June 16, 1936. J. H. KEENAN 2,044,614

CYCLONE SEPARATOR

Original Filed Aug. 30, 1933

Fig. 1.

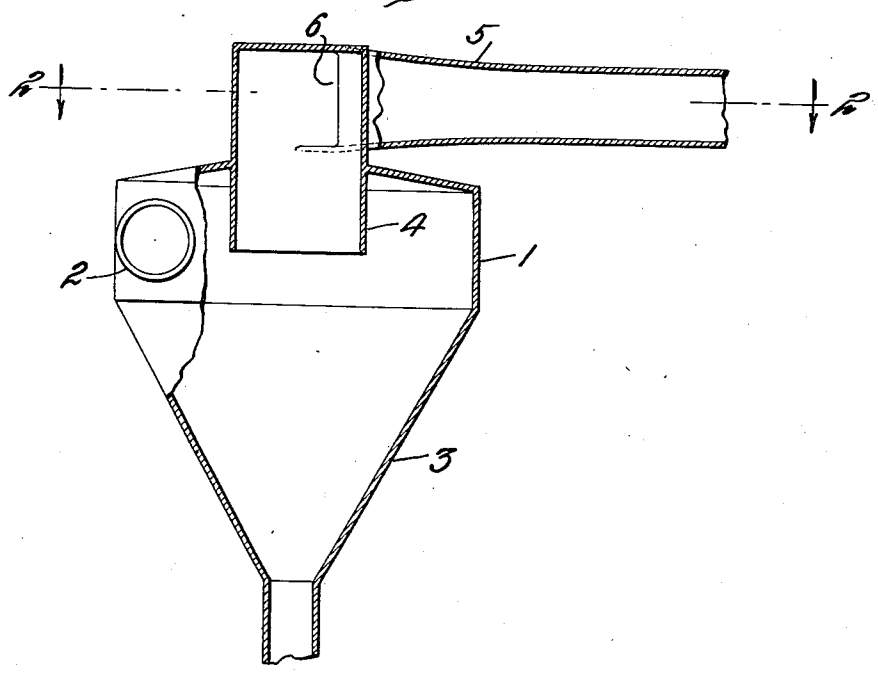
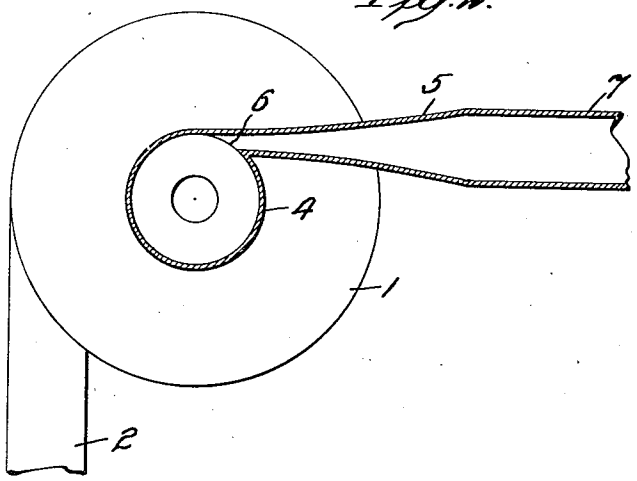


Fig. 2.



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CYCLONE SEPARATOR

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Original application August 30, 1933, Serial No. 687,401. Divided and this application January 16, 1936, Serial No. 59,334

1 Claim. (Cl. 183—83)

This invention relates to improvements in devices for separating particles of denser substance from liquid or gas streams by swirling the stream and its particles in a free or constrained vortex. I shall refer to all such devices, whether for completely separating particles and stream or merely for concentrating the particles within a portion of the stream, as cyclone separators. The present application is a division of my application Serial No. 687,401, filed August 30, 1933 now Patent 2,033,470 issued Mar. 10, 1936.

The common type of cyclone separator consists of the following parts: a cylinder into which the particle-laden stream is introduced through a duct of round or approximately square cross-section, the outside wall of the duct being tangent to the cylinder wall at entrance; a conical chamber below the cylinder for collecting or leading off the separated material; a central outlet pipe, attached to the top of the cylinder and projecting down some distance into it, leading directly to the atmosphere or to a duct.

There are, of course, many variations on this common type of design. In some cases the inside wall of the incoming stream, instead of the outside wall, is made tangent to the cylinder. This arrangement usually involves a departure from the usual circular cross-section of the cylinder toward a spiral cross-section. In some cases there is no outlet pipe projecting down into the cylinder. Sometimes a number of cylinders of various diameters are placed one below the other in the order of descending size and connected by truncated conical pieces. In some designs guide vanes are arranged within the cylinder. My invention is applicable to all of these types.

In any vortex or swirl in a fluid stream which completely fills the vortex chamber, (that is, it is not bounded at the top by a liquid surface) there is a pressure gradient, the pressure decreasing toward the center of the vortex. This pressure gradient provides the radially inward accelerations to the stream which are necessary to the swirling motion. If, as in the usual cyclone separator, the stream leaves the cylinder or separating chamber through a central hole at the top and passes directly to the atmosphere or to a duct then the minimum drop in static pressure across the most perfect collector of this type would be the pressure gradient integrated along a line passing through the vortex center between the inlet opening and the rim of the outlet hole. The pressure drop along the stream path in a vortex results in an increase in the kinetic energy of the stream which, except for friction effects, is an essentially reversible process; that is, the kinetic energy could, presumably, be reduced again to the original or entrance magnitude with a rise in pressure equivalent (except for friction) to the drop experienced in the separating vortex.

My invention provides means for recovering a large part of the pressure drop through a separating chamber by reducing the velocity of the stream after it leaves the separating cylinder in a properly designed chamber or passage and includes a diffusing passage arranged for substantially unidirectional flow connected tangentially to the central discharge pipe of a cyclone separator. The fluid stream is led out of the central outlet pipe of the separating chamber tangentially and in the direction of rotation into a gradually diverging passage the outlet area of which is approximately the same as the inlet area of the separating chamber if discharging directly to the atmosphere, or is the same as the cross-section area of the duct into which it leads. The cross-section area of this diffusing passage at inlet generally should be smaller than the inlet area of the separating chamber because the velocity of the stream is higher at this smaller distance from the vortex center. This device is essentially different from the ordinary tangential outlet heretofore used by some manufacturers in that it uses the kinetic energy of the stream issuing from the vortex to raise the static pressure in the diffuser exit as well as to supply the velocity head in the exit duct. The tangential outlet method used heretofore results in almost no pressure rise through velocity reduction because the area at the separator exit is equal to the inlet area and is consequently too large for the higher velocity stream. The main stream of fluid in such case fills only part of the cross-section area, the remainder being occupied by eddies which dissipate kinetic energy and reduce the possibility of diffusion.

The process of increasing the pressure along the path of a fluid stream by reducing its velocity I shall hereafter refer to as diffusion, and the passage or chamber in which the process is carried out I shall call a diffuser, a diffusing passage, or a diffusing chamber. A diffuser is essentially a reversed nozzle since in a nozzle the stream increases in velocity and decreases in pressure in the direction of flow while in a diffuser the stream decreases in velocity and increases in pressure in the direction of flow.

The utility of my device consists in the reduction in power consumption in the fan or com-

pressor which provides the pressure differential for overcoming the various frictional resistances in the path of the stream. It is obvious that any device which reduces the pressure drop in any part of the flow path will reduce the power input to the fan almost in direct proportion for the same rate of fluid flow.

In the accompanying drawing:

Fig. 1 is a vertical sectional view of a cyclone separator embodying my invention; and

Fig. 2 is a transverse section on line 2—2 of Fig. 1.

The separator shown in the drawing comprises vertical cylinder 1 in which the denser particles are separated from the fluid stream which enters through approach pipe 2, lower conical hopper 3 for collecting or leading off the denser separated material, and covered central discharge pipe 4 which projects some distance above the top of the separator and through which the stream passes on its way to diffusing passage 5. Diffuser 5 is attached tangentially to outlet pipe 4, leading off in the direction of motion of the rotating stream in the outlet pipe at that point. The inlet cross-section area 6 of diffuser 5 should be less than the separator inlet area 2 because of the higher velocity existing at 6. Between inlet 6 and outlet section 7 the diffusing passage gradually increases in area until the area of the discharge duct 7 is reached. If the diffuser discharges directly to the atmosphere its exit area may be made as large as is economical; the larger it is, the smaller will be the pressure drop across the device.

The invention claimed is:

The combination with a cyclone separator having a cylindrical separating chamber, a tangential inlet passage therefor, and a central axial discharge pipe, of a tangential discharge passage for said discharge pipe, said discharge passage having an inlet area smaller than that of said inlet passage and gradually increasing in cross-sectional area in the direction of air flow to its terminus.

JOSEPH H. KEENAN.