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(54) GAS SEPARATOR WITH VORTICAL WHIRL

(54) SEPARATEUR DE GAZ AVEC GIRATION TOURBILLONNAIRE

(57) Abstract:

This invention relates to the separation of undesired particles such as dust from gas and vapours, particularly air, by means of centrifugal or vortex type separators. In such separators, which are usually described as cyclone separators, a gas or vapour is introduced near the top of a cylindrical body which is closed at the bottom and is provided with a baffled central clean gas outlet at the top. The spinning air follows a helical path throwing suspended particles outwardly and eventually reversing the vertical direction of flow while maintaining the same direction of rotation so as to pass upwardly centrally of the body toward the central outlet, while the suspended particles are collected in the lower regions of the cylindrical body.

Because of the many applications in which it is important, in the interests of both operators and other employees, and of the work in which they are engaged, to be able effectively to separate dust and the like from air, and in view of the importance in special fields of removing suspended material generally from gases and vapours, a great deal of attention has been paid to this question and many proposals have been made. Because cyclone separators require a large amount of power for their operation due to the pressure drop between inlet and outlet, it is frequently not economical to achieve sufficiently complete separation by coupling several cyclone separators in series. Accordingly the proposals which have been made have been directed to improving the efficiency of the cyclone type of separator, and important advances have been made. Thus it is recognized that the cylindrical body of the separator must be of sufficient length to allow centrifugal force to bring suspended particles to the wall of the separator body, and the diameter must be relatively

small in relation to the length of the body because the centrifugal force on the suspended particles is greater when the radius is made small. Further it is recognized that it is not sufficient to provide a cylindrical body of such length that the vortical action takes place only in the upper region with the intention that suspended particles reaching the cylindrical wall of the body will fall by gravity to a lower region where they will not be picked up by the vortex, but that an arrangement must be made whereby downward movement of the particles in a helical path is not discontinued, when most of the gas reverses the direction of flow and moves upward centrally of the body to the outlet duct, but is caused to continue in the original direction to a point where it is clear of the vortex and may be collected. Thus it has been proposed to provide at the bottom of the cylindrical body a conical section leading to a dust hopper and tapering to an opening of such diameter that the portion of the gas in which the particles are concentrated is caused to continue in its helical path and to pass through the opening while the remainder of the gas moves upwardly to the outlet duct. It has also been proposed to provide deflectors in conjunction with the conical section at the bottom of the cylindrical body in order to improve the separation.

The present invention is directed primarily towards providing an improved separation without the application and expense of deflectors and the like, and avoiding the re-mixing of particles with gas returning from the hopper to the separator body. It has been found that important improvements in efficiency can be made without such devices, the discovery being based on the realisation that what takes place in the cylindrical body is essentially a concentration of particles in the thin layer of gas

which is caused to pass into the hopper, and that the actual separation of particles from the flowing stream of air takes place in the hopper and can be made more effective by a hopper construction which causes the separated particles to be thrown out and kept out of the area from which the air returns from the hopper to the cylindrical body.

According to the present invention there is provided in centrifugal separator apparatus of the type comprising a relatively long and small diameter substantially cylindrical separator body, a gas inlet at one end thereof including a scroll chamber for the tangential introduction of gas to the body and a relatively long conical section at the other end of said body terminating in an opening of small diameter in relation to that of said body, a clean gas outlet duct arranged substantially concentric with the separator body at the scroll end thereof and having a substantially cylindrical section projecting into the separator body beyond the inlet scroll chamber and a conical section connected to the inner end of the substantially cylindrical section, said substantially cylindrical section having a diameter between about 0.55 and 0.6 times the diameter of the separator body and the conical section having an opening at its inner end of approximately one-third the diameter of the separator body, and a hopper of a substantially cylindrical cross-section surrounding and enclosing said opening terminating said conical section, the cross-sectional dimension of the hopper being substantially equal to that of said separator body and the hopper being substantially co-axial to said separator body. It is preferred that the diameter of the hopper be from about three-fourths to about one and one-half times the diameter of the cylindrical body, and of a length from about one and one-half to three times the diameter of the separator body, the significance of the proportions being that the hopper should contain sufficient air to be spun by the air entering the hopper from the conical section at a

sufficient rate to effect centrifugal separation of particles and to hold them outward of the central portion of the hopper where the air which enters from the conical section reverses its vertical direction of flow and passes centrally through the opening at the end of the conical section and into the separator body.

According to a further feature of the invention improved efficiency is obtained by arranging the substantially cylindrical section of the clean gas inlet duct to project into the body beyond the inlet scroll chamber a distance of approximately 0.75 times the diameter of the separator body. According to a further feature of the invention the entrance from the inlet scroll chamber to the separator body is faired to form a rounded shoulder having a radius of curvature of at least 0.10 times the diameter of the body.

The invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a vertical section of an embodiment of a separator according to the invention, and

Figure 2 is a section through the inlet scroll on the line 2--2 of Figure 1.

As appears from Figure 1, the separator body 10 is cylindrical and it is relatively long in relation to its diameter, the length of the cylindrical section being desirably about three times the diameter of the body. A gas carrying particles to be separated is introduced to the body 10 by means of an inlet scroll 11 having a contracted nozzle 12. At its lower end the separator body 10 is provided with a conical section 13 which is relatively long and opens into a dust hopper 14, the diameter of the opening 15 into the hopper being approximately one-third the diameter of the separator body whereby the volume of gas per second skimmed the lip 16 of the opening in passing into the hopper 14 is between about 10% and about 15% of the volume of gas per second

entering the separator body.

The hopper 14 is substantially co-axial to the separator body 10 and it is shown as substantially cylindrical, as is preferred, but it may be another shape, such as a regular polygon, which approximates the cross-section of a cylinder, so that it will not prevent adequate spinning of the air within the hopper. The cross-sectional dimension of the hopper is shown as substantially the same as that of the body 10 and this is preferred. It has been found desirable that the cross-sectional dimension of the hopper be from about three-quarters to about one and one-half times that of the body 10 and of a length from about one and one-half to three times the diameter of the body 10 so that the hopper contains sufficient air to be spun by the air entering the hopper 14 from the conical section 13 to effect centrifugal separation of particles and to hold them outward of the central portion of the hopper 14. In the operation of the separator the greater portion of the gas entering the separator body reverses its vertical direction and passes upwardly as mentioned above while a thin layer of gas in which the particles have been concentrated at the wall of the separator body continues its helical path along the conical section 13 and passes through the opening 15. Centrifugal force then throws the particles outwardly and the small quantity of gas which is passed through the opening 15 reverses its vertical direction and passes upwardly centrally through the opening 15. This means that the area of the hopper from which air returns upwardly through the opening 15 is positioned directly below the opening 15 and in the upper portion of the hopper, and because the hopper is of the cross-section described and co-axial to the body 10 and is of the dimensions referred to, the air is returned from an area which is substantially free of particles.

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The air which passes upwardly in the separator body passes out of it through a cylindrical clean gas outlet duct 17 which is positioned substantially centrally at the scroll end which in the embodiment illustrated is the upper end. Since the centrifugal forces within the separator are very large compared with the acceleration of gravity, the separator may be mounted vertically as shown in the attached sketch or it may be mounted horizontally or inverted. If the air contains some relatively large particles, such as chips of wood, the position illustrated is to be preferred. The gas outlet duct 17 is formed in two sections firstly, a cylindrical section 18 which is closely concentric with the body 10 and preferably has a diameter of between 0.55 and 0.6 times the diameter of the separator body and projects into the separator body beyond the lower wall 19 of the inlet scroll 11 a distance of approximately 0.75 times the body diameter. The second section of the duct is a conical section 20 preferably having a length of between 0.4 and 0.45 times the diameter of the collector body with an opening at its inner end of close to one-third the diameter of the collector body. After the gas has reversed its vertical direction within the body 10 and passes upwardly centrally of it, it continues to spin at high speed, and any particles which it still contains are thrown outwardly into the downward flowing helix of gas. It is essential to avoid turbulence in the collector body and one of the great disadvantages of the known separators has been the creation of turbulence in the reversal of the vertical direction of the gas and in its upward passage in the opposite direction to the incoming particle-carrying stream of gas. The gas outlet duct 17 according to the invention markedly stabilizes the air flow and minimizes such turbulence by making the reversal of direction both gradual and smooth.

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As mentioned above, the nozzle 12 is contracted so as to give more uniform velocity distribution at the entrance to the scroll and hence less turbulence within the scroll, and separator body. As appears from Figure 2, the scroll chamber is larger in diameter than the cylindrical body 10 and moreover, the scroll terminates outside the projection of the cylindrical body 10 so that the vortex is fully formed in the scroll chamber 11 before the spinning stream of gas is contracted into the body 10. Thus there is obtained a flow which is as nearly symmetrical about the axis of the body 10 as possible. The result is to minimize turbulence. To the same end, the shoulder 21 is gradually curved so that the entrance from the scroll chamber 11 into the body 10 is faired with a relatively large radius to eliminate surface discontinuities and thus minimize turbulence. It is preferred that the radius of curvature be not less than about 0.10 times the diameter of the body 10.

The separator may be supported in any suitable manner depending on the particular installation. It may for example, be supported as illustrated by suitably braced legs 22 and 23 connected respectively to the hopper 14 and the body 10. The provision for removal of collected particles from the hopper likewise depends on the installation and may consist of an outlet 24 normally closed by a butterfly valve 25.

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HE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. In a centrifugal separator apparatus of the type comprising a relatively long and small diameter substantially cylindrical separator body, a gas inlet at one end thereof including a scroll chamber for the tangential introduction of gas to the body and a relatively long conical section at the other end of said body terminating in an opening of small diameter in relation to that of said body; a clean gas outlet duct arranged substantially concentric with the separator body at the scroll end thereof and having a substantially cylindrical section projecting into the separator body beyond the inlet scroll chamber and a conical section connected to the inner end of the substantially cylindrical section, said substantially cylindrical section having a diameter between about 0.55 and 0.6 times the diameter of the separator body and the conical section having an opening at its inner end of approximately one-third the diameter of the separator body, and a hopper of a substantially cylindrical cross-section surrounding and enclosing said opening terminating said conical section, the cross-sectional dimension of the hopper being substantially equal to that of said separator body and the hopper being substantially co-axial to said separator body.

2. Apparatus as claimed in claim 1 in which the substantially cylindrical section of the clean gas inlet duct projects into the body beyond the inlet scroll chamber a distance of approximately 0.75 times the diameter of the body.

3. Apparatus as claimed in claim 1 or 2 in which the entrance from the inlet scroll chamber to the separator body is faired to form a rounded shoulder having a radius of curvature of at least 0.10 times the diameter of the body.

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4. Apparatus as claimed in claim 1 or 2 in which the hopper is from about three-quarters to one and one-half times the cross-sectional dimension of the body.

5. Apparatus as claimed in claim 1 or 2 in which the hopper is from about three-quarters to one and one-half times the cross-sectional dimension of the body and is of a length of from about one and one-half to three times the cross-sectional dimension of the body.

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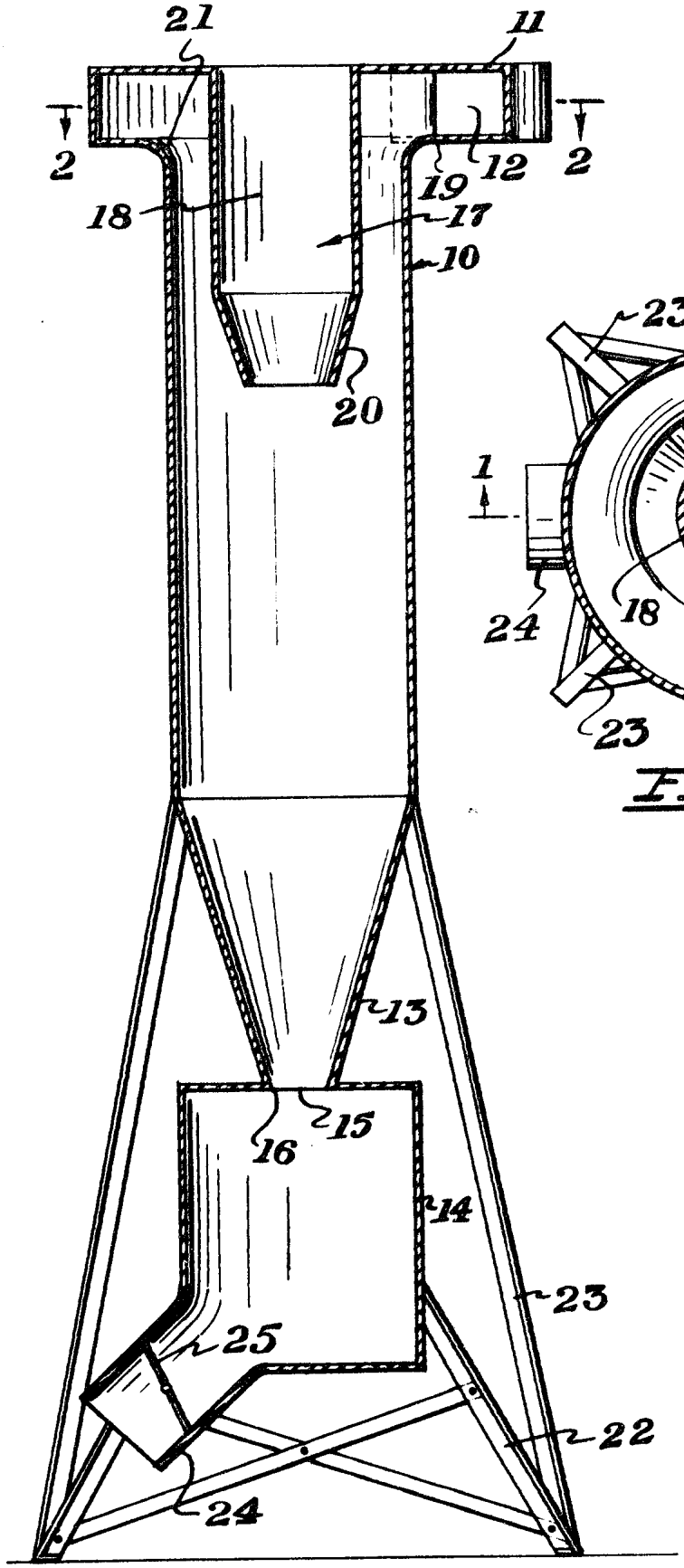

FIG. 1.

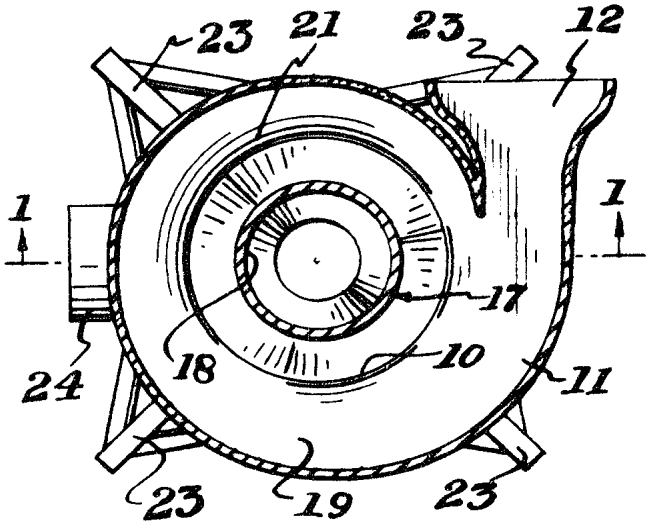

FIG. 2.

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