June 30, 1953 L. A. ROWELL 2,643,734

TANGENTIAL PNEUMATIC SEPARATOR

Filed Jan. 4, 1951 4 Sheets-Sheet 1

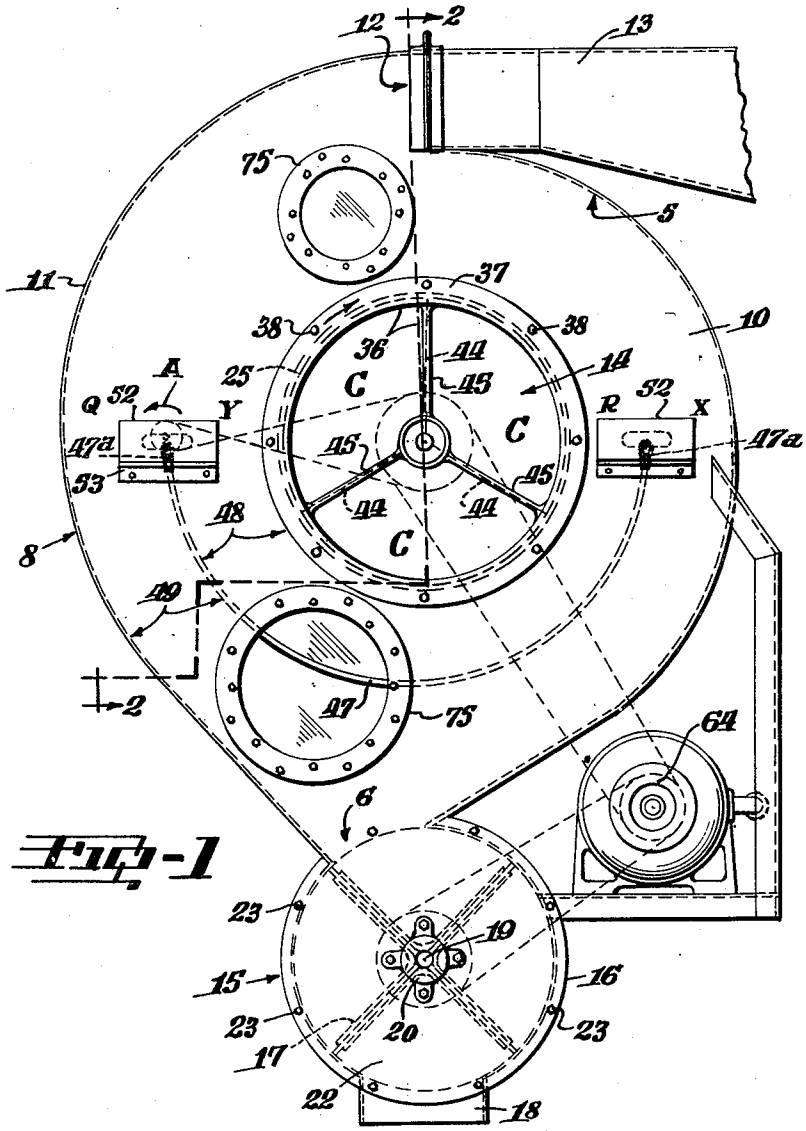


Fig-1

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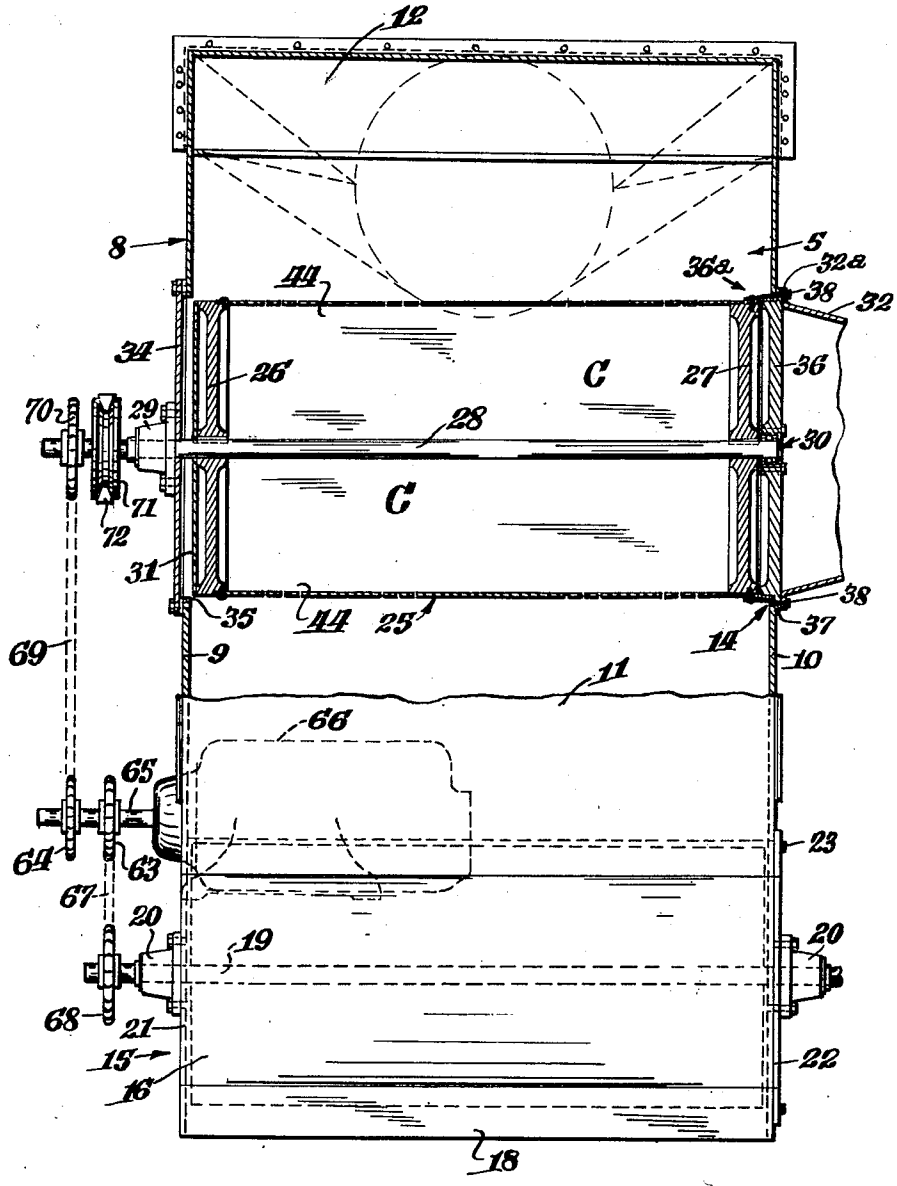


Fig-2

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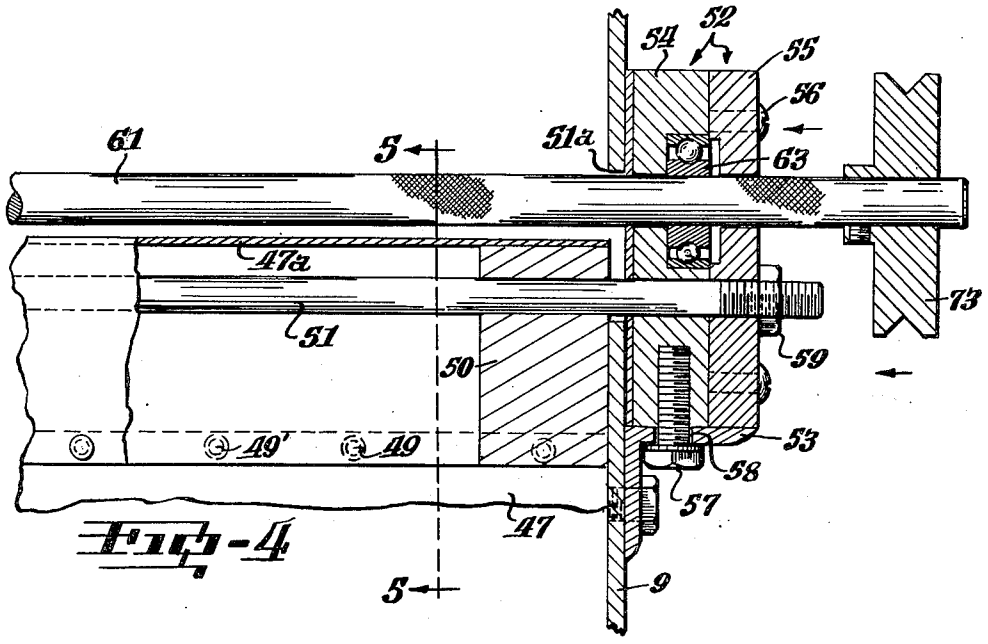


Fig-4

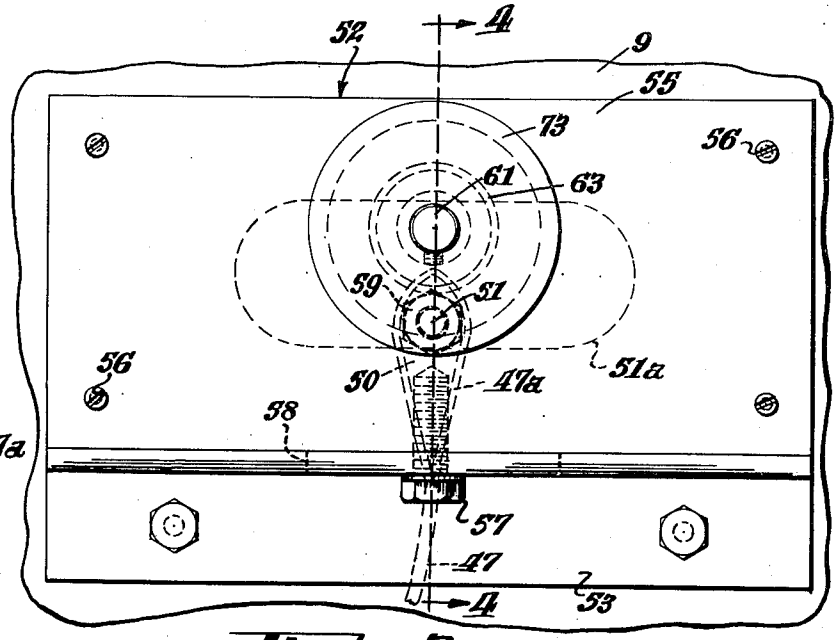


Fig-3

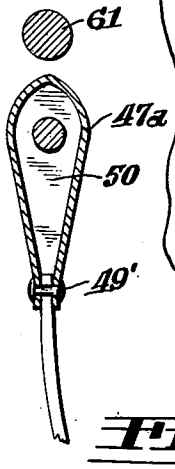


Fig-5

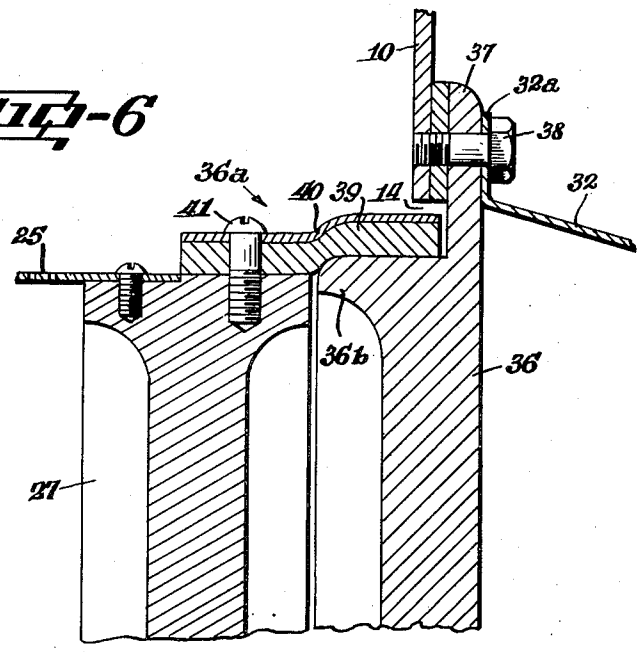
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TANGENTIAL PNEUMATIC SEPARATOR

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Fig-6



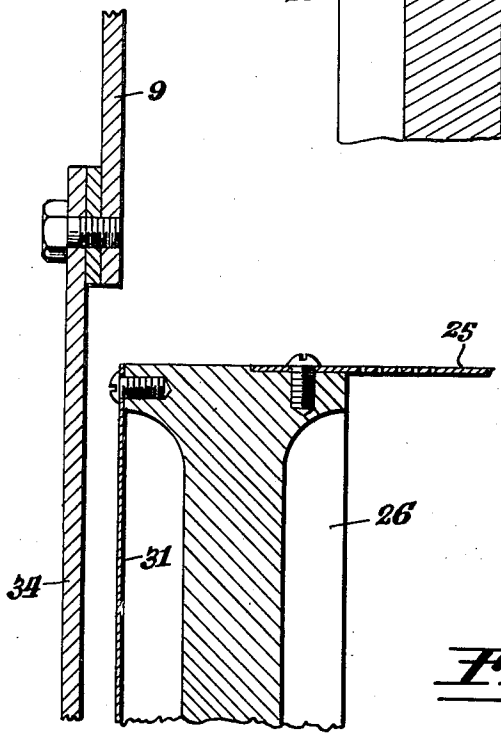


Fig-7

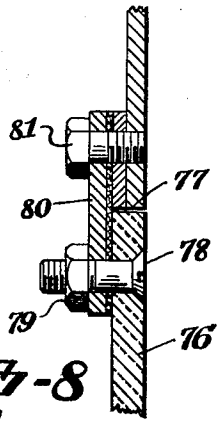


Fig-8

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UNITED STATES PATENT OFFICE

2,643,734

TANGENTIAL PNEUMATIC SEPARATOR

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Application January 4, 1951, Serial No. 204,307

2 Claims. (Cl. 183—63)

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This invention relates to pneumatic conveying systems and resides in the provision of an improved pneumatic cyclone-type separator for use at stations where the conveyed material is to be separated from the conveying air stream.

One object of the invention is to provide for a more efficient removal of the conveyed material from the conveying air stream of so-called "closed" pneumatic conveying systems, i. e., systems in which the conveying air stream is recirculated to the loading point for re-use.

A further object is to provide for a more efficient removal of all conveyed material, except very fine dust, from the conveying air stream before the latter is exhausted to the outside atmosphere or is filtered for return to the room or for recirculation to the loading point of the system.

A further object is to provide a compact pneumatic cyclone-type separator which, for a given size, is characterized by greater efficiency and by a greater air and material handling capacity as compared with conventional cyclone and other types of pneumatic separators heretofore used in connection with pneumatic conveying systems.

The conventional cyclone separator comprises a vertical cyclone casing which is either conical throughout its length or is formed with a cylindrical upper portion and a conical lower portion. In either case the air stream entraining the material to be separated is introduced laterally into the upper portion of the casing through a tangential inlet and the air from which the conveyed material has been separated is discharged through the top of the casing through a centrally located discharge opening or discharge tube. The material which is separated from the air stream in the separating chamber of the cyclone casing is removed through an air lock outlet provided at the bottom of the casing. In this type of cyclone separator the material which is separated from the air stream drops by gravity to the air lock outlet at the bottom of the cyclone casing against an upward force created by the centrifugal force on the material acting on the incline of the cone provided by the casing. If this centrifugal force is great enough its vertical component created by the inclined sides of the cone overcomes the force of gravity with the result that the material entrained by the whirling air stream will not fall to the air lock outlet at the bottom of the cone but will repeatedly travel around the cyclone casing at the top of the cone. As more material enters the cyclone casing the ring of material at the large diameter of the cone becomes larger

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until its friction against the wall of the casing causes the speed of rotation to decrease until the centrifugal force no longer counteracts the force of gravity and the material then drops to the airlock outlet at the small diameter of the cone. This results in an intermittent flow of material to the air lock outlet which may cause blockage at this point. This blockage is considered an inherent defect of standard cyclone separators when used in connection with pneumatic conveying systems and, as hereinafter set forth, is completely eliminated in the improved separator afforded by my invention.

It is also important to note that when a standard cyclone separator is used on the suction side of a fan small air leaks in the air lock at the bottom of the cone seriously impair the separating efficiency. Air leaking into the separator from the atmosphere at this point travels up the centre of the cyclone vortex to the air outlet directly above. This air may carry with it relatively large material which should have been separated and discharged through the air lock outlet. Moreover, if the air leak is great the material will not drop into the air lock outlet against the rising current of air as it passes through the small diameter of the cyclone cone. This results in blockage due to building up of material on and above the air lock outlet. Since the standard cyclone connected to the suction side of a fan cannot tolerate air leaks in the rotary air lock, the maintenance cost involved in keeping the air lock outlet sufficiently airtight is exceedingly high.

The improved cyclone-type separator provided in accordance with my invention differs from standard cyclone separators in a number of important respects which contribute to increased efficiency and capacity and to the elimination of the previously mentioned defects inherent in the design and operation of standard cyclone separators. For example, the design of my improved separator is such that blockage of the air lock outlet is reduced to a minimum by virtue of the fact that the centrifugal forces existing in the cyclone separating chamber are utilized to assist gravity in separating the conveyed material from the air stream and throwing the separated material out of the separating chamber and into the air lock outlet. The design of my separator also ensures that any air leaking into the separating chamber through the air lock outlet is immediately caught in a swirling air stream which causes any material which may have been carried from the air lock outlet into the separating chamber by the leakage air to be again thrown to

the outer periphery of the separating chamber and returned to the air lock outlet. Consequently, small air leaks at the air lock outlet of my improved separator have negligible effect on the separating efficiency but should, of course, be kept within reasonable limits because of their adverse capacity reducing effect with respect to the amount of air handled in the conveying duct leading to the separating chamber.

Another important feature of my improved separator is that the design eliminates the cone characteristic of standard cyclone separators, and enables the size of the air lock outlet to be increased to a much greater extent than in the case of the standard cyclone separator where the size of the air lock outlet is limited by its location at the small diameter end of the conical portion of the separating chamber. The increased size of air lock outlet thus made possible by my invention not only increases the discharge capacity but further tends to minimize the hazard of blockage at this outlet.

A still further important feature of my improved separator is that the design lends itself to the use, within the cyclone separating chamber, of a rotating cylindrical screen through which the air leaving the separator is forced to pass. This screen serves two functions: (*a*) in case of blocking of the separator it prevents the escape of any conveyed material other than that which will pass through the small perforations of the screen; (*b*) it greatly decreases the pressure drop through the separator by reducing the entry loss to the discharge opening.

A further feature of my improved separator is that the screen and the air lock outlet are arranged to accomplish their respective functions without in any way interfering with the repeated whirling of the material-conveying air stream around the interior of the cyclone separating chamber.

The foregoing and other objects and characteristic features of the invention will be more readily understood from the following detail description of the accompanying drawings, in which:

Fig. 1 is a side elevational view of a separator embodying my invention.

Fig. 2 is a sectional view taken substantially along the section line 2—2 of Fig. 1.

Fig. 3 is an enlarged detail view of certain parts appearing in Figs. 1 and 2.

Fig. 4 is a sectional view taken substantially along the section line 4—4 of Fig. 3.

Fig. 5 is a sectional view taken substantially along the section line 5—5 of Fig. 4.

Fig. 6 is an enlarged detail sectional view showing the method of mounting and sealing the open end of the screen appearing in Figs. 1 and 2.

Fig. 7 is a view similar to Fig. 6 but showing the closed end of the screen and the adjacent casing structure.

Fig. 8 is a detail view showing the method of mounting the inspection windows in the wall structure of the casing of the separator.

As shown in these drawings my improved separator comprises a cyclone separating chamber 5 in which the material-conveying air stream is formed into a whirling mass repeatedly whirling around the chamber in a vertical plane so that the centrifugal forces to which the conveyed material is subjected directly assist gravity in separating the conveyed material from the air stream and directing the conveyed material from the separating chamber through a bottom outlet 6.

Chamber 5 is defined and enclosed by a casing 8 presenting substantially flat vertical side walls 9 and 10 and a circumferential wall 11. The wall 11 is provided with the previously mentioned bottom outlet 6 and also with a full width inlet opening 12 through which the material-conveying air stream is directed tangentially into the top of separating chamber 5 in a stream flowing through inlet 12 in a direction paralleling the side walls of the separating chamber. The inlet opening 12 communicates with a suitable conduit 13 through which the material-conveying air stream is delivered through said opening.

The circumferential wall 11 of chamber 5 is suitably curved so that the material-conveying air stream entering said chamber through inlet 12 is repeatedly whirled around the inside of the chamber in a vertical plane and eventually escapes laterally through a central discharge opening 14 provided in the side wall 10.

The centrifugal forces existing in separating chamber 5 directly assists gravity in causing the conveyed material to be thrown downwardly toward the bottom of the separating chamber and discharged through the bottom outlet 6 into an exterior air lock outlet generally indicated at 15. This air lock outlet comprises a casing 16 housing a conventional 4-blade air lock rotor 17 and having a bottom discharge outlet 18. Rotor 17 is carried by a shaft 19 journalled in bearings 20 fastened to the end walls 21 and 22 of casing 16, the end wall 22 being removably secured in place by bolts 23 to provide for convenient removal and placement of the air lock rotor 17 and its shaft 19.

It may be noted here that an important feature of this invention is the location of the air lock rotor 17 exteriorly of separating chamber 5 so that this rotor does not prevent the desired repeated whirling of the material-conveying air stream in a vertical direction around the inside of the separating chamber. The tangential direction of the material-conveying air stream into the top of separating chamber 5 and the tangential discharge of the separated material through the bottom outlet 6 of the separating chamber into the air lock 15 serves, in conjunction with the whirling of the material-conveying air stream in a vertical direction around the separating chamber, to enable the centrifugal force developed by the whirling mass to directly assist gravity in discharging the separated material through outlet 6.

In the present instance the circumferential wall 11 of separating chamber 5 is shown as being substantially scroll shaped. However, it will be understood that the circumferential wall 11 may be made of true cylindrical form and provided with a suitable tangential inlet through which the material-conveying air stream is directed tangentially into the top portion of the separating chamber.

In order to increase the efficiency of the separator a rotary cylindrical screen 25 is preferably arranged in separating chamber 5 in spaced relation to the circumferential wall 11 as shown to advantage in Figs. 1 and 2. The screen 25 is carried by spiders 26 and 27 keyed to a shaft 28 journalled in suitable anti-friction bearings 29 and 30. The screen 25 extends across chamber 5 between the side walls 9 and 10 and is closed at one end by a closure plate 31 secured to the spider

26. The other end of screen 25 is in open communication through spider 27 with the air outlet opening 14 of casing wall 10 and with an air discharge conduit 32 leading from said opening.

The bearing 29 of screen 25 is carried by a plate 34 closing an opening 35 in the side wall 9 of casing 8. The bearing 30 of screen 25 is housed in a stationary spider 36 fitted in the air discharge opening 14 and fastened to wall 10 by means of the flange 37 and the bolts 38, the latter also serving as the fastening bolts for the flanged end 32a of air discharge conduit 32. The spider 27 of screen 25 is separated from the adjacent bearing supporting spider 36 by a slight gap which is closed by a sealing member generally indicated at 36a. This sealing member comprises a hard felt band 39 backed by a steel band 40, said bands being fastened to the screen spider 27 by screws 41 and being disposed to ride a rim portion 36b of spider 36.

When it is desired to remove screen 25 from separating chamber 5, this may be accomplished by removing plate 34 and withdrawing the screen through opening 35 or by removing the conduit 32 and the stationary spider 36 and withdrawing the screen through the air discharge opening 14.

The screen 25 is rotated, as hereinafter described, in a direction opposite to the direction of the swirl of the material-carrying air stream around the separating chamber 5 in the cyclone space provided between the screen and the circumferential wall of said chamber. This direction of rotation of screen 25 serves, in conjunction with the centrifugal forces to which the conveyed material is subjected, to throw said material away from the screen to minimize blocking of the latter. As a further guard against blocking of the screen any suitable type of brush or scraper may be arranged in the chamber 5 in wiping contact with the exterior surface of the screen.

In some instances it is desirable to dampen swirling movement of the air within screen 25 and this is accomplished by dividing the interior of the screen into separate compartments C by means of partition plates 44 secured to and extending between the spokes 45 of the spiders 26 and 27.

The screening efficiency of the separator is further enhanced by the provision of a curved baffle indicated at 47. This baffle is arranged in separating chamber 5 so that it encircles the lower half of screen 25 in spaced relation thereto and in spaced relation to the opposing portions of the circumferential wall 11 of said chamber. The baffle 47 thus divides the lower portion of the separating chamber into an upper passage 48 lying between the screen and the baffle and a lower passage 49 lying between the baffle and the lower portion of the circumferential wall 11 of said chamber. The baffle 47 is preferably eccentrically arranged with reference to cylindrical screen 25 so that the area of passage 48 gradually diminishes from a maximum area at the entrance end Y to a minimum area at the exit end R. However, provision is made for lateral adjustment of baffle 47 to permit adjustment of this baffle to provide the optimum conditions for the product being handled by the separator. In this connection it will be noted that the baffle is provided with terminal loops 47a each formed by bending a sheet of metal into substantially U-form and fastening the edges of the bent sheet to one end of the side edges of the baffle by rivets 49' or other suitable fastening means. Each of the terminal loops 47a is closed at its ends by

solid plugs 50 provided with suitable openings for the passage therethrough of a baffle-supporting shaft 51 having its ends extending outwardly through horizontal slots 51a in the side walls 9 and 10 of chamber 5 and supported by slides 52 slidably mounted on angle brackets 53 secured to said walls. Each of the slides 52 is divided vertically into sections 54 and 55 fastened together by screws 56. The section 54 is adjustably fastened to angle bracket 53 by a bolt 57 working in an elongated slot 58 provided in said bracket. The baffle-supporting shafts 51 are provided with threaded ends on which nuts 59 are screwed to bear against the outer sections 55 of slides 52. When it is desired to adjust the baffle 47 laterally this is accomplished by loosening the bolts 57 fastening the slides 52 to angle brackets 53 and moving the slides horizontally on the angle brackets to the desired position of adjustment. The leading edge of baffle 47 located at the entrance end of passage 48 is protected against undesirable building up of solid material on said edge by means of an overlying rotary knurled shaft 61. The ends of this knurled shaft extend outwardly through the slots 51a in the side walls 9 and 10 of chamber 5 and though bearings 63 carried by sections 54 of slides 52. The knurled shaft 61 is rotated continuously as hereinafter described and effectively prevents the build up of solid material on the underlying leading edge of baffle 47.

One function of baffle 47 which contributes to greater separating efficiency is that it isolates air turbulence at the bottom outlet 6 of separating chamber from the vicinity of screen 25. Another function of this baffle is that it causes the incoming layer of air travelling downwardly from inlet 12 to be directed toward the bottom outlet 6 through the lower passage 49 separating the baffle from the lower portion of the circumferential wall 11 of the air chamber.

During passage of the material-conveying air current through passage 49 most of the conveyed material is thrown into the air lock casing 15 through the bottom outlet 6 and is discharged from the air lock casing through the outlet 18. The air leaving passage 49 at the exit end X may carry with it some particles of conveyed material but since these particles are carried around the separating chamber above the screen 25 and through the passage 48, they have approximately 270° of rotation in which to move out toward the peripheral wall 11 of the separating chamber where they are entrained by the air currents travelling adjacent said wall and are again carried through the passage 49.

The air travelling upwardly from the exit end of passage 49 and around the upper part of screen 25 is deflected into the entrance end Y of passage 48 by the incoming air entering the separating chamber through the inlet 12. By this time the air which now traverses passage 48 is free of any large particles of conveyed material and contains only small dust particles. The separation of these dust particles continues in passage 48 by reason of the fact that the particles are thrown downwardly onto the baffle 47 and leave the baffle at the exit end R of passage 48. In the next 180° of rotation around the separating chamber these dust particles will move sufficiently close to the peripheral wall 11 of the separating chamber to be directed into the entrance end Q of passage 49 instead of being returned to the entrance end of passage 48. During their passage through passage 49 these dust particles are directed from the separating chamber through the bottom outlet 6 and air lock 15.

The rotating parts of the separator comprising screen 25, air lock rotor 17 and knurled shaft 61 may be driven by any suitable form of drive mechanism. In the present instance the driving mechanism shown comprises sprocket wheels 63 and 64 mounted on the armature shaft 65 of an electric motor 66. The sprocket 63 is connected by chain 67 to a sprocket 68 on the shaft 19 of the air lock rotor 17. Sprocket 64 is connected by chain 69 to a sprocket 70 on the shaft 28 of screen 25. The shaft 28 of screen 25 also carries a pulley 71 connected by belt 72 to a pulley 73 at one end of the knurled shaft 61 which is mounted above the leading edge of the curved partition 47. The component parts of this drive mechanism are preferably arranged so that the screen 25 is driven in a direction opposite to the direction of the swivel of the material travelling toward the inlet ends of the passages 48 and 49 of the separating chamber while the knurled shaft 61 is driven in the opposite direction as indicated by arrow A in Fig. 1. However, it will be understood that the screen 25 may, if desired, be driven in the same direction as the knurled shaft 61.

The side walls 9 and 10 of casing 8 are provided with inspection doors 75 through which to view the separating action within the casing. As shown in Fig. 8 each of these inspection doors comprises a transparent panel 76 mounted in an opening 77 provided in an end wall of casing 8, said panel being fastened by bolts 78 and nuts 79 to a plate 80 which, in turn, is fastened to the end wall of the casing by stud bolts 81.

Having thus described the nature and practical embodiment of my invention, it will be understood that various modifications may be resorted to within the scope and spirit of the invention as defined by the appended claims.

I claim:

1. A cyclone separator for pneumatic conveying systems comprising a separating chamber having an unobstructed vortex space in which the material-conveying air stream is repeatedly whirled around a horizontal axis to produce a vortex spiralling toward said axis, said chamber being defined and enclosed by a casing presenting substantially flat vertical side walls and a curved circumferential wall, the latter being provided with an upper tangential inlet through which the material-conveying air stream is tangentially directed into the top of the separating chamber in a stream flowing in a direction parallel to said side walls and being also provided with a bottom outlet opening through which the material separated from the air stream is discharged from the separating chamber, the curvature of said circumferential wall being such that the material-conveying stream of air entering the unobstructed vortex space through said inlet is repeatedly whirled around said space in a vertical plane and eventually escapes horizontally from the separating chamber through a central air discharge outlet provided in one of said side walls, an air lock outlet comprising an external casing secured to the circumferential wall of the separating chamber over the bottom outlet of said chamber and a rotor rotatably journalled in said air lock outlet casing, the latter being provided with a bottom discharge opening for the material delivered thereto from the separating chamber, a cylindrical screen extending between and supported by the side walls of the separating chamber in spaced relation to the circumferential wall of said chamber, one end of said screen being closed and the other end being in open communication with the aforesaid central discharge outlet opening provided in one of the side walls of the separating chamber, a curved baffle encircling the lower half of the screen in spaced relation thereto and in spaced relation to the lower portion of the circumferential wall of said chamber, and a rotating member mounted above and adjacent the upstream side edge of said baffle to prevent undesirable building up of solid material on said edge.

2. A separator as set forth in claim 1, in which the said rotating member comprises a knurled shaft and means for rotating said shaft.

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