March 10, 1936. J. H. KEENAN 2,033,471

CYCLONE SEPARATOR

Filed Aug. 30, 1933 2 Sheets-Sheet 1

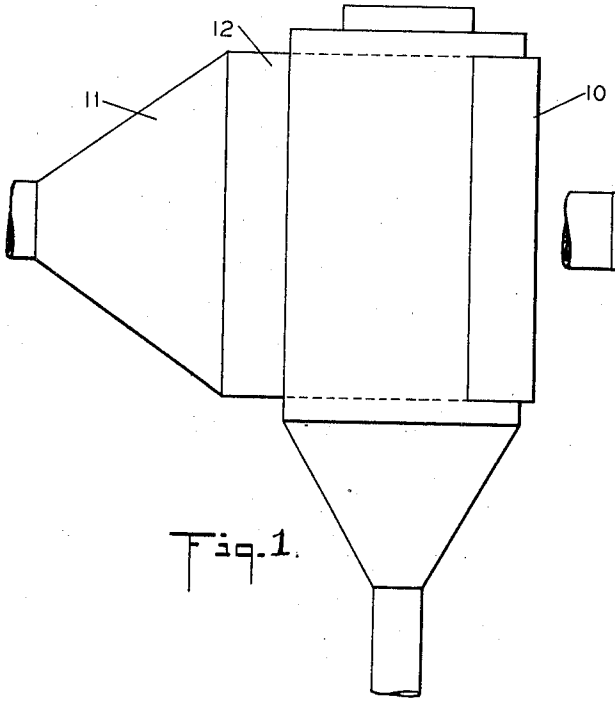



Fig. 1.

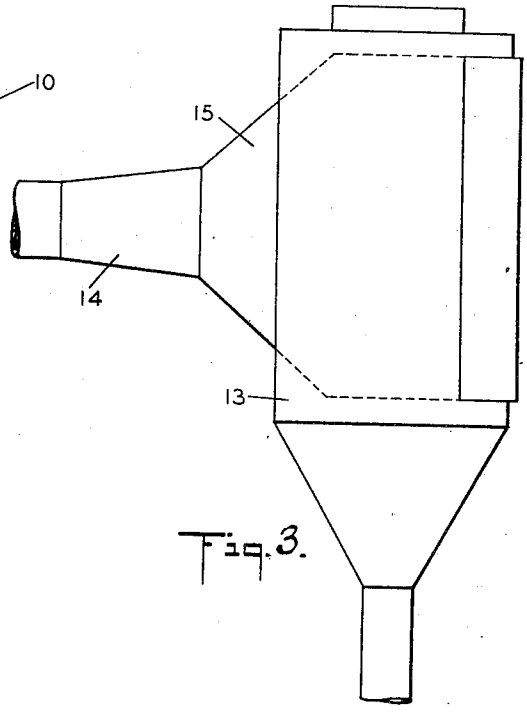



Fig. 3.

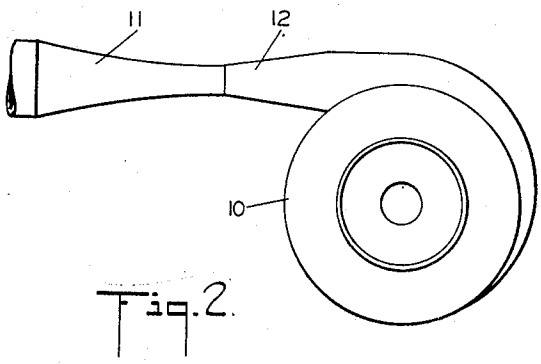



Fig. 2.

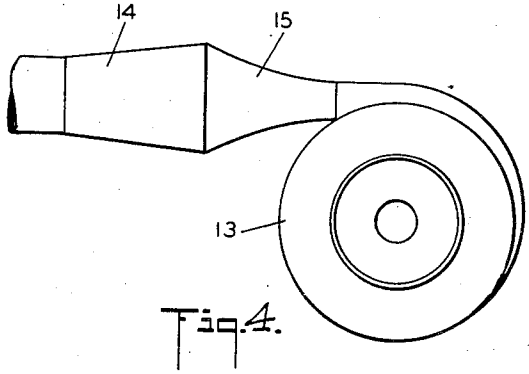



Fig. 4.

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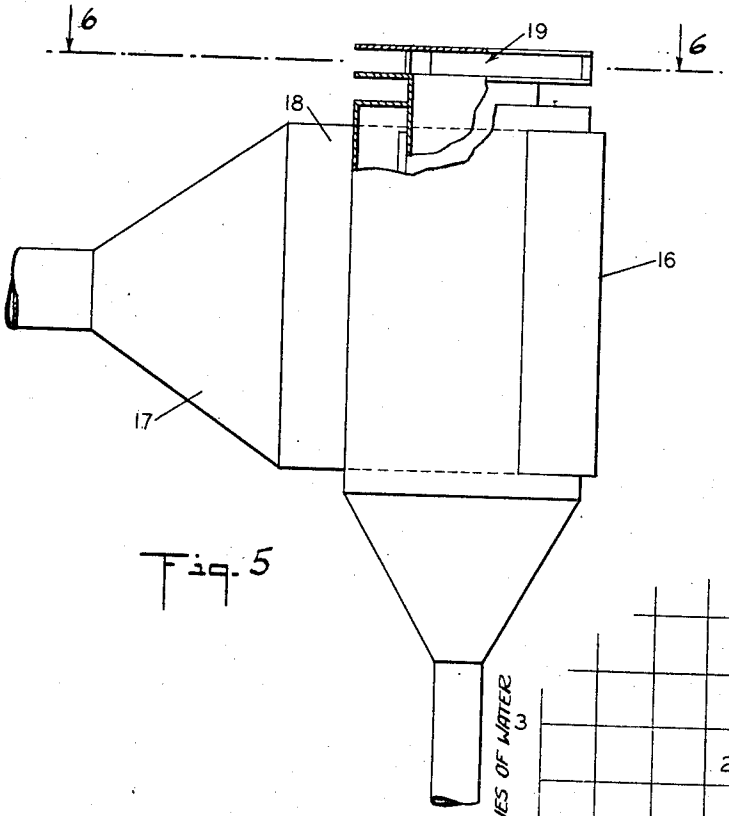



Fig. 5

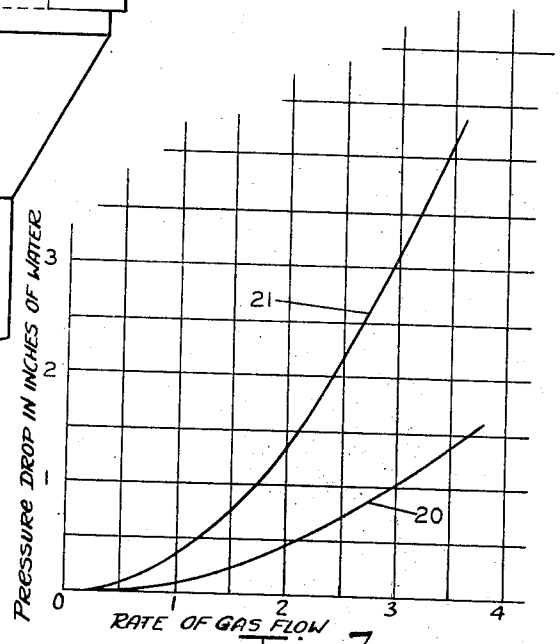



Fig. 7.

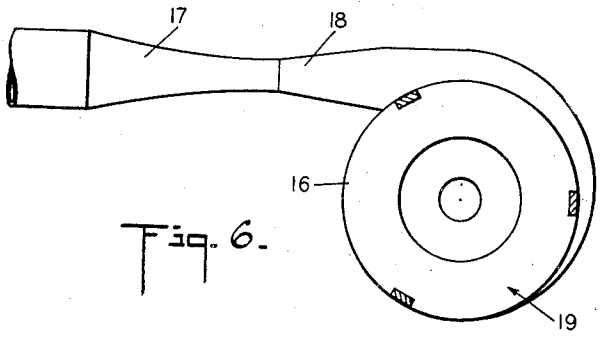



Fig. 6.

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# UNITED STATES PATENT OFFICE

2,033,471

## CYCLONE SEPARATOR

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Application August 30, 1933, Serial No. 687,402

9 Claims. (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 pressure drop through a cyclone separator is determined by the rate of change of pressure with radius and the radial distance the stream must travel between inlet and outlet. Any increase in outlet diameter for a given cylinder diameter reduces this radial distance the stream must travel and so reduces the pressure drop, provided that no additional pressure losses are introduced.

My invention, in a preferred form hereinafter described, includes a squeezer or spreader which spreads the stream into a tall, narrow passage without altering appreciably the degree of uniformity of velocity which exists in the duct, a diffusing passage preceding the inlet to the separating chamber and an unusually large ratio of separator outlet diameter to separating cylinder diameter, namely, greater than 0.5. The tall, narrow stream formed by the squeezer can pass between the separating cylinder wall and the large diameter outlet pipe without being restricted, consequently without causing additional pressure losses.

The squeezer causes the stream to enter the separator as a sheet, thin in the radial dimension. Consequently, all of the particles to be separated are concentrated near the separator wall and can be separated more easily than in existing types of separators. A larger outlet diameter may now be used and the outlet pipe may terminate adjacent or even above the inlet opening without short-circuiting the vortex and without reducing the efficiency of separation below that of existing types of separators of the same cylinder diameter. The result is a smaller pressure drop across the collector for the same efficiency of separation because the stream passes through a smaller range of the vortex pressure before it is discharged.

The diffusing passage preceding the separator inlet reduces the velocity entering the separating chamber below that in the duct and utilizes the excess duct velocity to raise the pressure at the separator inlet. Further, the lower entrance velocity causes a smaller pressure drop in the separating vortex between the cylinder inlet and the outlet pipe. Consequently the entrance diffuser serves to keep pressure drop or diameter or both smaller than in existing separators.

It is evident that though the squeezer, the large diameter outlet pipe and the diffuser have their respective useful functions, in combination they provide benefits which result from intimate interrelation of these functions and which are more than the accumulation of their individual effects.

The combination of entrance squeezer, entrance diffuser and exit diffuser with a cyclone separator having an outlet pipe diameter greater than half the separating cylinder diameter yields an extremely low pressure drop for a high quality of separation or it permits the use of a small cylinder diameter as compared with existing cyclone separator designs.

The following definitions apply to the corresponding terms throughout these specifications and the claims that follow them:

Diffusion is the process of increasing the pressure along the path of a fluid stream by reducing its velocity.

A diffuser or a diffusing passage is a passage in which diffusion is accomplished.

A squeezer is a passage for a fluid stream of substantially uniform cross-section area in planes normal to the mean direction of stream flow, the shape of the cross-section changing from round or substantially square at entrance to tall and narrow at exit; the change in shape being accomplished in such manner as not to cause a marked decrease in the degree of uniformity of velocity between the entrance and exit of the passage.

Separating cylinder diameter is twice the distance from the vertical line passing through the center of the outlet hole or pipe to the nearest point on the cylinder wall.

In the accompanying drawings:

Fig. 1 shows a cyclone separator with an inlet squeezer followed by a diffuser.

Fig. 2 is a plan view of the device shown in Fig. 1.

Fig. 3 shows a cyclone separator with an inlet diffuser followed by a squeezer.

Fig. 4 is a plan view of the device shown in Fig. 3.

Fig. 5 shows a cyclone separator with an inlet squeezer, an inlet diffuser and an outlet diffuser.

Fig. 6 is a section along 6—6 through the device shown in Fig. 5.

Fig. 7 exhibits experimental data showing the saving realized by a device similar to that shown in Figs. 5 and 6 over a well-designed existing type of separator.

In Figs. 1 and 2 a cyclone separator 10 has an outlet diameter greater than half the separating cylinder diameter and is fitted at entrance with squeezer 11 followed by diffuser 12.

In Figs. 3 and 4 the order of squeezer and diffuser is reversed. To cyclone separator 13 is connected inlet diffuser 14 followed by squeezer 15.

In Figs. 5 and 6 is shown cyclone separator 16 fitted with inlet squeezer 17 followed by diffuser 18, and, mounted on top of the separator, exit diffuser 19.

Fig. 7 shows the substantial saving in pressure drop realized by a combination similar to the one shown in Figs. 5 and 6 (curve 20) over one of the best existing cyclone separator designs (curve 21). The abscissae of Fig. 7 are rate of gas flow in arbitrary units.

The invention claimed is:

1. A combination in a cyclone separator of a squeezer having an inlet cross-section fitting that of the supply pipe and an outlet cross-section the height of which is more than four times its width, a gradually diverging diffusing passage leading to an inlet opening in the wall of the separating cylinder which is so disposed that the direction of the stream in this opening is substantially perpendicular to a vertical plane passing through the center-line of the cylinder and the inlet opening, a separating cylinder, at least as tall as the inlet opening communicating with a chamber below for collecting separated material and with a central outlet pipe above, the diameter of which is more than half the cylinder diameter.

2. A combination in a cyclone separator of a gradually diverging diffusing passage leading from the approach pipe to a squeezer, a squeezer connected to the cylinder for changing the cross-section of the diffused fluid stream from the section of the diffuser outlet to a tall, narrow cross-section, the height of which is more than four times its width, and an outlet pipe from the cylinder having a diameter greater than half the cylinder diameter.

3. A combination in a cyclone separator of a combined squeezer and diffuser inlet passage which spreads the air stream over a tall, narrow cross-section area, the shape of the passage being such that it increases in cross-section area so gradually in the direction of flow that practically the entire final section of this passage is filled with fluid flowing in one direction, and an outlet pipe from the cylinder having a diameter greater than half the cylinder diameter.

4. A combination in a cyclone separator of a squeezer having an inlet cross-section like that of the approach pipe and an outlet cross-section the height of which is more than four times its width, a gradually diverging diffusing passage leading to an inlet opening in the wall of the separating cylinder which is so disposed that the direction of the stream in this opening is substantially perpendicular to a plane passing through the center-line of the cylinder and the inlet opening, a separating cylinder, at least as tall as the inlet opening, this cylinder communicating with a chamber below for collecting separated material and with a central outlet pipe whose diameter is more than half the cylinder diameter, two substantially parallel plates supported above the separating cylinder, the lower of the two plates being provided with a central hole and being attached to the exit pipe of the separating cylinder so that the hole in the plate is concentric with the exit pipe of the cylinder.

5. The combination with a separator having a cylindrical separating chamber, an imperforate outlet pipe, a settling space, and an elongated vertical tangential inlet, of means in advance of said inlet for squeezing and diffusing the mixture to be separated.

6. A cylindrical separating chamber adapted to confine a tall narrow circumferential vortex of gas and dust having an outlet pipe having its periphery closed, and an inlet passage of uniform cross-sectional area shaped at the one end for connection to a pipe and having a tall narrow opening at the inner end, a diffusing passage connected thereto and tangentially to said chamber to admit dust laden gas to said chamber in a tall narrow stream at reduced velocity, said gas outlet being disposed centrally of said chamber.

7. In combination, an inlet pipe for carrying mixed dust and gas, means connected therewith for converting and squeezing said mixture into a relatively tall and narrow stream of greater area than that of the inlet pipe and of substantially uniform velocity, a cylindrical separator having an inlet tangentially receiving said stream to whirl same and deposit dust, a central gas outlet pipe having its periphery closed for admitting outlet gas at its bottom, and an outlet diffuser connected to the outer end of said outlet pipe.

8. The combination with a separator having a cylindrical separating chamber, an imperforate outlet pipe, a settling space, and an elongated vertical tangential inlet, of means in advance of said inlet for squeezing and diffusing the mixture to be separated, and an outlet diffuser connected to the outer end of said outlet pipe.

9. In combination, an inlet pipe for carrying mixed dust and gas, means connected therewith for converting and squeezing the mixture into a relatively tall and narrow stream, a cylindrical separator having an inlet tangentially receiving the stream to whirl it and deposit dust, a central gas outlet pipe and an outlet diffuser connected to the outer end of the outlet pipe.

JOSEPH H. KEENAN.