

April 5, 1960

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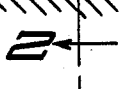
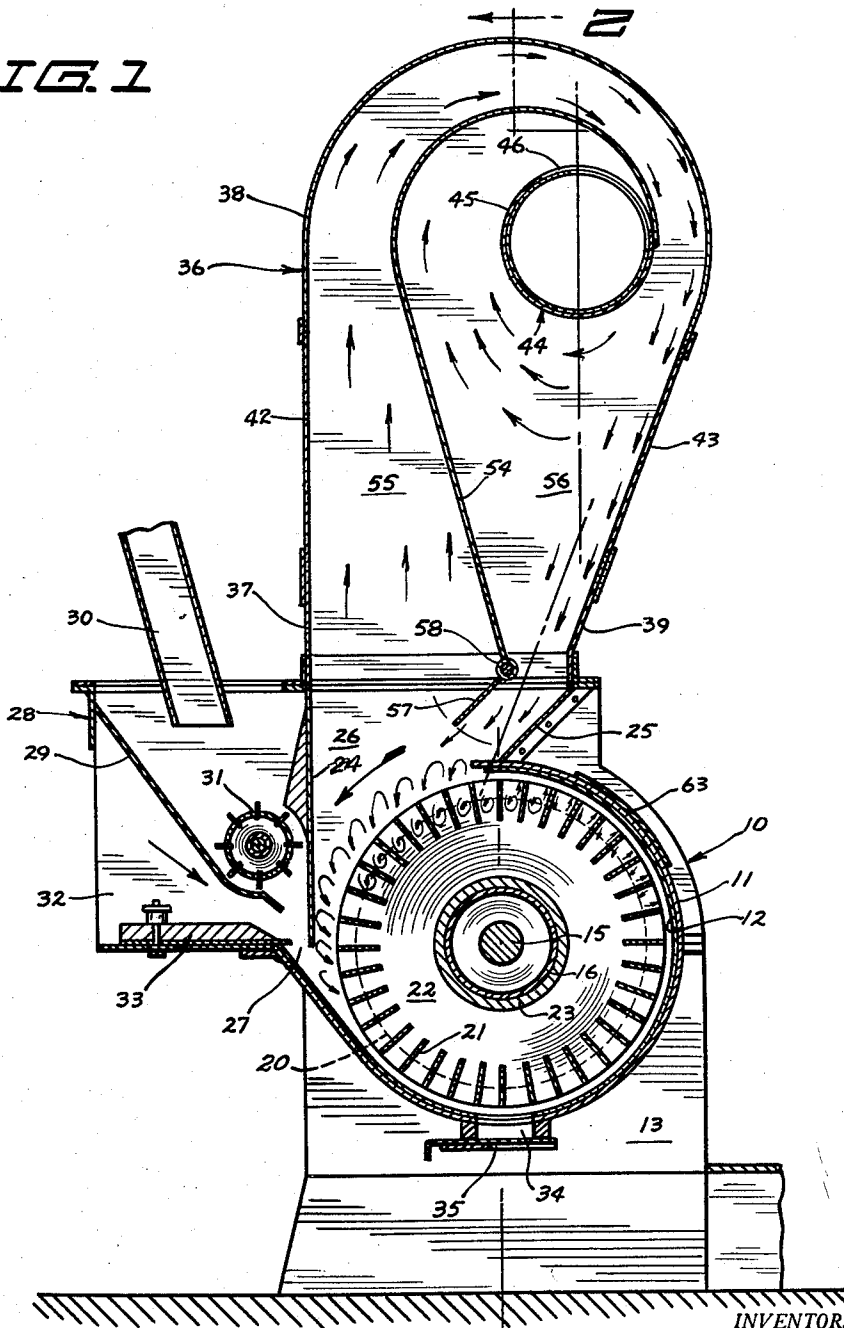
2,931,581

PRECISION GRINDER WITH FORCED CIRCULATION CLASSIFIER

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2 Sheets-Sheet 1

**FIG. 1**



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FIG. 2

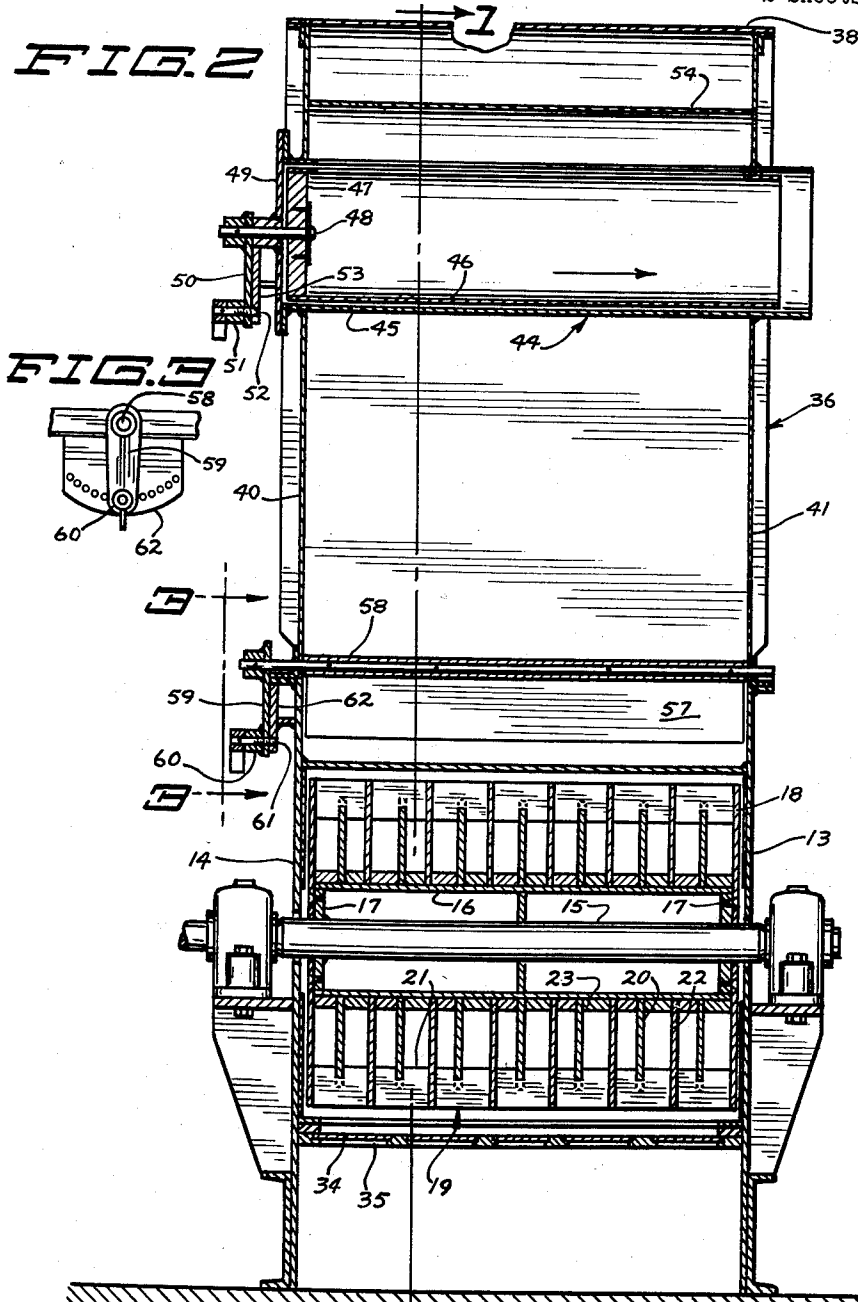
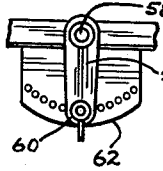


FIG. 3



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**PRECISION GRINDER WITH FORCED CIRCULATION CLASSIFIER**

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Application August 8, 1955, Serial No. 526,993

7 Claims. (Cl. 241—52)

This invention relates to means for grinding and classifying dry solid material. More particularly, this invention relates to a dry pulverulent material classifier for an open rotor type mill. Although not so limited, the classifier of this invention is especially adapted for use with horizontal open rotor type grinders such as are described in the copending United States applications of Henry G. Lykken and William H. Lykken, Serial Nos. 468,764, filed November 15, 1954, now Patent No. 2,875,956, and 497,194, filed March 28, 1955.

In fine grinding, it is essential to continuously remove the desired particle size material and finer from the mill load with a substantial air flow through the mill. This air flow will carry with it a percentage of oversize that must be segregated and returned to the grinding zone.

The principal object of this invention is to provide a simple no-power classifier having no moving operating parts but giving precision particle size control in which air and fines from a horizontal open rotor type mill are continuously recirculated in a regulated velocity of flow independently of any air flow through the mill, the fines being drawn out through a discharge and any oversize being returned in a circulating flow to the grinding zone.

Other objects of the invention will become apparent as the description proceeds.

To the accomplishment of the foregoing and related ends, this invention then comprises the features herein-after fully described and particularly pointed out in the claims; the following description setting forth in detail certain illustrative embodiments of the invention; these being indicative, however, of but a few of the various ways in which the principles of the invention may be employed.

The invention is illustrated by the drawings in which the same numerals refer to corresponding parts and in which:

Figure 1 is a vertical elevation, in section, of the classifier of this invention shown mounted on an open rotor type mill, the section being taken generally on the line 1—1 of Figure 2 and in the direction of the arrows;

Figure 2 is a vertical section taken on the line 2—2 of Figure 1 and in the direction of the arrows; and

Figure 3 is a partial end elevation showing damper control means, the view being on the line 3—3 of Figure 2 and in the direction of the arrows.

Broadly stated, the invention comprises apparatus including a classifier housing superimposed upon the housing of a horizontal open rotor type mill, the classifier housing including a vertical uptake duct, a semicylindrical top section, a down flow return duct to the mill, a horizontal outlet pipe extending lengthwise through the semicylindrical top section having an inlet slot along its upper periphery, and a dividing wall between the uptake and return ducts curved as an involute tangent to the outlet pipe. The rotor of the open rotor mill acts as a peripheral fan when rotated at substantial speed to induce air and airborne material into the mill housing the full length of the rotor through a peripheral opening along

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the front of the rotor and discharge the flow tangentially at the top of the rotor at substantially static pressure into the expanded portion of the mill housing.

The airborne material is reduced during its 270 degree turn about the rotor by high intensity, intrablade vortex action in and at the periphery of the rotor. The reduction is largely a high velocity impact and fluidal vortex action in a fluid mill load.

The fines expelled tangentially from the rotor into the expansion chamber are carried out by the air into the classifier above. The coarser material returns in the air stream to the feed inlet below for regrinding. The removal and return of the coarser particles is the result of a forced circulation through the classifier set up by the rotor independently of any air flow through the mill, without any air entering the mill or going out of the mill. As the circulating air returns to the mill the rotor discharge gives it an added impetus.

In the operation of the apparatus there is set up a continuous circulation of the coarser material around the rotor. At the same time the fines are continuously circulating at a high velocity in the classifier from and back into the mill with air flow induced by the rotor.

An independently driven suction fan is connected to the outlet pipe of the classifier, discharging to any suitable collector system. The outlet pipe is provided with a rotary pipe control valve to regulate the air flow out of the classifier, and hence to control the air flow through the mill and classifier. It will be noted that when this control valve is closed and no air flows through the mill, the circulation of air within the mill and classifier continues and the grinding process proceeds normally on any material in the mill, reducing it ever finer.

As the outlet control valve is opened additional air is drawn into the mill and through the mill removing the fines. Additional material can then be fed into the mill in controlled amounts.

The controlled circulating flow in the classifier provides a centrifugal throwout of the oversize and returns it to the grinding zone. The controlled air flow through the mill and classifier provides an effective and highly selective centripetal withdrawal of the wanted particle sizes.

Referring now to the drawings, the classifier is shown mounted on a mill of the type described in copending United States application Serial No. 497,194, indicated generally at 10. That mill comprises generally horizontal housing 11, preferably provided with a liner 12, which may be smooth or corrugated. Housing 11 is enclosed between two end plates 13 and 14. It will be noted that this mill is characterized by the absence of a self-contained fan. The end plates extend to a base or floor and are affixed by floor flanges.

A suitable bearing structure adequately sized to carry the rotor of the mill is mounted at each end of the mill outside the end plates. Upon the bearings there is mounted a shaft 15 extending through the end plates and running the entire length of the mill forming the axis thereof. Shaft 15 is driven by any suitable drive means. Shaft 15 is enlarged and reinforced through part of its length by a tube 16 supported by annular rings 17 welded or otherwise secured to the shaft, the shaft, tube and annular rings forming a rigid unitary structure upon which the grinding rotor units are mounted.

A rotor end disk 18 is mounted on each end of the tube secured to one of the annular rings. Mounted in series between the rotor end disks are a plurality of individual independent radial blade grinding or pulverizing units 19. As shown, each unit comprises an annular disk 20 perpendicular to the shaft carrying in radial slots around its periphery a plurality of flat radial blades 21 enclosed between a pair of disks 22. Radial blades 21 are positioned perpendicular to the slotted disk. Disks

22 have a diameter reaching to the periphery of blades 21. The slotted disks 20 and disks 22 are held spaced apart by annular spacer rings 23 of appropriate length keyed to tube 16. Radial blades 21 may likewise be in the form of rods mounted perpendicular to the rotor disks. Each rotor pulverizing unit acts as complete independent annular grinding zone from feed to finished product.

The upper forward quadrant of the cylindrical mill housing 11 is cut away and replaced by an upwardly extending section bounded between end plates 13 and 14 by a tangential front wall 24 and an outwardly sloping back wall 25 and forming an expansion chamber and mill outlet 26. Below this expansion chamber along the center line of the housing is a lip forming a tangential inlet 27 extending the length of the housing for both air and the material to be reduced.

A material and gas inlet means indicated generally at 28 is provided along the full length of the mill for controllably feeding the material to be reduced to the inlet opening 27. In the form here illustrated the material feeder comprises an elongated hopper 29 fed from a supply pipe 30 with a rotary metering gate 31 which is preferably driven by a variable speed drive for precise feed rate control.

An air inlet chamber 32 is provided below the feed hopper. The air inlet has a sliding gate or damper 33 associated with the tangential inlet 27 for precise inlet air control. By these means the material as fed is drawn into the mill with the air.

The bottom of the grinder housing is provided with an opening 34 or a plurality of openings along the length of the mill, connected with an outlet gate or duct having slide dampers 35 or similar means for progressively withdrawing bits of sand, stone, grit, metal and like extraneous heavier material from the mill load. Initially this grit trap will become filled with the material to be reduced, but as grit and like material is introduced into the mill, it will, because of its greater density, drop to the bottom of the trap.

The classifier housing, indicated generally at 36, comprises a hood or canopy including a front wall 37 which extends as a projection of front wall 24 of the mill expansion chamber, a semi-cylindrical dome portion 38 and an inwardly extending back wall 39 sloping down to meet the back wall 25 of the mill expansion chamber. The classifier housing is enclosed between two parallel end plates 40 and 41. Both the front and back walls of the classifier housing are preferably provided with removable sections 42 and 43.

Positioned within the classifier housing 36 generally within the semi-cylindrical dome portion 38 but displaced toward the back wall is a generally cylindrical outlet duct 44. Outlet duct 44 is positioned so that the passage defined between the duct 44 and the rear edge of the classifier housing wall is approximately only  $\frac{1}{4}$  to  $\frac{1}{2}$  as large as the corresponding space between duct 44 and the front wall of the classifier housing.

Outlet duct 44 is formed from two telescoping cylindrical tubes, an outer tube 45 fixed in end plates 40 and 41 and an inner movable tube 46 having a slidable fit within the outer tube. The portion of outer tube 45 which is within the classifier housing is open along its rearward upper quadrant. The opening may be a single cut-out section or it may consist of slots, perforations, or the like. Inner tube 46 is likewise provided with an opening over at least about one quadrant of its surface, the opening registering with the corresponding opening in the outer tube. Thus, by rotating inner tube 46 with respect to outer tube 45 the area of the opening is varied and the amount and velocity of air flow through the mill and classifier may be controlled.

One end of inner tube 46 is provided with an annular disk 47 welded or otherwise secured to the tube and keyed to rotate with a shaft 48. The corresponding end of the outer tube 45 has a ring flange to which is fixed

an annular plate 49 carrying a bearing block in which shaft 48 is journaled for rotation. A crank arm 50 is keyed to the outer end of shaft 48 which extends from the bearing block. The handle 51 of crank 50 has a screw threaded or spring loaded pin 52 which projects outwardly and engages one of a plurality of openings in a plate 53 supported by end plate 49 (similar to the damper control shown in Figure 3) to provide a plurality of predetermined settings for rotary inner tube 46. The open end of duct 44 is connected to a suction fan and collector system (not shown).

Positioned within classifier housing 36 is a dividing wall 54 which rises from a line adjacent to the top of the mill expansion chamber and is curved at its upper end in the form of an involute tangential to tubular duct 44 along its rearward edge. Dividing wall 54 defines an uptake duct 55 at the front of the classifier housing, wide at the bottom and narrowing toward the top and a return duct 56 at the back of the classifier housing tapering to a narrow opening just above the sloping back wall 25 of the mill expansion chamber.

At the bottom edge of dividing wall 54 there is positioned a damper 57 extending the length of the classifier housing. Damper 57 is keyed to pivot with the rotation of a shaft 58 which is journaled in the end plates 40 and 41 of the classifier housing. One end of shaft 58 has a crank 59 keyed to it to rotate the shaft and move damper 57. The handle 60 of crank 59 has a screw threaded or spring loaded pin 61 which projects outwardly for engagement with one of a plurality of openings in perforated plate 62 supported from the housing. By means of crank 59 damper 57 can readily be set in any one of a plurality of predetermined positions to regulate the velocity of the return flow of air and coarser particles to the mill.

The mill housing is preferably split horizontally so the top half may be lifted off and the rotor lifted out, providing complete access for cleaning and servicing. If desired, an access door 63 may also be provided in the mill housing. The rotor may be turned end for end to reverse the blade wear and produce a self-sharpening blade wear. As the rotor blades wear back the running clearance in the mill increases. This does not materially affect the mill capacity so long as it is not excessive. Before this point is reached an extra inner liner may be inserted. For grinding most materials a smooth liner may be used.

The material to be reduced and classified is fed from hopper 29 by rotary gate 31 into opening 27 from which it is induced along with air tangentially the full length of the rotor into the mill and rotor by the high speed rotary action of the rotor itself. The charge, both feed and air, in controlled amounts, enters the mill at its lower forward quadrant. Reduction takes place in the course of its travel about the rotor by high intensity intrablade vortex action in a manner well understood in the art.

The product is continuously discharged by the rotor tangentially from the rear top quadrant of the rotor every 270 degree turn about the rotor into the forward expansion chamber 26 leading to the classifier mounted over the grinding chamber. Obviously this insures the complete removal of all finished product from the mill load at every revolution of the rotor. The coarse oversize is returned to the grinding zone for further reduction, once again around the rotor and so on until reduced to desired fine particle size.

In the expansion chamber the finished product is caught up in a continuously recirculating air flow through the classifier and carried up through uptake duct 55 around the top of the classifier and into return duct 56. The velocity of flow of this air stream, circulating independently of air flow through the mill and out through the discharge, is regulated by adjustment of damper 57.

At the same time the velocity of the flow of air through the mill and out through the discharge duct 44,

which is induced by a suction fan connected to the discharge outlet, is regulated by adjustment of the rotary pipe valve means embodied in duct 44. The particle size fineness control is a function of the controllable air circulation and its velocity in the classifier and the controllable air flow and velocity through the mill and out of the classifier.

The controlled circulating flow in the classifier provides a centrifugal throwout of the oversize particles from the stream of particles from the mill as it passes around the top of the classifier from the uptake duct and into the return duct. The oversize is returned through duct 56 to the grinding zone. The controlled air flow through the mill and classifier provides an effective and highly selective centripetal withdrawal of the wanted particle sizes from the top of the return duct around and into the opening in the outlet duct 44 and thence out to a suitable collector system.

It will be seen that the mill rotor acts as a fan to induce the air and material into the mill, to maintain a substantial air pressure in the mill, to maintain an intensive recirculation of the air and the product in the classifier and to return the oversize or tailings to the grinding zone with circulating air while the flow through the mill and classifier induced by an outside source of constant regulatable suction provides precision particle size control.

It is apparent that many modifications and variations of this invention as hereinbefore set forth may be made without departing from the spirit and scope thereof. The specific embodiments described are given by way of example only and the invention is limited only by the terms of the appended claims.

What is claimed:

1. A classifier for dry solid pulverulent material adapted to be mounted over the discharge duct of a horizontal open rotor reducing mill having a generally cylindrical mill housing, the rotor of said mill comprising a plurality of closed end radial blade grinding units, said rotor being associated with a tangential air and material inlet port to said housing, said rotor being positioned within said housing to constitute a peripheral fan unit having a peripheral discharge above the rotor, an expansion chamber mounted in the mill housing over one quadrant thereof on the same side as the inlet port forming the outlet of the grinding rotor chamber, said expansion chamber being in direct fluid communication with the interior of the housing over that quadrant to receive the peripheral discharge from the rotor, said tangential air and material inlet extending along the length of said rotor along the front of the mill, said classifier comprising a vertical uptake duct extending upward above said expansion chamber, a semi-cylindrical top section at the top of said uptake duct, a downflow return duct extending from said top section back to the expansion chamber of the mill, a horizontal outlet duct open at one end extending lengthwise through said top section, an inlet slot along the upper periphery of said duct and a dividing wall between the uptake and return ducts, said dividing wall extending upwardly from the expansion chamber and curving in the form of an involute tangent to the horizontal outlet duct.

2. A classifier according to claim 1 further characterized in that said horizontal outlet duct comprises an air flow control valve, said duct including a pair of telescoped tubes, each open around about one quadrant of its surface, one of said tubes being rotatable with respect to the other for varying the size of the outlet slot.

3. A classifier for dry solid material adapted to be mounted over the discharge duct of a horizontal open rotor mill having a generally cylindrical mill housing, the rotor of said mill comprising a plurality of closed end radial blade grinding units, said rotor being associated with a tangential gas and material inlet port to the mill housing, said rotor being positioned within said housing

to constitute a peripheral fan unit having a peripheral discharge above the rotor, an expansion chamber mounted in said cylindrical mill housing over about the upper forward quadrant thereof forming the outlet of the grinding rotor chamber, said expansion chamber being in direct fluid communication with the interior of the housing over that quadrant to receive the peripheral discharge from the rotor, said tangential gas and material inlet extending the length of the rotor along the front of the mill, said classifier comprising a forward vertical uptake duct extending above the expansion chamber, a semicylindrical top section at the top of said uptake duct, a rearward downflow return duct extending from said top section back to the expansion chamber, a horizontal outlet duct open at one end extending lengthwise through said top section, said outlet duct having an inlet slot along its upper periphery and including a pair of telescoped tubes, each open around about one quadrant of its surface, one of said tubes being rotatable with respect to the other for varying the size of the outlet slot, means for rotating the rotatable tube externally, and a dividing wall between the uptake and return ducts, said dividing wall extending upwardly from the expansion chamber and curving in the form of an involute over said outlet duct and tangent thereto along its rearward edge.

4. A classifier for dry solid pulverulent material adapted to be mounted over the discharge duct of a horizontal open rotor mill having a generally cylindrical mill housing around the rotor forming a grinding rotor chamber, the rotor of said mill comprising a plurality of closed end radial blade grinding units, a tangential air and material inlet port extending along the length of said rotor along the front of the grinding rotor chamber, said rotor being positioned within said housing in association with the tangential inlet to constitute a peripheral fan unit having a peripheral discharge above the rotor for the induction of air and material into the housing and to provide an increased and relatively high air pressure at the tangential peripheral rotor discharge, an expansion chamber mounted in the mill housing over one quadrant thereof forming the outlet of the grinding rotor chamber to receive the peripheral discharge from the rotor; said classifier adapted to be mounted on the mill above the expansion chamber comprising a vertical uptake duct extending upward above said expansion chamber, a semi-cylindrical top section at the top of said uptake duct, a downflow return duct extending from said top section back to the expansion chamber of the mill, a horizontal outlet duct open at one end extending lengthwise through said top section, an inlet slot along the upper periphery of said duct and a dividing wall between the uptake and return ducts, said dividing wall extending upwardly from the expansion chamber and curving in the form of an involute tangent to the horizontal outlet duct, whereby an air and entrained material circulation is maintained by the high discharge air pressure of the rotor fan unit in the classifier and through the outlet duct.

5. A classifier for dry pulverulent material adapted to be mounted over the expansion chamber of a horizontal open rotor mill, said classifier comprising a forward vertical uptake duct of diminishing cross-sectional area in the upper direction, a semicylindrical top section at the top of said duct, a rearward downflow return duct of diminishing cross-sectional area extending from the top section back to the mill, a horizontal outlet duct open at one end extending lengthwise through said top section rearward of the center thereof, said outlet duct having an inlet slot along its upper periphery and including two telescoped tubes each open around about one quadrant of its surface, one of said tubes being rotatable with respect to the other for varying the size of the outlet slot, said rotatable tube being keyed to a shaft extending through the classifier wall for rotation from externally of the classifier, a dividing wall between the uptake and return ducts, said dividing wall being curved at its upper end in the form of an in-

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volute passing over said horizontal outlet duct and tangent thereto along its rearward edge, and a pivotally mounted damper in the lower end of the return duct for regulating air flow therethrough.

6. A classifier for dry pulverulent material adapted to be mounted over the expansion chamber of an open rotor grinding mill, said classifier comprising a forward vertical uptake duct, a semi-cylindrical top section at the top of said uptake duct, a rearward downflow return duct extending from said top section back to the mill, a horizontal outlet duct open at one end and extending lengthwise through said top section, an inlet slot along the upper periphery of said duct, said horizontal outlet comprising a pair of telescoped tubes, each open around about one quadrant of its surface, one of said tubes being rotatable with respect to the other for varying the size of the inlet slot to said outlet duct, and a dividing wall between the uptake and return ducts, said dividing wall being curved

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at its upper end in the form of an involute tangent to the horizontal outlet duct along its rearward edge.

7. A classifier according to claim 6 further characterized in that said rotatable tube is keyed to a shaft extending through the classifier wall for rotation from externally of the classifier.

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