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CENTRIFUGAL SEPARATOR AND METHOD OF OPERATING THE SAME

Filed April 9, 1951

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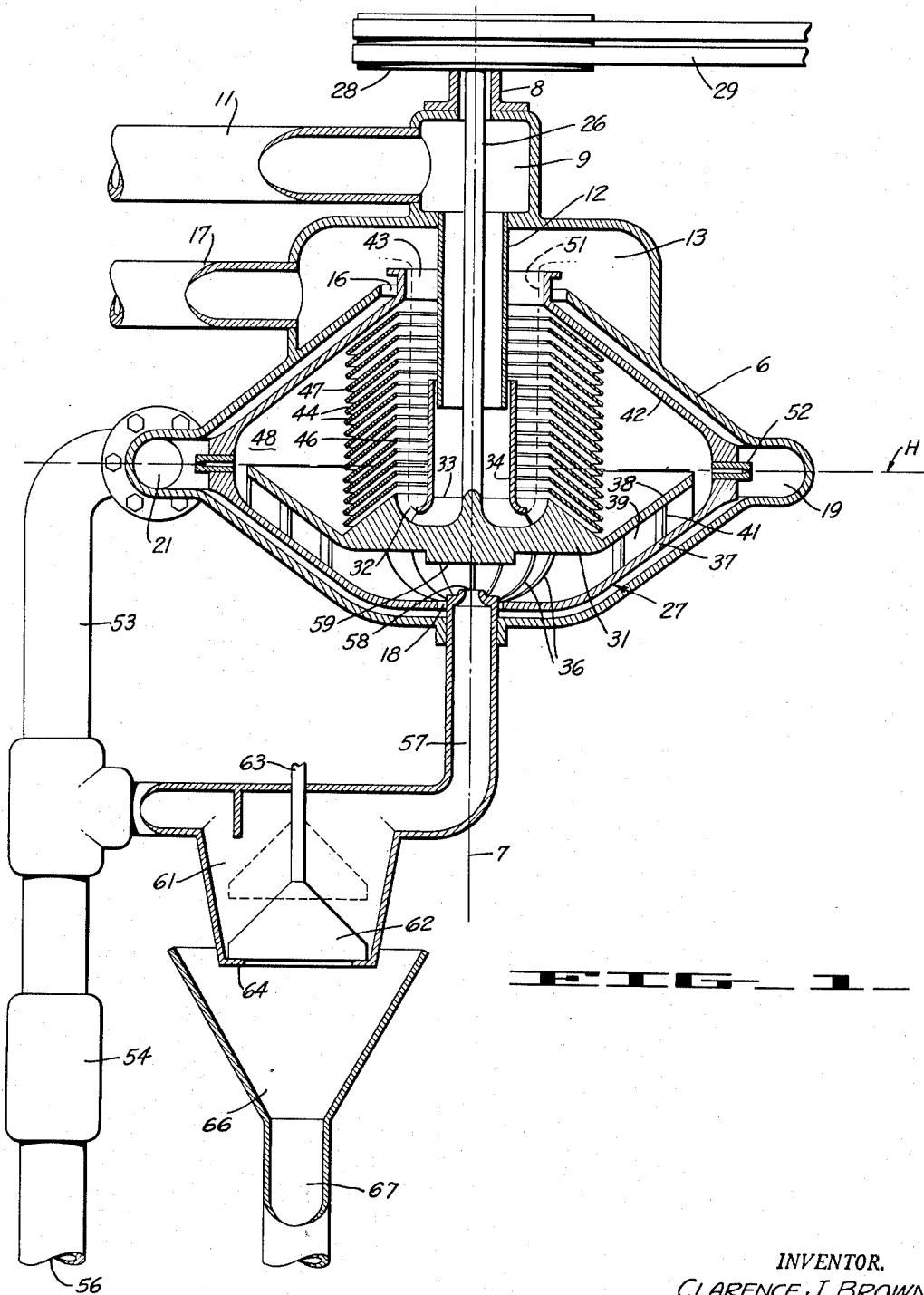


FIG. 1

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2 Sheets-Sheet 2

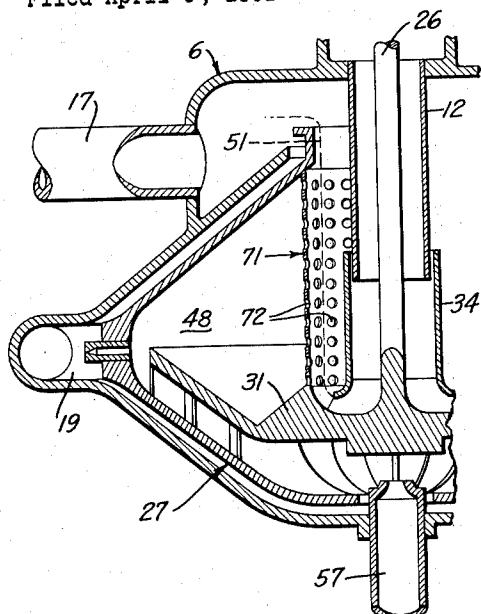
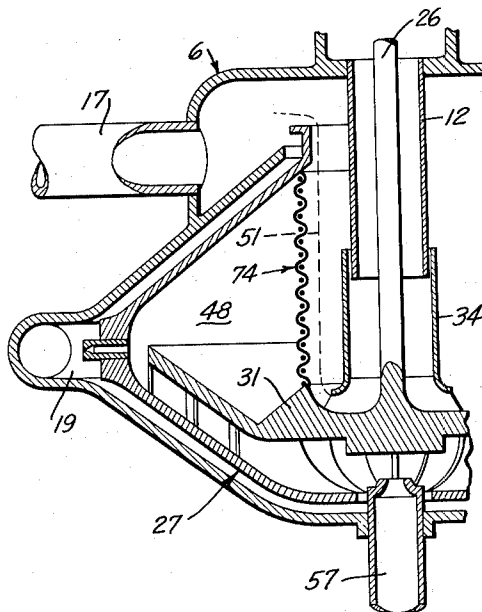


FIG. 2

FIG. 3

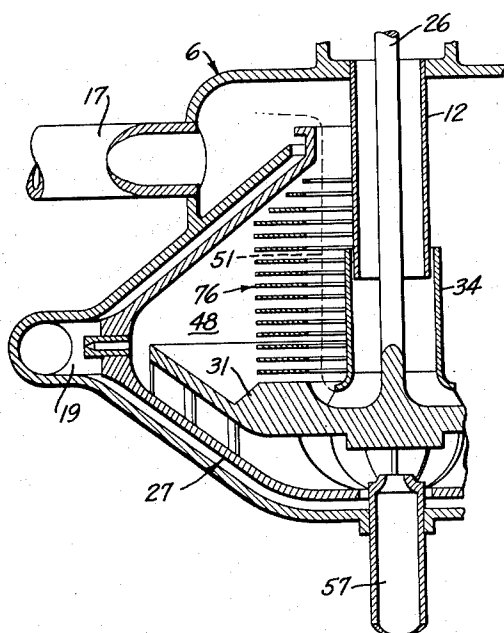
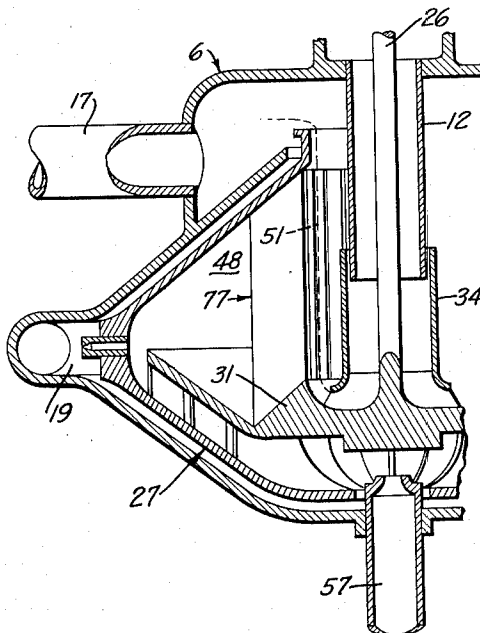


FIG. 4

FIG. 5

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**CENTRIFUGAL SEPARATOR AND METHOD OF
OPERATING THE SAME**

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Application April 9, 1951, Serial No. 220,008

16 Claims. (Cl. 233—2)

My invention relates to centrifugal separators for assisting in settling out particles from a liquid medium and is particularly concerned with a centrifugal separator of a continuously or substantially continuously operating type particularly one having a return underflow of some of the discharged material. My invention also relates to a method of operating centrifugal separators having a return underflow in order to improve the operating characteristics thereof and particularly to achieve better separation.

It is an object of my invention to improve the separation of solids from and the clarification of liquids carrying solids in suspension.

Another object of the invention is to increase the density of solids discharged from the underflow return circuit, particularly where the solid components of the feed consist of or include particles of normally slow settling characteristics.

A further object of the invention is in general to improve the separating operation of centrifugal separators, particularly those having an underflow return.

A still further object of the invention is to devise a method of operating centrifugal separators in an improved fashion to increase the yield of separated materials.

A still further object of the invention is to provide a centrifugal separator generally compatible with separators now commercially available, yet which is effective to produce enhanced results.

Other objects of the invention, together with the foregoing, are attained in the embodiment of the invention described in the accompanying description and illustrated in the accompanying drawings, in which—

Figure 1 is a diagrammatic section on a generally vertical plane through a diameter of a centrifugal separator constructed in accordance with my invention and having diagrammatically illustrated some of the associated fluid circuits.

Figure 2 is a fragmentary diagrammatic view similar to Figure 1 but showing a modified form of rotor for a centrifugal separator of the general type illustrated in Figure 1.

Figure 3 is a view comparable to Figure 2 but showing a further modified form of rotor.

Figure 4 is another view similar to Figure 2 and showing a still further modified form of rotor.

Figure 5 is a view like Figure 2 but showing an additionally modified form of rotor.

While the centrifugal separator of my invention can be embodied in a number of different ways and is susceptible to various different modes of operation, it is practically embodied in a form substantially as illustrated in Figure 1. It is assumed in this environment that the separator is designed to operate on a liquid medium carrying solids of various sizes, shapes, densities and other characteristics more or less in suspension and that such solids are to be removed insofar as possible from the liquid in order to afford a dense, substantially concen-

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trated discharge of solids with some liquid as distinguished and separated from a relatively light, substantially clear, liquid.

For this purpose, I provide a housing 6 preferably symmetrical about a central, vertical axis 7. The housing 6 is of a generally double conoidal configuration or is any other convenient figure of revolution having appropriate modifications to serve as a suitable enclosing and supporting structure. At its upper end, the housing 6 is extended to provide a bearing mounting 8 resting upon a feed chamber 9. A feed conduit 11 extending from a source of material to be separated; for example, a tank (not shown) containing the liquid and solid mixture, merges with the feed chamber 9. This leads into a feed tube 12 stationarily mounted in the housing 6 and depending past an overflow chamber 13 into the central portion of the housing 6.

The overflow chamber 13 extends from a central opening 16 to an overflow conduit 17 leading to any suitable point of discharge of the finally separated and clarified liquor. The housing 6 is approximately symmetrical about a horizontal plane H and in its lowermost portion is provided with a coaxially disposed underflow opening 18. Substantially midway between the underflow opening 18 and the overflow opening 16, the housing 6 is formed to provide a volute passageway 19 leading to a discharge opening 21.

On the bearing housing 8 and suspended therefrom is the central drive shaft 26 of a centrifugal rotor 27. The drive shaft at its upper end carries a pair of pulleys 28 engaged by belts 29 extending from any suitable source of rotary drive such as a motor (not shown). The shaft 26 extends through the feed chamber 9 and through the stationary inlet feed tube 12 and at its lower end flares into the base 31 of the rotor. The base 31 is spread and curved upwardly partially to define a feed cavity 32 and is connected by impelling vanes 33 to a rotatable feed pipe 34 in effect telescoping over the feed tube 12 and forming a substantial continuation thereof. The rotor base 31 is extended by impeller blades 36 merging with a lower conical shell 37 extending upwardly and outwardly. The base 31 is similarly extended by an inner conical shell 38 that, with the shell 37 defines a duct 39. In addition to the impellers 36, supplemental impellers 41 connect the inner and lower shells.

Above the horizontal plane of symmetry, the upper portion of the rotor is contoured to provide an upper conical shell 42 converging inwardly to terminate in an overflow weir 43 or opening.

Disposed between the inner shell 38 and the upper shell 42 within the rotor and extending upwardly from the similarly contoured base 31, is a nest or series or plurality of conical bands 44 coaxially arranged to define the envelope surface of an inner, circular cylinder 46. This cylindrical envelope surface divides the interior of the rotor into an inner chamber and an outer chamber, is established only by the inner rims of the various conical bands 44, is referred to as a "wall" or "diaphragm," and constitutes the outer wall of the inner chamber. This circular cylindrical diaphragm is concentric with the axis 7 and preferably has a slightly larger internal diameter than the overflow opening 43. The outer peripheries of the conical bands 44 likewise terminate in what in effect is a circular cylindrical envelope surface 47. The conical bands are disposed between and help define the feed cavity 32 as an inner chamber, as distinguished from the remaining volume 48 constituting an outer chamber within the hollow rotor.

In the starting or initial operation of this structure and following out the general method of my invention, the pulleys 28 are appropriately driven to spin the rotor 27 at a relatively high speed. A liquid material containing

solids to be substantially separated from it is caused to flow substantially continuously through the feed conduit 11 into the feed chamber 9 from whence the material flows downwardly through the stationary feed tube 12 and into the revolving feed pipe 34. In the feed pipe 34 the material encounters the rotating impelling vanes 33 that bring it up to the speed of the rotor itself. The material is discharged largely by centrifugal force from the lower end of the feed pipe 34 by the impellers 33. The material continues to flow by centrifugal force out between the lower ones of the nested conical bands 44 and begins to occupy the chamber 48. As this chamber fills, some of the material flows out of nozzles 52 disposed at appropriate intervals around the periphery of the rotor and discharging in such a direction that the reaction assists in turning the rotor. The discharged fluid issued from the nozzles travels through the scroll passageway 19 and through the discharge opening 21 into a conduit 53. The material continues to flow through the conduit and past a regulating device 54 to an outlet 56 from which the material is released from the system.

Preferably, some of the efflux is diverted from the conduit 53 above the regulator 54 into an underflow return conduit 57 extending to the underflow inlet opening 18. At that point, the conduit 57 is provided with an orifice plate 58 so that a jet of returning material is reintroduced into the housing and impinges upon a target plate 59 on the lower part of the rotor base 31. The material so impinging, being diverted laterally, is engaged by the revolving impellers 36 and 41 and so is moved by centrifugal force again outwardly into the chamber 48 adjacent the nozzles 52. The rate of material supply is enough greater than the initial rate of material discharged so that the chamber 48 and the interstices between the conical bands fill with fluid. When sufficient material has entered, there is built up over the diaphragm 46 a continuous, annular layer 51 of liquid and solids, established at a predetermined thickness of sufficiently small inner radius to cause discharge at the upper end over the upper overflow opening 43. The liquid so discharged is collected in the chamber 13 and flows from the separating system through the overflow conduit 17.

After the starting operation, adjustments for protracted operation are made. The quantity of feed entering through the conduit 11, the quantity of material leaving the structure through the outlet 56 and the quantity of recirculated material travelling through the conduit 57 are such that a film or layer, or annulus of liquid, losing its solids as it ascends, is established within the diaphragm 46 which therefore defines an interface between axially stationary and axially moving material. The body of material within the chamber 48 prevents radial outflow of the liquid component but receives the settled out radially travelling solid particles. There is an upward, axial flow of material over the inside rims of the nested conical bands between which pass the solid fractions of material being treated.

Since the settlement of the solid particles, as distinguished from the liquid, is radially outward, the particles tend to collect within the chamber 48. The heavier particles tend to agglomerate or congregate in the outward portion of the rotor but some of the particles which are lighter, tend to form an intermediate layer outside the conical bands but within the turbulent chamber 48 in a position to block or impede other particles tending to travel toward the nozzles 52. Solid particles passing outwardly between the bands 44 by centrifugal force tend to lodge on the inner or under faces of the conical bands to build up and substantially restrict the space between the bands. Since all of these factors tend to interfere with optimum clarification of the overflow liquid or with optimum recovery of solids from the outlet 56, I provide a means for overcoming these deficiencies.

In the underflow return conduit 57 I provide a rela-

tively large chamber 61; large, that is, with respect to the volumetric capacity of the rotor. The chamber 61 is provided with a valve 62 having an operating stem 63 and is arranged normally to be closed with the valve seated on the rim 64 of the chamber 61. The valve is, as shown in Figure 1, of substantial size relative to the volume of the chamber. When the valve is opened, its discharge capacity is very great and it permits the entire contents of the chamber 61 quickly to discharge. The chamber 61 is sometimes referred to as a "dump" chamber. It is of sufficient capacity so that any further entering material coming from the conduit 53 does not flow into the underflow return opening 18 but rather is bypassed through the rim 64 into a hopper 66 leading to a pipe 67 and out of the separating system.

In the normal operation of the device, the outflow from the system through the outlet 56, the amount of the flow through the conduit 57 and the amount of feed are such that a given quantity of overflow passes in an annular layer or stream upwardly over the diaphragm 46 to maintain a stable interface. But because of the formation of a blocking intermediate layer of particles within the chamber 48, because of the aggregation of particles on the conical bands, and for other reasons, the valve 62 is periodically opened suddenly. It is held open long enough for the chamber 61 to be evacuated, for the flow through the opening in the orifice plate 58 to be completely interrupted, and correspondingly, for the liquid level to recede outwardly and to occupy a new position in the rotor chamber 48.

During this time, the denser materials which have been accumulating near the nozzles are rather quickly discharged from the system, particles from the intermediate zone and the finer particles adjacent the diaphragm 46 are suddenly removed outwardly into a zone previously occupied by denser material. Denser material discharges from the rotor periphery through the nozzles and leaves a much less dense material in the rotor periphery. Also, particles which have deposited on the under and inner faces of the conical bands are flushed or swept off for ultimate discharge through the nozzles 52. As soon as this abrupt change in operating conditions has taken place, the valve 62 is again closed, permitting the underflow again to travel into the rotor and reestablishing the annular upflow over the diaphragm or interface 46 and finally over the weir 43.

The adjustment of the various flows is such that the duration of opening of the valve 62 is very brief, perhaps of the order of, say, 5 per cent, of the total operating time of the device. The recovery, despite this brief interruption, is in most instances greater than normal because the operating characteristics of the centrifugal separator for the remaining part of the time are considerably improved.

The valve stem 63 is operated periodically in any suitable fashion, preferably by an automatic apparatus that causes it to function intermittently. The flow through the nozzle 58 and the overflow from the conduit 17 are interrupted in part or entirely when the valve 62 is open but feed through the inlet conduit 11 is continuous. The annular upflowing stream operates uniformly for most of the operating time of the centrifuge but periodically recedes suddenly in response to the opening of the valve 62 to a much greater radius and is then restored to its former characteristics when the valve 62 is closed.

Since one of the functions of the nest of conical bands 44 is to reduce turbulence of the zone of liquid adjacent the incoming material which flows upwardly, parallel to the axis, various different mechanical constructions are possible for the same end. For example, as shown in Figure 2, the structure otherwise is substantially identical with that previously described but in place of the conical bands 44, I preferably introduce a circular cylindrical trommel 71. This comprises a metallic cylinder of appropriate diameter perforated at frequent intervals to

provide apertures 72 which serve as checks to or dampeners of turbulence surrounding the cylindrical stream of incoming material as it rises within the interior of the trommel. The size of the apertures in the trommel is such that solid particles can leave radially from the rising liquid.

Comparably, in Figure 3 I have illustrated a somewhat equivalent device in which the other parts are substantially the same but in place of the conical bands 44 I utilize a woven or reticulated screen 74 (or a plurality of concentric similar screens) contoured to define a substantially circular cylindrical member affording an escape for the radially outward travel of solids but also defining a diaphragm surface within the rotor to isolate the turbulent liquid in the chamber 48 from the non-turbulent, upwardly flowing, inner annulus of liquid.

In Figure 4 there is illustrated a further modification in which the nested devices rather than being cones are annular, flat discs 76 of suitable interior and exterior radii to serve as means for channeling the radially outwardly travelling solids and for affording a suitable interior diaphragm so as to reduce the disturbance of the axial flow of liquid a minimum amount.

In Figure 5, comparably, there is shown in full lines a somewhat similar device in which the conical bands are replaced by substantially radial blades 77 extending outwardly to any desired distance from the center in the manner of impellers. Although these permit the solid materials to pass radially outward therebetween in diverging paths, they also define an interior diaphragm and act, furthermore, since they are radially disposed, more or less as impellers. The advantage of the impeller arrangement is that the material between the blades is brought up to the angular velocity of the rotor at the instant radius. Settling particles agglomerate on the leading face of the blades readily sloughing off in agglomerate masses, thereby increasing the density of the underflow.

What is claimed is:

1. The method of operating a centrifugal separator having a return underflow which comprises establishing an upwardly flowing annular stream of material within a continuously rotating annular body of material supplied by said return underflow and then periodically increasing the inside diameter of said annular body by periodically interrupting completely all underflow to said body.

2. The method of operating a centrifugal separator which comprises continuously establishing a whirling body of material with a circular cylindrical hollow center, withdrawing material from said body and returning at least some of said withdrawn material as underflow to said body, establishing an upward flow of material over said body through said hollow center, and periodically increasing the inside diameter of said whirling body by periodically interrupting completely all underflow to said body.

3. The method of operating a centrifugal separator having a rotor with a circular cylindrical envelope surface which comprises establishing an upward flow of material over the inside of said envelope surface, continuously maintaining an annular whirling body of material around the outside of said envelope surface, maintaining an underflow of material from said body and back to said body, and periodically increasing the inside diameter of said annular whirling body by interrupting completely all underflow to said body.

4. The method of operating a centrifugal separator having a rotor with an envelope surface which comprises establishing a flow of material over the inside of said envelope surface, continuously maintaining an annular whirling body of material around the outside of said envelope surface, maintaining an underflow of material from said body and back to said body, continually bleeding material from said underflow, and periodically increas-

ing the inside diameter of said annular whirling body by interrupting completely all underflow to said body.

5. The method of operating a centrifugal separator which comprises continuously establishing an annular whirling body of material with a hollow center, establishing a flow of material through said hollow center, withdrawing material from said body, releasing some of said withdrawn material, returning the unreleased withdrawn material to said body as underflow, and periodically increasing the inside diameter of said hollow body by periodically interrupting completely all underflow to said body.

6. The method of operating a centrifugal separator which comprises continuously establishing an annular whirling body of material with a hollow center concentric with an axis, establishing a flow of material into said hollow center and establishing a flow of some of said material axially along the hollow center of said body, withdrawing some of said material from the periphery of said body, releasing some of said withdrawn material, returning the unreleased withdrawn material to said body outside of said hollow center as underflow and periodically increasing the inside diameter of said hollow body by periodically interrupting completely all underflow to said body.

7. A centrifugal separator for separating heavier and lighter fractions of feed material comprising a housing, a rotor mounted for rotation in said housing about a central axis, means on said rotor including solid wall portions with spaces therebetween defining a circular cylindrical envelope surface concentric with said axis and constituting the outer wall of an inner chamber, means for conducting material containing heavier and lighter fractions into said inner chamber to a location on the interior of said envelope surface whereby the heavier fraction during separation passes through said spaces in said outer wall in a radially outward direction to the outer portion of said rotor, a recirculating impeller on said rotor, a conduit for conducting material from the periphery of said rotor to said recirculating impeller, a dump chamber in said conduit of substantial volume relative to the volume of said rotor, a valve in said dump chamber for quickly releasing material from said chamber, and a pipe for releasing material from said conduit.

8. A centrifugal separator for separating heavier and lighter fractions of feed material comprising a housing, a rotor mounted for rotation in said housing about a central axis, means on said rotor including solid wall portions with spaces therebetween defining a circular cylindrical envelope surface concentric with said axis and constituting the outer wall of an inner chamber, means for conducting material having heavier and lighter fractions into said inner chamber to a location on the lower interior of said envelope surface whereby the heavier fraction during separation passes through said spaces in said outer wall in a radially outward direction to the outer portion of said rotor, means for releasing material from the outer portion of said rotor into the outer part of said housing, a conduit for returning material from the outer part of said housing back to the central part of said rotor, means on said rotor for impelling returned material from said central part of the rotor to flow to the outer portion of said rotor in a path in part separate from the path of said heavier fraction passing through said outer wall to the outer portion of said rotor, and a valve in said conduit for releasing material therefrom.

9. A centrifugal separator comprising a housing symmetrical about a vertical axis, a rotor mounted for rotation in said housing about said axis, means on said rotor including a number of spaced barriers concentric with said axis, the inner portions of said barriers defining an envelope surface for dividing said rotor into an inner chamber and an outer chamber, means for introducing material including heavier and lighter fractions into said rotor within the lower portion of said inner chamber

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whereby the heavier fraction during separation passes through the envelope surface in a radially outward direction to the periphery of said rotor, means in said housing for receiving said heavier fraction from the periphery of said rotor, means for conducting said heavier fraction from said receiving means back to said outer chamber of said rotor, means for releasing said heavier fraction from said conducting means, and means for releasing said lighter fraction from the upper portion of said inner chamber.

10. A centrifugal separator comprising a housing, a rotor mounted for rotation in said housing about a vertical axis, means on said rotor dividing said rotor into a radially inner chamber and a radially outer chamber, said dividing means including spaced apart barriers considered together constituting a substantially cylindrical envelope surface concentric with said axis and establishing the outer wall of said inner chamber, means for introducing material having heavier and lighter fractions into the lower portion of said inner chamber, means for releasing material having a larger proportion of said light fraction from the upper portion of said inner chamber, means for discharging material having a smaller proportion of said light fraction from the periphery of said rotor into said housing, and means for returning part only of said material having a smaller proportion of said light fraction from said housing to said outer chamber.

11. A centrifugal separator comprising a housing, a rotor mounted for rotation in said housing about a vertical axis, a circular cylindrical wall concentrically disposed on said rotor dividing said rotor into a radially inner chamber and a radially outer chamber, said wall having openings accommodating movement of material substantially outwardly from said inner chamber to said outer chamber, means for introducing material having heavier and lighter fractions into said inner chamber adjacent the lower portion thereof, means on said rotor for spinning said material with said rotor, means for releasing material from the upper end of said inner chamber, and means for releasing material having a smaller proportion of said light fraction from said outer chamber at the periphery of said rotor.

12. A centrifugal separator comprising a housing, a rotor mounted for rotation in said housing about a vertical axis, a circular cylindrical wall concentrically disposed on said rotor dividing said rotor into a radially inner chamber and a radially outer chamber, said wall having openings accommodating movement of material substantially outwardly from said inner chamber to said outer chamber, means for introducing material having heavier and lighter fractions into said inner chamber adjacent the lower portion thereof, means on said rotor for spinning said material with said rotor, means for releasing material having a larger proportion of said light fraction from the upper end of said inner chamber, means for releasing material having a smaller proportion of said light fraction from said outer chamber at the periphery of said rotor, means for conducting released material having a smaller proportion of said light fractions back to said outer chamber of said rotor, a dump chamber in said conducting means of substantial volume relative to the volume of said rotor, and a valve in said dump chamber of substantial size relative to the volume of said dump chamber for quickly releasing material from said dump chamber.

13. A centrifugal separator comprising a housing substantially symmetrical about a central axis and having upper and lower axial openings and an annular scroll passageway positioned substantially midway between said axial openings, a rotor mounted for rotation in said housing about said axis, a circular cylindrical wall on said rotor concentric with said axis dividing said rotor into inner and outer chambers, said wall having openings therein for accommodating movement of material out-

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wardly, means for conducting feed material through said upper opening into the lower portion of said inner chamber, an overflow weir coaxially disposed on said rotor adjacent said upper opening and having a diameter less than the diameter of said wall, means for releasing material from said outer chamber into said scroll passageway, a conduit for conducting material from said scroll passageway through said lower opening into said outer chamber, a dump chamber in said conduit large relative to the volume of said rotor, and a valve for quickly releasing material from said dump chamber.

14. A centrifugal separator comprising a rotor having a peripheral discharge, means for mounting said rotor for rotation about a vertical axis, a circular cylindrical wall on said rotor concentric with said axis and dividing said rotor into an inner chamber and an outer chamber, said wall having openings for accommodating movement of material outwardly from said inner chamber to said outer chamber, a feed tube on said mounting means and extending downwardly into said rotor from the upper end thereof to a point of discharge adjacent the lower portion of said inner chamber, and means on said rotor adjacent the lower portion of said inner chamber for spinning feed material discharged by said tube into said rotor.

15. A centrifugal separator comprising a housing having a vertical axis and having an upper overflow opening, a peripheral discharge opening, and a lower underflow opening; a hollow rotor disposed in said housing and mounted to revolve about said axis; means on said rotor constituting a perforate member and dividing said rotor into an inner feed cavity and an outer settling chamber; said perforate member constituting the outer defining wall of said feed cavity; a feed tube on said housing extending through said overflow opening into said feed cavity and annually spaced from said perforate member; nozzles on said rotor establishing communication between said settling chamber and said discharge opening; a duct in said rotor establishing communication between said underflow opening and said settling chamber; means for revolving said rotor; a conduit for conducting material from said discharge opening to said underflow opening; means for continuously releasing material from said conduit; and a dump chamber of large volume relative to the volume of said rotor for intermittently releasing material from said conduit whereby conductive material to said underflow is interrupted.

16. A centrifugal separator comprising a housing having a vertical axis and having an upper overflow opening, a peripheral discharge opening, and a lower underflow opening; a hollow rotor disposed in said housing and mounted to revolve about said axis; means on said rotor constituting a perforate member and dividing said rotor into an inner feed cavity and an outer settling chamber; said perforate member constituting the outer defining wall of said feed cavity; a feed tube on said housing extending through said overflow opening into said feed cavity and annularly spaced from said perforate member; nozzles on said rotor establishing communication between said settling chamber and said discharge opening; a duct in said rotor establishing communication between said underflow opening and said settling chamber; means for revolving said rotor; a conduit for conducting material from said discharge opening to said underflow opening; and means for continuously releasing material from said conduit.

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