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ANNULAR HORIZONTAL CURRENT GRAVITY LIQUID CLASSIFIER

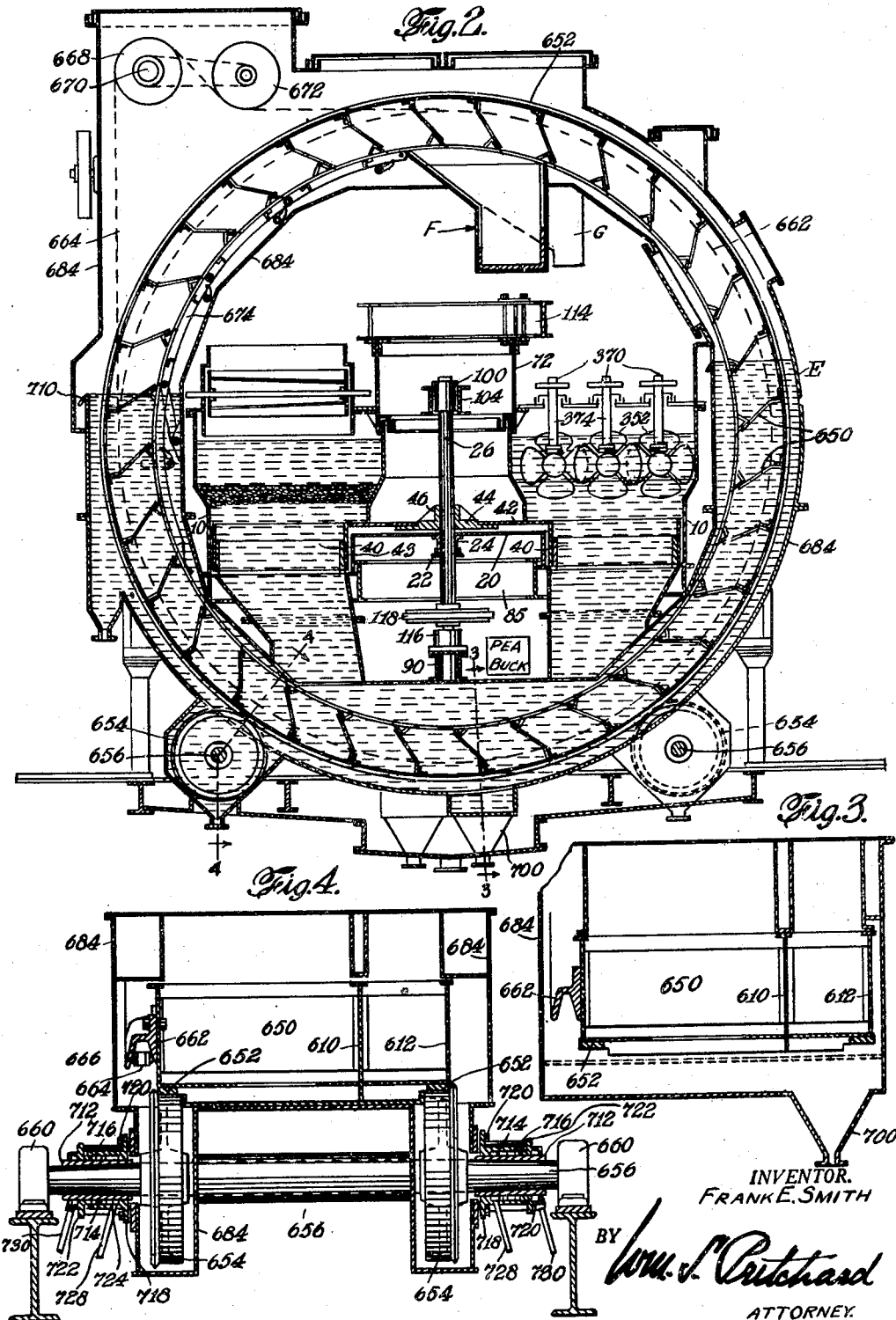
11 Sheets-Sheet 1



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Aug. 16, 1949.

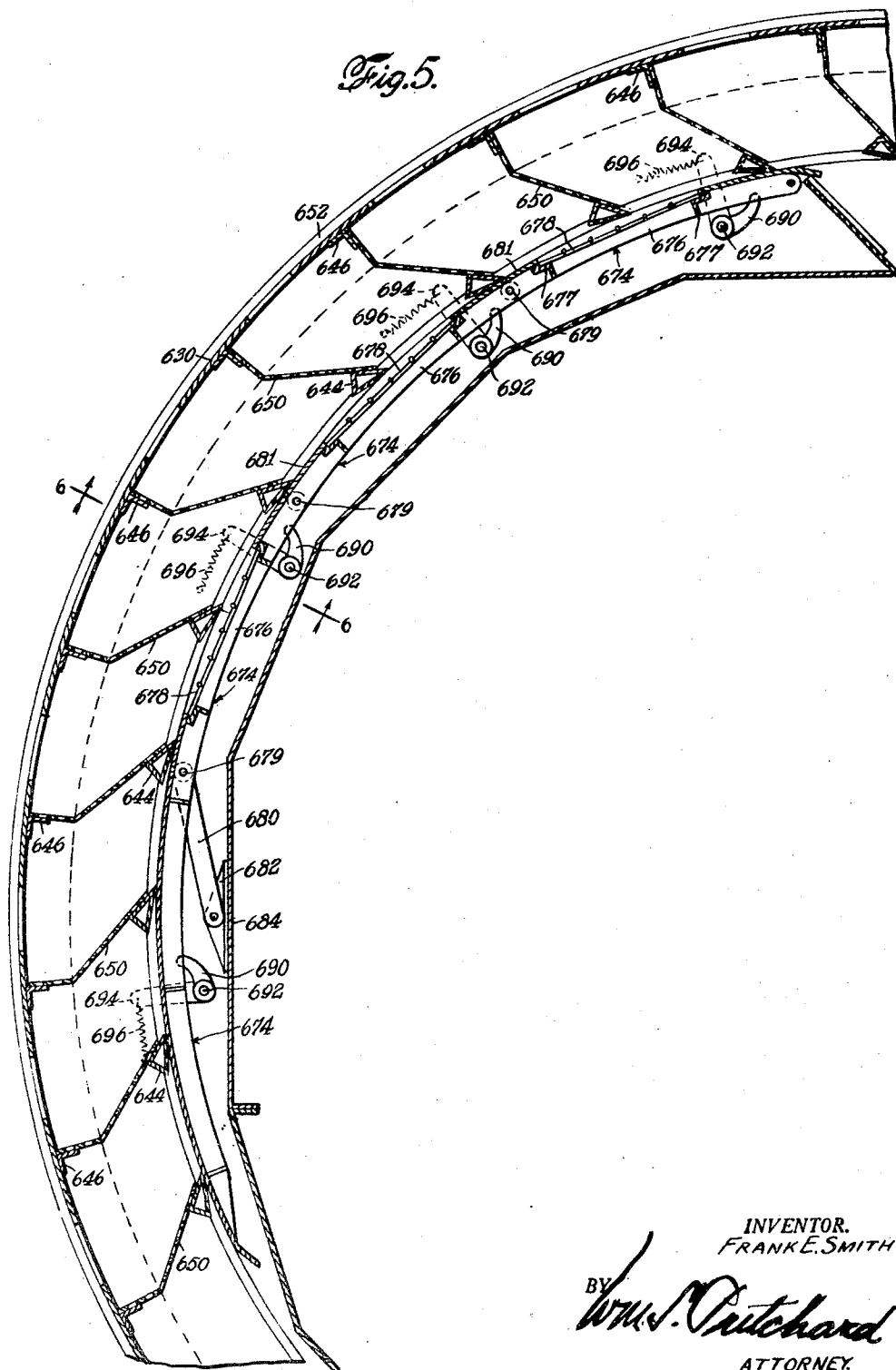
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11 Sheets-Sheet 3



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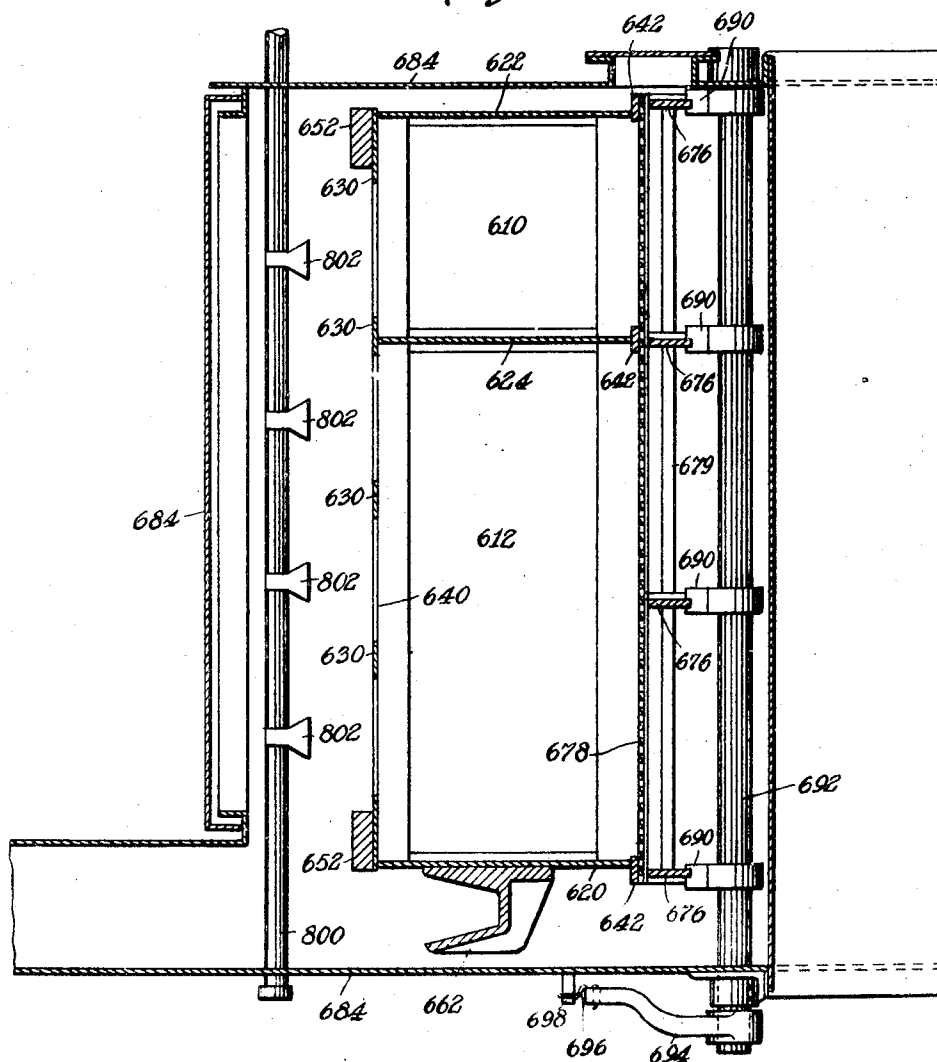
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Fig. 6



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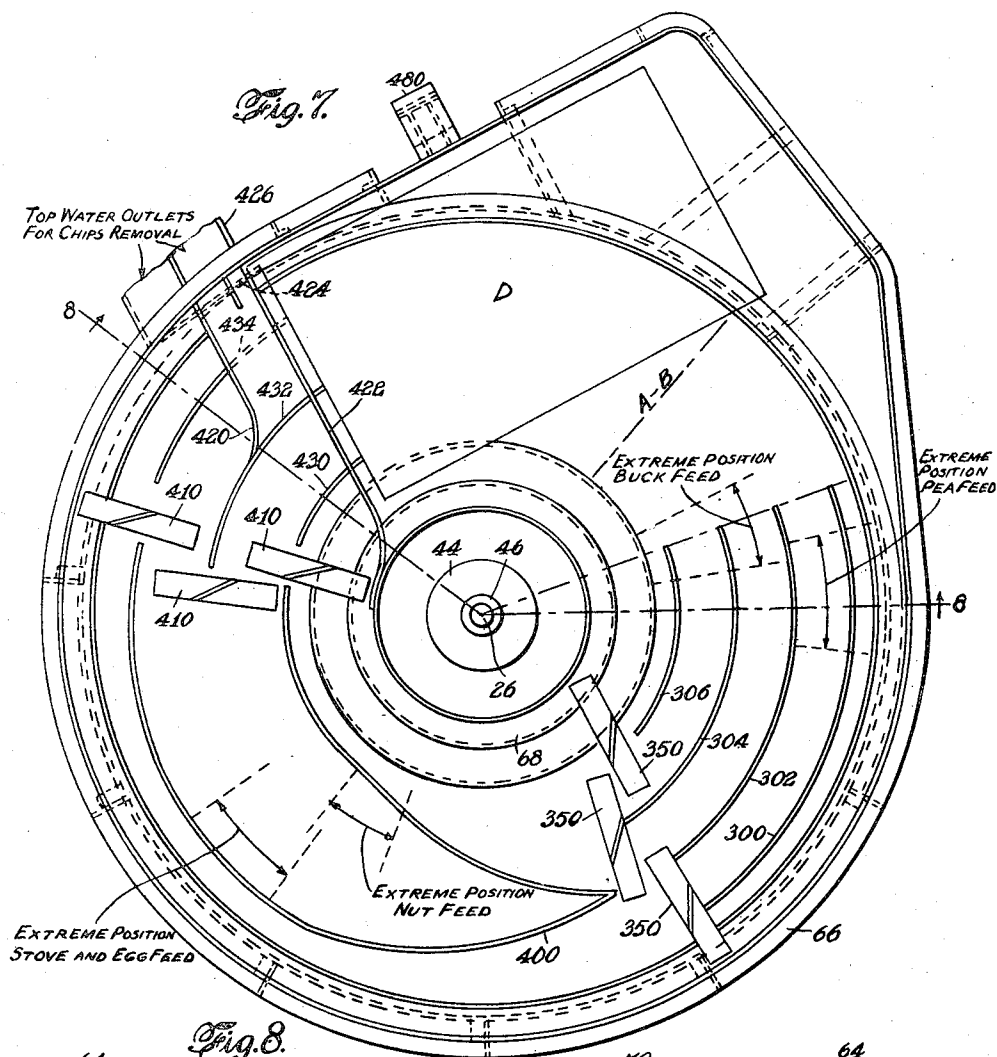
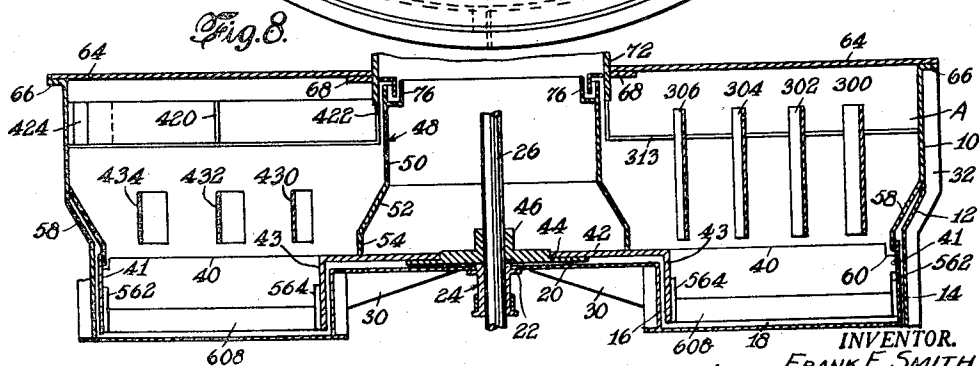
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11 Sheets-Sheet 5



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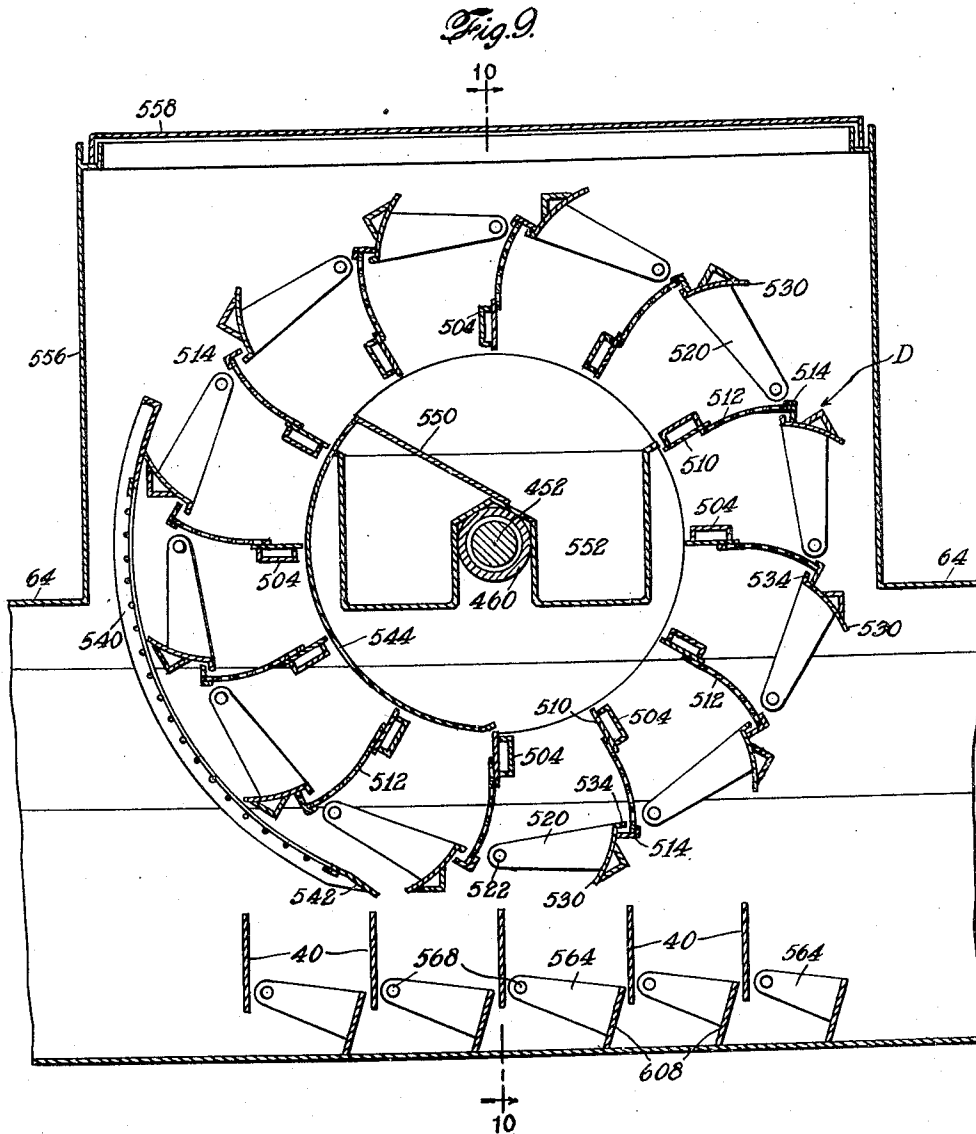
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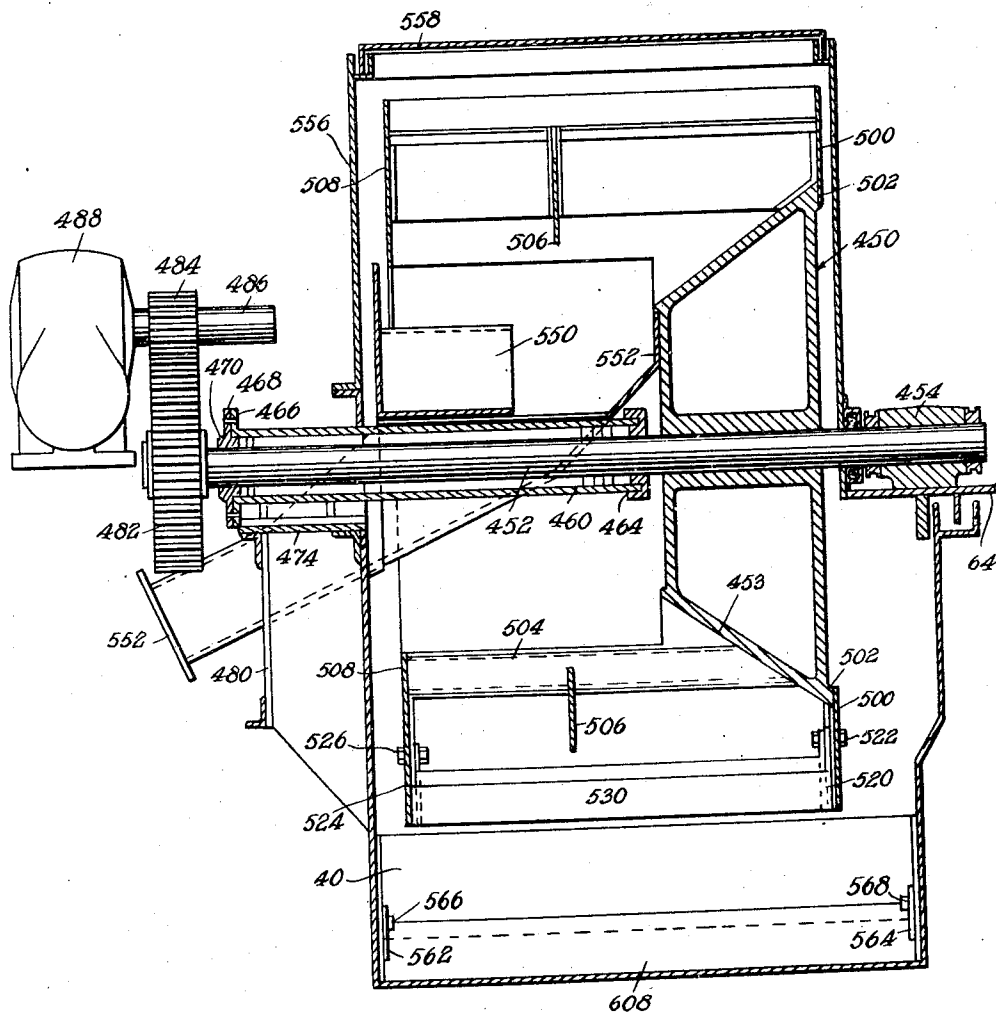
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Fig. 10.



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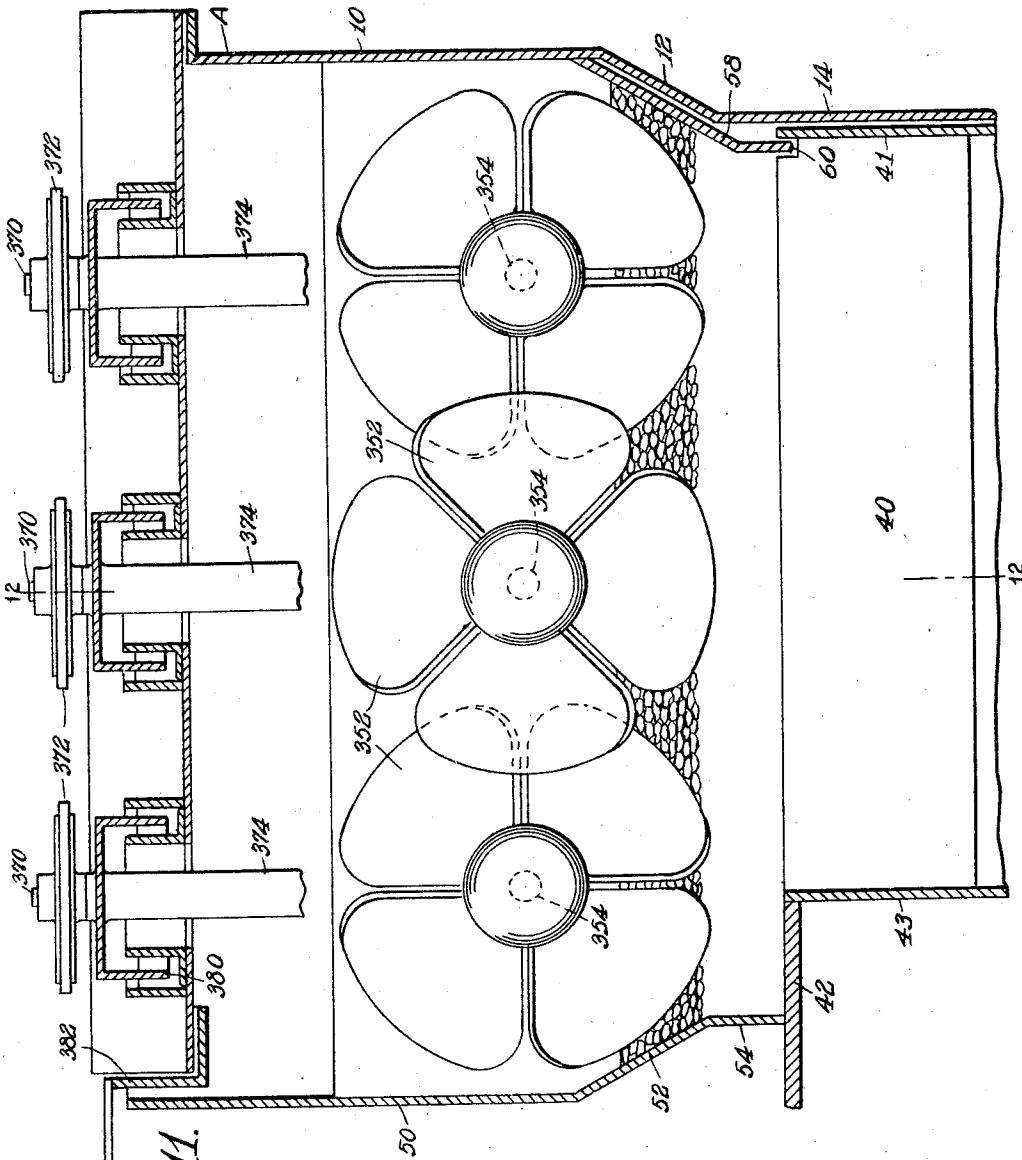
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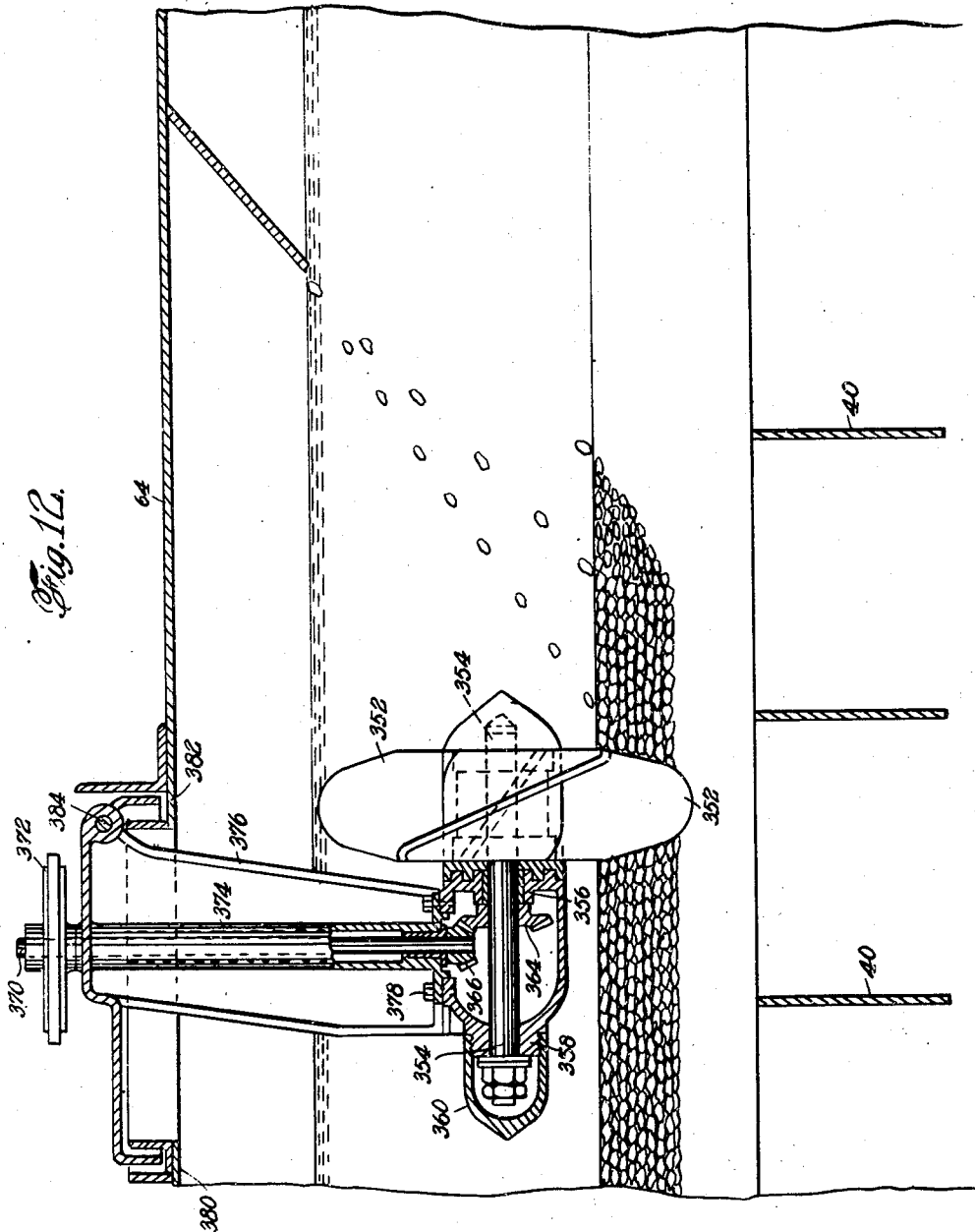
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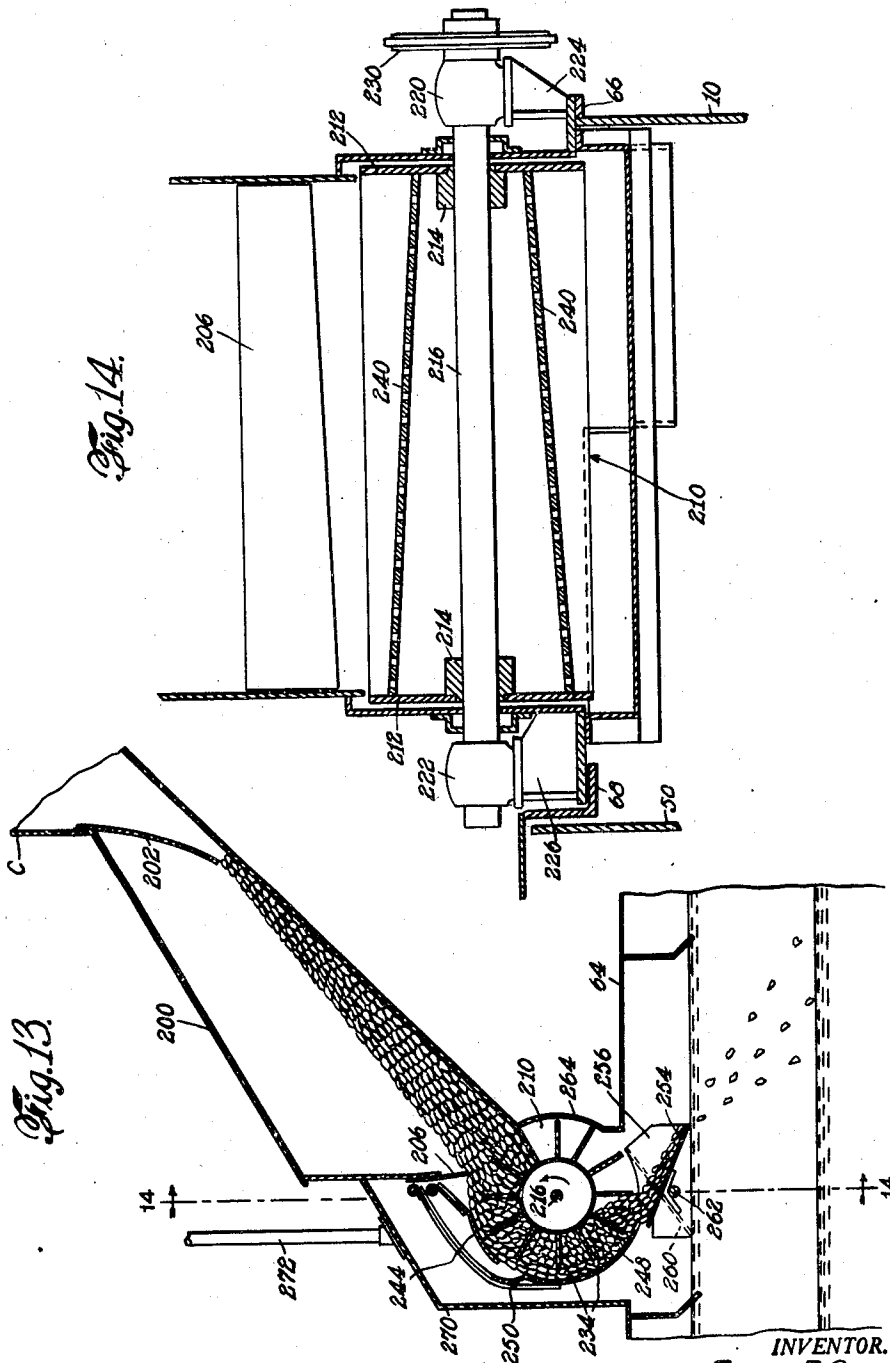
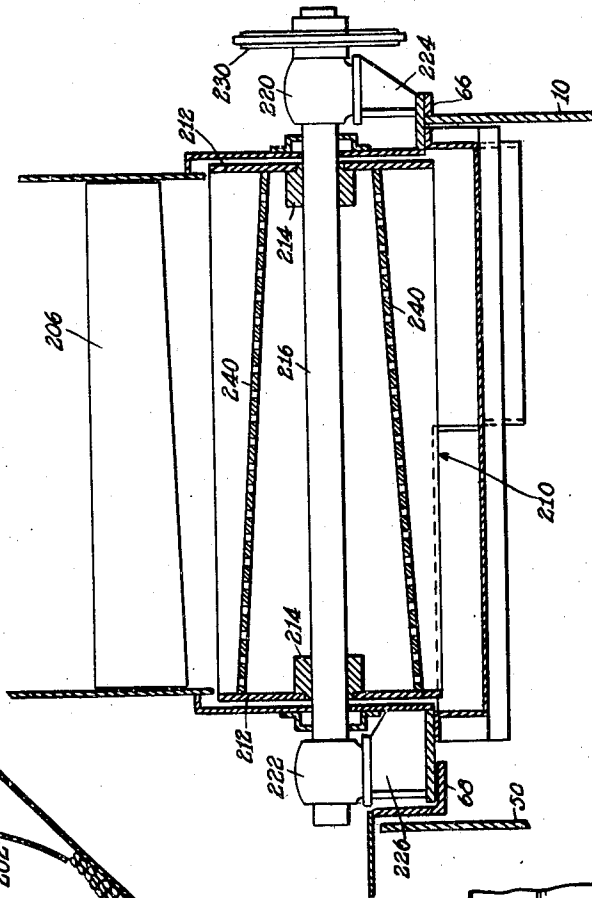
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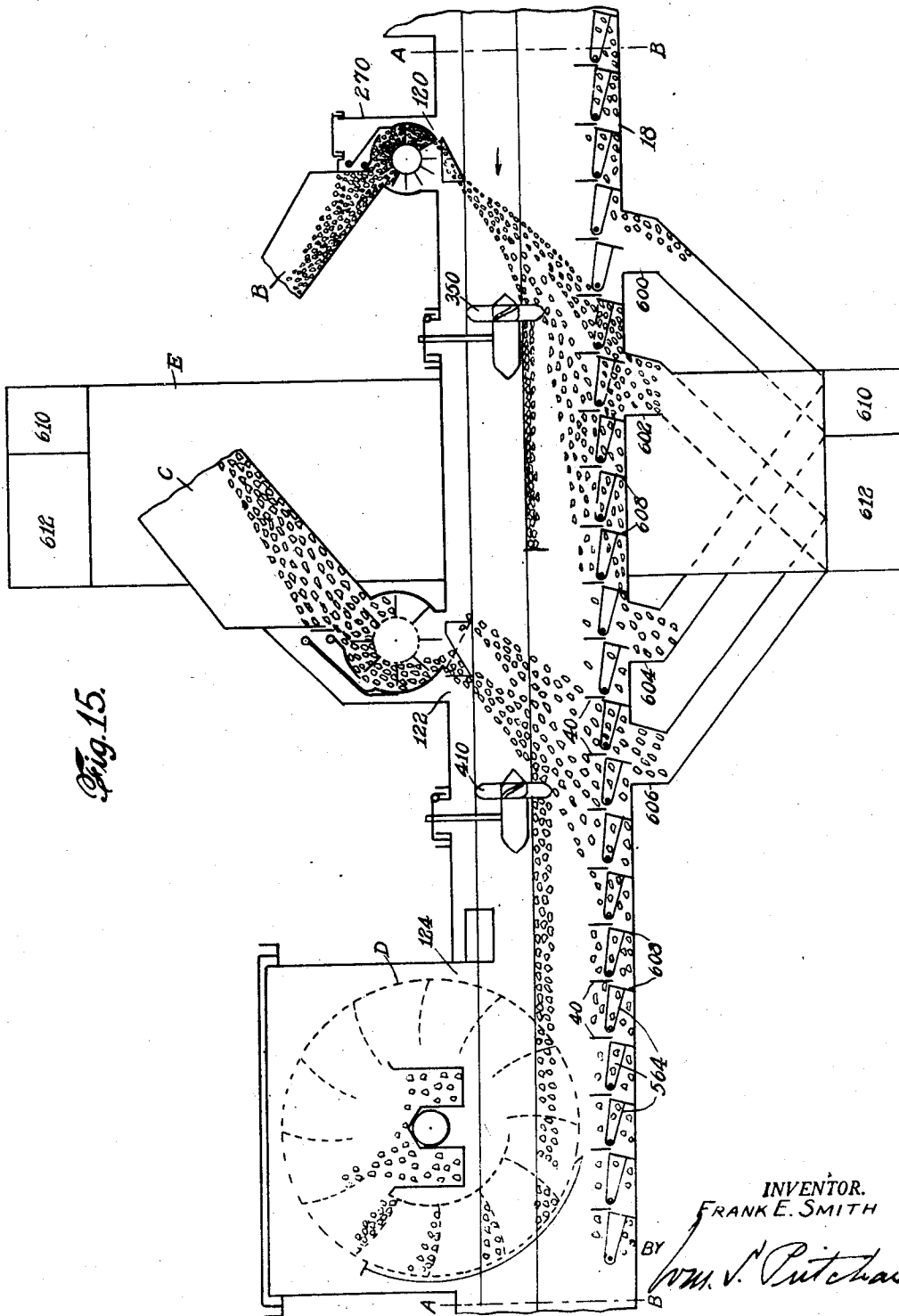
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UNITED STATES PATENT OFFICE

2,479,141

ANNULAR HORIZONTAL CURRENT GRAVITY
LIQUID CLASSIFIERFrank E. Smith, Niagara Falls, N. Y., assignor to
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Application June 29, 1945, Serial No. 602,318

8 Claims. (Cl. 209—172)

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This invention relates to the separation of solids of different specific gravities by the use of a liquid of intermediate specific gravity. More particularly, it relates to a 3-part separation of such solids.

United States Patent No. 2,150,899 discloses a procedure wherein a mineral composed of solids of different specific gravities, such as coal and its impurities, is separated into sinks and floats by means of a separating medium. United States Patent No. 2,150,946 discloses a procedure to effect a further separation in the mineral that sinks, and is based on the difference in falling velocity of sink material wherein a particle with a specific gravity close to the specific gravity of the liquid or medium will fall very slowly and a particle of a specific gravity appreciably greater than the specific gravity of the liquid or medium will fall faster.

According to the procedure disclosed in United States Patent No. 2,150,946, the materials to be separated are subjected to the horizontal classifying action of a moving stream of light liquid, such as water, and thereafter subjecting the so-classified materials to the vertical classifying action of a moving stream of liquid of specific gravity intermediate the specific gravities of the materials to be separated, the moving liquids being utilized for the transportation of the separated solids.

An object of this invention is to provide a new and improved method for the separation of solids of different specific gravities.

Another object of this invention is to provide a method for the separation of solids of different specific gravities by horizontal classification in a liquid of intermediate specific gravity.

An additional object of this invention is to provide a new and improved apparatus for separation of solids of different specific gravities by currents of a liquid of intermediate specific gravity.

A further object of this invention is to provide new and improved means for creating currents in the liquid of intermediate specific gravity.

A still further object of this invention is to provide new and improved means for positively transporting the separations of the sink material.

A still further object of this invention is to provide new and improved means for removing each of the separations respectively.

A still further object of this invention is to provide an apparatus in which a plurality of feeds or feeds of different sizes can be fed at different points whereby it is possible to utilize the full area of the separator for classification.

Other and additional objects will become apparent hereinafter.

The objects of the invention are accomplished, in general, by subjecting the material, composed

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of solids of different specific gravities to be separated, to the horizontal classification of a stream of a liquid of a specific gravity intermediate the specific gravities of the particles to be separated (hereinafter called "parting liquid") in a circular trough in which there is located a de-rafter for breaking up the bed and releasing trapped sinks, a rotating zoner, and devices for feeding the separated sinks to respective outlets in the bottom of the trough through which they fall into bucket compartments of a revolving elevator wheel. By varying the speed of the zoner, the horizontal movement of the liquid can be varied to give a change in the apparent cut between the light and heavy sinks. The wheel is divided into two sets of compartments to receive the two different fractions of the sinks. By rotation of the wheel, the material in the respective buckets is carried to where it is discharged by gravity. A perforated cover cooperates with the buckets of the elevator wheel to permit drainage therefrom and retain the particles in the buckets during the up run to the point of discharge. The cover is supported so that it will adjust itself due to irregularities or out-of-round of the wheel. The floats, due to the moving stream of parting liquid, are transported to a place where a rotating take-out wheel dips below the float bed and carries it out of the liquid to a place of discharge. Partitions divide the float take-out wheel into compartments and means are provided to retain the floats in the respective compartments during the up run of the float take-out wheel until discharge.

Since the trough is circular, the outside of the separator has a greater speed and area and, therefore, can accommodate more material than on the inside. Hence, as will hereafter appear, since the feeder should give a uniform rate the full width of the separator trough, the feeder is provided with tapered compartments.

As will hereafter appear, the invention contemplates feeds at different points whereby the full area of the separator can be used for classification. Though the apparatus is capable of use with only a parting liquid, it is also capable of use with a stream of water superimposed thereon. When a stream of water is employed, the de-rafter also aids in providing a current therein.

The nature and details of the apparatus will become apparent from the following description when taken in conjunction with the drawings, wherein:

Figure 1 is a central vertical section of the separator and including the float take-out wheel and the middling and refuse elevators;

Figure 2 is a section on line 2—2 of Figure 1;

Figure 3 is a section on line 3—3 of Figure 2;

Figure 4 is a section on line 4—4 of Figure 2;

Figure 5 is an enlarged fragmental view of the elevator wheel showing the perforated cover;

Figure 6 is a section on line 6—6 of Figure 5;

Figure 7 is a plan view showing details of the tank, partitions and zoner;

Figure 8 is a section on line 8—8 of Figure 7;

Figure 9 is a section on line 9—9 of Figure 1;

Figure 10 is a section on line 10—10 of Figure 9;

Figure 11 is an enlarged vertical sectional view showing the mounting of kickers in the trough;

Figure 12 is a section on line 12—12 of Figure 11;

Figure 13 is a vertical section of one of the feed chutes;

Figure 14 is a section on line 14—14 of Figure 13; and

Figure 15 is a linear development on line A—B of Figure 7, showing the details and functions of the separator.

Referring now to the drawings wherein like reference characters and numerals designate like parts, the reference character A designates an annular separator to which the materials to be separated are fed from the hoppers B and C. As will hereafter become apparent, the material fed to the separator A is carried around and is separated into floats, middlings and refuse. The floats are removed by a float take-out wheel D, and the middlings and refuse are discharged from the separator into respective compartments of a middling and refuse rotating elevator E, which conveys such materials to a position where the contents of the respective buckets are discharged by gravity into chutes F and G respectively.

For reasons which will become apparent hereinafter, the joints of the separator A are made vapor-proof by water seals, and the float take-out wheel D and the middling and refuse elevator E are provided with casings in which the joints are made vapor-proof by water seals.

The separator A comprises a stationary shell having an outer peripheral side wall which decreases in diameter in a direction from the top to the bottom. As shown in Figures 1 and 8, the peripheral side wall of the separator shell comprises three integral sections 10, 12 and 14, the section 10 being of the greatest diameter and the section 14 being of the smallest diameter. The section 12, which connects sections 10 and 14, is inclined inwardly. The separator shell also has a short inner peripheral wall 16, and an annular plate 18 is secured to the lower end of the section 14 of the outer peripheral wall and to the lower end 16 of the inner peripheral wall. A circular plate 20 is secured to the top ends of the inner peripheral wall 16. The circular plate is provided with an aperture whereby it is seated on a flange 22 of a stuffing box 24 on a vertical shaft 26. The stationary separator shell is also provided with stiffening members 30 and 32.

As is shown in Figures 1 and 8, the inner peripheral wall 16 is of a height which is less than the height of section 14 of the outer peripheral wall and, together with the bottom plate 18, forms an annular trough. A plurality of zoners 40 are disposed in spaced relationship with respect to each other throughout the trough. Each zoner is integrally formed with a ring 42 which is secured on a flange 44 of a hub 46 secured to the shaft 26, whereby rotation of the shaft will impart rotation to the zoners in the trough. The bottom of each zoner terminates in spaced relationship to the bottom plate 18, the outer end 41 terminates in spaced relationship to section 14 of the outer peripheral wall of the shell, and the

inner edge 43 of the zoner terminates in spaced relationship to the inner wall 16 of the shell.

In order to confine the liquids and to make the separator A annular throughout its entire height, a drum 48 is rigidly secured to the ring 42. The shape of the peripheral wall of the drum 48 is complementary to the outer peripheral wall of the shell. As shown in Figure 8, the drum 48 increases in diameter in a direction from the top to the bottom and is formed in three integral sections 50, 52 and 54. The top section 50 is of smaller diameter than the bottom section 54, and the intermediate section 52 which unites section 50 and section 54 tapers outwardly in a downward direction.

From the foregoing description, it is apparent that the peripheral wall of the drum 48 cooperates with the outer peripheral wall of the shell, and particularly with sections 10, 12 and a portion of 14 thereof, to form an annular tank.

Upon rotation of the shaft 26, the zoners will be rotated and, since the drum 48 is secured to the zoners, it too will rotate.

For reasons which will become apparent, baffles 58 which serve as wearing plates and guide the sinks into the field of action of the zoners are provided. Each baffle 58 is secured to section 10 and is in spaced relationship with respect to section 12 of the peripheral wall. Each zoner 40 is provided with a notch 60 to permit clearance between it and the baffles 58.

The separator A is provided with a cover 64 which is seated at its outer peripheral edge on a peripheral flange 66 at the top of section 10 of the outer peripheral wall of the shell. The inner peripheral portion of the cover 64 is seated on a circular flange 68 carried by a ring 72. The ring 72 forms vapor-proof joints 76 with the rotating drum 48.

Referring now to Figure 1, the separator A is carried on radially extending I-beams 80, the respective outer ends of which are carried by columns 82 positioned on the floor 83 of the building and supported by I-beams 84. The inner ends 45 of the beams 80 are secured to an I-beam 85 which is carried on a column 86 carried on I-beams 84. A beam 90 is carried at one end thereof on a cross beam 92 and at the other end by a column 94 supported by a second beam 84.

As shown in Figure 1, the upper end of the shaft 26 is journaled in a bearing 100 whose flange is supported on a spider 102 mounted within the ring 72. The ring 72 is suspended from beams 112 and 114 of a supporting structure not shown. The lower end of the shaft 26 is rotatably mounted in a bearing 116 carried by the beam 90. A sprocket 118 secured to the shaft 26 and driven from any suitable source of power drives the shaft 26.

As is shown in Figure 15, the cover 64 is provided with feed inlets 120 and 122 and also with an opening 124 in which the float take-out wheel D is positioned.

As previously explained, two feeds are supplied to the separator A. In the form shown, one size of coal is supplied to the hopper B, and the same or a different size to the hopper C. Since the details of construction of each of the feeders associated with hoppers B and C are substantially the same, only one thereof will be described in detail.

Referring now to Figures 13 and 14, egg, stove and nut coal, after being supplied to the hopper C, passes into a chute 200. An apron 202 made of flexible material is secured at its top end to

the top of the chute at its feed end. This apron serves to prevent escape of vapors from the chute 200. If desired, a hinged plate can be used in place of the flexible apron. At the delivery end, the chute 200 is provided with an adjustable gate 206 which regulates the quantity of material delivered from the chute to a rotating feed wheel 210. The feed wheel 210 comprises a pair of end flanges 212, each of which is respectively secured to a hub 214 secured to a shaft 216. The shaft 216 is carried in bearings 220 and 222 adjacent the opposite ends thereof. The bearing 220 is carried on a support 224, and the bearing 222 is carried on a support 226. The shaft is provided with a sprocket 230 which is driven from a suitable source of power. The bearing support 224 is carried on the flange 66 of the separator. The bearing support 226 is carried on the circular flange 68 of the ring 72.

Since the separator is circular in form, the outside thereof has a greater speed and area and more material can be fed thereto than on the inner side thereof. In order to provide for a uniform feed across the entire width of the separator, the feed wheel 210 is provided with a plurality of compartments 234, the bottom 240 of each compartment being tapered whereby a gradually decreasing quantity of coal will be supplied to the separator from the outer to the inner periphery thereof. The bottoms 240 are also perforated to permit expulsion of air and permit the maximum supply to each compartment. A curved spring-pressed steel plate 244 serves to maintain the supply of coal delivered from the chute 200 to the feed wheel during the upper portion of its travel. A steel plate 248, of a shape complementary to the outer periphery of the wheel, is positioned adjacent the down run of the feed wheel and serves to prevent the coal from being discharged until the point of discharge is reached. The plate 248 is secured to a spring 250 which serves to maintain the plate 248 in position.

At the point of discharge from the feed wheel 210, there is provided a guide plate 254 having side walls 256 whereby the discharged material will be directed into the separator. The plate 254 is carried on a supporting member 260 which is pivoted, at 262, so that, if desired, the plate 254 may be shifted by movement of the support 260 on its pivot 262 whereby the coal may be discharged to the left instead of to the right, as shown in Figure 13. The bottom of the chute 200 is provided with a curved member 264 and it terminates on the cover 64 of the separator.

A housing 270 surrounds the feed wheel and it is provided with a vent 272 for the escape of air.

The pea and buck feeder is substantially of the same construction as that of the egg, stove and nut feeder except that it is smaller in size and in place of a vent a vapor seal is provided in the housing 270.

In the separator, as will hereafter be more fully explained, there is provided a layer of heavy liquid and a layer of water thereon. The rotation of the zoners 40 imparts currents to these liquids. In order to give uniform flow and prevent eddies, a plurality of parting liquid and water guide plates 300, 302, 304 and 306 are hung from a strap 310 carried by the cover 64. As shown in Figure 7, these guides, which extend through the water layer and into the parting liquid to a depth sufficient to clear the zoners, are curved and concentric whereby they will offer no impedance to and will direct the circular move-

ment of the currents. As also shown in Figure 7, the rear end of each of these parting liquid and water guide plates is positioned below the fine size feeding and their respective forward ends terminate in advance of kickers 350 arranged in staggered relationship.

Referring now to Figures 11 and 12, each kicker comprises a plurality of blades 352 secured on a shaft 354 which is journaled at 356 and 358 in a gear housing 360. A beveled gear 364 is secured to the shaft 354 and meshes with a gear 366 carried at the lower end of a vertical shaft 370. The shaft 370 is provided with a sprocket 372 and is driven from a suitable source of power. The vertical shaft 370 extends through a sleeve 374 formed on a support 376 which, at its lower end, is secured by means of bolts 378 to the gear housing 360. The support at the top thereof forms vapor-proof seals 380 and 382 with the cover 64. The casting 376 is mounted on a pin 384 carried on the cover 64. Upon removal of the pin, the support 376 may be elevated whereby access may be had to the kicker or the kicker and appurtenant structure removed.

The blades 352 of the kickers 350 extend through the water into the parting liquid and serve to open up the bed to release trapped material and also, since they are submerged in the water layer, to maintain uniform current therein.

Upon feeding the coal into the separator from the hopper B, the coal will fan out substantially as shown to the right in Figure 15. The light gravity material will float on the top of the parting liquid, and the middlings, since they have a falling velocity less than the refuse, will be conveyed by the currents and deposited on the bottom of the separator in spaced relationship with respect to the heavy sinks. In order to present a clean surface of the parting liquid for the egg, stove and nut feed, there is provided a plow 400 (see Figure 7), the forward point of which is just ahead of the kickers 350. The plow 400 (see Figure 8) is hung from the cover and lies beneath the surface of the water and on the parting liquid so that it will divert the material floating on the parting liquid, below the overlying water, to both sides to provide a clean space for the feed. Three kickers 410, of the identical construction as the kickers 350, are positioned in staggered relationship beyond the second feeder. Some impurities, such as wood chips and the like, float on the surface of the water layer. Beyond the plow 400, water guide plates 420 and 422, which are hung from the cover, extend just below the surface of the water and direct the material floating on the water to a weir 424, from which the floating materials overflow into a top water outlet 426. It is to be noted that the guide plates 422 extend substantially over the entire width of the separator and that the plate 420 is curved so that it will direct the chips and other material floating on the water to the outlet 426.

As shown in Figure 7, in advance of the kickers 410 there are provided concentric parting liquid guide plates 430, 432 and 434. These guide plates are hung from the cover by straps (not shown).

After the removal of the chips and other materials from the surface of the moving stream of water, continuous movement of the parting liquid conveys the floats thereon in position for removal by the float take-out wheel D.

Referring now to Figures 9 and 10, the float take-out wheel D comprises a frusto-conical casting 450 which is secured on a shaft 452 so that the peripheral wall 453 thereof tapers inwardly.

One end of the shaft 452 is journaled in a bearing 454 supported on the cover 64. As shown in Figure 10, the shaft 452 extends through a long sleeve 460, the inner end of which is provided with a stuffing box 464. The outer end of the sleeve 460 is provided with a flange 466 which is secured in any appropriate manner to the flange 468 of a stuffing box 470. The sleeve 460, which constitutes a long bearing, is supported on a shelf 474 supported by a frame, generally indicated by the reference numeral 480 (see Figures 7 and 10). A gear 482 is secured to the outer end of the shaft 482 and it is driven by a gear 484 mounted on the shaft 486 of the motor 488. A ring 500 is secured along its inner periphery to the frusto-conical casting 450, as at 502. A plurality of channels 504 are arranged in spaced relationship about the shaft 452. Each channel 504 has the inner end thereof secured, as by welding, to the tapered peripheral surface 453 of the frusto-conical casting 450. A stiffening ring 506, secured to the channels 504 intermediate the ends thereof, serves to reinforce the channels. A ring 508 is secured at its inner periphery to the outer ends of the channels 504.

As shown in Figure 9, each channel 504 carries a supporting plate 510 to which one end of a perforated plate 512 is attached. Each plate 512 extends outwardly and at its outer end it carries a stop member 514. The perforated plates 512 extend between the rings 500 and 508 and thereby form compartments.

A link 520 is pivotally mounted on a stud 522 in the ring 500. A similar link 524 is pivotally mounted on a stud 526 on the ring 508. A scoop 530 is carried at the lower ends of the links 520 and 524.

The scoop 530 is provided with a stiffening element 532 which forms a beveled edge at the free end of the scoop. For reasons which will become apparent, the scoop 530 is provided adjacent its rear edge with a bar 534 which is adapted to cooperate with the stop member 514.

As shown in Figure 9, each perforated plate 512 is provided with a cooperating scoop 530. Each scoop is so designed that it will, upon rotation of the float take-out wheel in the same direction as the currents, enter the bed of floats in a direction perpendicular thereto and pass therebeneath. Each scoop, upon continued rotation of the wheel, will direct the floats picked up thereby to the perforated plate 512 cooperating therewith. The perforated plates 512 can be made of a size so that they too can pass beneath the float bed to a greater or lesser degree. Since the scoops and plates 512 pass through the water layer, the floats are washed thereby and the liquids drain through the perforations in the plates. In general, the compartments formed by the perforated plates 512 and end rings 500 and 508 are open at the top and bottom thereof. As shown in Figure 9, a perforated shield 540 is provided adjacent the outer periphery of the take-out wheel along the up run of the wheel to prevent the floats from flowing out of the compartments. A guide 542 at the lower end of the shield serves to direct the scoops onto the shield 540. A fixed plate 544 cooperates with the opposite side and prevents the floats from passing therefrom during the up run of the wheel until the point of discharge. It is to be noted that during the rotation of the take-out wheel the stop 514 cooperates with the bar 534 to limit movement of the scoops 530 whenever this becomes necessary.

The floats, removed by a scoop 530 and coop-

erating perforated plate 512, are carried up to a point where they are discharged onto an inclined plate 550 which directs the floats to a chute 552 which transports the floats to the position for the next operation to be performed thereon. It is to be noted that the chute plate 550 is formed integral with the plate 544 and that any floats discharged on the inclined wall 453 of the casting 450 will be fed therefrom to the chute 552. During the up run, due to the construction of the plates 512 and the shield 540, the water will drain back into the separator. As previously mentioned, the float take-out wheel is mounted in a housing 556 provided with vapor-proof joints 558.

In the separator A, provision is made to separately remove the sink fraction. The water and parting liquid in the annular separator are moving at a fixed speed to the left as viewed in Figure 15. When the feed strikes the parting liquid, the floats are separated from the sinks. The sinks, falling at various speeds, are separated into light and heavy sinks. Since they are moving horizontally at a fixed rate, this material is separated into the fan shape shown in Figure 15 and horizontally classified. By placing an outlet in the separator for the heavy sinks at an established distance from the feed point, depending on the specific gravity of the sinks and the speed of the currents, all of these heavy sinks can be made to drop out of such outlet. The light sinks or middlings are carried forward to another outlet provided in the trough.

In one embodiment of the invention, each zoner 40 is provided adjacent its bottom with a yieldable scraper 608 which is designed to move the sinks, particularly those on the bottom 18 of the separator A, to the respective outlets. In the form shown in Figures 1, 2, 8, 9, 10 and 15, each scraper 608 is secured to the ends of a pair of spaced arms 562 and 564. Arm 562 is pivotally mounted on a pin 566 carried by the outer end member 41 of the zoner 40, and arm 564 is pivotally mounted on a pin 568 carried by the inner end member 43 of the zoner 40.

As shown in Figure 15, the annular bottom plate 18 of the trough is provided with outlets 600, 602, 604 and 606. Assuming that pea and buck coal is fed through hopper B, the heavy sinks thereof will be discharged through the outlet 602 and the middlings thereof will be discharged through the outlet 604. Assuming also that egg, stove and nut coal is fed from the hopper C, the heavy sinks thereof will be discharged through the outlet 606 and the middlings thereof will be discharged through the outlet 600.

To each of the outlets, there is connected a chute and, as shown in Figure 15, the chutes which are connected to outlets 600 and 604 feed the separated middlings to a bucket 610 of the elevator E. The heavy sinks which pass from the separator through outlets 602 and 606 are conducted by chutes to a bucket 612 of the elevator E.

As shown by Figure 2, the elevator E is, in general, in the form of a wheel and, as shown by Figures 3, 4 and 6, the wheel is divided into refuse buckets 612 and middling buckets 610.

As is shown in Figures 3, 4 and 6, the elevator E is provided with side rings 620 and 622. An imperforated partition 624 extending through the wheel divides it into the middling and refuse compartments 610 and 612. The outer periphery of the wheel is provided with a plurality of rings 630 to which is secured a metallic screen 640. The inner periphery of the wheel is open

and constitutes the entrance side through which the material is fed from the chutes. For reasons which will become apparent, the inner periphery of the wheel is provided with a plurality of rings 642 which, in the form shown, are carried by the end pieces 620 and 622 and the partition 624 respectively. Partitions 650, formed of a perforated material, divide the wheel transversely to form the respective compartments. As shown in Figure 5, one end of the partition 650 is secured to a shoe 644 extending transversely of the wheel, and the other end is secured to an angle 646 secured to the rings 630.

The elevator wheel E is provided on its outer periphery with a pair of rails 652, one at each side thereof. The rails 652 are adapted to ride on flanged wheels 654 secured to a shaft 656, the end of which is rotatably mounted in a bearing 660.

The outer ring 620 is provided with a sheave 662 which cooperates with a chain 664 having shoes 666 thereon. The chain 664, as shown in Figure 2, passes around a sprocket 668 mounted on a shaft 670, which is driven from any suitable source of power. A counterweighted idler 672 (see Figure 2) maintains the chain taut. As is shown in the drawings, four wheels 654 are provided and the elevator E rests thereon.

The middlings and refuse are discharged into the respective buckets of the wheel, as previously described. As shown in Figure 1, the refuse in the compartment 612 is discharged in the refuse chute F, which conducts the refuse to a suitable place for disposal. At the same time, the middlings in the bucket 610 are discharged into the chute G, which feeds them to a place for further treatment as may be necessary.

During the up run of the elevator wheel, after the respective buckets thereof have received the middlings and sinks from the separator, means are provided to retain the materials in the buckets until the point of discharge. Referring now to Figures 5 and 6, there is provided a yieldable frame formed in four sections 674. Each section comprises four spaced links 676, each having secured near the ends thereof angles 677 on which a wedge wire screen 678 is secured. A pair of smooth plates 681 are secured between the angles 677 of adjacent sections. The links 676 of adjacent sections are hingedly mounted on a hinge shaft 679. It is to be noted that opposed ends 683 of the plates 681 are slightly spaced above the hinge shaft 679. This construction provides a smooth surface over which the material in the buckets rides. A pair of arms 680, each of which has its upper end pivotally secured to the hinge shaft 679, between the first and second section and the other end pivotally secured to a lug 682 on the casing 684, surrounds the inner periphery of the elevator wheel and positions the frame so that the screen 678 is in contact with the stiffening rings 642. Each link 676 is seated in a recess of a pawl 690. As shown in Figure 6, each group of pawls 690 cooperating with one section is mounted on a shaft 692. An arm 694 has one end thereof secured to the shaft 692, and a spring 696 yieldingly secures the other end of the arm 694 to a pin 698 carried by the casing. Due to the tension of the spring, the shaft is urged in such a direction that the pawls which engage the swinging frame sections urge them toward the inner periphery of the wheel. Since the swinging frame is made in sections, it is apparent that the pawls of each section independent of the others will tend to maintain contact between the screen

678 and the stiffening members 642 on the inner periphery of the elevator wheel and that movement of any of the sections will not necessarily effect any movement of the other section. The means terminate, as shown in Figure 5, at the point where it is desired to begin the discharge of the contents of the bucket.

As previously mentioned, the elevator is provided with the casing 684 which is appropriately secured to the supporting structure and all joints therein are of the sealed type. At the bottom the casing is provided with wells 700 for the reception of any extraneous material and to permit removal of the liquid from the separator when it is desired to clean the machine.

Parting liquid and water, if used, are introduced into the separator in any convenient manner to the desired levels. The casing 684 of the elevator E will be filled with parting liquid to a level lower than that at which it is in the separator because of a greater depth of water in the elevator. The level of the parting liquid in the separator is maintained by separator overflow 702, as shown in Figure 1. The separator overflow 702 is connected at the bottom thereof by means of a conduit 704 to the interior of the elevator casing 684. The overflow 702 is provided with any liquid level control means, such as, for example, a weir, and the overflow is fed from the overflow 702 through the outlet 706 to any suitable storage supply. The separator has a water layer, the upper level of which is maintained by the chip weir overflow 426. The elevator also has a layer of water, and the level thereof is maintained by the overflow weir 710 (see Figure 2).

To prevent leakage of parting liquid from the elevator casing 684, and particularly where the shafts 656 extend therethrough, each shaft 656 is provided with a stuffing box adjacent the side of the casing 684 through which the shaft 656 extends. As shown in Figure 4, the stuffing box is provided with a wearing sleeve 712 positioned on the shaft. Packing 714 is disposed in a packing housing 716. A flange 718 is secured by bolts 720 to the elevator casing 684. A packing gland 722 cooperating with the packing housing 716 maintains the packing 714 in position. The packing housing 716 and the packing gland 722 are provided with annular passages 724 and 726 respectively. Passage 724 is connected to one end of a pipe 728 through which water under a slight pressure is supplied. Passage 726 is connected to one end of a pipe 730 through which water under a slight pressure is supplied. Obviously, when water under slight pressure fills the passages 724 and 726, water rings are formed which inhibit any parting liquid from passing from the casing 684, and if there be any leakage, water from the water rings will pass into the casing where it will rise to the top of the parting liquid.

Though the invention has been described in connection with the use of both a water stream and a parting liquid stream wherein the desired horizontal classification is obtained, the former may be omitted and only a parting liquid used. In either embodiment, the parting liquid can be any of those disclosed in United States Patent 2,150,899. In place of the usual organic heavy liquids, other media can be used as parting liquids, namely, suspensions of finely divided material such as water suspensions of sand, magnetite, ferro-silicon, clay, and the like. Also, aqueous solutions of salts such as calcium chloride, zinc chloride, lead sulfamate, and the like

can be used as parting liquids. When aqueous suspensions or solutions are used as parting liquids, the machine of course will be operated with a single liquid level. It is generally preferred to utilize water-immiscible heavy liquid as parting liquid covered with a layer of water, but the other types indicated above can be used in practicing the invention.

The velocity of the currents can be controlled by the rate of rotation of the zoners and kickers. In general, the speed of the take-out wheel is the same as the speed of the currents and rotates in the same direction as the flow of the currents.

The feed wheels are not restricted to the construction herein described. Each feed wheel can be made to supply two or more different sizes by forming the compartments thereof into bins by appropriate partitions.

Both the buckets of the float take-out wheel and the elevator wheel in their up travel pass through the water layer, whereby the materials carried by them will be washed. In order to more completely wash the materials, a water spray may be provided. In Figure 6, there is shown an embodiment wherein water is fed from a suitable source of supply to a manifold 800 from which sprays 802 deliver it to the buckets passing thereby.

The present invention provides a continuous three-part separation of solids of different specific gravities by the use of a parting liquid which is caused to circulate in a circular trough and to which a plurality of feeds are simultaneously fed, and each of the separations, i. e. floats, middlings and sinks, are separately removed from the separator and respectively delivered to stations for such further treatment as necessary.

Through the use of an annular trough, horizontal currents can be obtained without removing the liquids from the machine and recirculating them by large pumps, pipes, weirs, etc. The location of the outlets from the trough at certain distances from the points of feed permits obtaining a true three-part separation. The horizontal movement of the liquid is controlled by the speed of rotation of the zoners. Thus, by varying the speed of rotation of the zoners, the horizontal movement of the liquid can be regulated to give a change in the apparent cut between the light and heavy sinks. The use of a plurality of feeds at different points utilizes the full area of liquids for classification. The means for removing the separated material does not remove the liquids from the apparatus. The removal devices are such as to permit the liquids to drain therefrom as the devices leave the liquids. In addition to the foregoing, the apparatus is simple to construct and easy to operate.

Since it is obvious that many changes and modifications can be made in the above-described details without departing from the nature and spirit of the invention, it is to be understood that the invention is not to be limited thereto except as set forth in the appended claims.

I claim:

1. In an apparatus for classifying a mineral mass containing solids of different specific gravities, a horizontally disposed annular trough containing a parting liquid having a specific gravity intermediate the specific gravities of said solids, means to move said parting liquid in a circular path in said trough with sufficient velocity to produce a horizontal classifying effect in said mineral mass and make a three part separation, and means to feed a substantially uniform

amount of said mineral mass across substantially the entire width of the moving annular stream of parting liquid, said feeding means comprising a rotating feed wheel having a plurality of transversely extending compartments around the periphery thereof, each compartment being tapered whereby a decreasing amount of said mineral mass will be supplied to the annular parting liquid from the outer to the inner periphery thereof.

2. In an apparatus for classifying a mineral mass containing solids of different specific gravities, a horizontally disposed annular trough containing a parting liquid having a specific gravity intermediate the specific gravities of said solids, means to move said parting liquid in a circular path in said trough with sufficient velocity to produce a horizontal classifying effect in said mineral mass, a plurality of spaced feeds disposed above said trough to supply said mineral mass simultaneously at spaced positions in the circular path of travel of the moving annular stream of parting liquid, and a plow positioned in cooperative relationship with the surface of said parting liquid to divert the floats thereon whereby a clean surface will be presented to the feed.

3. In an apparatus for classifying a mineral mass containing solids of different specific gravities, a horizontally disposed annular trough containing a parting liquid having a specific gravity intermediate the specific gravities of said solids, means to move said parting liquid in a circular path in said trough with sufficient velocity to produce a horizontal classifying effect in said mineral mass, means to feed said mineral mass to the moving annular stream of parting liquid, and a float take-out wheel spaced from the feed and in the path of travel of said parting liquid, said float take-out wheel comprising a shaft, means to rotate said shaft in the direction of travel of the parting liquid, a plurality of compartments, each compartment being separated from the adjacent compartment by a perforated plate, means securing said plates to said shaft, and a scoop disposed in cooperative relationship with the outer end of each perforated plate, each of said scoops being of such a design that it will, upon rotation of the float take-out wheel, enter the bed of floats in a direction perpendicular thereto and pass therebeneath and, upon continued rotation, will direct the floats picked up thereby to the perforated plate cooperating therewith.

4. In an apparatus for classifying a mineral mass containing solids of different specific gravities, a horizontally disposed annular trough containing a parting liquid having a specific gravity intermediate the specific gravities of said solids, means to move said parting liquid in a circular path in said trough with sufficient velocity to produce a horizontal classifying effect in said mineral mass, means to feed said mineral mass to the moving annular stream of parting liquid, and a float take-out wheel spaced from the feed and in the path of travel of said parting liquid, said float take-out wheel comprising a shaft, means to rotate said shaft in the direction of travel of the parting liquid, a plurality of compartments, each compartment being separated from the adjacent compartment by a perforated plate, means securing said plates to said shaft, means pivotally mounting a scoop in cooperative relationship with each perforated plate, each of said scoops being of such a design that it will, upon rotation of the float take-out wheel, enter the bed of floats in a direction perpendicular thereto and pass therebeneath and, upon continued rotation, will direct

the floats picked up thereby to the perforated plate cooperating therewith, and cooperating means on each of said scoops and the perforated plate adjacent thereto to limit the movement of said scoop.

5. In an apparatus for classifying a mineral mass containing solids of different specific gravities, a horizontally disposed annular trough containing a parting liquid having a specific gravity intermediate the specific gravities of said solids, means to move said parting liquid in a circular path in said trough with sufficient velocity to produce a horizontal classifying effect in said mineral mass, means to feed said mineral mass to the moving annular stream of parting liquid, and a float take-out wheel spaced from the feed and in the path of travel of said parting liquid, said float take-out wheel comprising a shaft, means to rotate said shaft in the direction of of travel of the parting liquid, a plurality of compartments open at the top and bottom thereof, each compartment being separated from the adjacent compartment by a perforated plate, means securing said plates to said shaft, a scoop disposed in cooperative relationship with each perforated plate, each of said scoops being of such a design that it will, upon rotation of the float take-out wheel, enter the bed of floats in a direction perpendicular thereto and pass therebeneath and, upon continued rotation, will direct the floats picked up thereby to the perforated plate cooperating therewith, and means cooperating with the compartments to retain the floats therein during the up run of said wheel to the point of discharge.

6. In an apparatus for classifying a mineral mass containing solids of different specific gravities, a horizontally disposed annular trough containing a parting liquid having a specific gravity intermediate the specific gravities of said solids, means to move said parting liquid in a circular path in said trough with sufficient velocity to produce a horizontal classifying effect in said mineral mass, means to feed said mineral mass to the moving annular stream of parting liquid, and a float take-out wheel spaced from the feed and in the path of travel of said parting liquid, said float take-out wheel comprising a shaft, means to rotate said shaft in the direction of travel of the parting liquid, a plurality of compartments open at the top and bottom thereof, each compartment being separated from the adjacent compartment by a perforated plate, means securing said plates to said shaft, a scoop disposed in cooperative relationship with each perforated plate, each of said scoops being of such a design that it will, upon rotation of the float take-out wheel, enter the bed of floats in a direction perpendicular thereto and pass therebeneath and, upon continued rotation, will direct the floats picked up thereby to the perforated plate cooperating therewith, means cooperating with the compartments to retain the floats therein during the up run of said wheel to the point of discharge, and a chute to receive the floats discharged by gravity from said compartments.

7. In an apparatus for classifying a mineral mass containing solids of different specific gravities, a horizontally disposed annular trough containing a parting liquid having a specific gravity intermediate the specific gravities of said solids, means to move said parting liquid in a circular path in said trough with sufficient velocity to

produce a horizontal classifying effect in said mineral mass, means to feed said mineral mass to the moving annular stream of parting liquid, means to remove the floats on said parting liquid, means for feeding the separated sinks to respective outlets in the bottom of said trough through which the sinks are removed, an elevator wheel having a plurality of compartments to receive the sinks and convey them to a position where said sinks will be discharged therefrom by gravity, means to direct the separated sinks falling through said outlets in accordance with the specific gravity thereof to respective compartments of said elevator wheel, and yieldable means cooperating with the inner periphery of the elevator wheel to maintain said sinks in the respective compartments during the up run of said elevator wheel to the point of discharge, said yieldable means comprising a frame formed of a plurality of independently yieldable sections.

8. In an apparatus for classifying a mineral mass containing solids of different specific gravities, a horizontally disposed annular trough containing a parting liquid having a specific gravity intermediate the specific gravities of said solids, means to move said parting liquid in a circular path in said trough with sufficient velocity to produce a horizontal classifying effect in said mineral mass, means to feed said mineral mass to the moving annular stream of parting liquid, means to remove the floats on said parting liquid, means for feeding the separated sinks to respective outlets in the bottom of said trough through which the sinks are removed, an elevator wheel having a plurality of compartments to receive the sinks and convey them to a position where said sinks will be discharged therefrom by gravity, means to direct the separated sinks falling through said outlets in accordance with the specific gravity thereof to respective compartments of said elevator wheel, and yieldable means cooperating with the outer periphery of the elevator wheel to maintain said sinks in the respective compartments during the up run of said elevator wheel to the point of discharge, said yieldable means comprising a frame formed of a plurality of independently yieldable sections, each section comprising a plurality of spaced links having a screen secured thereto, and means to yieldingly urge said section in contact with the inner periphery of said elevator wheel.

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