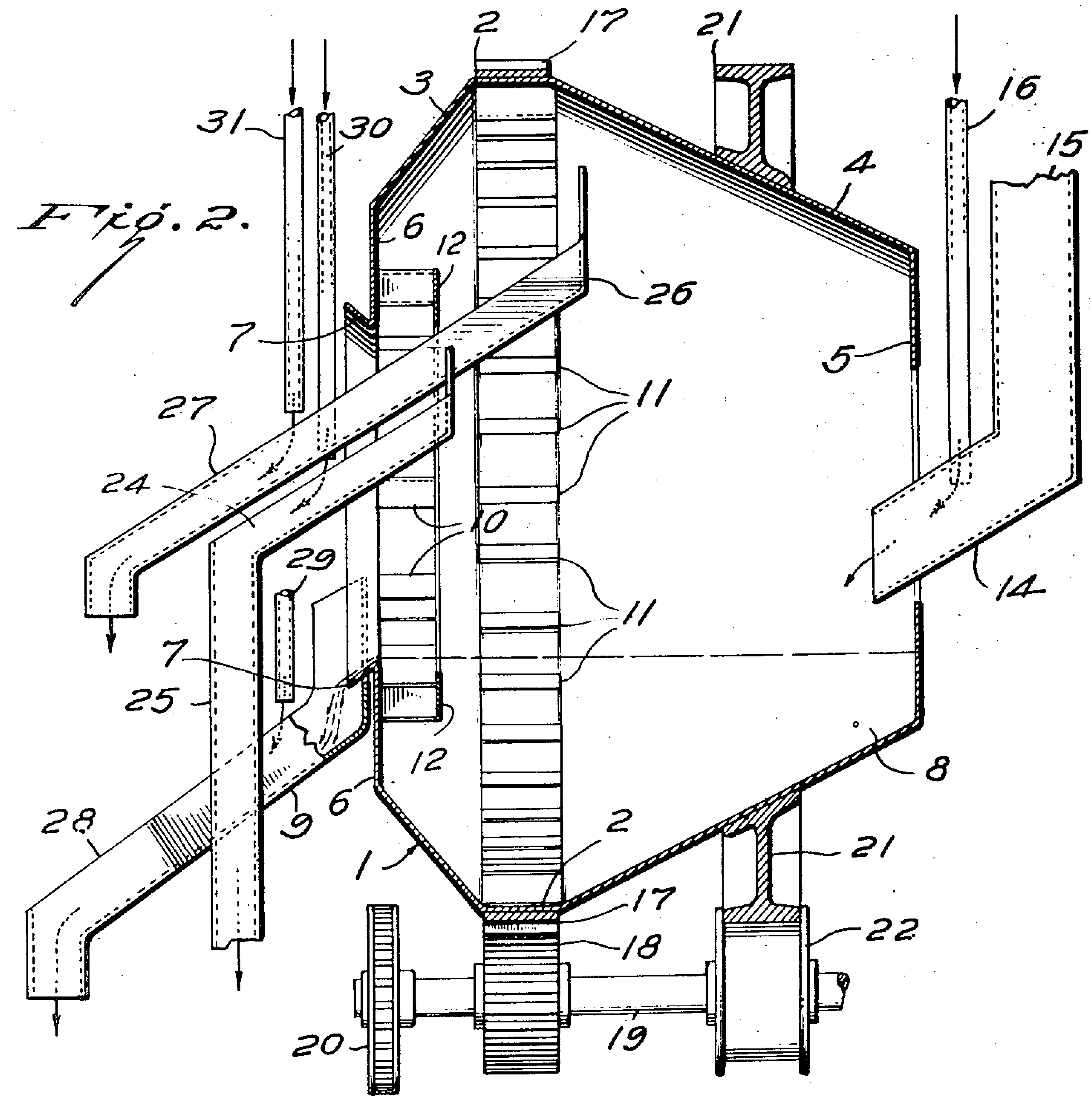

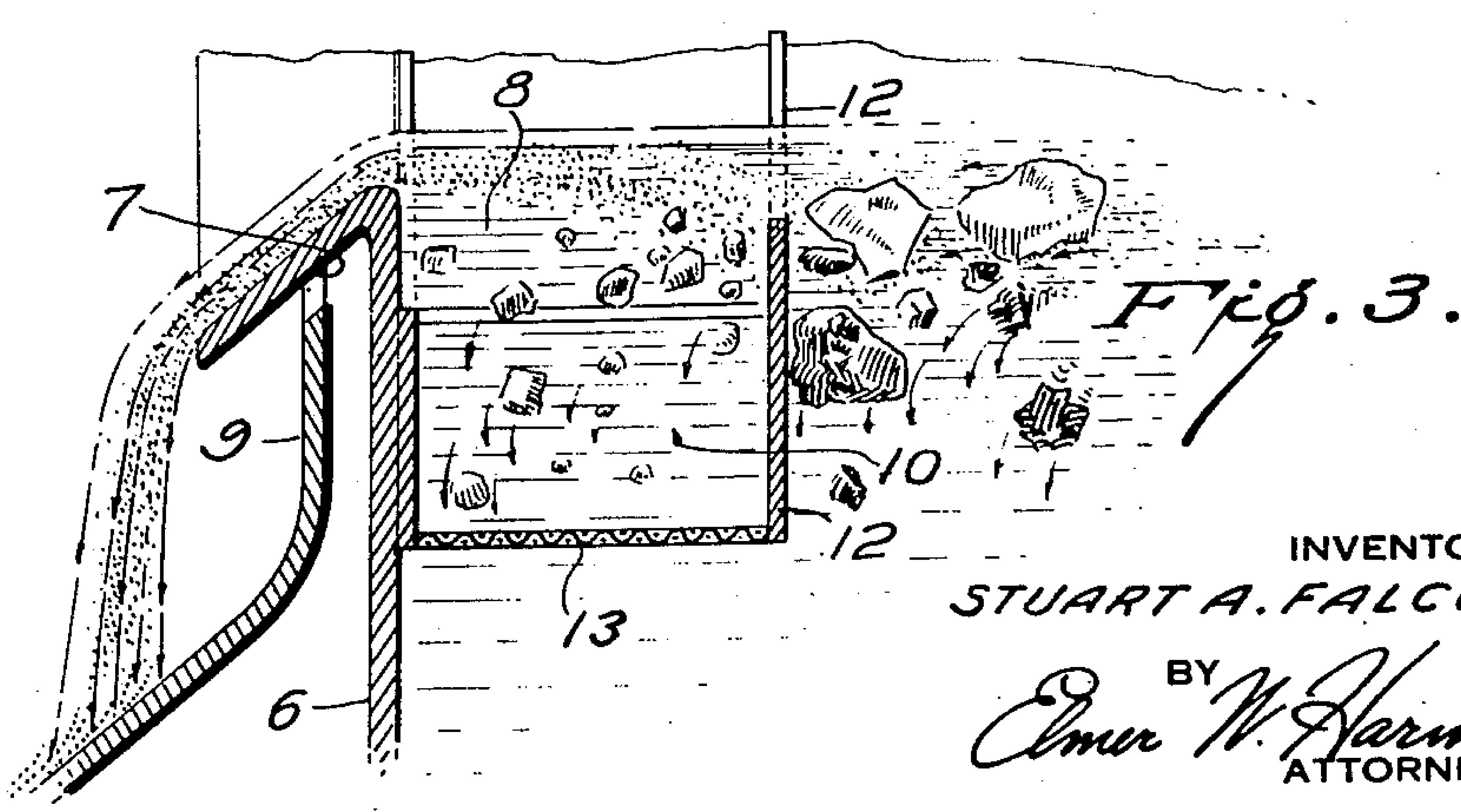

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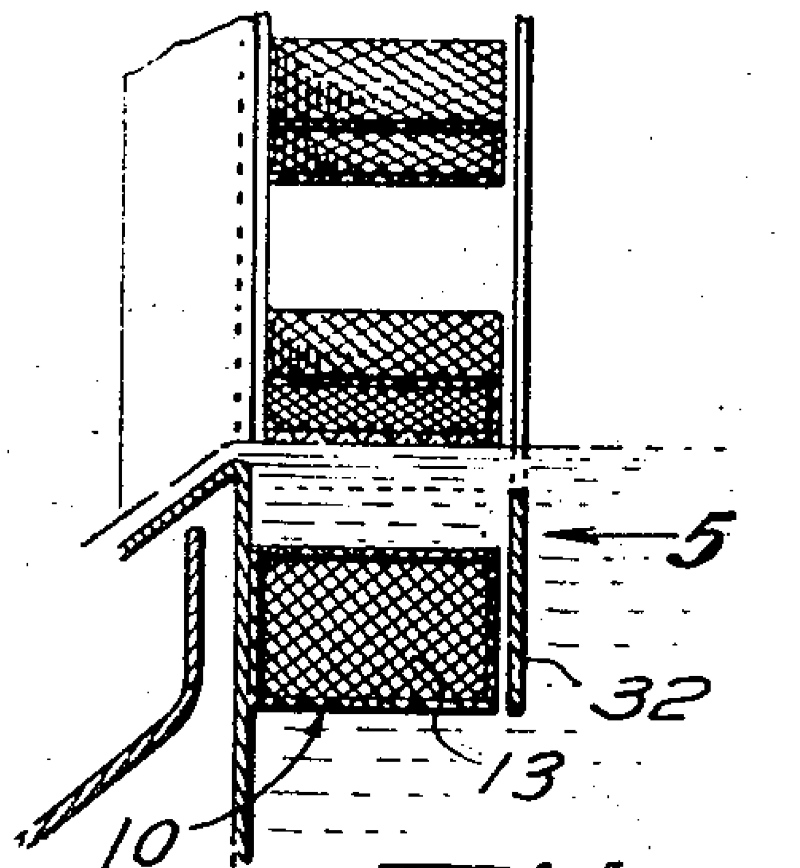


Fig. 4.

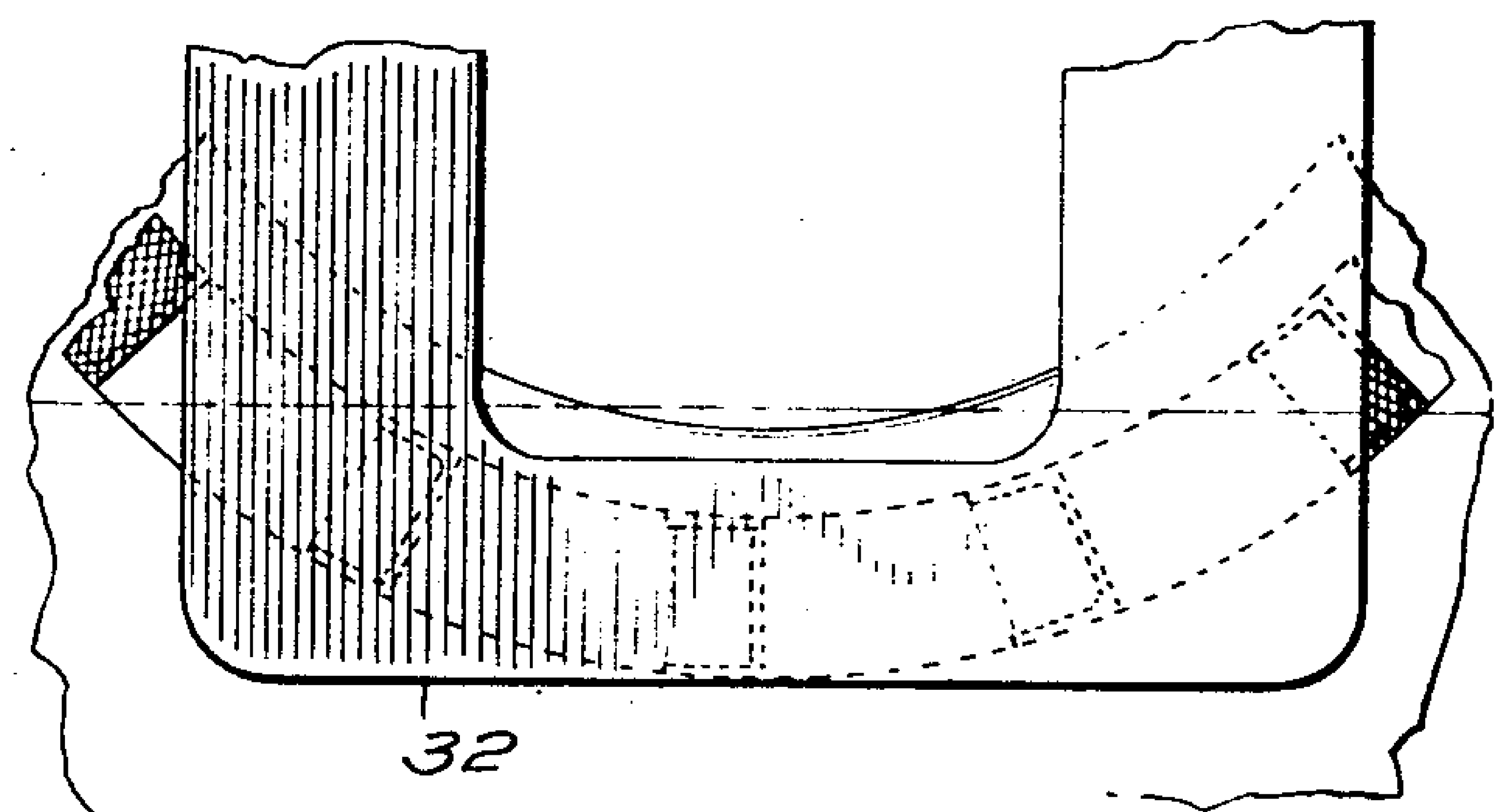


Fig. 5.

Fig. 6.

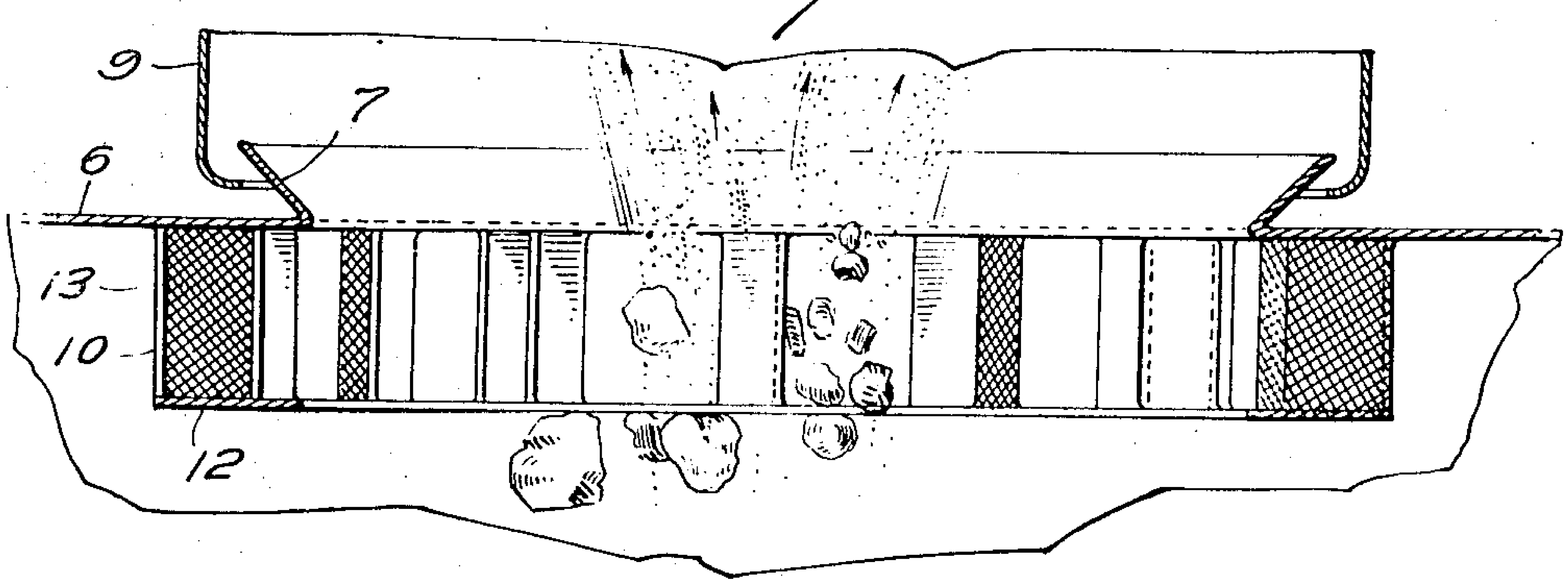
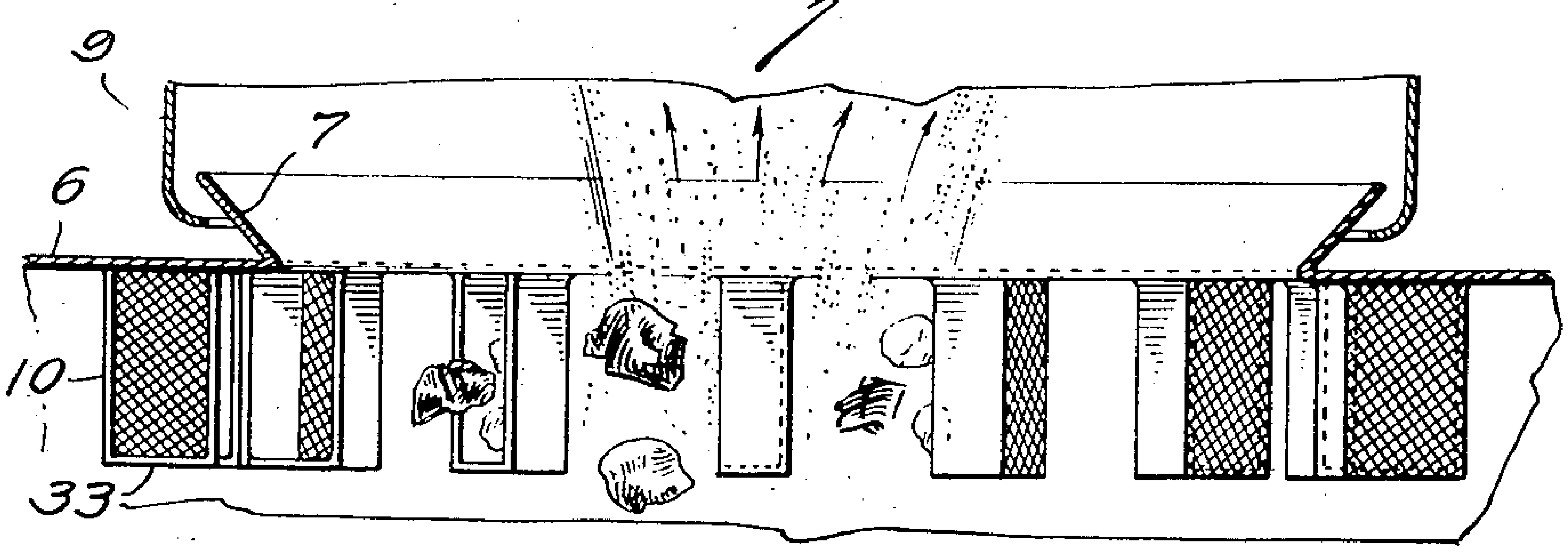


Fig. 7.



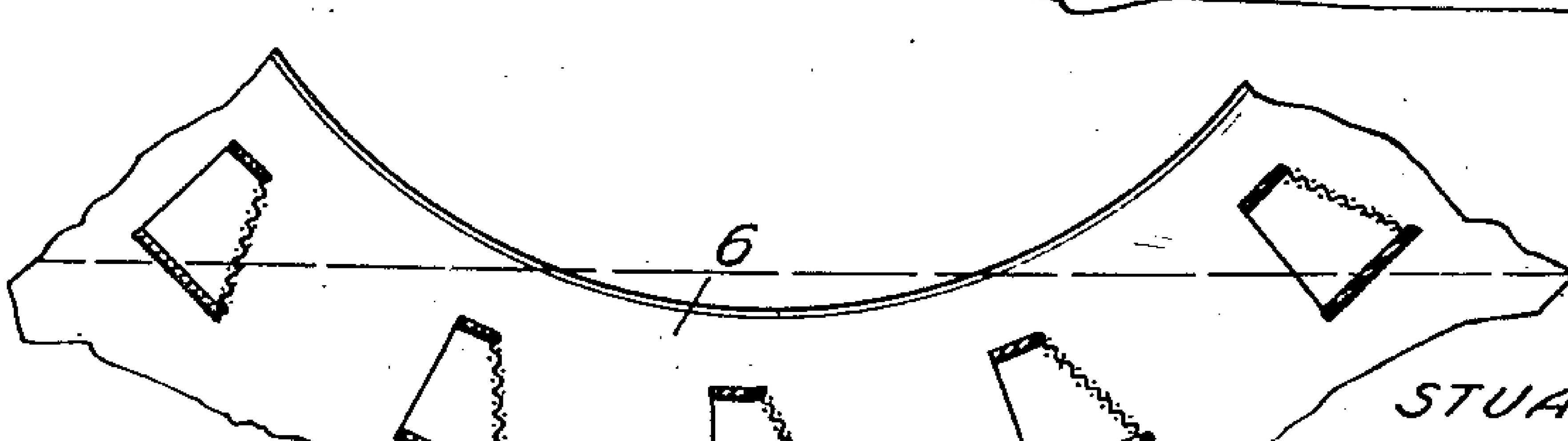


Fig. 8.

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FLOAT REMOVAL DEVICE FOR ROTATABLE TYPE HEAVY-MEDIA SEPARATORS

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5 Claims. (Cl. 209—173)

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This invention is concerned with an improvement in heavy-media separation of solid particles. In particular, this invention is concerned with an improved apparatus and method for handling particle mixtures of materials of different specific gravity, the material of lesser specific gravity having present a preponderance of large pieces.

In recent years, a growing industrial interest has developed in various operations for the separation of solid particles by their differences in specific gravity. In such processes, a mixture of particles having different specific gravities is immersed in a fluid having a density approximating, and usually between, the gravities of the particles to be separated. In the more usual case, where the fluid density is intermediate the specific gravities of the solids to be separated, the particles are separated into a "float" fraction of lesser gravity than the fluid and a "sink" fraction of greater specific gravity than the fluid. The present invention is primarily concerned with such types of operations.

One of the primary requisites of the heavy-media separation is that the size range of the particles to be separated be capable of being handled by the apparatus. Since the particle size which must be treated may vary for numerous reasons, this limitation may be serious in some cases. Either or both gravity fractions may be present over a wide size range and either may be preponderant in quantity. Where the float fraction is comprised of particles varying in size over a wide range, no satisfactory handling method or apparatus has been available. This is true whether the float alone or both fractions contain both fine and large pieces.

The present invention is particularly concerned with the handling of these types of float fractions. Handling of some types of coal are good examples. Slate, which may be present as the lesser fraction, usually constitutes the sink. The float fraction often will contain not only small fines but intermediate sizes up to very large pieces. Some of the latter often exceed 6 inches or more in average diameter, and some may be as large as several feet. There is thus presented a physical problem of actually removing all the differently-sized float fraction material from the apparatus.

In the past, a number of more or less conventional types of heavy-media separatory vessels have been developed. In substantially all of these, the lesser gravity fraction is removed simply by over-flowing the float fraction, together

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with some of the separatory fluid, over a restricted lip or weir. As long as the float fraction comprises relatively small particles, this method of removal presents no serious problem.

However, when this fraction begins to contain large pieces, a number of difficulties arise. In addition to the previously-noted problem of physically removing the large pieces from the vessel, another problem, really an outgrowth thereof, is presented. If sufficient overflow of fluid to carry out the large pieces is utilized, it becomes substantially impossible to maintain practical hydraulic balance within the separatory vessel. Further crushing or grinding to reduce the oversize pieces is not practical as a solution since the resultant product will ordinarily contain an excessive amount of fine.

It is, therefore, the primary object of the present invention to devise a process and apparatus whereby a particles mixture in which the float fraction may contain appreciable amounts of both large pieces and relatively small fines, may be handled efficiently. It is a further object of the invention to provide a process and apparatus which not only permit the handling of feed but also permit maintenance of relatively stable hydraulic conditions in the principal zone of separation within the vessel. A still further object is to provide an apparatus which is easily maintained and is operable over extended periods with minimum attention.

In general, the objects of the present invention have been met by the construction of a relatively simple separatory vessel. The latter comprises a rotary chamber, provision for removing the fine float as one fraction being specially provided together with special handling equipment for removing all the sink as a second fraction and the coarse float as a third fraction. Motivation of the apparatus involves only rotation of the vessel. This is a particular advantage in that no moving parts are necessarily operated within the separatory fluid in which the material being treated is immersed. In this way, there is no problem of abrasion from the particles which may be quite hard.

The invention will be more fully discussed in conjunction with the accompanying diagrammatic drawings, in which:

Figure 1 is a front elevation showing the arrangement of the elements of the present invention within the vessel;

Figure 2 is a vertical elevation partly in section along line 2—2 of Figure 1;

Figure 3 is an enlarged partial section of a portion of Figure 2;

Figure 4 is a vertical section of a modification of Figure 3;

Figure 5 is a front elevation of the modification shown in Figure 4;

Figure 6 is a horizontal view, partly in section, of the modification shown in Figure 3 and, with

Figure 7, which is also a horizontal view, partly in section, of a still different modification of several methods whereby extra large feed is handled; and

Figure 8 is a partial horizontal elevation, partly in section, showing a still further modification.

As will be seen from the drawings, the separatory vessel proper comprises a closed vessel, generically indicated as 1, mounted to rotate about a horizontal axis. This vessel, in general, may be given any cylindrical surface. Preferably, however, as best shown in Figure 2, the outer shell is not a simple cylinder, but is so designed that one section is of definitely larger diameter than the remainder. As shown in Figure 2, this comprises a relatively narrow central cylindrical section 2 on either side of which is a conical section 3 and 4. These, as shown, are essentially conical frustrums. Their larger diameters coincide with the diameter of the cylindrical central section, and the smaller diameters are fitted with annular endplates 5 and 6 respectively.

It will be noted that annular endplate 6 is of larger outer diameter than is endplate 5. The end formed by plate 5 will be designated, for the purpose of this description, as the feed end. The opposite end will be designated as the discharge end. Probably, as best seen in Figure 2, the outer edge of the opening in annular disc 6 is surrounded by a conical flange 7.

Also, as seen from Figures 1 and 2, by this arrangement, when the cylinder is mounted in horizontal operating position and partially filled with the separatory fluid 8, the depth of the latter will reach an overflow level. At this level it will be retained by endplate 5 but will overflow the bottom of the opening in the annular endplate 6. Conical flange 7 leads this overflow to a suitable launder 9. By means of this launder 9, it is conducted to any suitable subsequent operation, which, forming no part of the present invention, is not illustrated.

It will be seen that cylindrical section 2 forms a low point in the separatory fluid. This has the advantage that the sink fraction is more readily collected in a restricted area, i. e., at the low point, and is thereby capable of being more efficiently removed from the apparatus, as will be described below.

Within the separatory vessel 1, surrounding the opening of annular disc 6, is a series of lifter plates 10. Also within the cylindrical section of the vessel is a second set of lifter plates 11. These plates 11 are substantially the same width as the length of cylindrical section 2 and should be equi-distantly spaced completely about this section.

As shown in Figures 1 to 3 and 6, the inner ends of the set of float lifters is a single annular plate 12, the opening in plate 12 being somewhat larger than the opening in plate 6. The fines float which accumulates near the surface of separatory fluid is thus enabled to flow over the opening in plate 12 and out the opening in plate 6. Because a single plate 12 comprises the ends of all of the blades 10, sink material which has not quickly classified and dropped is thus prevented from entering the area from which it can be picked up by the lifter blades 10.

This is probably best shown in Figures 3 and 6, in which it will be seen that the fine float at or near the surface of the fluid is passing out by overflow over the edge of plate 6 down over flange 7 and into launder 9. If the larger float material, as shown by the lighter colored particles, accumulates near the surface, but does not ride as high into the top layers, it is able to pass over the edge of the opening in plate 12 but falls sufficiently so that it cannot be overflowed over the lip of the opening in plate 6. It is, accordingly, picked up and carried forward by the lifter blades 10. As probably best seen in Figure 3, the bottoms of the lifter blades 10 are composed of mesh or screen 13 so that as the blades lift solids it will be possible for at least a part of the liquid carried on the particles to drain directly back within the separatory vessel. Further, at the same time the sink particles which are near the surface of the fluid, shown in Figure 3 as dark particles, are prevented by plate 12 from entering the area in which they can be lifted by the blades or lifters 10.

A downwardly-sloping feed trough 14 extends into the apparatus through the opening in the annular rear wall 5. Trough 14 in turn receives the material from a suitable chute 15 from a conventional feed launder, bin, or the like. Trough 14 is also provided with a suitable conduit 16 which enters the chute just outside the separatory chamber. Separatory medium is introduced into the feed chute through conduit 16 to assist the flow of feed and to pre-wet the particles before they are introduced into the separatory vessel. It has been noted that the opening in the annular endplate 5 is considerably smaller than the opening in the annular endplate 6. The difference in diameter should be such as to prevent any overflow of separatory fluid through the opening in endplate 5.

Mounting of the separatory vessel may be in accordance with any of several conventional methods. One such is shown in the drawings. It will be seen that around the outer periphery of the cylindrical section 2, the cylinder is provided with gear teeth 17, which mesh with and are supported by a suitable pinion 18. The latter is mounted on a suitable shaft 19, and the latter is driven by a suitable gear 20. Gear 20 is in turn powered from some conventional source, which, forming no part of the present invention, is not shown.

As a further support, and to strengthen the separatory vessel, the conical section 4 is surrounded by an annular ring 21. Ring 21 rests upon and is supported by a series of idler rolls 22, which in turn are supported in any conventional manner. As seen in Figure 1, ring gear 17 also rests upon and is supported by a plurality of idler gears 23. Since these do no driving, they may be supported in any conventional manner, which forms no part of the present invention.

Extending into the separatory vessel in an upwardly-slanting direction, is a fan-shaped launder 24. This launder is wide enough at the broader part of the fan to receive any material dropped by lifter plates 10 as they become inverted through rotation of the vessel itself. Launder 24 carries the material, which comprises the coarse float fraction, to a suitable conduit 25, by which the material is conducted to any other subsequent operation.

Immediately above fan-shaped launder 24 is a second and wider fan-shaped launder 26. Launder 26 extends into the vessel sufficiently far, and is sufficiently broad, to receive all the material dropped from the lifter plates 11 as the latter are inverted at the top of their rotary travel. The narrow end of launder 26 conducts this material, which is the sink product, to a suitable conduit 27, by which it too is conducted to some subsequent operation, which is not a part of the present invention. Launder 9, which was previously noted, also connects to a similar conduit 28, whereby the fine float fraction is conducted to any suitable destination as may be desired.

It should be noted that fan-shaped launder 26 should be so located and be of sufficient size so that material dropped from lifter blades 11 cannot be picked up in, or caught by, launder 24. As best seen in Figure 2, launders 9, 24, and 26 are provided with conduits 29, 30, and 31, respectively, by means of which medium may be introduced into the launders. This is done to insure movement of the discharged fraction and to keep the launders clear.

If necessary, these various conduits may be extended into the vessel, through the opening of plate 6, to a point at or near the top of launders 24 and 26.

Operation of the apparatus is believed to be apparent from the foregoing description. Feed to be separated, pre-wet by separatory fluid from conduit 16, is introduced into the separatory fluid within the chamber. The more dense fraction gradually settles to the bottom of the separatory fluid and is accumulated at the low level constituted by the larger diameter cylindrical section 2. Rotation of gear 18 causes rotation of gear 17 and in turn this motivates the cylinder. Rotation of the latter causes movement of both sets of lifter blades raising both the coarse float and the sink fractions up through the fluid to the upper part of the chamber. In the normal progress of rotation of the vessel, both sets of lifter blades become inverted and discharge their contents into the respective launders 24 and 26. From the latter products are taken from the apparatus through conduits 25 and 27.

The less dense fraction which floats to the surface of the separatory liquid and contains the finer particles is differently handled. Floating at or near the upper surface of the separatory fluid, discharge of this fraction may best be seen in Figure 3. The natural tendency of the density differential effect produced by the overflow is to de-water the medium. The upper surface of this overflow will have a density practically that of water and contain little or no solid material. The density, however, builds up very rapidly in successive layers until it has reached about separation density at the level of the overflow lip itself. Fine particles of float which ride in these layers pass out of the chamber over the apron 7 and into launder 9. From there, they pass into conduit 28 and so pass out of the system of the present invention.

It is usually desirable to maintain the fine float and coarse float fractions separately, hence the provision of the separate chutes and launders. However, it may not be either necessary or desirable to do so, and in such case the discharge may be directed into a common chute; i. e., if so desired, launders 9 and 24 may both discharge into a common conduit such as conduit 28. However, since the products are separately collected, it is usually desirable to maintain them separately to simplify subsequent handling. It is an important advantage of the present invention that this can be done. This advantage will seldom be sacrificed.

The illustrated arrangement provides that most of the returned separatory fluid be used to pre-wet the feed, although some is used to aid the discharge of the various products. This is generally found to be a preferable arrangement. If so desired, however, it is perfectly feasible to provide a separate conduit for introducing a part of the fluid directly into the vessel without being used to pre-wet the feed. Similarly, if so desired, additional conduits may be provided entering the chamber through the opening in endplate 5, and extending down into the separatory fluid. This enables introducing separatory fluid of any desired density at different levels within the vessel. Since these latter arrangements actually form no part of the present invention, they have not been illustrated, even though their use has been contemplated.

While the foregoing descriptions have been largely concerned with the particular apparatus elements of specific design, it is obvious that the invention is not necessarily restricted thereto. However, functional equivalents of the various elements are necessary. The exact design or nature of these elements is not critical. For example, different supporting and rotary drive systems may be used. The contour of the separatory vessel itself may be varied, the specific shape, inclination and number of the lifter blades or buckets may be varied. The exact location of the sink lifter blades may be widely varied with design changes.

Functionally, the following elements must pertain. There must be a rotatable conical or cylindrical shell. The shell, to constitute the vessel, must have annular endplates. The central opening of the discharge end must be appreciably larger than the central opening of the feed end. There must be a means for introducing the material to be treated into the vessel. There must be means for introducing separatory fluid into the vessel. There must be a lifting mechanism adapted to raise the sink out of the separatory fluid, and remove the raised sink without admixing it with the float fraction. There must be provision for a continuous fluid overflow to remove the fine float. There must be a lifting mechanism adapted to raise that portion of the float fraction too large to be overflowed with the minimum amount of medium required to remove the fine fraction. There must be means for removing the raised float fraction without its becoming admixed with the sink. So long as these functional elements are present, the process of the present invention may be operated, regardless of the remaining apparatus limitations, such as the specific shape of the launders, delivery chutes, and the like. The arrangement shown in the drawings has been found to be preferable.

As seen in Figures 1 to 3 and 6, the ends of lifter blade 10 are comprised of a single annular ring 12. This is a simple form of construction. As was noted above, some such type of obstruction is necessary to prevent the smaller and more slowly settling sink particles from being carried up and out with the coarser float material. The use of a solid annular plate for this purpose has certain limitations it limits the overflow to the material which will pass over the two arcuate openings, one in plate 12 and the other in plate

6. It may be desirable to provide a larger opening in the inner plate, also it may be desirable to be able to change the size of this opening from time to time without completely rebuilding the vessel. An arrangement for this purpose is shown in Figures 4 and 5.

As shown in Figure 4, the lifter blades need not have a solid end in this form, but the screen or mesh 13 forms not only the bottom but also the sides of the plates. Closely adjacent to the ends of the lifter blades is mounted a U-shaped solid plate 32. This may be readily suspended in any desired manner from the same frame work which supports the fan-shaped launders 24, 26, or their mechanical equivalent. In extent, plate 32 should be of sufficient width and depth to prevent the smaller and lighter of the sink particles from entering the zone in which they can be picked up by the lifter blades. In this manner, a wide but shallow opening, the bottom of which is substantially parallel to the liquid level, can be provided for the passage of the fine float and fluid over the plate. The difference in the effective area of the openings may be seen by comparing Figures 5 and 8

As shown in Figure 6, the use of an annular endplate 12 to form the ends of lifter blades or buckets 10 prevents passage into the zone in which they can be lifted by blades 10 of float fraction particles too large to pass over the arcuate lip of the plate. In such a case, a compromise construction can be utilized. This is best shown in Figure 7. Each of the individual lifter blades or buckets 10 is provided with its own individual endplate 33. In this way particles which are too large to pass over the arcuate lip may pass through the opening between the lifter blades or buckets into the zone from which they can be carried upwardly and out of the fluid by the lifters.

In order to provide more efficient handling, it may also be desirable in some cases to shape or position the lifter blades for the float material somewhat differently. For example, it may be desirable to insure collection of the material taken up by the blades at or near the outer wall. For this purpose, the blades or buckets may be given a slanting bottom. This is shown in Figure 8. Other similar modifications may be readily made.

I claim:

1. A heavy-media separatory apparatus comprising in combination a cylindrical separatory vessel mounted for rotation about a substantially horizontal axis, an annular end plate secured to said vessel at the feed end thereof, means for introducing particles to be separated into said vessel from the feed end thereof, means for introducing separatory fluid into said vessel, a second annular end plate secured to said vessel at the discharge end thereof, the central opening in said second-mentioned annular plate being of appreciably larger diameter than the opening in said first-mentioned plate, the said second-mentioned annular plate being so constructed and arranged that a relatively shallow weir is provided over which a fine float fraction overflows, a plurality of float lifter blades arranged in spaced relation and extending substantially horizontally outwardly from the inner peripheral edge of said second-mentioned annular plate so as to remove from the zone of said weir a coarse float fraction too large in size to overflow said weir, at least the bottom portions of said blades being composed of foraminous material, an annular baffle at the inner ends of said blades, the central opening in said baffle being larger than the opening in said second-mentioned annular plate a plurality of sink lifter blades arranged in spaced relation and extending substantially horizontally outwardly from the inner periphery of said vessel, a first discharge launder positioned adjacent to the discharge end of said vessel to receive said fine float fraction, a second discharge launder extending interiorly of said vessel from the discharge end thereof to receive said coarse float fraction deposited thereon by said first-mentioned set of lifter blades, a third discharge launder extending interiorly of said vessel from the discharge end thereof to receive a sink fraction deposited thereon by said second-mentioned set of lifter blades, and means to rotate said vessel whereby said sink and coarse float fractions are carried forwardly by said sets of lifter blades so as to be deposited on said launders.

2. A heavy-media separatory apparatus comprising in combination a separatory vessel mounted for rotation about a substantially horizontal axis, said vessel being composed of two frustoconical sections joined at their larger diameters to an intermediate section of a diameter that coincides therewith, an annular end plate secured to said vessel at the feed end thereof, means for introducing particles to be separated into said vessel from the feed end thereof, means for introducing separatory fluid into said vessel, a second annular end plate secured to said vessel at the discharge end thereof, the central opening in said second-mentioned annular plate being of appreciably larger diameter than the opening in said first-mentioned plate, the said second-mentioned annular plate being so constructed and arranged that a relatively shallow weir is provided over which a fine float fraction overflows, a plurality of float lifter blades arranged in spaced relation and extending substantially horizontally outwardly from the inner peripheral edge of said second-mentioned annular plate so as to remove from the zone of said weir a coarse float fraction too large in size to overflow said weir, at least the bottom portions of said blades being composed of foraminous material, an annular baffle at the inner ends of said blades, the central opening in said baffle being larger than the opening in said second-mentioned annular plate a plurality of sink lifter blades arranged in spaced relation and extending substantially horizontally outwardly from the inner periphery of said intermediate portion of said vessel, a first discharge launder positioned adjacent to the discharge end of said vessel to receive said fine float fraction, a second discharge launder extending interiorly of said vessel from the discharge end thereof to receive said coarse float fraction deposited thereon by said first-mentioned set of lifter blades, a third discharge launder extending interiorly of said vessel from the discharge end thereof to receive a sink fraction deposited thereon by said second-mentioned set of lifter blades, and means to rotate said vessel whereby said sink and coarse float fractions are carried forwardly by said sets of lifter blades so as to be deposited on said launders.

3. An apparatus according to claim 2 in which said baffle is an annular ring unitarily attached to the inner ends of said float lifter blades and forms pockets therewith.

4. An apparatus according to claim 2 in which said baffle is mounted independently of the rotatable elements of said combination.

5. An apparatus according to claim 2 in which

each of said float lifter blades comprises a five-sided, open-top box, at least the bottom of which is of screen material, the openings in which are sufficiently small to retain fine particles but sufficiently large to pass media solids.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
Re. 16,674	Chance	July 12, 1927
29,837	White	Aug. 28, 1860
1,095,071	Beer	Apr. 28, 1914
1,958,309	Lockett	May 8, 1934
2,150,946	Smith	Mar. 21, 1939
2,479,141	Smith	Aug. 16, 1949
2,482,747	Davis et al.	Sept. 27, 1949

FOREIGN PATENTS

Number	Country	Date
176,370	Great Britain	of 1923
21,601 of 1935	Australia	Mar. 1, 1935