Aug. 26, 1958 W. J. SAKOWSKI 2,849,078

APPARATUS FOR SEPARATION ENTRAINED PARTICLES FROM GASES

Filed Sept. 9, 1955 2 Sheets-Sheet 1

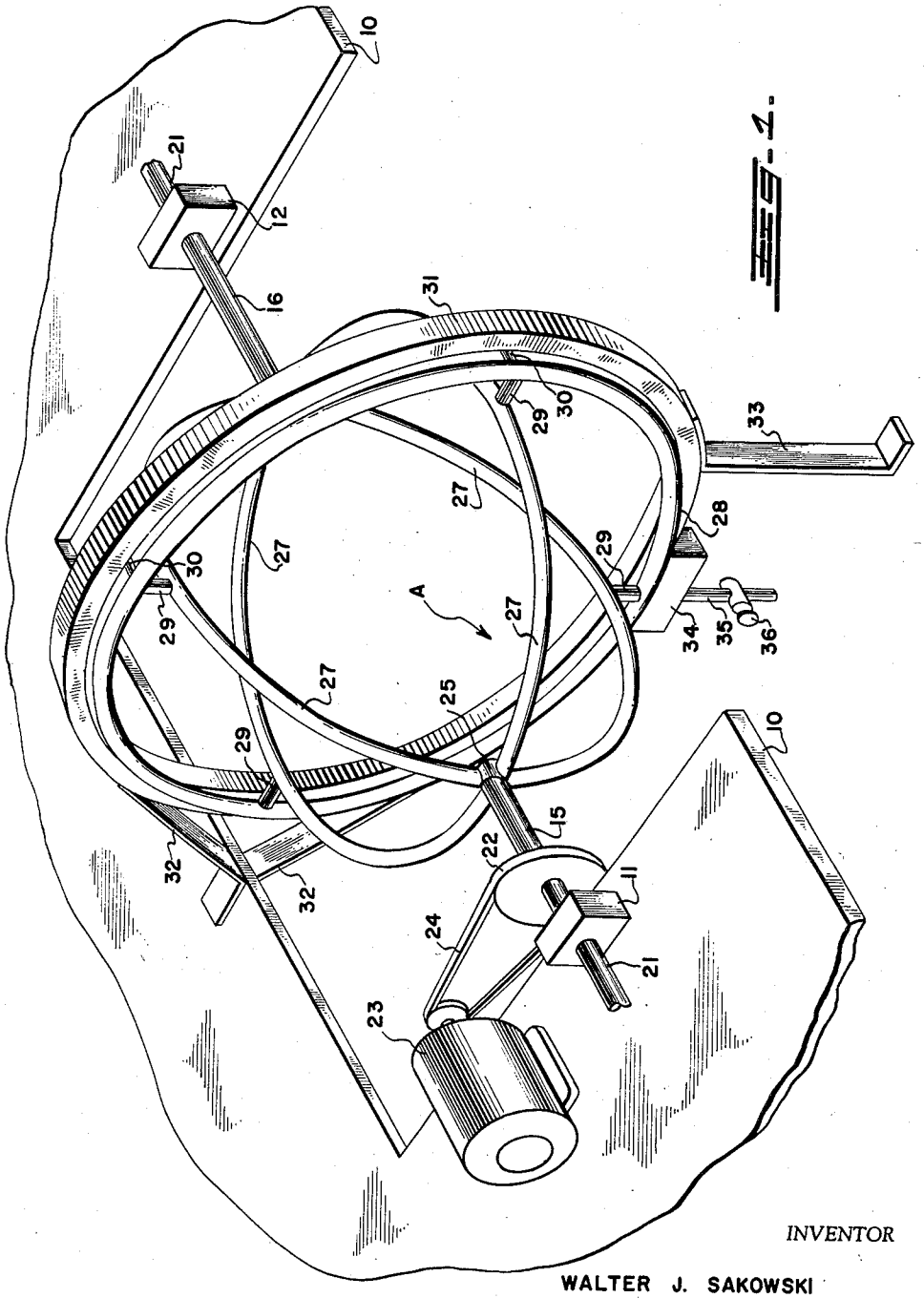


FIG. 1.

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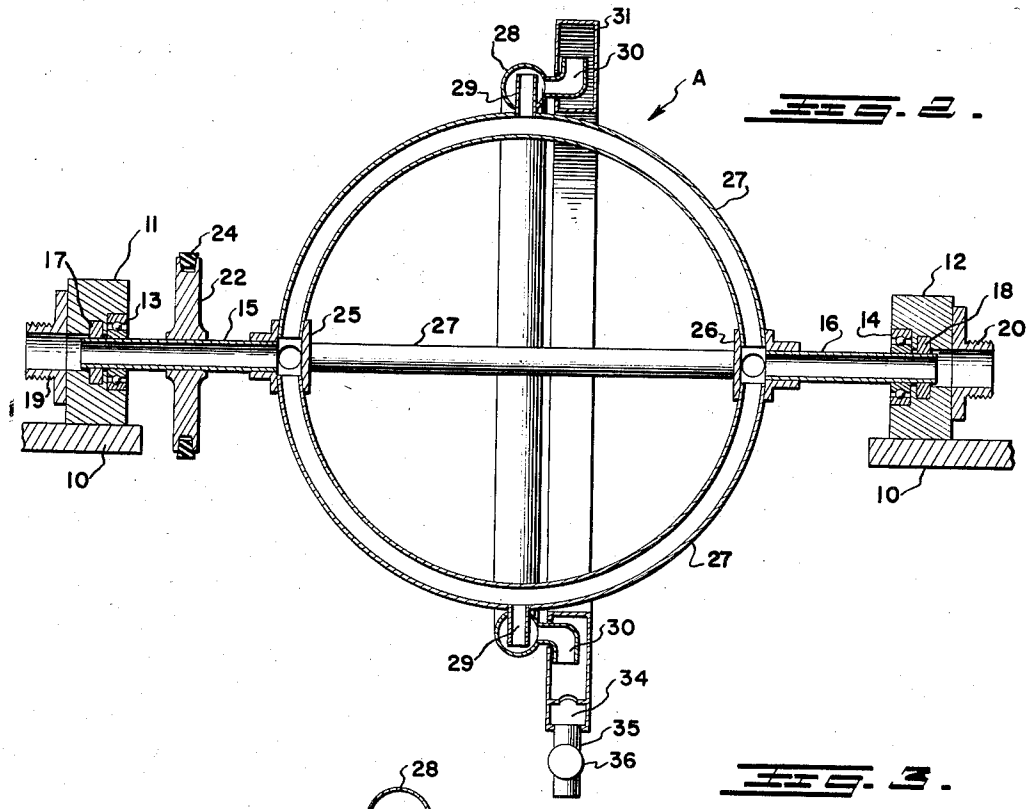


FIG. 2.

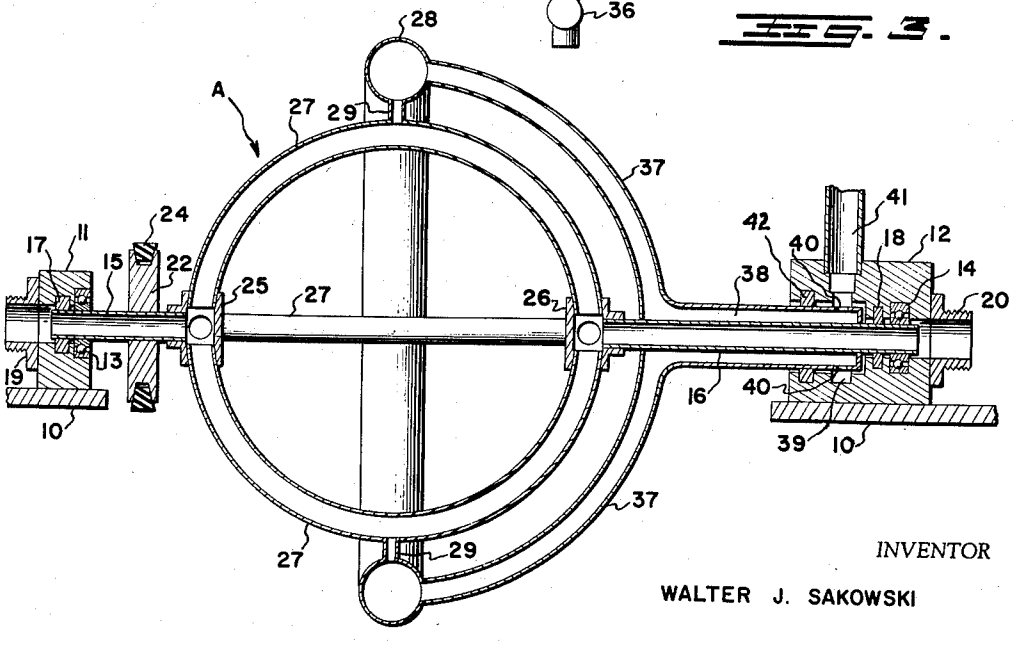


FIG. 3.

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APPARATUS FOR SEPARATING ENTRAINED PARTICLES FROM GASES

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Application September 9, 1955, Serial No. 533,432

7 Claims. (Cl. 183—77)

This invention relates to the mechanical separation of gases from entrained material such as solid and liquid particles and in particular provides a centrifuge type separator for such purpose.

In many industrial processes, gaseous streams are obtained which contain minute particles of liquid suspended therein in the form of a mist. It is usually desirable to remove such mists because the suspended material has sufficient value to justify its recovery or because the gaseous stream is not useful unless the contamination is removed, or both. The removal of such mists from gases is frequently difficult. Previously, expansion chambers have been included in the lines carrying such gases for the purpose of reducing the linear velocity of the gas sufficiently to permit settling and separation of the entrained particles. While this may be effective if the particles are of a sufficient size, the particles are often so finely divided that separation by settling does not occur within a reasonable holding period.

It is a principal object of this invention to provide a centrifugal device which achieves the separation of such mists or other minute particles entrained in a gas stream by imparting to the gas stream a high radial stress without materially affecting the linear flow through the device. The suspended particles thus impinge upon limiting surfaces, coalesce and can be removed as a mass.

This and other objects of the present invention are obtained by a centrifuge having a rotor, means for rotating the rotor, and means for guiding a flowing gas generally axially into the rotor during rotation, then generally outward from the axis of the rotor, thereafter toward the axis of the rotor, and then generally out of the rotor. The centrifuge is also provided with a continuous annular passage about the rotor intermediate the axial ends of the rotor. This annular passage is substantially concentric with the rotor and rotatable therewith for receiving centrifugally separated material which passes from the means for guiding the flowing gas through means defining a passage communicating between the means for guiding the flowing gas and the annular passage. The centrifuge is further provided with means for discharging the centrifugally separated material from the annular passage while substantially preventing escape of gas from the rotor.

In the accompanying drawings a preferred embodiment of the invention is illustrated, and in which—

Figure 1 is a perspective view illustrating the centrifuge mounted on a suitable supporting structure;

Figure 2 is a cross section of the apparatus of Figure 1, the section being taken axially therethrough and illustrating a preferred means for removing centrifugally separated material from the rotor while substantially preventing escape of gas, and

Figure 3 is a cross section of the apparatus, the section being taken axially therethrough, and illustrating a modified form of means for removing centrifugally separated material from the rotor.

In the centrifuge illustrated in the figures, there is shown

a platform 10 upon which standards 11 and 12 having passages therethrough are fixedly monuted. Standards 11 and 12 are provided with ball type bearings 13 and 14 in which hollow shafts 15 and 16 freely rotate. Mounted within the standards are annular packing members 17 and 18 to prevent escape of gas between hollow shafts 15 and 16 and the standards. The standards are provided with threaded pipe connecting members 19 and 20 for connecting the centrifuge to a line 21 (Fig. 1) through which a fluid containing entrained material flows.

Fixedly attached to hollow shaft 15 is a pulley 22 which is connected to an electric motor 23 by V-belt 24. Motor 23 is preferably a high speed motor to provide the rotor with the desired high rate of rotation.

Shafts 15 and 16 of the rotor, generally indicated at A, have their inner ends attached to coupling members 25 and 26. Coupling members 25 and 26 are connected by means of a plurality of semicircular-shaped conduits 27 which form the body of rotor A and have their ends connected to the coupling members. Semicircular-shaped conduits 27 are radially spaced about the axis of the centrifuge so that the arcs between adjoining semicircular-shaped conduits is substantially the same, e. g. arcs defined by angles of about 90° as illustrated by the four semicircular-shaped conduits in the drawings. The sum of the cross-sectional areas of semicircular-shaped conduits 27 is preferably at least as large as the cross-sectional areas of hollow shafts 15 and 16 so that the linear velocity of gas passing through conduits 27 is not substantially greater than the velocity of the gas as it enters and leaves the rotor.

About rotor A is a continuous annular passage or conduit 28 which is substantially concentric with the rotor and preferably lies in a plane which is substantially perpendicular to the axis of the rotor and substantially equidistant from the ends of rotor A. Annular conduit 28 rotates with rotor A and receives centrifugally separated material which passes from semicircular-shaped conduits 27 to annular conduit 28 through tubes or conduits 29 which connect annular conduit 28 to each of semicircular-shaped conduits 27. Preferably, conduits 29 extend in a direction generally radial with respect to the axis of the rotor.

In Figure 2, conduits 29 extend a substantial distance to within annular conduit 28. Extending from annular conduit 28 are a plurality of relatively short material discharge tubes or conduits 30, having one end opening on annular conduit 28 and the other end extending generally away from the axis of the rotor. In the device of Figure 2, the end of discharge tube 30 which is in communication with annular conduit 28 is closer to the axis of rotor A than the point at which conduits 29 terminate within annular conduit 28. The outer ends of discharge tubes 30 extend into and are in spaced relation with annular trough 31 about rotor A, which trough is held stationary with respect to rotor A by supporting brackets 32 and 33 (Fig. 1). Trough 31 is preferably of substantially rectangular cross section, the continuous opening of the trough lying in a plane which is substantially perpendicular to the axis of the rotor. Attached to the lower portion of trough 31 is a condensate trap 34, and outlet line 35 having valve 36.

In operation, rotor A is driven at a relatively high rate of speed by motor 23 and a gas, for example, a gas containing entrained liquid particles, is introduced to standard 11 through pipe 21. The gas passes axially through hollow shaft 15 and then generally away from and then generally toward the axis of the rotor as it passes through semicircular conduits 27 wherein centrifugal force is imparted to entrained liquid particles in the gas. The liquid particles, by reason of the centrifugal force imparted to them by rotor A pass from semicircular-shaped conduits

27 through conduits 29 and into collecting ring or annular conduit 28. Liquid condensate forms in collecting ring 28 and the amount thereof increases to that level at which it can flow from annular conduit 28 through discharge tubes 30 and into annular trough 31. When condensate in collecting ring 28 reaches the level where it can flow therefrom through discharge tubes 30, the end of conduits 29 extend below the surface of the condensate in annular conduit 28 and are sealed by the condensate to prevent escape of gas from the rotor. Liquid is collected in trap 34 at the bottom portion of annular trough 31 and is removed through line 35 by opening valve 36. The gas from which entrained particles have thus been removed passes from the rotor through hollow shaft 16 and standard 12 to pipe 21.

In Figure 3, a modified form of means for removing centrifugally separated material from the rotor while substantially preventing escape of gas therefrom is illustrated. In this embodiment, the rotor A is provided with a plurality of conduits 37 which rotate with the rotor and extend from collecting ring 28 generally toward the axis of the rotor and then generally along the axis of the rotor and into annular chamber 38 which forms a part of shaft 16. Preferably, the centrifuge is provided with the same number of conduits 37 as semicircular-shaped passages. In this form of the apparatus, standard 12 extends about annular chamber 38 and is provided with an annular passage 39. The interior of annular chamber 38 communicates with annular passage 39 by means of a plurality of openings 40 in chamber 38. Annular passage 39 communicates with outlet pipe 41 to which is attached means, such as a vacuum pump, for reducing pressure within conduits 37 and chamber 38. An annular sealing ring 42 is utilized to provide a seal between chamber 38 and standard 12.

Operation of the centrifuge illustrated in Figure 3 is as follows. Gas containing entrained material, such as finely divided liquid particles, passes into the rotating rotor in the same manner as described in connection with the centrifuge illustrated in Figure 1. The liquid particles, by reason of the centrifugal force imparted to them by rotor A, pass from semicircular-shaped conduits 27 through radially extending conduits 29 and into annular collecting ring or conduit 28. Liquid condensate in collecting ring 28 once it collects in sufficient quantity to block the openings of conduits 37 into collecting ring 28, is drawn through conduits 37 and into annular chamber 38 and is removed therefrom through openings 40 and outlet pipe 41 by pressure reducing means, such as a vacuum pump connected to outlet pipe 41.

While the centrifuges shown in the drawings are described as being rotatable about a horizontal axis, it will be apparent that they can readily be constructed with minor modification of their supports, and in the case of the device of Figures 1 and 2 with a change in position of drain outlet 35, for rotation about a vertical or inclined axis.

It is claimed:

1. A centrifuge for separating entrained materials including solid and liquid particles from gases which comprises a rotor mounted for rotation about an axis including a first elongated conduit having an inlet end and an outlet end disposed on said axis, the central portion of said conduit being displaced from said axis, a second conduit in the form of a closed loop disposed substantially concentric with said rotor and radially beyond said first conduit, and means interconnecting the interiors of said first and second conduits opening into said first conduit at the portion along the length thereof most displaced from said axis; means for rotating said rotor about said axis; and means for removing centrifugally separated solid and liquid particles from said second conduit during rotation of said rotor while substantially preventing escape of gas from said second conduit.

2. The apparatus of claim 1 in which the means for removing centrifugally separated material from the second conduit comprises means rotatable with said rotor for guiding said material from said second conduit generally toward the axis of the rotor, then generally axially of the rotor and then from said rotor.

3. The apparatus of claim 1 in which said interconnecting means extends into and terminates within said second conduit, and in which said means for removing centrifugally separated material from said second conduit comprises means defining a passage having one end opening into said second conduit and the other end extending generally away from said axis, said passage having a portion thereof nearer said axis than the point at which said interconnecting means terminates within said second conduit, and stationary means about said rotor for receiving centrifugally separated material from said passage.

4. A centrifuge for separating entrained materials including solid and liquid particles from gases which comprises a rotor mounted for rotation about an axis including a plurality of elongated conduits, each said conduit having an inlet end and an outlet end disposed on said axis, the central portions of each said conduit being displaced from said axis and spaced from each other, said inlet ends being adjacent each other, said outlet ends being adjacent each other, inlet means connected to said adjacent inlet ends, outlet means connected to said adjacent outlet ends, a conduit in the form of a closed loop disposed about said axis and outside of said plurality of elongated conduits, and means interconnecting the interior of each of said plurality of conduits to the interior of said loop conduit, said interconnecting means opening into each of said plurality of conduits at the portion along the length of each most displaced from said axis; means for rotating said rotor about said axis; and means for removing centrifugally separated solid and liquid particles from said loop conduit during rotation of said rotor while substantially preventing escape of gas from said loop conduit.

5. A centrifuge for separating entrained materials including solid and liquid particles from gases which comprises a rotor mounted for rotation about an axis including a plurality of semi-circular pipes, each said pipe having an inlet end and an outlet end disposed on said axis, the central portions of said pipes being displaced from said axis and spaced from each other, said inlet ends being adjacent each other, said outlet ends being adjacent each other, an inlet pipe coaxial with said axis connected at one end to said inlet ends, an outlet pipe coaxial with said axis connected at one end to said adjacent outlet ends, a closed circular pipe disposed about said axis and outside of said plurality of semi-circular pipes, a plurality of straight pipes disposed radially of said axis, each said straight pipe connected at its inner end with the interior of one said semi-circular pipe at the portion along the length thereof most displaced from said axis, and each said straight pipe being connected at the outer end thereof with the interior of said circular pipe; means for rotating said rotor about said axis; and means for removing centrifugally separated solid and liquid particles from said circular pipe during rotation of said rotor while substantially preventing escape of gas from said circular pipe.

6. A centrifuge according to claim 5 in which the means for removing centrifugally separated material from the circular pipe comprises an arcuate pipe member mounted on said rotor with one end near said axis and with the other end connected to and opening into said circular pipe, and a straight pipe section mounted on said rotor coaxially with said axis connected at one end thereof to the end of said arcuate pipe near said axis and with the other end of said straight pipe section extending away from said semi-circular pipes.

7. A centrifuge according to claim 5 in which each of said radial pipes extends into and terminates within said circular pipe, and in which said means for removing centrifugally separated material from the circular pipe comprises a plurality of discharge tubes, each said dis-

charge tube being connected at one end and opening into said circular pipe at a point closer to said axis than the point at which each of said radial pipes terminates within said circular pipe, the other ends of said discharge tubes being directed outwardly of said axis, a stationary continuous annular trough disposed about said rotor aligned with the outwardly directed ends of said discharge tubes to receive material discharged therethrough.

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