

April 2, 1935.

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1,996,076

CENTRIFUGAL SEPARATING APPARATUS

Filed July 28, 1932

2 Sheets-Sheet 1

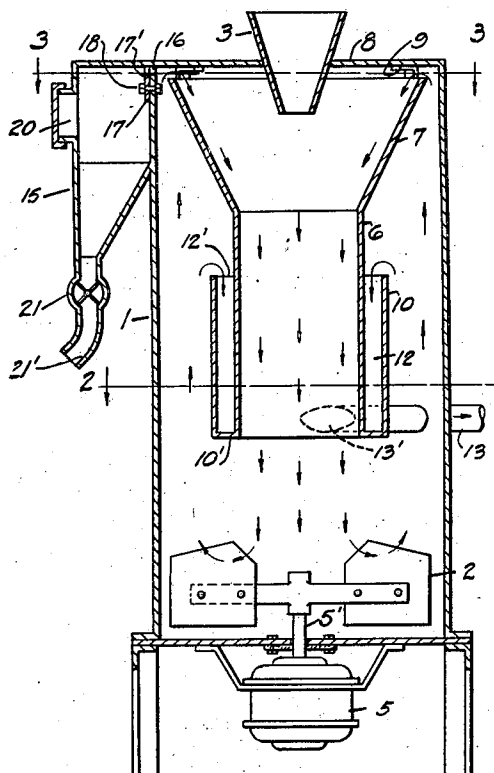


FIG. 1

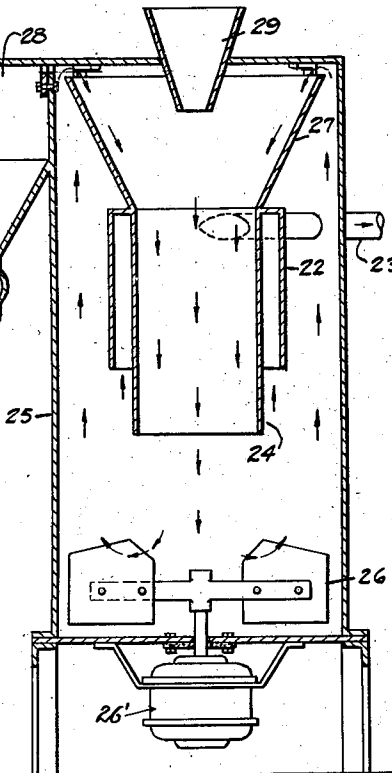


FIG. 4

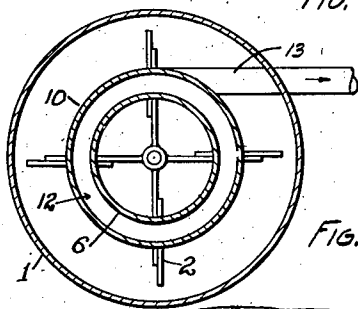


FIG. 2

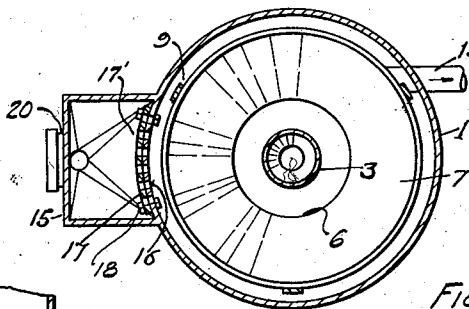


FIG. 3

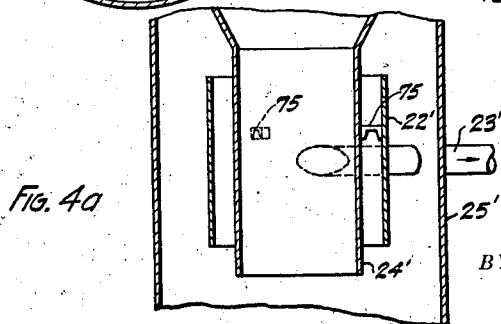


FIG. 4a

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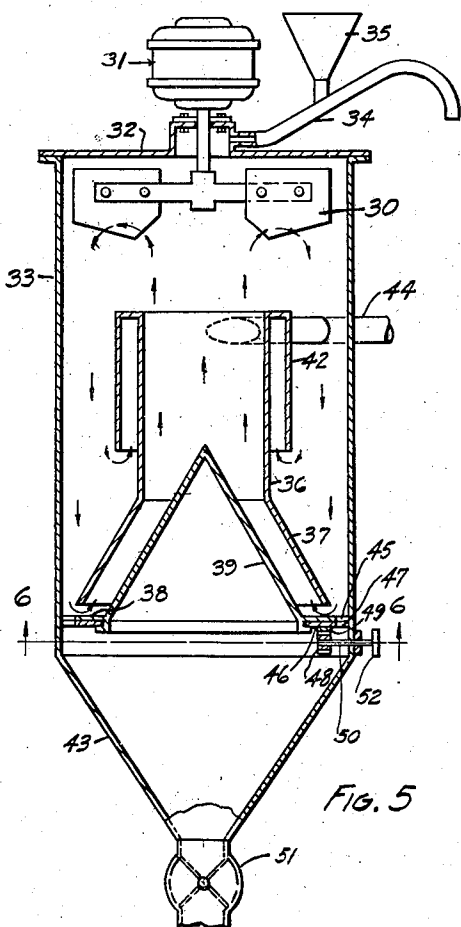


FIG. 5

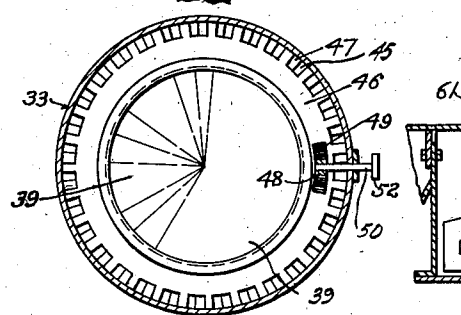


FIG. 6

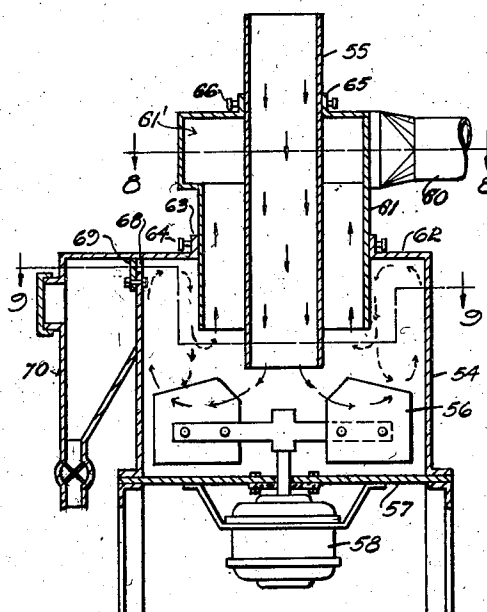


FIG. 7

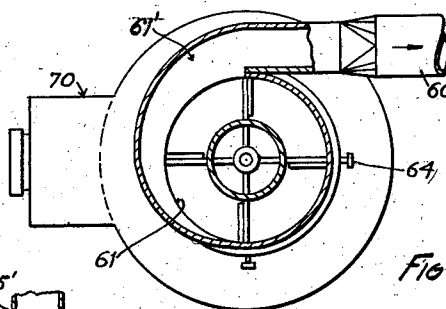


FIG. 8

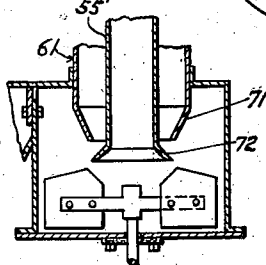


FIG. 9

FIG. 10

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CENTRIFUGAL SEPARATING APPARATUS

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Application July 28, 1932, Serial No. 625,369

9 Claims. (Cl. 209-144)

This invention relates to an improvement in centrifugal classifiers or apparatus for separating divided materials of different size. The main object of the invention is to provide apparatus of this character which will have large capacity and at the same time will effect a sharp separation between the coarser particles of the material and the finer portions thereof. The invention is particularly intended and adapted for separation from coarser material of extremely fine material as hereinafter set forth.

In the usual types of classifiers it has been found difficult to effect a sharp separation between the constituents of different size in the material to be operated upon and the operation of such a classifier generally results in the production of a coarser fraction having more or less fines mixed with it and a finer fraction containing some of the coarser material. To avoid this difficulty my invention provides for subjecting the material to be treated to the action of a moving body of air in a suitable casing in such manner that the fines are forcibly removed from adherence to the coarser particles and are sharply separated therefrom by the counteractions of centrifugal force and gas entrainment, and the finer particles are then removed from the body of gas under such conditions as to minimize the passage of coarser particles therewith.

The invention may be employed for separation of materials of different sizes or densities from a body of gas in which such materials are suspended, either by forcible distribution into such gas of material to be classified, or by the operations of furnaces, mills, or other apparatus which result in production of gas having materials of different sizes or densities dispersed therein.

The accompanying drawings illustrate my invention and referring thereto:

Fig. 1 is a vertical section of one form of the invention.

Fig. 2 is a section on line 2-2 in Fig. 1.

Fig. 3 is a section on line 3-3 in Fig. 1.

Fig. 4 is a vertical section of another form of the invention.

Fig. 4a is a partial vertical section showing a further possible modification of the forms of apparatus shown in Figs. 1 and 4.

Fig. 5 is a vertical section of a further modification.

Fig. 6 is a section on line 6-6 in Fig. 5.

Fig. 7 is a vertical section of another modification.

Fig. 8 is a section on line 8-8 in Fig. 7.

Fig. 9 is a section on line 9-9 in Fig. 7.

Fig. 10 is a vertical section of a further modification.

The form of my invention shown in Figs. 1 to 3 comprises a casing 1, an impeller or fan 2 mounted within said casing, means indicated at 3 for supplying to the interior of the casing the material to be treated, deflector means mounted within the casing for guiding the air or gas currents therein in such manner as to effect the desired separation, and suitable outlet means for the coarse material and for the fine material respectively. The coarse material outlet means, shown at 16, is preferably disposed adjacent the opposite end of the casing from the impeller 2.

The casing 1 is of substantially circular cross-section, and is preferably cylindrical although it may be tapered slightly in a longitudinal direction, and is preferably mounted with its axis vertical, although if desired, it may be mounted in any other suitable manner.

The impeller or fan 2 is shown in Fig. 1 as positioned at the lower portion of the casing 1 or adjacent to the bottom of said casing and is driven by a suitable motor 5 whose shaft 5' extends through the bottom of the casing and carries the blades of the fan 2.

The deflector means comprises a suction tube or cylindrical partition member 6 mounted coaxially in casing 1 and having at its upper end an upwardly flaring cone or frusto-conical deflector means 7 spaced at its upper edge from the top 8 of the casing 1 and from the side walls of said casing, said deflector means being supported by brackets 9, secured, for example, to the top member 8. An additional partition or deflector means 10 is provided around the lower portion of the member 6, said means 10 consisting preferably of a cylindrical member mounted coaxially with the member 6 and connected thereto at the lower end thereof by a transverse web 10', so as to form an annular space or chamber 12 between the members 6 and 10, said space being closed at the bottom and open at the top as shown at 12', so as to establish communication of said annular space with the interior of the casing 1 through the open upper end 12' at a position longitudinally intermediate the impeller 2 and the coarse material outlet means 16. A fines outlet conduit 13 leads tangentially from this annular space 12 and extends therefrom through the casing 1 to a suitable point of delivery. Said fines outlet conduit opens into the annular space through an opening 13' which is preferably located at a position longitudinally removed from the open end 12' of said space, for example, near the bottom thereof.

The coarse material outlet means consists, in the form shown in Figs. 1 and 3, of a bin or box 15 mounted on the side of the casing 1 near the upper end thereof and communicating with the interior of the casing 1 through ports or passages 16. In some cases it is desirable to provide for adjustment of these passages and for this purpose a regulating or closure plate 17 may be mounted to slide on the outside of the casing 1 by means of bolts 18 engaging in suitable holes in the member 17, said plate 17 being provided with ports 17' adapted to register with the ports 16 aforesaid to a greater or less extent according to adjustment of the plate 17. A hand hole 20 may be provided in one side of the box 16 to facilitate access to the interior thereof, for example, for adjustment of the closure plate 17. The coarse material may be discharged from bin 15 through a rotating pocket feeder 21 which prevents passage of air and thence through conduit 21' to storage means or to any other suitable means for further treatment or handling.

In this form of my invention, provision is made for introducing a certain amount of gas or air, hereinafter referred to as breathing air, into the casing 1 along with the material to be classified, said material being introduced into a hopper or funnel 3 which extends through the top 8 of the casing 1 and is of sufficient size to permit a certain amount of air or gas to be drawn into the casing along with such material. The operation of the fan or impeller results in production of a radial outward pressure within the casing in such manner that a flow of gas through the apparatus is produced, involving inflow of air or gas through the material inlet 3 and outflow of such air or gas through the fines outlet 13. In addition to this through flow of gas, there is an internal circulation produced within the casing in the manner hereinafter described, resulting in the effective separation and classification of the material.

The operation is as follows: The material to be classified is introduced into casing 1 at 3, together with a small amount of breathing air. The fan impeller 2, actuated by the means 5, keeps the air within casing 1 whirling at a high rate. The maximum rate of whirling takes place in the plane of the fan, the minimum occurs at the top end of casing 1, furthest away from the source of energy, the reduction in whirling rate being due to frictional and eddy losses. Thus, the integrated pressure increase from the axis to the periphery of casing 1 due to the radial acceleration of the whirling body of gas is maximum at the fan end and minimum at the top end of the casing. The pressure differential at the walls causes the whirling gas stream to spiral upward along the cylindrical walls, and then inward into cone 7 and suction tube 6, which leads the gas to the suction of the fan, where the fan supplies the additional energy required to compensate for the energy losses in friction and eddies encountered by the gas stream in making a circuit. Immediately adjacent the cylindrical walls of casing 1 is a region of strong eddies where energy is dissipated rapidly, due to the high rate of shear in the gas stream on account of the relative velocity between the main gas stream and the stationary wall. This zone of intense eddies disintegrates the material to be classified, and causes an air emulsion to be formed with the finer fractions. Radially inward from this zone of strong eddies, there is a region where the stream lines of the rapidly whirling gas are smoothed out. In this region of smooth stream lines, the radial accelera-

tion is kept very high, several hundred times that of gravity, due to the whirling of the gas maintained by the action of the fan. Opposed to this strong radial acceleration outward there is a small inward component of the gas stream towards the entrance 12' to annular space 12, and thence to the breather outlet tube entrance at 13', which inward flow will entrap sufficiently fine particles. This inward component of motion can be varied by varying the volume of breather air, without affecting the whirling or recirculation volume from the fan. Thus, the fines reach the breather outlet, where they may be collected, if desired, by any suitable means.

The heavier particles always remain adjacent to the cylindrical walls of casing 1, and finally reach holes 16 leading into the oversize bin 15. By regulating the number or size of the holes 16 leading into this bin, it is possible to regulate the dispersion or washing action to which this oversize material is subjected by changing the number of complete circuits which this oversize will make before passing through said holes.

The form of my invention shown in Fig. 4 is similar to that above described except that the breather outlet tube indicated at 22 is open at its lower end and closed at its upper end, the outlet pipe 23 for fines opening tangentially into the space between the breather outlet tube and the suction tube 24 at a position preferably near the upper end of said space. The construction and arrangement of the casing 25, fan 26, and its driving means 26', deflector cone 27, coarse material receiving means 28, and material and breather inlet 29 may, as shown, be the same as above described.

Another possible modification is shown in Fig. 4a, in which the breather outlet tube 22' is open at both the upper and lower ends, so as to establish communication from the interior of the casing 25' to both ends of the fines-receiving space between said tube 22' and the suction tube 24'. Said tube 22' may be supported in any suitable manner, as for example by supporting arms or brackets 75 secured to suction tube 24'. The fines outlet pipe 23', as before, communicates tangentially with the annular space between the tubes 22' and 24', preferably at a level intermediate the ends of said space, for example adjacent the mid-height thereof.

If desired, the fan or impeller may be located at the upper end of the casing as in the form of apparatus shown in Figs. 5 and 6, wherein the fan 30 and its driving motor 31 are shown as mounted on the top plate 32 of the cylindrical casing 33. In this case the inlet for breather air or gas is shown as a pipe 34 opening into the top of casing 33 and provided with means indicated at 35 for feeding or supplying thereto the material to be classified. The suction tube 36 is mounted coaxially within the casing 33 and is provided at its lower end with a deflector cone 37 extending adjacent to the bottom 38 of casing 33 and to the side wall of said casing. In order to insure picking up of the fines from the bottom portion of the space within the casing 33, a deflector cone 39 is provided within the cone 37 so as to maintain a sufficiently high velocity in the air or gas as it passes upwardly between said cones.

The breather outlet tube 42 in this case is shown as open at the bottom and closed at the top and communicates with the fines outlet pipe 44 which leads tangentially therefrom and extends through the wall of casing 33.

Outlet openings 45 are provided at the bottom 75

of casing 33 adjacent the cylindrical wall thereof for discharging the coarse material into a suitable bin or receiving means 43, and in order to regulate the rate of discharge closure means may be provided for said openings consisting, for example, of a ring 46 having openings 47 adapted to register with the openings 45, said ring being adjusted in any suitable manner, for example, by means of a pinion 48 engaging a rack 49 on the ring 46, said pinion being carried by a shaft 50 mounted on the casing 33 and having an operating handle 52. For continuous operation, bin 43 may be provided with suitable means such as indicated at 51 for discharging coarse material therefrom without permitting appreciable inflow or outflow of air through said bin.

In case the breather air, or the through flow of gas, is of very considerable volume, the fines outlet pipe extending across the space between the breather outlet tube and the outer casing would, in some cases, offer objectionable resistance to the whirling movement of the gas within the casing and in such cases the construction shown in Figs. 7 to 9 may be used. In this form of my invention the casing 54 is preferably relatively short as compared with the forms above described and the material and breather air inlet tube 55 extends coaxially with the casing 54 from the upper part thereof into proximity with the fan 56 which is adjacent the lower end 57 of the casing, the driving motor 58 for said fan being mounted on the bottom of the casing. The fines outlet pipe 60 in this case opens tangentially or by an involute connection 61' from a cylindrical outlet chamber 61 disposed coaxially about the tube 55 and extending through the top 62 of the casing 54 to a suitable height intermediate the fan 56 and the top of said casing. In order to adjust this height for most effective operation, the member 61 may be slidably mounted in an annular flange 63 on the top of casing 54 and may be adjustably secured in any desired position by screw 64. In order to adjust the material and breather air inlet tube 55 independently of the adjustment of the outlet member 61 said member 55 may be mounted to slide vertically in an annular flange 65 on member 61 and may be fastened by screw 66.

A coarse material outlet opening 68 discharging into a bin 70 is provided in the casing 54 adjacent the top thereof and a regulating plate 69 may be provided therefor similar to that shown in Fig. 1.

In this form of the invention, the inner recirculation is especially vigorous and increases with any increase in the rate of feed of the material to be classified. The integrated pressure increase from the axis to the periphery of casing 54 is maximum at the fan end and minimum at the top of the casing away from the fan. The resulting pressure differential at the walls in an axial direction causes the whirling gas stream to spiral upward along the cylindrical walls in an outer vortex to the top end of the casing and to return in a gas stream spiralling downward in an inner vortex toward the fan suction, where the fan supplies the additional energy required to compensate for the energy lost in friction and eddies encountered by the gas stream in making a circuit. As part of the gas stream in the inner vortex is withdrawn through tube 61 to the breathing air outlet 60, there results a component of motion radially inward. Particles beyond a certain definite size are not stable in the inner vortex as the component of motion radially inward is

not sufficient vigorous to overcome the outward radial acceleration due to the high rate of whirling of the gas stream. These larger particles therefore move radially outward into the outer vortex. Thus, the oversize particles repeat again and again a small circuit towards the top end of casing 54. As this region is quite closely coupled to the fan, a high rate of whirling of the gas stream is maintained by the fan, and this causes strong eddies close to the walls due to the high rate of shear in the gas stream caused by the relative velocity between the whirling gas stream and the stationary walls. These strong eddies wash off the fines adhering to the larger particles causing an air emulsion to be formed which is removed with the breathing air carrying the fines in suspension. The oversize particles finally escape into the oversize bin 70 through coarse material outlet opening 68. The pressure differential available to produce the internal recirculation is the result of the energy loss in the gas stream due to friction and eddies while making a circuit. If the rate of feed of the material to be classified is increased, then more material is present adjacent to the outer walls of the casing. This material is constantly picked up by the whirling air stream, causing friction and eddy losses. The increased pressure differential causes an increased rate of recirculation through the fan, thus withdrawing energy from the fan at a higher rate to maintain a high rate of whirling in the dispersion zone, independent to a large extent from the rate of feed of the material to be classified.

In this form of the invention the material to be separated is introduced along with the breather air or gas through the inlet pipe 55, it being understood that such material may consist of finely divided solid material, for example, suspended in such air or gas either by distribution of such material into such air or gas by suitable dispersion means or by reason of the presence of such suspended material in air or gas coming from industrial operations in furnaces, mills or other apparatus.

The operation of this form of my invention is as follows: A breather air or gas is drawn through the inlet pipe 55 into the separating chamber 54, by the operation of the centrifugal fan 56 and a vortical motion of the air or gas is produced within said chamber 54 by the operation of said centrifugal fan with the result that the heavier or coarser solid particles are eventually discharged through the outlet means 68 and the finer or lighter solid particles are eventually discharged through the breather outlet 60.

In case a closer or sharper separation is desired so that only extremely fine particles will be allowed to pass to the breather outlet, the construction shown in Fig. 10 may be adopted. This construction is similar to that shown in Fig. 7, except that the tubular member 61' leading to the breather outlet is provided at its lower end with an inwardly tapering frusto-conical deflector 71 approaching sufficiently close to the inlet tube 55' for gas and suspended material to restrict the passage of fine material to the breather outlet to the extent desired. To assist in this selective operation, the lower end of the breather inlet tube 55' may be provided with an outwardly and downwardly flaring flange 72. The construction and operation may be otherwise as described in connection with Fig. 7.

I claim:

1. A centrifugal separating apparatus com- 75

prising a casing of circular cross-section, centrifugal impeller means within said casing adjacent one end thereof, means for rotating said impeller means, outlet opening means for coarse material in open communication with the interior of said casing adjacent the other end of said casing and adjacent the periphery thereof, means for supplying to the interior of the casing adjacent the axis thereof gaseous medium together with material to be separated, and tubular deflector means extending coaxially within said casing, said tubular deflector means being open at one end toward said centrifugal impeller and open at the other end toward the end of the casing adjacent the outlet means for coarse material, a cylindrical partition means surrounding said tubular deflector means and forming therewith a fines-receiving space opening into the interior of the casing at a position intermediate the axis and periphery of the cylindrical casing so as to be in a zone of pressure intermediate the zone of minimum pressure at the axis of the casing and the zone of maximum pressure at the periphery of the casing, and fines-outlet means communicating with said fines-receiving space.

2. A centrifugal separating apparatus as set forth in claim 1, and also comprising a coarse material-receiving chamber communicating with said coarse material outlet means, said chamber being substantially closed against outflow of gas so as to substantially prevent passage of gaseous medium through said coarse material outlet opening means.

3. A centrifugal separating apparatus as set forth in claim 1, and also comprising a coarse material-receiving chamber communicating with said coarse material outlet opening means, said chamber being substantially closed against outflow of gas so as to substantially prevent passage of gaseous medium through said coarse material outlet opening means, and means for adjusting the size of said coarse material outlet opening means so as to regulate the discharge of coarse material from the interior of said casing into said receiving chamber.

4. A construction as set forth in claim 1, in which the tubular deflector means is provided at one end with a flaring frusto-conical portion extending outwardly nearly to the periphery of the cylindrical casing and nearly to the end wall of said casing adjacent said coarse material outlet means.

5. Centrifugal separating apparatus comprising a substantially cylindrical casing, centrifugal impeller means located near one end of said casing, tubular means within said chamber coaxially with the centrifugal impeller means, deflector means extending within the cylindrical casing and around said tubular means and forming a fines-outlet chamber between said tubular means and said deflector means, a fines-outlet communicating with said fines-outlet chamber, and coarse material outlet opening means in open communication with the interior of said casing at the periphery of said casing and at the end thereof remote from the centrifugal impeller.

6. A construction as set forth in claim 5, in which the outlet from the fines-outlet chamber extends tangentially from said chamber.

7. A construction as set forth in claim 5, in which the fines-outlet chamber communicates with the interior of the casing at a position disposed longitudinally intermediate the centrifugal impeller and the coarse material outlet opening means.

8. A construction as set forth in claim 5, said tubular member being open at one end toward said centrifugal impeller means and open at the other end toward said end of the casing remote from said impeller means, so as to provide for recirculation of gas within said casing through said tubular means.

9. A construction as set forth in claim 5, said tubular means being open at one end toward said centrifugal impeller means and extending at its other end through said end of the casing remote from said impeller means, so as to provide for inflow of gas to the interior of said casing.

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