United States Patent

[11] **3,581,477**

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[33] **Great Britain**
[31] **8618/68**

[54] **CENTRIFUGAL SEPARATORS**
5 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **55/347,** 55/348, 55/396, 55/397, 55/450, 55/457
[51] **Int. Cl.** **B01d 45/16**
[50] **Field of Search** ..... 55/345-48, 396-97, 235-39, 456-57, (SA) 450; 261/79.1

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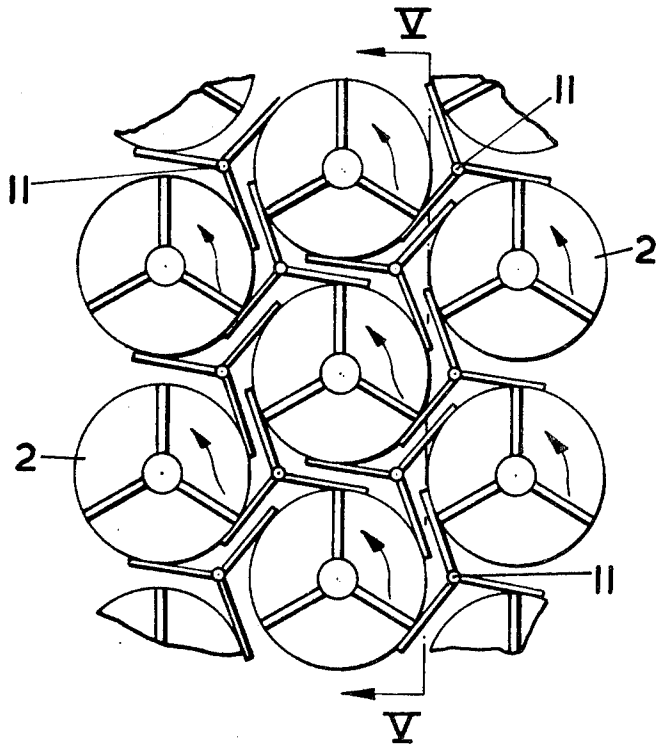
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Assistant Examiner—Vincent Gifford
Attorney—Cameron, Kerkam & Sutton

ABSTRACT: A helical vane assembly extends along a cylindrical tube with an annular space surrounding the vane. Air passing along the center of the tube is swirled by the vanes and any particles of dust or other foreign matter are centrifuged into the annular space to be entrained by axial flow passing along it to a flow diverter whereby it is led away from the main stream which is then "deswirled." The annular space may be divided circumferentially by radial vanes extending along the tube in an axial sense. A number of tubes may be assembled together in a panel; a more compact panel may be obtained by the use of hexagonal tubes. In a further development, the intermediate walls between adjacent vane assemblies are omitted and a series of trefoil baffles inserted in the interstices between the assemblies. The arms of the baffles cooperate with the vane assemblies to define axially extending passages around them and to provide support.



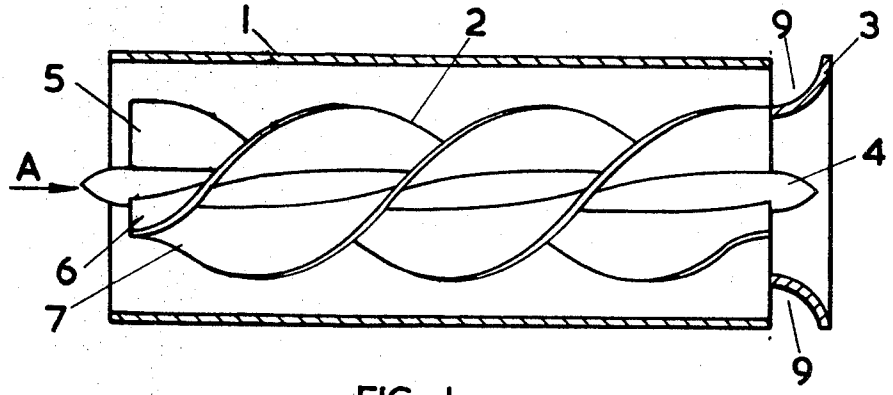


FIG. 1.

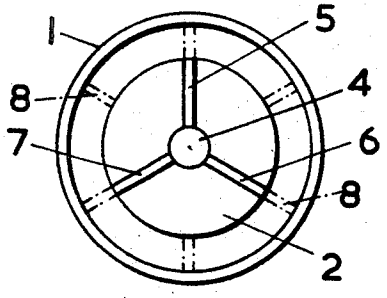


FIG. 2.

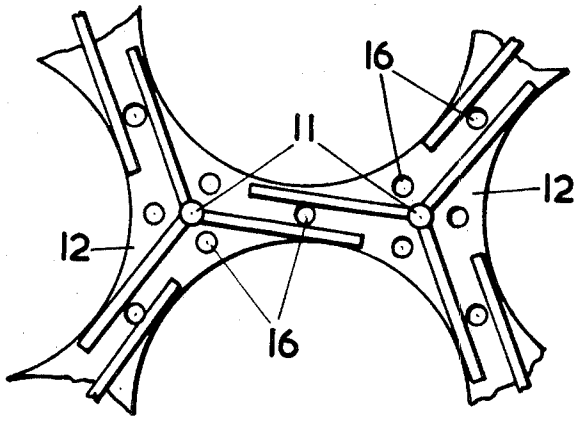


FIG.6.

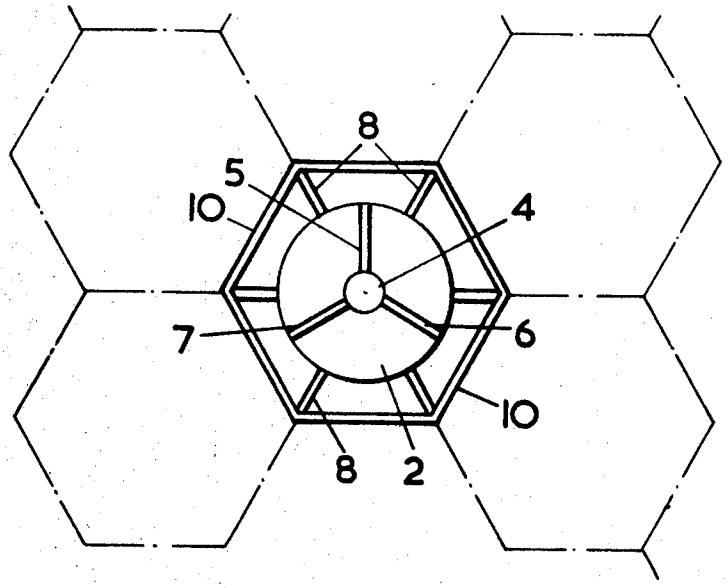


FIG. 3.

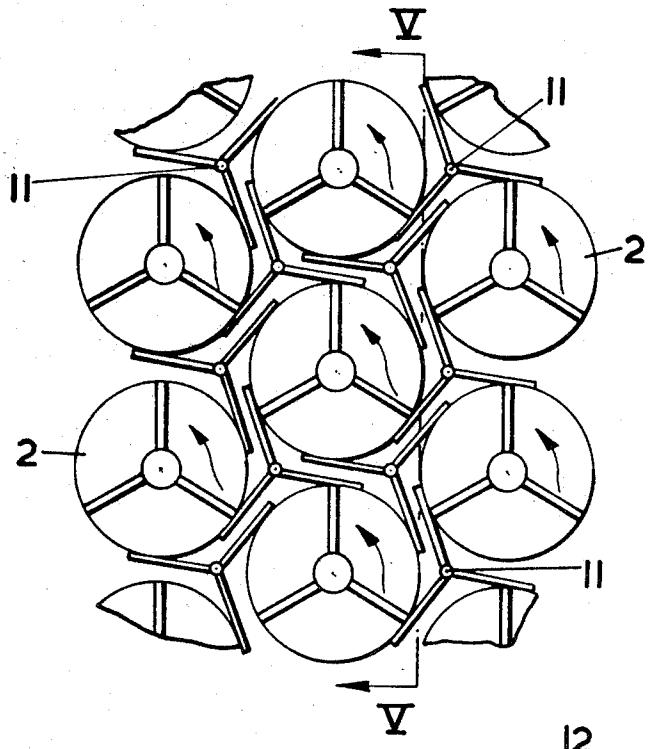


FIG. 4.

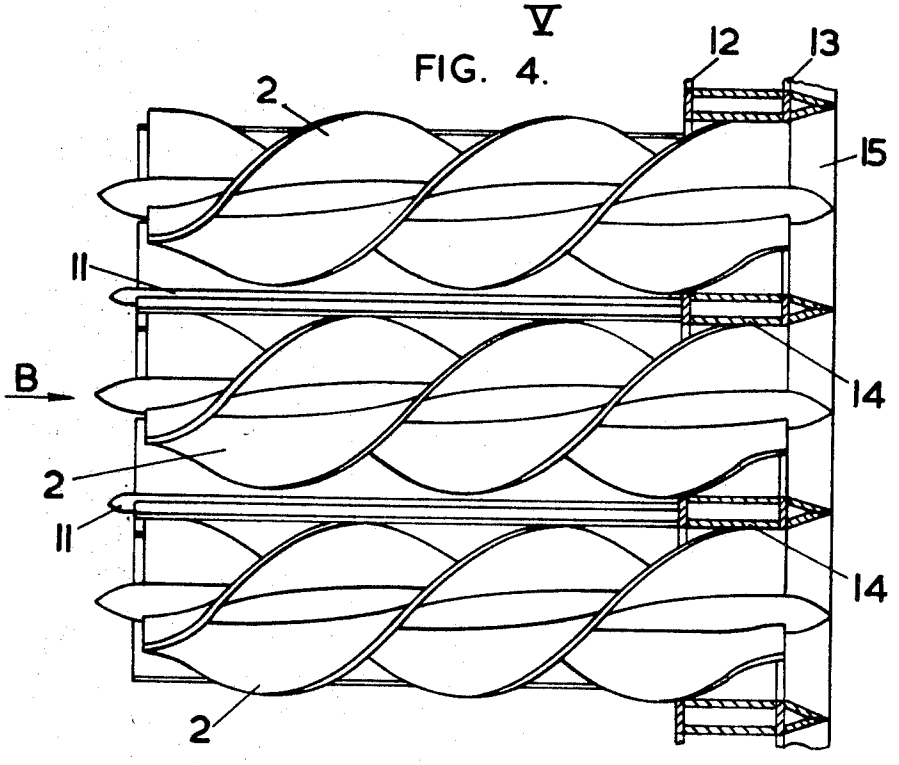


FIG. 5.

CENTRIFUGAL SEPARATORS

The invention relates to centrifugal separators used, for example, for removing dust particles from airstreams by imparting a swirling motion to the air.

One such separator which is extensively used comprises an open-ended cylindrical tube containing a helical-vaned swirler mounted towards one end and extending radially outward to the wall of the tube. Air flowing into the separator is swirled by the helical vanes and any foreign matter such as dust particles is centrifuged towards the periphery of the tube. A flow diverter is provided at the tube outlet whereby the radially outer layers of air which contain the centrifuged foreign matter are diverted from the main flow.

It has been shown that such a velocity can be imparted to particles that they are bounced back into the clean air area after striking the periphery of the tube, usually at some point too close to the outlet for them to be recentrifuged to the outer layers of air.

Such separators are necessarily of small diameter and thus have a small volume flow. Where a large volume flow is required, numbers of such separators are assembled into panels, which, because of the separation which must occur between cylindrical members, results in a relatively large frontal area in relation to the flow.

Another disadvantage in certain applications is that the air passing from the swirler into the main body of the tube continues to rotate and an uncontrolled vortex may be set up leading to undesirable flow losses. In any case where it is desired that the flow should be "deswirled" before being released to the outlet, the lead-in angle of any blades used for this purpose is related to the angle of lead of the rotating air and, since this varies with different throughputs, compromise blades are the only solution, with consequent losses.

A centrifugal separator according to the invention includes at least one flow channel with a swirler comprising a helical vane assembly extending along the axis of the channel with radial clearance from at least part of the peripheral boundary of the channel to define therewith a substantially circumferentially extending passage, and a flow divider located at or near the downstream end of the flow channel to separate fluid flowing along the passage from that flowing through the swirler.

In one embodiment of the invention, there is a plurality of swirlers spaced apart and the peripheral boundaries of the respective flow channels are constituted by baffles disposed in the interstices formed between adjacent swirlers.

Various embodiments of the invention will now be described by way of example with reference to the accompanying diagrammatic drawings, of which:

FIG. 1 is a part axial section of a centrifugal separator;

FIG. 2 is an end view of the centrifugal separator of FIG. 1 looking in the direction of the arrow A in that FIG.;

FIG. 3 is a similar view to FIG. 2 of a modified form of centrifugal separator;

FIG. 4 is an end view of part of a multichannel centrifugal separator;

FIG. 5 is an axial section of the separator of FIG. 4, with certain components removed, taken on line V–V in FIG. 4;

FIG. 6 is a detailed view of part of the separator of FIG. 4.

FIGS. 1 and 2 show a centrifugal separator comprising a cylindrical tube 1 containing a vane assembly 2 and having a flow diverter 3 at one end. The vane assembly consists of a centerbody 4 extending along the axis of the tube and carrying three circumferentially spaced vanes 5, 6, 7. The vanes extend radially from the centerbody towards each end of it and describe helical paths in between, the angle of the helix being at a maximum midway along the centerbody i.e., the vanes have a zero helical angle at one end which increase to approximately 55° halfway along the centerbody and decreases again to zero at the other end. The diametral measurement of the vane assembly is less than the inside diameter of the tube 1 to give an annular axially extending flow passage between the vanes and the tube. The vane assembly is supported in the tube by circumferentially spaced longitudinal ribs 8 (omitted from FIG. 1 for the sake of clarity, and shown in dotted lines in FIG. 2) which extend radially inwards from the periphery of the tube. The flow diverter 3 is in the form of a bell mouth of is attached at its narrower end to the vanes at one end of the vane assembly so that its wider end is spaced axially beyond the end of the tube 1. The narrower end of the flow diverter is of the same diameter as the diametral measurement of the vane assembly and the diameter of its wider and corresponds to that of the tube. A circumferential passage 9 is thus formed between the tube and the flow diverter. Air flowing along the separator as indicated by the arrow A in FIG. 1 will be divided into two streams, a core passing through the vane assembly and being swirled thereby to pass through the center of the flow diverter, and an outer layer passing axially along the flow passage between the vane assembly and the tube to pass out of the circumferential passage around the flow diverter. Any foreign bodies such as dust particles in the core flow will be centrifuged by the swirling action into the outer layer to be entrained thereby and carried with it out of the circumferential passage. Particles ejected from the vane assembly at high velocity will be slowed down by the axial flow before striking the wall of the tube and again after rebound and thus are unlikely to reenter the core stream. Maximum velocity is likely to be imparted to particles near the midpoint of the separator where the helical angle of the vanes is greatest and, since the swirling action will continue almost to the point of exit of the core stream, any particles reentering this stream will be again centrifuged out of it. The air passing through the center of the flow diverter will be substantially dust free and may be led to an engine intake or other environment where clean air is desirable. Air passing round the outside of the flow diverter, together with any foreign matter entrained in it can be led away to any convenient disposal point.

Where large volumes of air are required several centrifugal separators as the foregoing may be assembled together in a matrix, but a reduction in overall frontal area may be obtained by making the outer tube hexagonal as 10 in FIG. 3, in which the same reference numerals are used to denote components corresponding to those in the previous embodiment. The alignment of adjacent tubes is shown in dotted lines and it is envisaged that the section of tube wall between such tubes will be common to both.

Axial flow exists on either side of the separating walls which thus serve no aerodynamic purpose and the entrainment effect on any particle likely to strike a wall and bounce back would be substantially the same if the wall were not there. However, elimination of the intervening walls would lead to interaction between the swirling flows of adjacent vane assemblies with a tendency for counterrotating vortices to be formed in the interstices. Some other means of supporting the structure would also be required in this case.

FIG. 4 shows a matrix comprising a plurality of vane assemblies 2 as in the previous embodiments, each spaced apart from its neighbors and arranged in parallel rows with adjacent rows displaced vertically so that the respective axes of the vane assemblies in each row are opposite the spaces between adjacent vane assemblies in the next row. In each interstice between three adjacent vane assemblies there is a longitudinally extending baffle 11 of trefoil section having arms extending radially from a center point and mutually spaced at 120°. The arms of each baffle 11 bear tangentially against peripheral points of the three respective vane assemblies, and extend generally towards the next baffle in each appropriate direction, the two adjacent arms in each case being substantially parallel to one another and overlapping to a significant extent. As a result, each vane assembly is separated from its neighbors radially by a series of longitudinal channels overlapping circumferentially and defined by successive baffles.

In FIG. 5 the nearest baffles 11 have been omitted for convenience. The relative alignment of others is shown but these are not accurately represented as regards detail. At their downstream ends, the direction of flow being indicated by the

arrow B, the vane assemblies 2 pass into a supporting structure which also acts as a flow diverter. The supporting structure comprises two end plates 12, 13 which are pierced by a number of circular holes of the same diameter as that of the vane assemblies 2 and correspondingly spaced. The end plates 12,13 are spaced apart by sleeve members 14 which surround corresponding holes in the end plates to form passages into which the downstream ends of the vane assemblies are fitted. The end plate 13 carries on its downstream face a diffuser section 15 by which the circular holes in the said end plate are faired out to a hexagonal shape at the separator outlet plane, adjacent hexagons being mutually linked by common edges to present a maximum outlet area. The baffles 11 are attached to the upstream face of the end plate 12 and by virtue of their interrelationship with the vane assemblies 2, serve to locate and support the latter.

As shown in FIG. 6, the end plate 12 is pierced by a number of holes 16 disposed between the baffles 11 and the sleeve members 14 whereby the longitudinal channels defined by the baffles as aforementioned are connected to the space between the two end plates which surrounds the sleeve members 14.

Air flowing into the separator matrix will be divided into a series of cores passing down the vane assemblies and being swirled thereby, each surrounded by axial flow guided by the baffles 11. The core flows will pass through the passages in the supporting structure bounded by sleeve members 14 and so to the diffuser section and the separator outlet. The axial flow will pass through the holes 16 in the end plate 12 and into the space between the end plates whence it may be led to a conveniently placed exit which may be provided with a dust filter or other suitable foreign matter collecting means. Any foreign matter in the core flows will be centrifuged out and entrained by axial flow air. Particles whose velocity is such as to cause them to strike the baffles would in general be diverted thereby against the overlapping portion of an adjacent baffle and possibly back again until its energy is sufficiently reduced for it to be entrained by axial air. Should the trajectory or velocity of a particle be such that it passes completely through a channel into the core flow of another vane assembly, it will be either immediately rejected into the same channel by the counterrotation of flow at this point or centrifuged into another channel. Particles entrained in the axial air will be carried by it towards the holes 16 in the baseplate 12, as will any foreign matter already carried by that flow.

The separator matrix will be enclosed peripherally by a casing suitably shaped for a particular installation and provided with ducting in the region between the two baseplates for leading away axial flow air. The operation of the separator will be the same whether air is blown or sucked through it, though in the latter case additional suction might be applied to the space between the two baseplates to extract air therefrom. Generally, the vane assemblies will be arranged to swirl the flow through them in the same angular direction, though in some circumstances it may be advantageous to vary the direction of swirl. In all cases, the provision of baffles in the interstices between adjacent vane assemblies should be adequate to control the formation of undesirable circulation patterns.

The continuous helix controls the rotation of core air with a minimum of losses by ensuring smooth transition from axial to rotary to axial flow and also permits the formation of stronger vortices without breakdown. Potential losses are also reduced in that the air which eventually passes away with the foreign matter is not centrifuged.

We claim:

1. A centrifugal separator for separating particles from a gaseous suspension thereof comprising a plurality of swirlers each formed by an assembly of helical vanes extending along an axis, the swirlers being mounted in a plurality of rows and having their axes parallel to each other, adjacent rows of swirlers having their axes mounted in offset relation to each other and alternate rows of swirlers having their axes mounted in aligned relation to each other with interstices between adjacent swirlers, and axially extending baffles disposed in said interstices, the baffles cooperating to define a plurality of individual flow channels each containing a vane assembly and having an inlet at one end of said axes and an outlet at the other end of said axes, each of the baffles being formed with three circumferentially spaced radial arms, the arms being arranged to bear tangentially against peripheral points on different swirlers and arms of adjacent baffles together defining axially extending particle-discharge passages therebetween in communication with the adjacent flow channels, and flow-diversion means located adjacent the outlets of the flow channels and the particle-discharge passages for separately discharging the flow of the particles through the passages from the gaseous flow through the channels.

2. A centrifugal separator according to claim 1 in which the flow diversion means comprises two plates spaced axially apart and mounted transversely relative to the axes of the swirlers, sleeves extending between the plates coaxial with the swirlers and arranged to define said outlets for flow through the channels, and apertures formed in the plate which is located further upstream relative to flow through the channels and so disposed as to connect the axially extending passages with the space between the plates.

3. A centrifugal separator according to claim 2 further comprising diffuser sections at the swirler flow outlets.

4. A centrifugal separator according to claim 1 in which the helical angle of each vane assembly, varies along the axis of the vane assembly.

5. A centrifugal separator according to claim 4 in which the helical angle varies between a minimum near the inlet and the outlet of the flow channel and a maximum at an intermediate position.