March 1, 1966 G. D. HUMPHREYS 3,237,766

MECHANICAL AIR CLASSIFIER

Filed Oct. 18, 1961 4 Sheets-Sheet 1

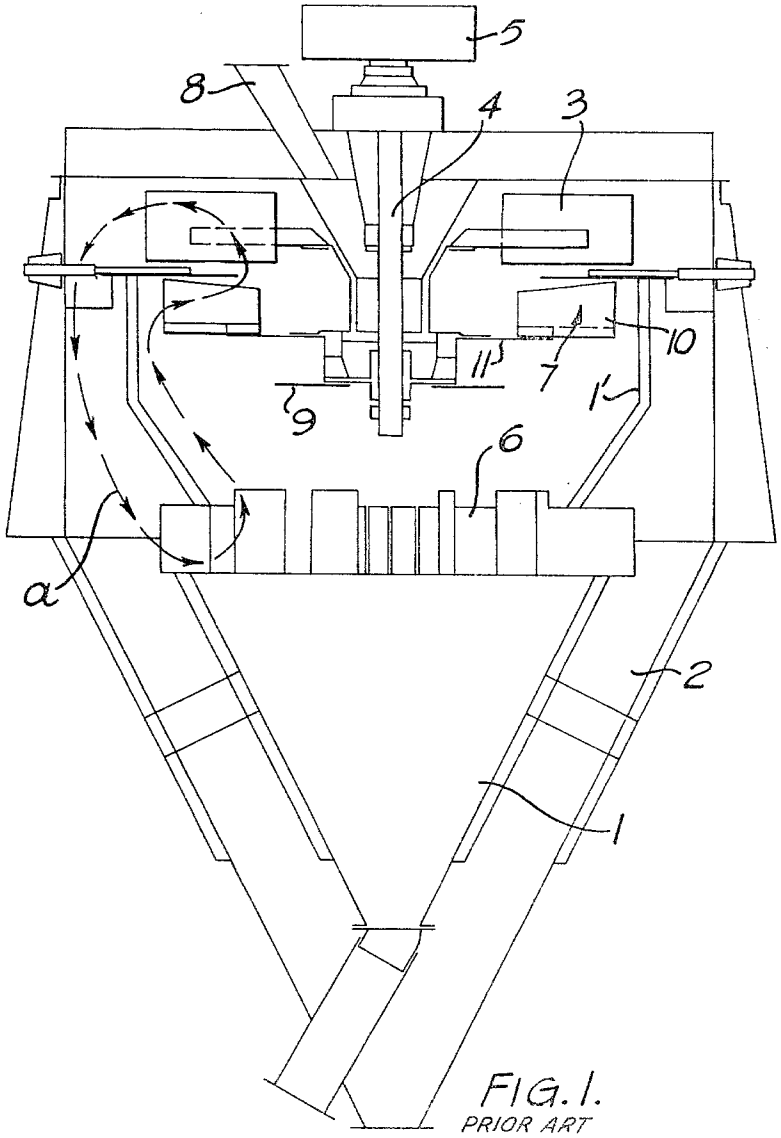


FIG. 1.
PRIOR ART

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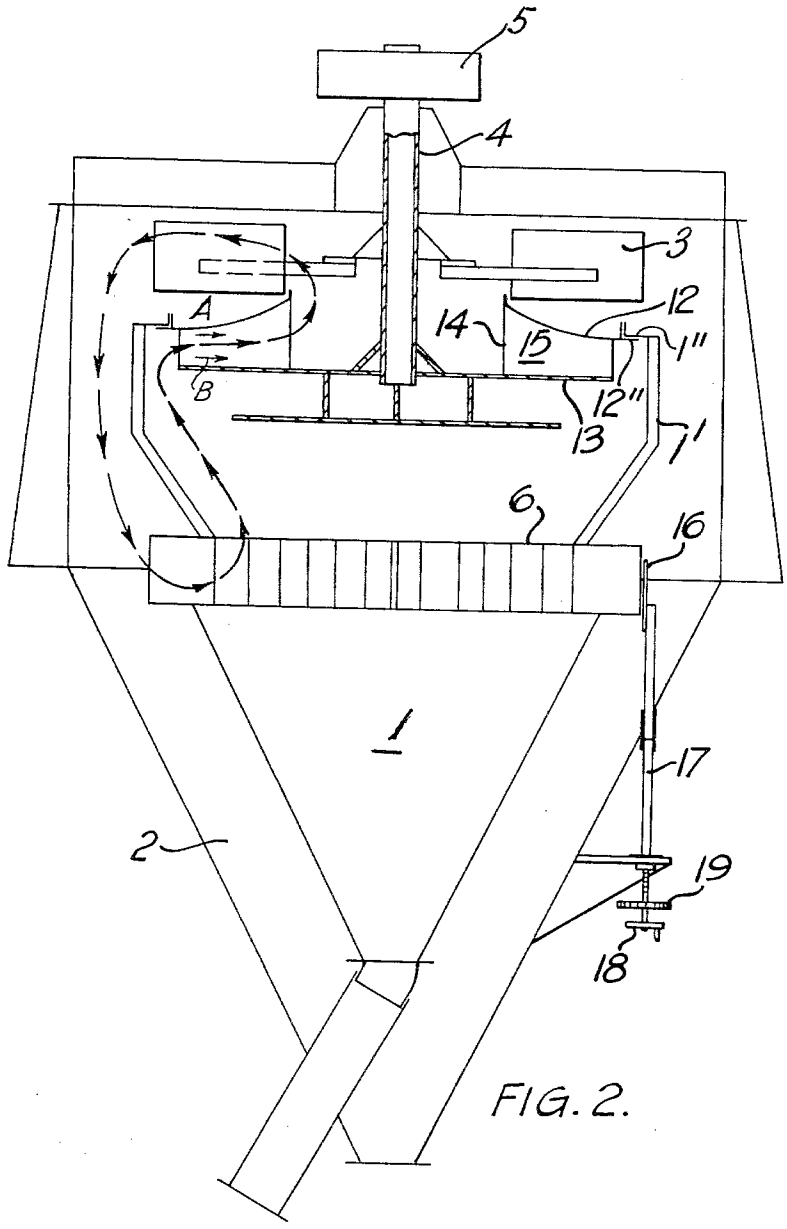


FIG. 2.

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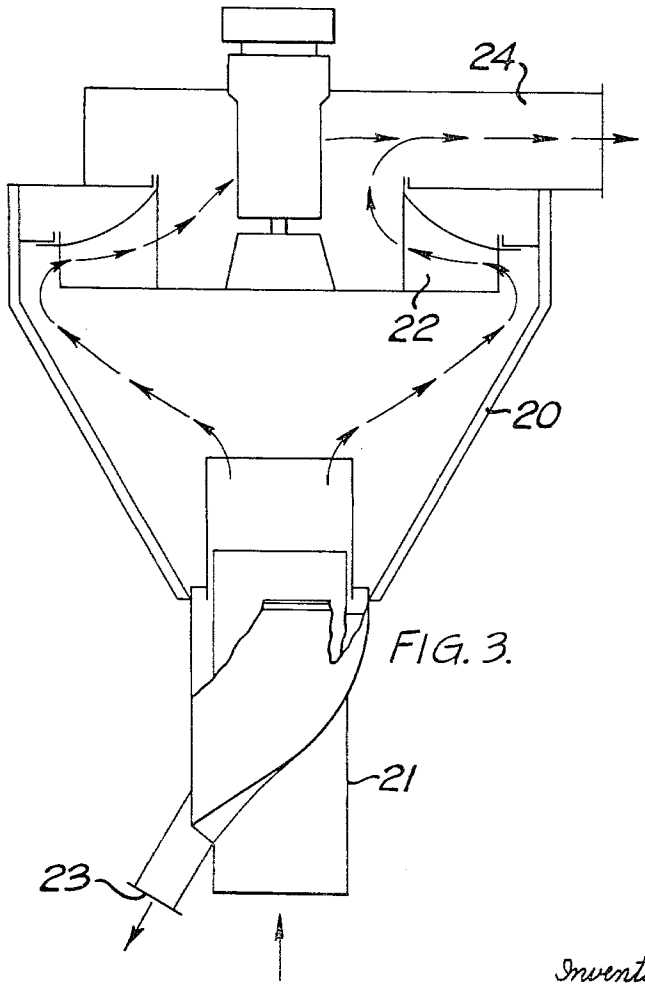


FIG. 3.

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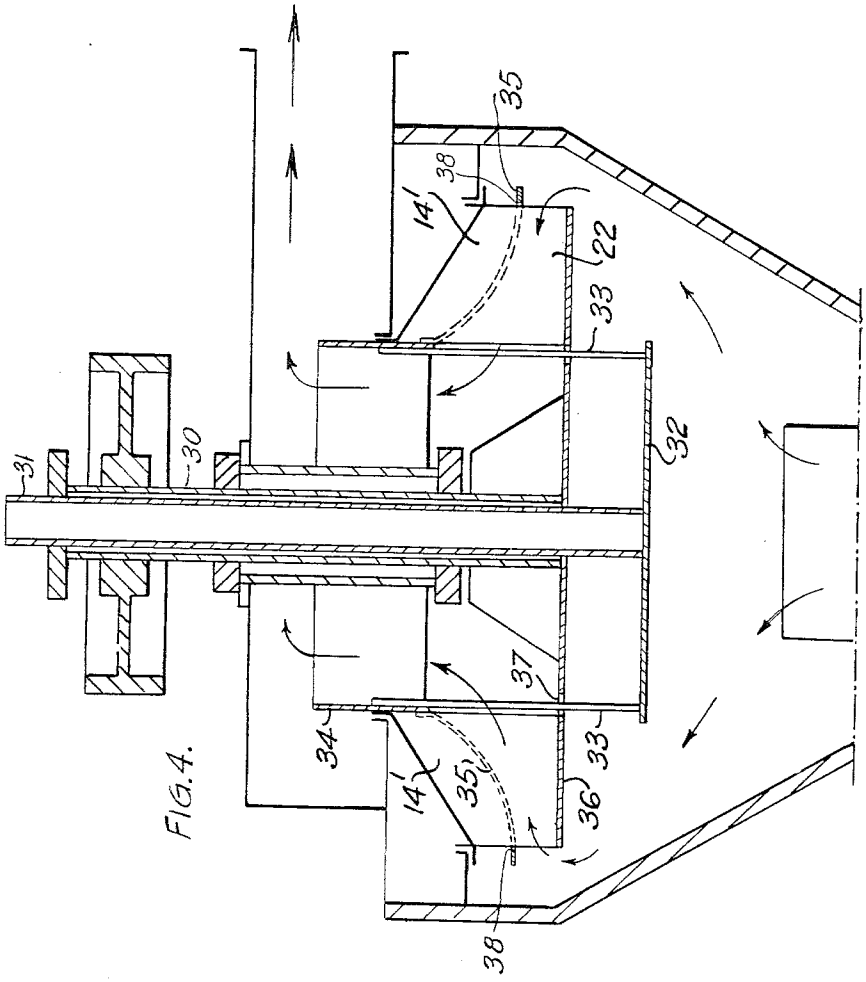


FIG. 4.

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MECHANICAL AIR CLASSIFIER

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Claims priority, application Great Britain, Oct. 21, 1960, 36,282/60
6 Claims. (Cl. 209—139)

This invention relates to classifying machines.

Air or gas classifiers operate on the principle of subjecting airborne particles to centrifugal forces which act in a direction different from the direction of flow of the air or other working fluid.

In the standard type of classifier, the material to be classified is fed into the innermost of two concentric cones, air being drawn upwardly through the inner cone by an inbuilt fan at the top, thereby drawing air up through the inner cone and down through the annular space separating the cones. Material fed in at the top falls onto a rapidly revolving feed plate, by which it is thrown outwardly in a thin layer by the centrifugal force and some of the coarsest material falls to the bottom of the inner cone, most of the material being lifted by the fan into the classifying zone. The material passing through the classifying zone proceeds through the fan into the outer cone, where it separates from the carrying air as in a cyclone.

In the classifying zone the particles of the material are subjected to a frictional drag force, which is caused by the flow of air induced by the fan, and a centrifugal force caused by the rotation of the classifying zone. In the more successful commercial classifiers these two forces are induced to act in substantially opposite directions, but in many classifiers these forces are at right angles to each other. If a homogeneous material (i.e. the density of each particle is independent of the particle size) is carried by an air stream of a given velocity and is caused to rotate at a given velocity and radius about the centre of a classifier, there is a critical size of particle, for which the centrifugal and drag forces are equal.

In practice it is found that the drag force exerted on a particle increases rapidly as the particle travels inwards, whilst the centrifugal force exerted on the particle decreases progressively with the result that only a small proportion at the periphery of the classifying zone is effective.

To overcome this difficulty, it has been proposed so to design the classifier that the vertical height within the classifying zone increases as the radius becomes less i.e. it is greater at the centre than at the periphery. With this construction it becomes possible to produce a design in which the ratio of drag and centrifugal force acting on a particular particle is independent of the radius of rotation i.e. its position in the classifying zone with the result that at all points across the classifying zone, there is virtually a proper balance between drag and centrifugal force acting on the particles. However hitherto, practical difficulties in constructing a classifier have resulted by reason of the tendency of the cut size particles to remain stationary at a particular section without moving either inwardly or outwardly.

According to this invention, in the operation of a classifier of the single or double cone type, the cross section of the classifying zone is greater at or adajcent the centre than at its periphery so that at all points the drag set up by the air or gas flow substantially balances the centrifugal force acting on a particle of the size

at which a cut is desired and the direction of flow of the air or gas, prior to entry into the classifying zone, is approximately parallel to the axis of rotation in order to ensure inside the classifying zone a change in rate of flow extending vertically across it whereby cut particles, which are suspended in the air stream, will be released and rejected, when, due to gravity, they move downwards into that part of the stream where the drag, due to reduced velocity, no longer balances the centrifugal force.

The invention is illustrated in the accompanying drawings in which:

FIGURE 1 is a diagrammatic sectional view of a mechanical air classifier having a standard, i.e. prior art type of classifying zone,

FIGURE 2 is a part sectional view wherein the classifying zone is in accordance with a preferred embodiment of the invention,

FIGURE 3 is a sectional view of a classifier for use in an air swept grinding circuit having a classifying zone in accordance with the invention,

FIGURE 4 is a sectional view of a classifier similar to that shown in FIGURE 3 but provided with means for adjustment of the depth of the classifying zone.

In the drawings, there is shown in FIGURE 1 a classifying machine of previously known construction having inner and outer cones, respectively indicated at **1** and **2**, circulation of air being by means of a fan **3** fast upon a central shaft **4** having a drive pulley **5**. The inner cone **1** includes an upper portion **1'**, the two parts **1** and **1'** having secured therebetween an apertured partition plate **6** in the form of radial or skew vanes so as to provide circumferentially spaced circulation passages for the return circuit of the air flow set up by the fan **3**, the path taken by the air flow being shown by the arrows *a*. Solid material to be classified is fed to the classifier through a feed chute **8** from whence it falls onto a revolving feed plate **9** fast on the shaft **4** and by means of which the material is distributed across the air stream.

The material received by the plate **9** is thrown outward in a thin stream by centrifugal force and some of the coarsest material falls to the bottom of the inner cone. Most of the material however is entrained in the air-stream and lifted by the fan **3** into what is known as the classifying zone **7**. The material passing the classifying zone **7** proceeds through the fan **3** into the outer cone **2**, where it separates from the carrying air as in a cyclone. After this separation the air is recirculated by passage through the vanes **6** into the inner cone **1** thus completing its cycle. The heavier material rejected in the classifying zone **7** falls to the bottom of the inner cone **1**.

In existing designs of classifier the classifying zone is made up of radial blades **10** carried by a lower shroud plate **11**, which assembly rotates with the fan shaft **4**.

Referring now to FIGURE 2, which shows a casing having inner and outer cones **1** and **2**, as in FIGURE 1, the classifying zone according to this invention is bounded by a continuous annular upper shroud plate **12** and a table or lower shroud plate **13**, secured between which are a series of radially arranged blades or walls **14** and it will be seen that the shape of the top shroud **12** is such that the cross-sectional area of the space **15** between adjacent blades or walls **14** increases towards the centre. The upper part **1'** of the inner cone **1** serves as a cylindrical guard ring, a part of which surrounds the classifying zone, the arrangement being such that air moved by the fan **3** passes between the guard ring and the periphery of the table **13** and thence through the classifying zone toward the axis of the table **13** and through the central outlet delineated by the radially inner edge of the annular shroud

plate 12. The guard ring is formed with an inwardly directed lip 1'' and the shroud plate 12 is formed with a portion 12'' which overlaps the lip 1'' and cooperates therewith to cause most of the air to enter the classifying zone.

As a result of the increase in cross section of the space 15 toward the centre, the velocity of the air passing through the classifying zone provided by the rotor 12, 13, 14 decreases in such a way that the frictional drag force exerted on a particular particle, which is traversing the classifying zone, decreases at the same rate as the centrifugal force acting on the particle. Thus, for any given speed of rotation of the hollow shaft 4, through which particulate material to be classified is fed, and setting of the air flow control damper 16, which is adjustable, the ratio of the drag and centrifugal forces on a particle in the classifying zone can be made virtually constant and independent of the position of the particle in the zone.

As stated above, when operating the classifier, there is a tendency for particles of the size at which separation is required, to remain in the classifying zone and neither to move radially inwards nor outwards because the inward drag more or less exactly balances the outward centrifugal force acting on them.

It has been found that this difficulty of removing the cut size particles can be overcome by arranging for the direction of the air flow, prior to entering the outer peripheral opening in the rotor to the classifying zone, to be in a direction, which is parallel, or approximately parallel, to the axis of rotation of the shaft so that on entering the classifying zone, it is forced to move in a path which is at right angles to the plane of the zone.

It follows that, at the point of entry, the air flow takes a sudden change of direction, as the result of which the inward velocity will vary vertically across the classifying zone throughout its entire length. Thus the air flow, as represented by the arrows A, will be at a maximum and substantially exceed the rate of the air flow represented by the arrows B immediately above the lower shroud plate 13.

As a result, cut size particles, which would otherwise tend to remain in position in the classifying zone, and which, after a period of time, would block the zone completely, will fall under the action of gravity from the region where the air stream is at the maximum or higher rate of flow to a region where it is a minimum.

In moving from a region where the air flow is at a maximum rate to one where it is lower, it will be obvious that centrifugal force, which remains constant for any given radius of rotation will cause the particles to be rejected because the centrifugal force is no longer balanced by the drag force set up by the air flow, which becomes smaller.

The value of the ratio of the drag and centrifugal force for any particle will clearly depend on the particle size. For a particle above a certain critical size the ratio of the drag to the centrifugal force will be less than unity, which results in the particle being rejected. This critical size may be increased or decreased by the opening or closing respectively of the control damper 16. This control damper consists of a sleeve surrounding the vanes 6 and supported by adjusting screws 17, of which there would normally be three. These adjusting screws are operated by handles 18 and may be linked together by sprockets 19 and a chain (not shown).

In the embodiment shown in FIGURE 2 the classifying zone is shown with a flat lower table or plate 13 and a curved upper shroud plate 12. Similar conditions in the classifying zone i.e. of balance between the inward areodynamic drag force and centrifugal forces acting outwardly on particles of critical size throughout the classifying zone may also be achieved in the case where the zone is bounded by top and bottom plates, either or both of which may be flat, conical or curved.

It is also possible to utilise the principle of the invention in the design of classifiers for air swept grinding mills, where the control of the air velocity is by means of an external fan. In this case the speed of rotation of the classifying section may also be varied for control purposes in order to select the appropriate critical particle size.

A typical arrangement for a classifier of this type is shown in FIGURE 3, in which the classifier comprises a conical chamber 20 having a bottom inlet 21 adapted for connection to a grinding mill to receive the air or gas flow from the grinding mill (not shown). On passage through the classifying zone 22, oversize particles are removed and injected into the chamber 20 and thence through a return conduit 23. The classified particles on leaving the outflow duct 24 pass, by induction of a fan (not shown) connected to the duct 24 externally of the classifier, to a cyclone or other material collecting device, or to the firing equipment in the case of a direct fired coal grinding circuit.

Referring now to FIGURE 4 there is shown a classifier similar to that of FIGURE 3 but in which provision is made for adjustment of the depth of the classifying zone.

In this arrangement the driving shaft 30 is tubular and is fitted with an interior sleeve 31, having at its lower end a flange 32 supporting at its perimeter a number of rods 33, to the upper end of which rods is secured a ring 34.

The ring 34 provides a support for the curved upper plate 35 of the classifying zone, while a lower plate 36 is provided with apertures 37 to accommodate the rods 33. Radial slots 38 are also cut in the plate 35 for the blades 14'.

Should it be necessary to adjust the height of the classifying zone 22, this can readily be done by raising or lowering the sleeve 31 and thus the ring 34 carrying the plate 35. The provision of an adjustable profile plate 35 enables the ratio of the drag to centrifugal force to be varied so that it is constant throughout the zone or either increasing or decreasing as the material passes from the periphery to the centre of the zone.

It has been found that with a constant ratio rejects which are reasonably free from fines will be obtained and a product which is reasonably free from coarse material. In some cases, however, it may be desirable (by suitable adjustment of the profile) to produce fines that are virtually free from coarse materials while allowing some fine material to pass out of the classifier with the rejects or vice versa.

It should be understood that the invention is not confined to the particular shape of the classifying zone shown in FIGURES 2–4 since the shape of the throat as determined by the upper shroud plate 12 or 35 may be varied according to the material to be handled and the gas used. The particle size, particle shape and operating gas velocity must all be taken into account when determining the optimum shape of the classifying zone in order that the frictional drag force exerted on the particles of the material traversing the classifying zone decreases at substantially the same rate as the centrifugal force thereon.

What is claimed is:

1. In and for a classifier of the centrifugal type for particulate material and comprising a casing; a first rotary table rotatable about an axis central in said casing; feed means for delivering particulate material substantially axially on to said rotary table for subsequent ejection therefrom at the periphery of said first table under centrifugal force; centrifugal fan means above said first rotary table for causing a flow of air past the periphery of said first rotary table, the ejected particulate material being entrained in said flow of air adjacent the periphery of said first table; a rotor comprising a second rotary table rotatable about said axis and located above said first rotary table and below the centrifugal fan means, walls on said second table having one end substantially at the periphery of said second table and extending a substantial distance

from the periphery thereof toward the axis thereof, and a shroud plate axially spaced above the surface of the second table to form a classifying zone therebetween for said air and entrained particulate material to flow therethrough in a centripetal direction and to be rotated by said walls, said shroud plate being of continuous annular construction to provide a peripheral opening serving as an inlet to said classifying zone for said flow of air with entrained particulate material, and as an outlet for particles rejected under centrifugal force, and to provide a central outlet for air and entrained particulate material, said second table and said shroud plate being shaped to provide a flow cross-section increasing toward said central outlet at a rate such that for a particle of given size the ratio of the inward radial aerodynamic drag force to the centrifugal force is substantially the same throughout said classifying zone, and a guard ring at least part of which surrounds the classifying zone and is substantially cylindrical and coaxial with the second table to cause air and entrained particulate material to enter the periphery of the classifying zone with different inward radial components of velocity over the depth of said peripheral inlet opening.

2. A classifier according to claim 1 in which said feed means comprises an axially rotatable tube journalled in said casing and terminating at its lower end above the first rotary table, said tube having affixed thereto the first and second rotary tables, and said fan means comprises a plurality of fan blades affixed to said tube.

3. A classifier according to claim 2 including a ring movable for effecting relative adjustment of the axial spacing between said shroud plate and said second table.

4. A classifier as claimed in claim 2 in which the guard ring is formed with an inwardly projecting lip and the shroud plate is formed with an overlapping portion for cooperation therewith.

5. A classifier as claimed in claim 2 in which said walls are in the form of radial blades and the shroud plate is secured thereto.

6. In and for a classifier of the centrifugal type for particulate material and comprising a casing; a first rotary table rotatable about an axis central in said casing; feed means for delivering particulate material on to said first rotary table for subsequent ejection therefrom under centrifugal force and including an axial duct terminating at its lower end above the first rotary table; external duct

means connected to said casing for delivering air into said casing and discharging air from said casing for thereby causing a flow of air past the periphery of said first rotary table, the ejected particulate material being entrained in said flow of air adjacent the periphery of said first table; a rotor comprising a second rotary table rotatable about said axis and located above said first rotary table, walls on said second table having one end substantially at the periphery of said second table and extending a substantial distance from the periphery thereof toward the axis thereof, and a shroud plate axially spaced above the surface of the second table to form a classifying zone therebetween for said air and entrained particulate material to flow therethrough in a centripetal direction and to be rotated by said walls, said shroud plate being of continuous annular construction to provide a peripheral opening serving as an inlet to said classifying zone for said flow of air with entrained particulate material, and as an outlet for particles rejected under centrifugal force, and to provide a central outlet for air and entrained particulate material, said second table and said shroud plate being shaped to provide a flow cross-section increasing toward said central outlet at a rate such that for a particle of given size the ratio of the inward radial aerodynamic drag force to the centrifugal force is substantially the same throughout said classifying zone, and a guard ring at least part of which surrounds the classifying zone and is substantially cylindrical and coaxial with the second table whereby air and entrained particulate material enter the periphery of the classifying zone with different inward radial components of velocity over the depth of said peripheral inlet opening.

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