Nov. 20, 1962 J. BRESLOVE, JR 3,064,411

SEPARATOR

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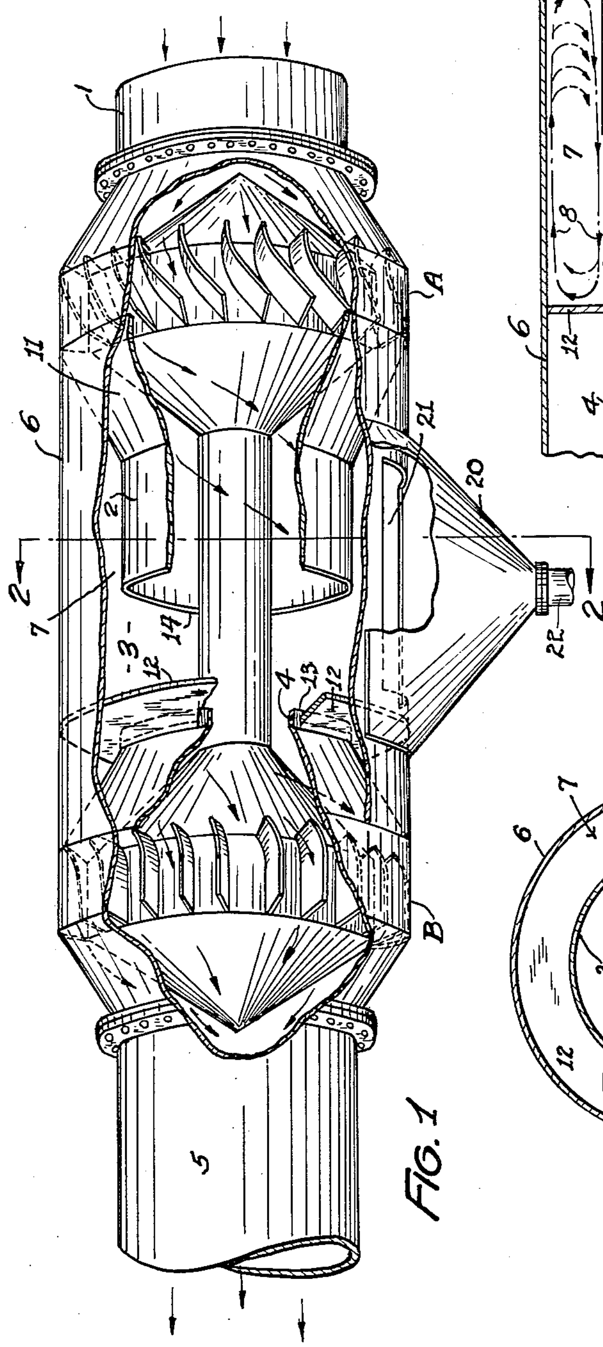

FIG. 1

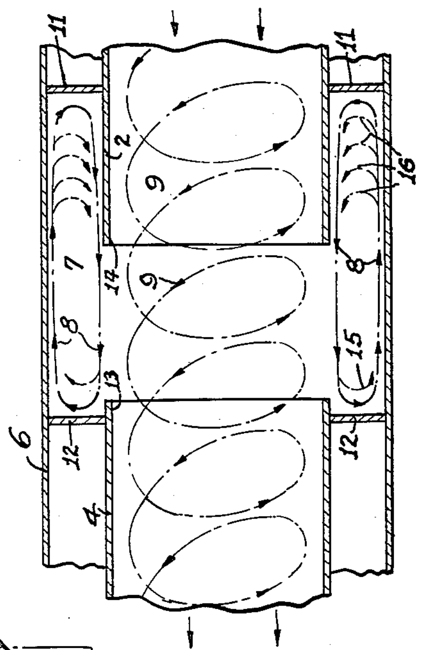

FIG. 3

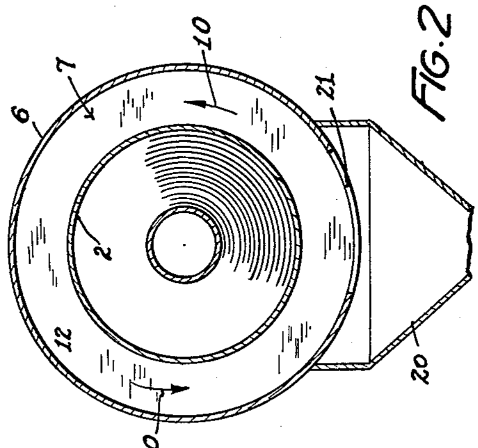

FIG. 2

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This invention relates to the art of separating solids from fluids in which the solids are entrained and more particularly relates to an improved means for efficiently separating solid particles from gases such, for instance, as the removal of cinders and fly ash from boiler flue gas or the removal of impurities, such as finely divided particles in exhaust systems and the like.

This invention, furthermore, is an improvement in structures, for instance, such as are disclosed, described and claimed in my Patent No. 2,487,633, granted Nov. 8, 1949 wherein an axially moving high rotational velocity stream of fluid carrying entrained materials is caused to pass between axially aligned spaced apart conduits, thus permitting entrained particles to be thrown out of the stream tangentially through the space and into the receiver chamber.

It is one of the objects of the present invention to produce a high rotational velocity in an axially moving gas stream in which particles of material, such as fly ash or other solids are entrained and to provide means of separating the entrained material, including the minutest particles, from the rotating stream with a very high degree of efficiency.

Another object of the invention is to overcome the re-entrainment of particles after they have been separated from the main axially moving stream rotating at high velocity and to direct the separated material to a collector.

Another object of this invention is to provide, in a straight-through cyclone separator construction, whether or not of the regenerative design, a receiver for the separated materials which includes an outer wall or cylinder spaced radially from the axially moving column of entrainment forming a closed compartment concentric with the axis of the high rotational velocity stream in which means is provided to limit the volume of such compartment outside the high velocity section of the device and inside the concentric wall defining the receiver.

A still further object of the invention is a construction of the type described whereby the axially moving and rotating gas stream will impart a secondary circulation of rotating gas within the receiver in such manner that this outer body of rotating gas will circulate in the axial direction of the main stream passing axially through the separator where it is close to the main stream and in the opposite axial direction near the outer wall or shell of the receiver concentrically spaced from the main stream.

A still further object of the invention is a device of the type defined in which the circulation of the outer or secondary gas stream within the receiver is such that it will meet a higher resistance in the area located at the upstream end of the receiver and a lower resistance in the area of the receiver at the downstream end of the receiver.

Another object consists in the application of simple means in the concentric receiver chamber whereby the secondary circulation of fluid and entrained particles in the chamber which were separated from the main axial moving rotating stream, is confined and maintained in the chamber in such relative axial position with respect to the axial movement of the main stream passing between spaced apart sections of the conduit carrying the same that such secondary circulation will encounter a higher resistance in the chamber at its upstream end, and a lower resistance in the downstream end of the chamber.

Another object is to provide a barrier or end wall defining the end of the receiving chamber which is in closer proximity to the end of the conduit section defining the upstream portion of the device than the end wall of the chamber which surrounds the spaced end of the conduit section defining the downstream portion of the device.

Another object is to eliminate the formation of objectionable eddies in the chamber.

A still further object is a device of the kind disclosed which is highly efficient over a wide range of flow rates.

Other objects and advantages of this invention will become more apparent as the following description of an embodiment thereof progresses, reference being made to the accompanying drawing in which like reference characters are employed to designate like parts throughout the same.

In the drawings:

FIGURE 1 is a side view of an apparatus embodying my present invention in which the outer shell and other parts are broken away to illustrate the internal construction of the device, the arrows indicating the direction of movement of the stream containing the entrained material;

FIGURE 2 is a transverse section taken on line 2—2 of FIGURE 1; and

FIGURE 3 is a view in diagrammatic form of a simplified version of the invention as applied to a straight-through type of separator.

The present invention resides in a relatively simple improvement over the type of apparatus illustrated in my Patent No. 2,487,633, granted Nov. 8, 1949 and is particularly adapted to be applied to separators of the straight-through type in which a fluid containing entrainment of particles, such as fly ash or the like, is caused to move in an axial stream through the apparatus at a high rotational velocity and to bridge a gap or space within the apparatus along the path of travel of the stream and through which particles are ejected or dis-entrained in a substantially tangential direction into an outer chamber which is in axial alignment with the axially moving stream. The particles thus dis-entrained into this chamber are eventually collected in a receiver and disposed of.

The present invention constitutes a distinct improvement in the art in that the efficiency of separation is greatly increased due to its ability to separate the very fine particles which, in former devices of this type, have become re-entrained in the axially moving stream because of the presence of undesirable eddy currents or turbulence in the receiving chamber and around the exposed portions of the stream passing through the adjacent spaced ends of the conduits through which the stream is passing.

The drawing illustrates in both practical and diagrammatic form the application of the present invention to a device of the kind disclosed. The apparatus shown in FIGURE 1 is of the type illustrated in my Patent No. 2,487,633 and its construction and operation is fully disclosed in said patent. However, the application of the present improvement to such a structure may be described as follows:

As illustrated in FIG. 1 and as disclosed in my Patent No. 2,487,633, the particle or impurity laden fluid column is caused to move axially in the direction of the arrows entering the separator unit A through the tube 1 to the right of the figure.

High rotational velocity is imparted to the axially moving fluid column by suitable means in the unit A, such as shown in my Patent No. 2,487,633, and as this column passes through the tube or cylinder portion 2 of the unit at high rotational velocity, it bridges the space or gap 3 between the end of the cylinder 2 and the adjacent end of the axially aligned cylinder 4 in unit B. The cylinder

4 communicates the fluid column with means in the unit B to reduce the rotational velocity and finally impart an axial substantially non-rotational flow to the unladen fluid column discharged through the conduit **5**.

An outer shell **6**, constituting a receiver for particles and other solids separated from the laden fluid, houses the cylinders **2** and **4** and is closed to the outside atmosphere. This shell is concentric with and is spaced from the cylinders **2** and **4** sufficiently to provide an annular chamber **7** between the shell inner surface and the cylinders **2** and **4**, into which particles are discharged substantially tangentially from the axially moving rotating fluid column as it passes from cylinder **2** into cylinder **4** across the gap **3**.

As the whirling fluid body or column enters the cylinder **2** it is rotating at high velocities. Under such conditions, the heavier particles entrained in the whirling column are caused to run along the inner surfaces of the cylinder wall of the member **2** and as the fluid column advances to the left, as in FIG. 1, they are finally discharged substantially tangentially over the free end of the cylinder into the chamber **7**. In addition, these heavier particles will be followed or mixed with the lighter particles which are also separated from the whirling fluid body and, as the rotating column moves axially, these particles too will be discharged substantially tangentially of the column into the chamber **7** as the column passes across the gap or space **3** between the cylinders **2** and **4**.

Referring now more particularly to FIG. 3, it will be seen that a secondary circulation is set up in the chamber **7** which is indicated generally by the arrows **8**, this circulation representing the general movement of the ejected particles as they pass into the chamber **7**.

The secondary circulation is confined within the annular chamber **7** which surrounds the end portions of the cylinders **2** and **4** and the axial space or gap **3** therebetween. Since the fluid column entering the cylinder **2** from the right in FIG. 3 is moving axially to the left at a substantially uniform rate, and since its rotational velocity is high and in the direction indicated by the directional arrows **9**, the secondary circulation set up in the chamber **7** will move in clockwise direction, as viewed at the top of FIG. 3, and, of course, will move in a counter clockwise direction, as viewed at the bottom of FIG. 3. Those areas of the circulation lying close to the outer surface of the exposed portions of the cylinders **2** and **4** will move in the direction of the axially moving fluid column passing through the cylinder **2** and **4**, while the areas of the secondary circulation running along the inner surface of the chamber **7** will, of course, be in an opposite direction.

The secondary circulation will, due to the high rotational velocity of the column passing from cylinder **2** to cylinder **4** be caused to rotate in the direction of rotation of the column, as indicated by the arrows **10**, this rotation being about the axis of the rotating column but within the chamber **7**.

I have discovered that this secondary circulation may be so controlled that it will not only produce a more complete separation of entrained particles from the fluid column, including those of extremely minute size, but will substantially prevent and eliminate re-entrainment of particles in the fluid column once they have been separated therefrom and delivered to the chamber **7**.

According to my invention, I provide a very simple means for obtaining this control. It will be noted that the secondary chamber **7** lies across the gap **3** separating the adjacent ends of the tubes **2** and **4** and is concentric with the common axis passing along the tubes **2** and **4**. It will also be noted in FIG. 3 that the chamber **7** overlies this end of the tube **2**, through which high velocity laden column passes, for a greater distance than that which overlies the adjacent end of the tube **4** and that this relationship extends circumferentially around the tube ends.

An end wall **11** defines the longitudinal limit of the secondary chamber **7** at one end while the end wall or baffle **12** defines the longitudinal limit of the chamber at its opposite end. Since the end wall or baffle **12** is located closely adjacent the inner end **13** of the tube **4** and the end wall **11** is located relatively remote from the inner end **14** of the tube **2**, a condition is created in the chamber **7** which offers less resistance to the rotation of the fluid in the chamber at the left hand end, as illustrated in FIG. 3, adjacent the baffle **12**, than the resistance which is encountered by the fluid at the right hand end adjacent the wall or baffle **11** as it continues its rotation within the chamber **7** in the direction of the arrows **8**. By this arrangement, such eddy currents as are produced and encountered in the rotating fluid in the chamber **7** are desirable and beneficial in the control, efficiency and completeness of separation of particles from the fluid because, for example, the eddy currents indicated at **15** occurring at the left end of the chamber **7** adjacent the baffle **12** offer very little resistance to the circulation at the downstream end of the chamber, while the eddy currents, indicated at **16** and occurring at the opposite or upstream end adjacent the end wall **11**, offer materially greater resistance to the circulation. The resultant slight differential pressure set up produces a highly efficient circulation in the chamber **7** and consequently assures separation of fine particles, as well as the heavier entrainment materials, while preventing reentry into the main high velocity rotational stream passing through the separator.

The separated matter may be collected in a receiver or hopper indicated generally at **20**. As the particles, separated from the main stream, move with the rotating fluid in the secondary chamber, as illustrated by the arrows **10** in FIG. 2, they will be discharged by gravity through an elongated opening **21** formed in the wall **6** and will pass into the hopper which surrounds this opening and closes it off from the outside atmosphere. The hopper being airtight permits circulation of fluid current into and out of the space or opening **21** and also permits the solids to settle in the hopper. A sealed connection conduit **22** may lead to a valved outlet through which the collected material may be discharged, without interference with the efficient operation of the separator.

Various changes may be made in the details of construction and arrangement of parts of the invention without departing from the spirit thereof or the scope of the appended claims.

I claim:

1. An apparatus for separating solid particles from an axially moving high velocity rotating fluid stream in which said particles are entrained, said apparatus including an outer cylindrical casing, conduit means directing said stream through the casing and comprising a pair of aligned conduits spaced apart axially and in end to end relation within the casing and concentrically spaced from said outer casing, a pair of annular end walls separating said conduits from said casing and forming between them a chamber communicating with the space between said conduits and receiving particles separated from said rotating laden fluid stream as it passes from one of the aligned conduits to the other aligned conduit, said outer casing having a particle discharge opening, and collector means communicating with said discharge opening to receive particles discharged from said chamber, said chamber constituting an enclosure in which the particles separated from the said fluid stream are deposited in an eddy flow and caused to travel both circumferentially and axially exteriorly of the laden fluid stream, one of the annular end walls of the chamber being located in close proximity to the inner end of one of the spaced apart aligned conduits in the casing and the other annular end wall being located remote from the inner end of the other spaced apart aligned conduit in the casing thereby to substantially eliminate the formation of an eddy flow in the downstream end of the chamber and opposed to said other eddy flow.

2. An apparatus for separating dust particles from an axially moving high velocity rotating fluid stream in which said particles are entrained, said apparatus including an outer cylindrical casing, conduit means directing said stream through the casing and comprising a pair of aligned cylinders spaced apart axially in end to end relation concentrically spaced from said outer casing, a flat, radially disposed annular wall connecting the outer cylindrical casing with one of said cylinders at a point closely adjacent the inner end of said one cylinder, an annular wall connecting said outer casing with the other cylinder at a point remote from the inner end of said other cylinder, said annular walls forming between them and the outer casing and the adjacent spaced apart inner ends of the cylinders a chamber communicating with the space between said cylinders to receive particles separated from said rotating laden stream after it passes from one of the aligned cylinders to the other across the spaced ends thereof, said chamber being characterized, during a separation of particles from said axially moving high velocity rotating fluid laden stream, by an eddy flow bridging the adjacent ends of said spaced apart cylinders and an overall slight differential pressure therein.

3. An apparatus for separating solid particles from an axially moving high velocity rotating fluid stream in which said particles are entrained, said apparatus including an outer cylindrical casing, conduit means within the casing directing said stream through the casing and comprising an inlet conduit, an outlet conduit, said conduits being spaced apart axially in end-to-end relation within the casing and concentrically spaced from the outer casing, an annular wall connecting the casing with said outlet conduit substantially at said conduit's inner extremity, and means connecting said inlet conduit and said casing, said annular wall and said means together with a portion of said inlet conduit forming between them a chamber for receiving particles separated from said rotating axially moving laden fluid stream as the fluid stream passes from the inlet conduit to the outlet conduit, said chamber having a particle discharge opening, and particle collector means communicating with the discharge opening to receive particles discharged from said chamber, one end of said chamber being characterized by the substantial absence of eddy currents tending to re-entrain in the main fluid stream minute particles discharged into the chamber.

4. An apparatus for separating solid particles from an axially moving high velocity rotating fluid stream in which said particles are entrained, said apparatus including an outer cylindrical casing, conduit means within the casing directing said stream through the casing and comprising an inlet conduit, an outlet conduit, said conduits being spaced apart axially in end-to-end relation within the casing and concentrically spaced from the outer casing, an annular wall connecting the casing with said outlet conduit substantially at said conduit's inner extremity, and means connecting said inlet conduit and said casing, said annular wall and said means together with a portion of said inlet conduit forming between them a chamber for receiving particles separated from said rotating axially moving laden fluid stream as the fluid stream passes from the inlet conduit to the outlet conduit, said chamber having a particle discharge opening through the casing and disposed to overlie the inlet conduit at one end thereof, and particle collector means communicating with the discharge opening to receive particles discharged from said chamber, one end of said chamber being characterized by the substantial absence of eddy currents tending to reentrain in the main fluid stream minute particles discharged into the chamber.

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