May 15, 1962 R. C. GIESSE 3,034,647

CYCLONE SEPARATOR

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Fig. 2

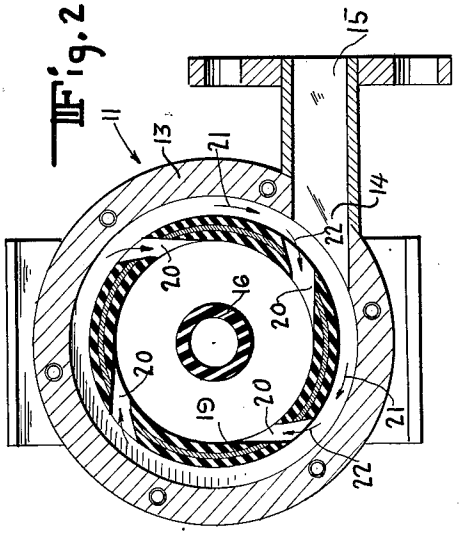

Fig. 3

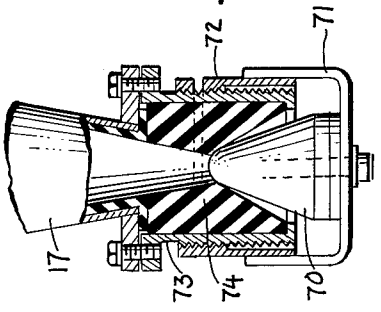

Fig. 1

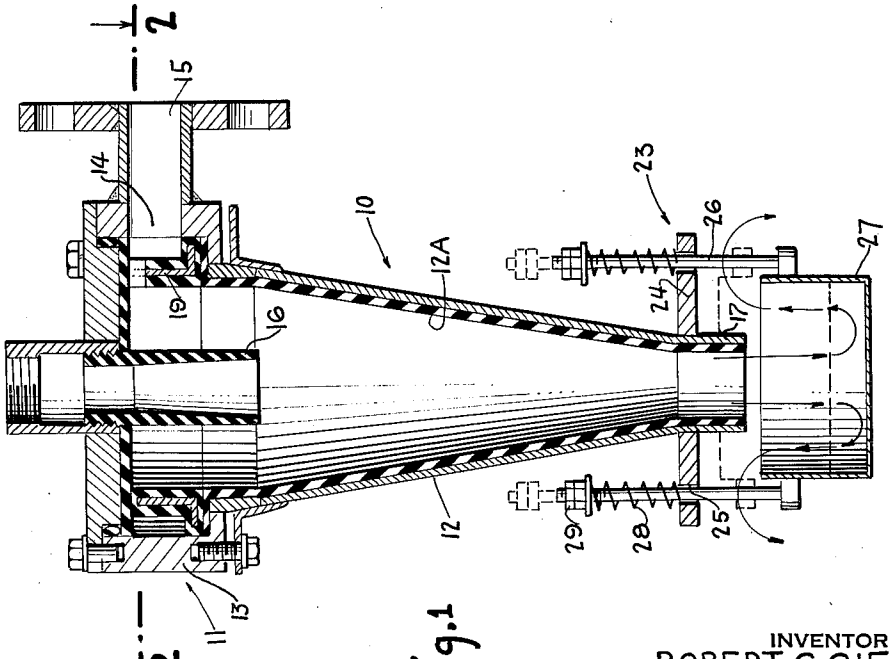

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Fig. 5

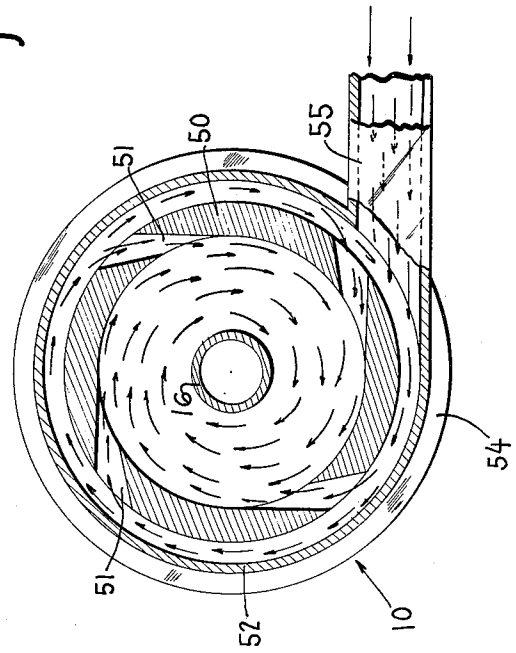
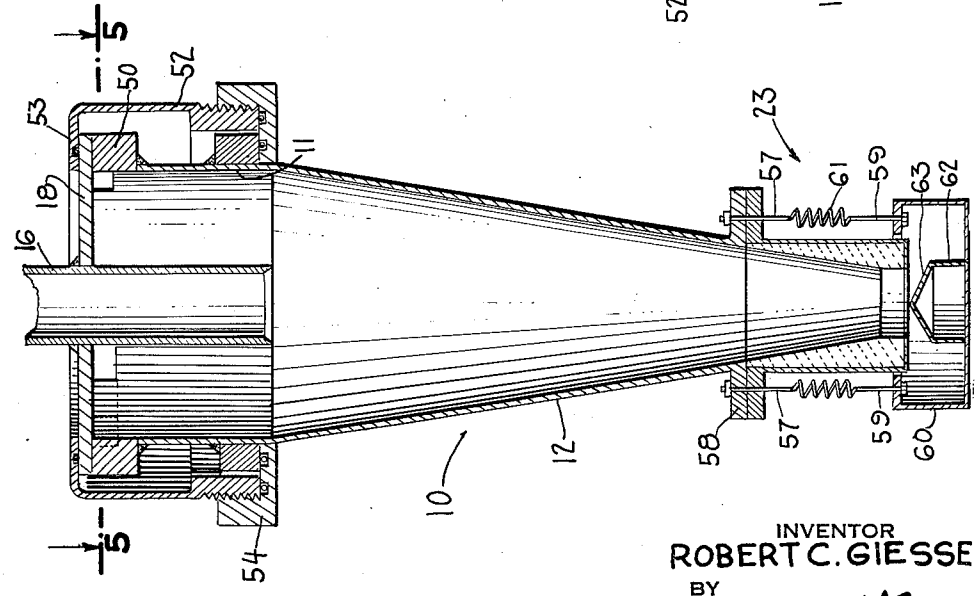


Fig. 4



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CYCLONE SEPARATOR

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This invention relates generally to a method and apparatus for the treatment of materials to effect a separating or classifying operation, and particularly to a cyclone separator in which the rotational or angular velocity is increased after the material enters the treatment chamber.

The use of cyclone separators for separation between heavier and lighter constituents of the material being treated is well known. In such apparatus the principles of vortex are used so that the heavier materials, which are forced by centrifugal force against the periphery of the chamber, form the underflow of the device and are withdrawn adjacent the bottom of the chamber; whereas, the lighter materials, which rotate at a high speed adjacent the axis of the vortex, form the overflow and are withdrawn at the top of the chamber. In utilizing the vortex principle, the most efficient separation occurs at extremely high rotational velocities. However, it has been found that introduction of the materials at the desired high feed pressures results in high nozzle wear and causes high entrance losses, thereby inhibiting the efficiency of the separation.

It is an object of this invention to provide a method and apparatus for efficiently separating the heavier and lighter constituents of a treated material through increased rotational velocity of the body of material being treated after it has entered the treating chamber, thereby minimizing the loss in the peripheral velocity of the body of material when it enters the chamber.

It is a further object of this invention to increase the rotational velocity of the body of the material after it is inside the chamber by stripping off a portion of the body tangentially at a plurality of circumferentially spaced points.

It is a further object of this invention to minimize entrance losses and nozzle wear by introducing the body of material being treated at a relatively low feed pressure and thereafter increasing the angular or rotational velocity of the body of material to ensure efficient separation.

It is a further object of this invention to provide apparatus for controlling the underflow discharge from the chamber.

The cyclone separator of the invention includes a treating chamber having a substantially cylindrical upper portion and means for introducing, under pressure, the material to be treated. This material is introduced tangentially into a peripheral portion of the interior of the upper portion so as to cause the rotation of the body of material about the longitudinal axis of the treating chamber. Within the treating chamber and in the path of flow of the body of material, means are provided which increase the rotational or angular velocity of the body of material inside the chamber to thereby effect an efficient centrifugal separation between the heavier and lighter constituents of the material. The overflow is withdrawn through suitable means at the upper portion of the treating chamber adjacent the longitudinal axis thereof. The underflow is withdrawn from the lower portion of the treating chamber through suitable means adjacent the longitudinal axis thereof. According to one aspect of the invention, the rotational velocity of the body of material is increased by stripping off portions of the body tangentially at a plurality of points in the rotational flow set up by the material introducing means.

By providing a plurality of openings connecting the outer and inner compartments of the treating chamber, the body of material is progressively stripped off thereby increasing the angular velocity of the stripped portion since each of the openings acts as a nozzle without causing undesirable entrance losses.

The foregoing and other objects, features and advantages hereof will become apparent from the following description and drawings which are merely exemplary.

In the drawings:

FIG. 1 is a cross-sectional elevational view of a cyclone separator embodying the principles of the invention;

FIG. 2 is a cross-sectional plan view of a cyclone separator according to the invention, taken along the line 2—2 of FIG. 1 looking in the direction of the arrows;

FIG. 3 is a cross-sectional view of a modified form of rate controller;

FIG. 4 is a cross-sectional elevational view of another form of cyclone separator embodying the principles of the invention; and

FIG. 5 is a cross-sectional plan view taken along the line 5—5 of FIG. 4 looking in the direction of the arrows.

The form of the invention, illustrated in FIGS. 1 and 2 of the drawings, includes a treating chamber 10 having an upper cylindrical portion 11 and a lower frusto-conical portion 12. An inlet pipe 15 introduces the material to be treated tangentially of the cylindrical portion 11 against the inner periphery thereof. A suitable pump (not shown) or other means, feeds the material to be treated, under pressure into inlet pipe 15. The material, due to its introduction into portion 11 in a tangential direction, is rotated at a high velocity. Since the operation is continuous, the interior of treating chamber 10 will always be filled with a body of the material being treated and the continuous feed through inlet pipe 15 insures the continuous rotation of this body. The rotational movement of the body of material in chamber 10 produces a vortex in which the heavier constituents of the material being treated move toward the peripheral surface of the chamber 10 and the lighter constituents rotate rapidly adjacent the axis of the chamber. Due to this action the lighter constituents may be removed upwardly as the overflow of the device through a centrally disposed tube 16. The heavier constituents which move toward the peripheral surface of the chamber travel downwardly and form the underflow of the device which is removed through nozzle 17 at the bottom of chamber 10.

In a device of the type described above, it has been found that the rotational velocity of the body of material is not at its desired maximum because of a loss in the peripheral velocity when the material enters chamber 10. Furthermore, it has been found that if the material is introduced at a relatively low pressure the nozzle life is materially increased. The device of the invention overcomes these difficulties and increases the effective rotational velocity of the body of material by stripping off portions of the body of material at circumferentially spaced points in a tangential direction. This is accomplished by providing a cylindrical tube 19 at the upper portion of chamber 10 on the interior thereof. A plurality of tangential openings 20 are formed in tube 19 so that as the body of material rotates in the direction illustrated by arrows 21, portions of the material will pass through openings 20, as illustrated by the arrows 22, into the interior of cylindrical tube 19. Due to this "stripping off" action the body of material on the interior of cylindrical tube 19 rotates at a higher velocity, thereby resulting in a more efficient separation action, since the entire body of material in chamber 10 will also rotate at a higher velocity. Annular ring 13 is secured to member 12 and is spaced outwardly from tube 19 and is provided with a tangential opening 14 for nozzle 15. The top of the chamber is closed off by suitable plate means 18.

In the form illustrated in FIGS. 1 and 2, the interior

of the separating device has a replaceable rubber liner 12A which minimizes the erosion of the metal parts. Nozzle 16 is also formed from a suitable hard rubber material.

In order to coordinate the rate of the underflow and the rate of the feed, a suitable control arrangement, generally designated as 23, is provided adjacent nozzle 17. This arrangement or device includes a support member 24 secured to the bottom of chamber 10 having a plurality of openings 25 therein. Rods 26, having an exterior diameter smaller than the interior diameter of openings 25, are vertically slidable in openings 25. The lower ends of rods 26 are secured to a cup-shaped member 27 positioned immediately below the exit end of nozzle 17. This cup-shaped member preferably has a larger radius than the discharge end of nozzle 17, since the material leaving discharge nozzle 17 has a tendency to move outwardly, due to the centrifugal force exerted thereon. In order to provide automatic control of the distance between the bottom of cup-shaped member 27 and the discharge end of nozzle 17, springs 28 and abutment nuts 29 are provided. The abutment nuts are preferably threaded onto the upper ends of rods 26 and the springs 28 surround rods 26. The ends of the springs 28 engage the upper surface of support 24 and the lower surface of abutment 29, respectively, so that the cup-shaped member 27 is urged toward the discharge end of nozzle 17. Thus, when the underflow of material is high, the weight of material in cup-shaped member 27 is also high and member 27 moves downwardly away from the discharge end of nozzle 17 against the action of springs 28. This results in increased flow, in the direction of the arrows, out of cup-shaped member 27. If the underflow decreases, the weight of material in cup-shaped member 27 also decreases, thereby causing cup-shaped member 27 to move upwardly under the action of springs 28 and decrease the flow of material out of cup-shaped member 27. Thus, the flow of material from the nozzle 17 is automatically controlled. The cup-shaped member 27 is shown in FIG. 1 in its down or loaded position by solid lines, and in an upper position by dotted lines. The springs 28 are selected so that the position of the cup-shaped member varies in response to the rate of the underflow.

A modified form of cyclone separator is illustrated in FIGS. 4 and 5. Similar parts in this form are given the same reference numerals, as used in FIGS. 1 and 2. In this form the upper cylindrical portion 11 is an integral part of chamber 10 and has no openings. A ring 50 is secured, as by welding, to the top edge thereof. This ring has a plurality of tangential openings 51 therein which correspond to openings 20 in cylindrical tube 19 of the FIGS. 1 and 2 modification. A second ring 52 having an inner diameter larger than the outer diameter of ring 50 is mounted on the outside of ring 50. This ring has an inwardly directed flange 53 which overlies top plate 18 and rests thereon. The ring is suitably positioned, as by threading it into a nut member 54, secured to the exterior of chamber 10. Ring 52 has an opening into which feed nozzle 55 introduces the material to be treated.

The modified form of the automatic control device 23, as illustrated in FIG. 4, includes downwardly extending rods 57 secured in support 58 connected to chamber 10 and upwardly extending rods 59 secured to a cup-shaped member 60 positioned below the discharge end of nozzle 17. Each pair of corresponding rods 57 and 59 are connected to a spring 61 which urges cup-shaped member 60 upwardly toward the discharge end of nozzle 17. A member 62 having a conical upper end 63 is centrally positioned on cup-shaped member 60, so as to control the size of the discharge end of nozzle 17. Except for the controlling of the size of the discharge nozzle by portion 63, the operation of the automatic underflow control device illustrated in FIG. 4, is the same as the operation described above, with respect to the control device illustrated in FIG. 1.

If desired, a manual underflow control valve may be used in place of the automatic types shown in FIGS. 1 and 4. One type of manual valve is illustrated in FIG. 3 and includes a tapered valve member 70 which is attached by yoke 71 to an annular ring 72 having interior threading thereon. Ring 72 is threaded onto an exteriorly threaded extension 73 secured to the bottom of nozzle 17. The extension 73 has a replaceable rubber valve seat 74 therein. When ring 73 is rotated so as to move valve member 70 closer to valve seat 74 the amount of underflow is decreased. Thus, the amount of underflow can be accurately controlled manually.

It is to be understood that the described exemplary embodiments of the method and apparatus of the invention are merely intended for the purpose of illustration, and that the principles of the invention are not to be limited thereto, except as defined in the appended claims.

What is claimed is:

1. A cyclone separator comprising a treating chamber having a substantially cylindrical upper portion, an annular chamber adjacent said cylindrical upper portion, the innermost portion of said annular chamber including an apertured cylindrical member disposed within and concentric with said cylindrical upper portion, said annular chamber additionally including upper and lower wall members spaced apart from each other and extending from the upper and lower portions, respectively, of said apertured cylindrical member to said cylindrical upper portion, means for introducing the material to be treated tangentially and under pressure into said annular chamber so as to cause the rotation of the material in said annular chamber about the longitudinal axis of said treating chamber, the apertures of said cylindrical member of said annular chamber adjacent the path of flow of the material in said annular chamber being adapted to increase the rotational velocity of the body of material inside the treating chamber by stripping off portions of the material in said annular chamber tangentially at a plurality of points in the rotational flow set up by said introducing means, said apertures stripping off said portions from said annular chamber into the interior of said upper portion so as to effect an efficient centrifugal separation between heavier and lighter constituents of the material, the combinational effect for the annular chamber and the apertures resulting in the stripping off of all of the material in said annular chamber, means adjacent the longitudinal axis of said upper portion for withdrawing the overflow from the upper portion of said treating chamber, and means adjacent the longitudinal axis of said chamber for withdrawing the underflow from the lower portion of said treating chamber.

2. A cyclone separator comprising a treating chamber having a substantially cylindrical upper portion and a frusto-conical lower portion open at the bottom, an annular chamber adjacent said cylindrical upper portion, the innermost portion of said annular chamber including an apertured cylindrical member disposed within and concentric with said cylindrical upper portion, said annular chamber additionally including upper and lower wall members spaced apart from each other and extending from the upper and lower portions, respectively, of said apertured cylindrical member to said cylindrical upper portion, means for introducing the material to be treated tangentially and under pressure into said annular chamber so as to cause the rotation of the material in said annular chamber about the longitudinal axis of said treating chamber, the apertures of said cylindrical member of said annular chamber adjacent the path of flow of the material in said annular chamber being adapted to increase the rotational velocity of the body of material inside the treating chamber by stripping off portions of the material in said annular chamber tangentially at a plurality of points in the rotational flow set up by said introducing

means, said apertures stripping off said portions from said annular chamber into the interior of said upper portion so as to effect an efficient centrifugal separation between heavier and lighter constituents of the material, the combinational effect of the annular chamber and the apertures resulting in the stripping off of all of the material in said annular chamber, means adjacent the longitudinal axis of said upper portion for withdrawing the overflow from the upper portion of said treating chamber, the underflow being discharged through the open bottom at the chamber, and means adjacent the longitudinal axis of said chamber for controlling the flow from said open bottom.

3. A cyclone separator comprising a treating chamber having a substantially cylindrical upper portion and a frusto-conical lower portion open at the bottom, an annular chamber adjacent said cylindrical upper portion, the innermost portion of said annular chamber including an apertured cylindrical member disposed within and concentric with said cylindrical upper portion, said annular chamber additionally including upper and lower wall members spaced apart from each other and extending from the upper and lower portions, respectively, of said apertured cylindrical member to said cylindrical upper portion, nozzle means for introducing the material to be treated tangentially and under pressure into said annular chamber so as to cause the rotation of the material in said annular chamber about the longitudinal axis of said treating chamber, the apertures of said cylindrical member of said annular chamber adjacent the path of flow of material in said annular chamber being adapted to increase the rotational velocity of the body of material inside the treating chamber by stripping off portions of the material in said annular chamber tangentially at a plurality of points in the rotational flow set up by said nozzle means, said apertures stripping off said portions from said annular chamber into the interior of said upper portion so as to effect an efficient centrifugal separation between heavier and lighter constituents of the material, the combinational effect of the annular chamber and the apertures resulting in the stripping of all of the material in said annular chamber, means adjacent the longitudinal axis of said upper portions for withdrawing the overflow from the upper portion of said treating chamber, the underflow being discharged through the open bottom of the chamber, and means adjacent the longitudinal axis of said chamber for controlling the flow from said open bottom.

4. A cyclone separator comprising a treating chamber having a substantially cylindrical upper portion, means for introducing under pressure the material to be treated tangentially into a peripheral portion of the interior of said upper portion so as to cause the rotation of the body of material about the longitudinal axis of said treating chamber, a cylindrical member inside of said upper portion at the upper end thereof and having spaced top and bottom wall members extending from said cylindrical member to said cylindrical upper portion forming an enclosed annular space therebetween, said cylindrical member having a plurality of tangentially disposed openings therein for stripping off portions of the rotating body of material in a tangential direction from the enclosed annular space into a peripheral portion of the interior of said member so as to increase the rotational velocity of said body of material to thereby effect a more efficient centrifugal separation between heavier and lighter constituents of the material, the combinational effect of the enclosed annular space and the means for stripping at a plurality of points resulting in the stripping off of all of the body of material, means adjacent the longitudinal axis of said upper portion for withdrawing the overflow from the upper portion of said treating chamber, and means adjacent the longitudinal axis of said chamber for withdrawing the underflow from the lower portion of said treating chamber.

5. A cyclone separator comprising a treating chamber having a substantially cylindrical upper portion and a frusto-conical lower portion open at the bottom, nozzle means for introducing under pressure the material to be treated tangentially into a peripheral portion of the interior of said upper portion so as to cause the rotation of the body of material about the longitudinal axis of said treating chamber, a cylindrical member inside of said upper portion at the upper end thereof and having spaced top and bottom wall members extending from said cylindrical member to said cylindrical upper portion forming an enclosed annular space therebetween, said cylindrical member having a plurality of tangentially disposed openings therein for stripping off portions of the rotating body of material in a tangential direction from the enclosed annular space into a peripheral portion of the interior of said member so as to increase the rotational velocity of said body of material to thereby effect a more efficient centrifugal separation between heavier and lighter constituents of the material, means adjacent the longitudinal axis of said upper portion for withdrawing the overflow from the upper portion of said treating chamber, the combinational effect of the enclosed annular space and the means for stripping at a plurality of points resulting in the stripping off of all of the body of material, the underflow being discharged through the open bottom of the chamber, and means adjacent the longitudinal axis of said chamber for controlling the flow from said open bottom, said last named means including a cup-shaped member positioned below said open bottom and slidably connected to said chamber by a plurality of rods, and spring means urging said cup-shaped member upwardly toward said open bottom so that as the underflow of the material in contact with said cup-shaped body increases it automatically moves further away from the open bottom to permit increased flow from said cup-shaped body.

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