

July 29, 1952

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2,604,956

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4 Sheets-Sheet 1

Fig. 1.

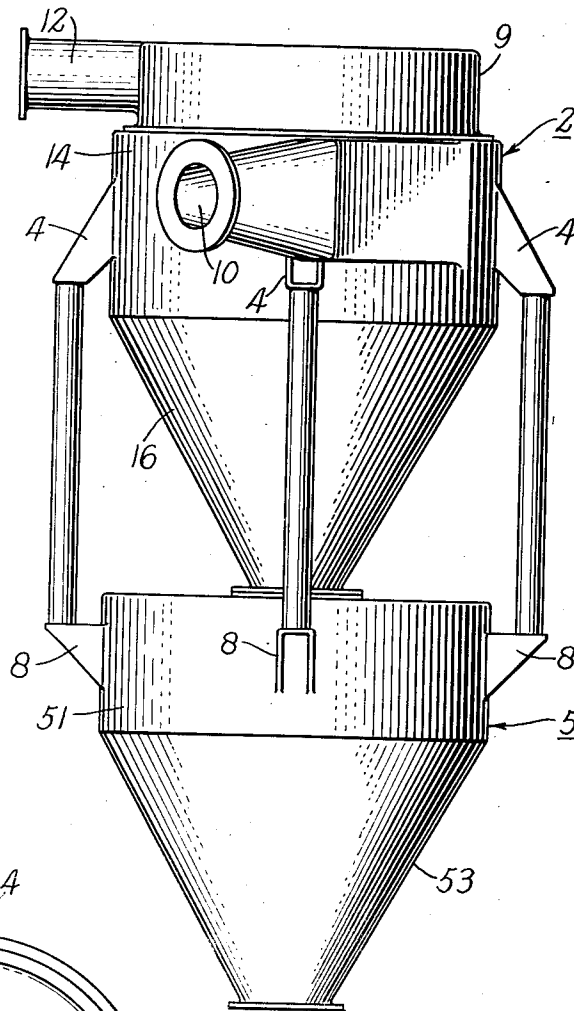
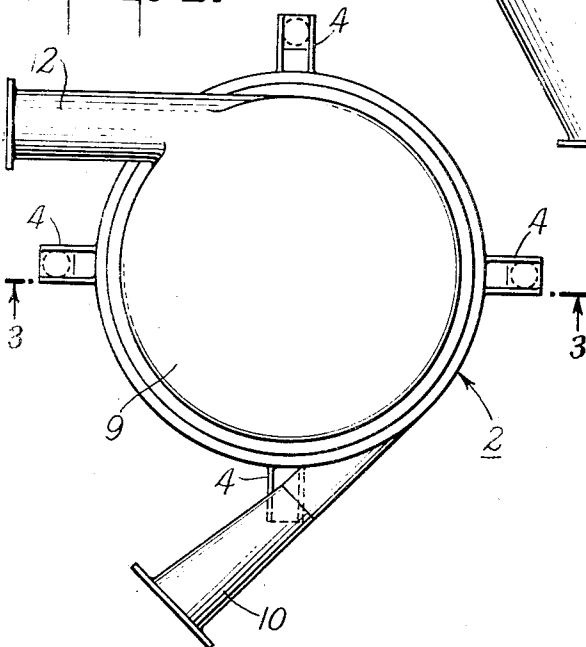


Fig. 2.



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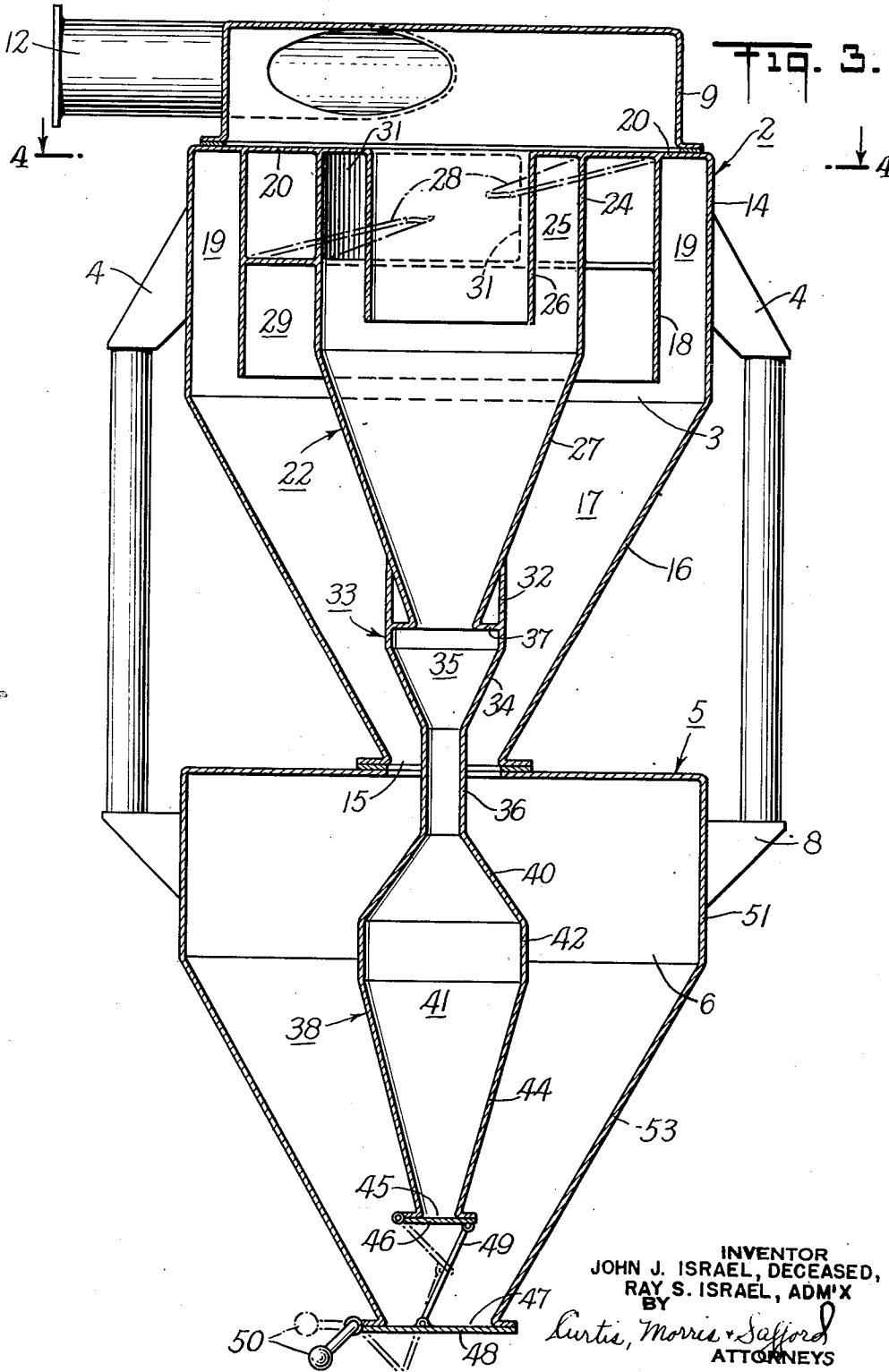
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Fig. 4.

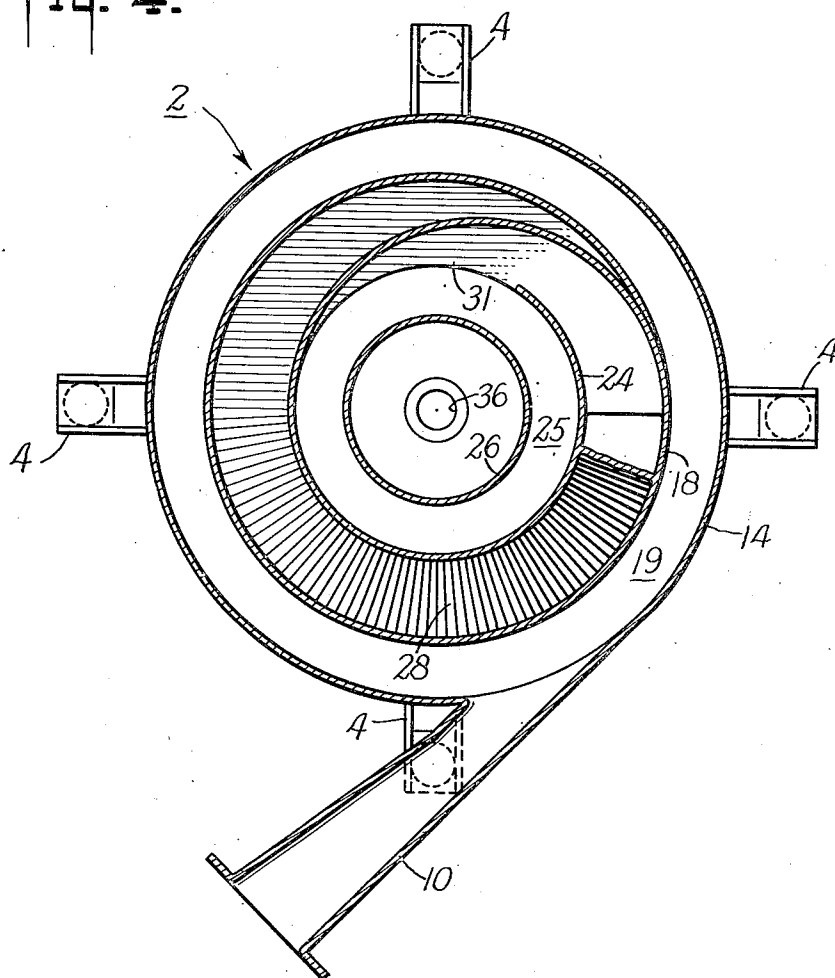
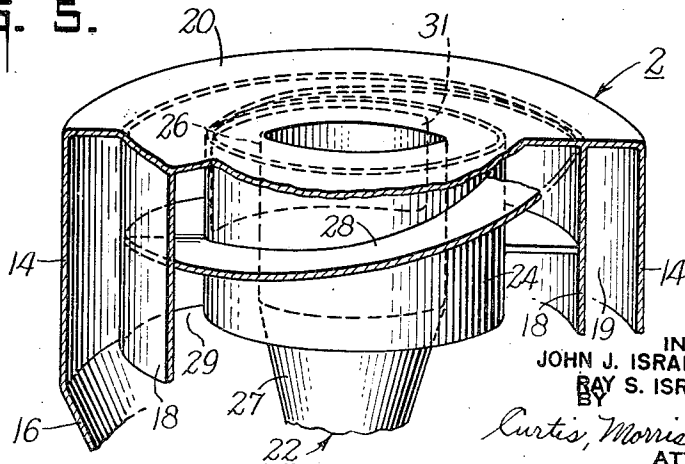


Fig. 5.



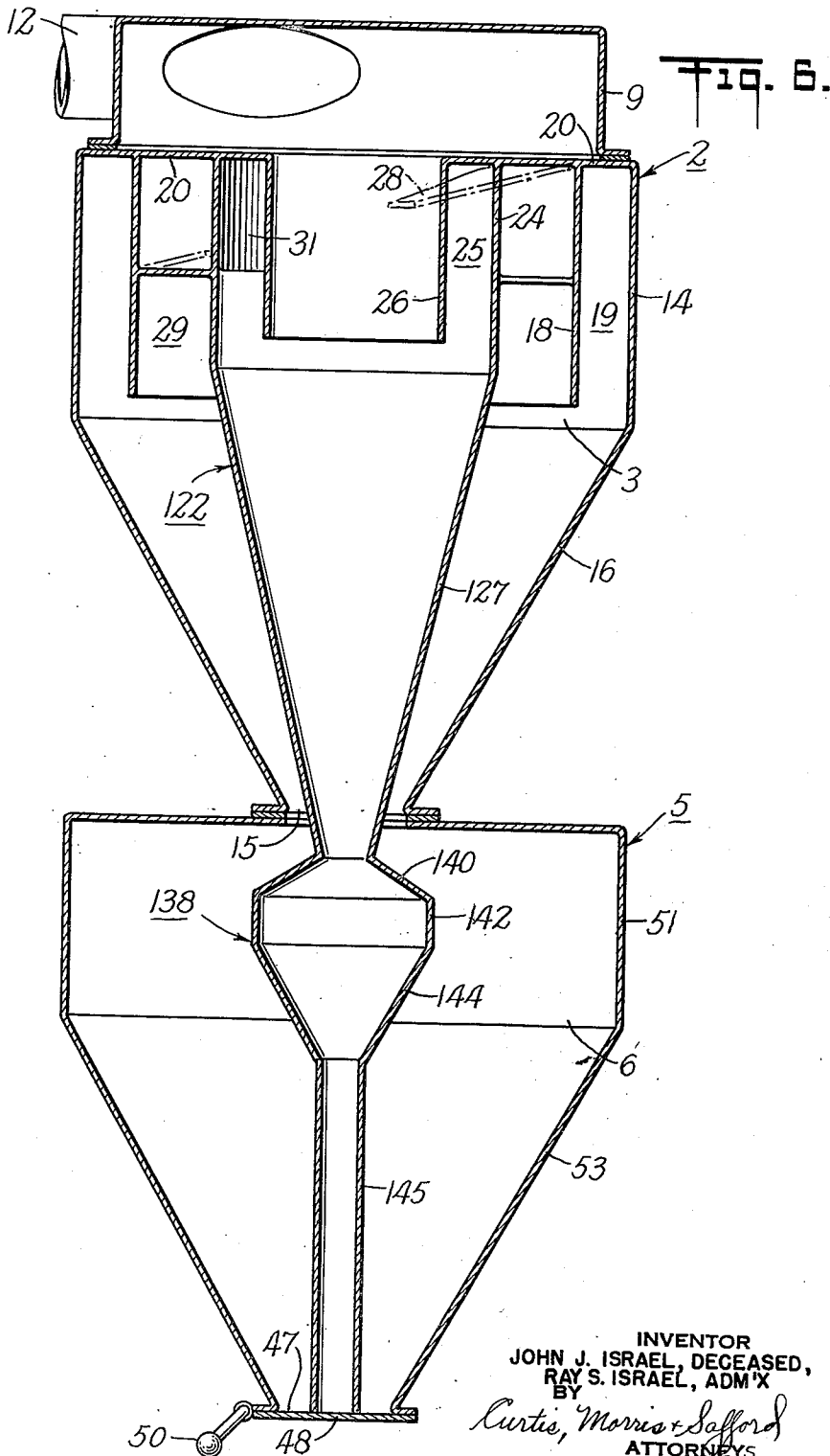
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UNITED STATES PATENT OFFICE

2,604,956

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Application December 4, 1948, Serial No. 63,531

3 Claims. (Cl. 183—83)

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This invention relates to cyclone separators, and more in particular to the removal of bulk products such as flour from a stream of air. The present invention is related to that disclosed in the co-pending application Serial No. 728,222, filed February 13, 1947, now Patent No. 2,572,862, dated October 30, 1951, which discloses systems for handling bulk products and it deals particularly with the handling, storing and distribution of one or more different kinds of flour in a bakery or the like.

An object of this invention is to provide an improved system for removing solid particles from air. A further object is to provide a method and apparatus for carrying out the above in such a manner that extremely small particles of the product are removed from the air with maximum efficiency and minimum over-all cost. A further object is to provide for carrying out the above with a product such as flour in such a manner as to avoid certain dangers and difficulties which have been encountered in the past. A still further object is to provide for the handling of food products in a sanitary manner which avoids wastage and contamination and which is free of dangers, such as explosion, which are inherent in the use of certain prior systems. These and other objects will be in part obvious and in part pointed out below.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts and in the several steps and relation and order of each of the same to one or more of the others, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

In the drawings:

Figure 1 is a side elevation of one embodiment of the invention;

Figure 2 is a top plan view of the embodiment of Figure 1;

Figure 3 is an enlarged vertical section on the line 3—3 of Figure 2;

Figure 4 is a horizontal section on the line 4—4 of Figure 3;

Figure 5 is a perspective view of the upper portion of the embodiment of Figures 1 to 4 with parts broken away; and,

Figure 6 is a sectional view similar to Figure 3 and showing another embodiment of the invention.

In the past difficulty has been encountered with cyclone separators in removing all of the product particles from the air. This has been particularly true when attempts have been made

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to handle flour in pneumatic conveying systems because flour is of relatively low specific weight and a relatively high percentage of the flour is of extremely small particle size. However, the removal of extremely small particles from the air is quite difficult even with products of high specific weight, such for example, as cinders, ashes and the like.

In accordance with the present invention the extremely small particles of products are removed from the air by creating an extremely high velocity vortex of relatively small diameter, and by providing such an arrangement that the product particles which are removed are not thereafter entrained into the air stream. In the illustrative embodiments of the present invention, the vortex passes through a zone of decreasing diameter and then passes from the zone of minimum diameter into an expansion zone where the vortex is substantially unconfined. It has been found that this arrangement facilitates the removal of the product particles and also prevents the reintroduction of the particles into the air stream.

In the illustrative embodiment of the invention of Figures 1 to 5 there are two collector units each of which provides a collector stage; and, the stream of air passes through these stages in series, so that there is a primary stage where the major portion of the product is removed from the air, and then the stream passes into the secondary stage where the remainder of the product is removed. Illustratively, the secondary stage is provided with two expansion chambers in series so that the vortex passes through the first expansion zone where it expands and thereafter it passes through a restricted zone to the second expansion zone. In this embodiment the secondary collector is concentrically positioned within the primary collector so that the outer wall of the secondary collector forms the core or central wall structure of the primary collector. This has many advantages in construction and operation.

Referring particularly to Figure 1 of the drawings, the primary collector has an upper section 2 which encloses a chamber 3 (see Figure 3) and is supported by brackets 4, and it has a lower section 5 enclosing a chamber 6 and supported by brackets 8. The stream of air enters the primary collector through a tangential air inlet conduit 10, and as will be pointed out more fully below, the air passes directly from the primary collector to the secondary collector. The air is discharged from the secondary collector through a

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header 9 at the top of the unit, and a tangential air outlet conduit 12 connected thereto. The upper section 2 has an outer cylindrical shell or wall 14 (see also Figure 3) to which the inlet conduit 10 is attached, and at the bottom of wall 14 there is a frusto-conical wall 16 which terminates at an opening 15 at the bottom and which encloses a collector zone 17. Concentrically mounted within wall 14 is a cylindrical baffle or wall 18 which forms with wall 14 an annular space 19 into which the incoming air is directed. Wall 18 is fixed at its upper edge to a top wall 20.

Top wall 20 also supports the secondary collector 22 which has a pair of concentric cylindrical walls 24 and 26 forming an annular space 25; wall 24 carries at its bottom edge a frusto-conical wall 27, and wall 26 forms a cylindrical outlet conduit for the outgoing stream of air passing to header 9. Positioned in the space 29 between walls 18 and 24 is a somewhat helical baffle 23 which extends counter-clockwise upwardly (Figure 5) to direct the air upwardly between these two walls; and wall 24 (Figure 4) is cut away to provide an opening 31 above baffle 23 from space 29 to the annular space 25 between walls 24 and 26.

Fixed to the bottom of wall 27 (Figure 3) is an expansion chamber structure 33 which encloses an expansion chamber 35 and is formed by a cylindrical wall 32, a frusto-conical wall 34, and an annular wall 37 which closes off the space between the lower end of wall 27 and the inner surface of wall 32. Wall 34 carries at its lower end a cylindrical wall or extension 36 which projects through the opening 15 at the bottom of wall 16 into chamber 6 and carries a secondary expansion chamber structure 38. Structure 38 encloses a chamber 41 and has an upper frusto-conical wall 40, a central cylindrical wall 42 and a bottom frusto-conical wall 44. At the lower end of wall 44 there is an outlet opening 45 which is closed by a hinged door 46 carried by wall 44. Section 5 has an upper cylindrical wall 51 and a lower frusto-conical wall 53 at the bottom of which there is an opening 47 which is closed by a hinged door 48. Doors 46 and 48 are mechanically connected by a bar 49 to open and close together, and they are normally urged closed by a counter-weight 50. During the collecting operation these doors are kept closed so that air enters the collector and is discharged therefrom only at the top, and these doors are opened to discharge the collected product when the air flow is stopped.

Referring to Figure 4 of the drawings, conduit 10 has a reduced discharge opening through which the stream of air carrying the product is directed tangentially into the annular space between cylindrical walls 14 and 18. The jet effect of the restricted outlet from conduit 10 causes an increase in the rate of air flow so that the air moves rapidly in a stiff thin stream or sheet and tends to cling to the outer wall 14. The air starts to whirl at a very rapid rate and (see Figure 3) forms a vortex which moves downwardly along the inner surface of wall 16. The decreasing diameter and space for the whirling stream of air causes the air to increase its speed of movement with the result that the larger suspended particles are thrown from the stream onto wall 16. At the lower end of wall 16 the vortex passes through opening 15 into chamber 6, and, being no longer closely confined, it suddenly expands in diameter with the result that its speed of rotation is reduced and in this zone additional particles

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are thrown from the stream. The vortex continues its rotation and it turns back up inside the downwardly moving outer air stream, and passes upwardly through opening 15 into chamber 17 and passes around the outer surfaces of walls 34, 32 and 27. During the upward movement the diameter of the vortex is lesser than during the downward movement and the rotation is more rapid. Thus, there is a tendency for particles to pass from this upwardly moving vortex outwardly into the downwardly moving vortex.

At the top of wall 27 the vortex passes into space 29 between walls 18 and 24 where the helical baffle 23 directs the air upwardly and tangentially through opening 31 (see Figure 4) into the top of the annular space 25 between walls 24 and 26. The stream of air passing through opening 31 between walls 24 and 26 flows along a path of slightly decreasing diameter so that somewhat of a nozzle is provided. This produces a jet effect which increases the speed of air flow and projects the air and the product particles borne thereby in a stiff rapidly moving stream tangentially against the inner surface of wall 24. The air flows downwardly again (Figure 3) in a spiral so as to form the secondary stage vortex along the inner surface of wall 27. This vortex continues downwardly at a decreasing diameter and an increasing speed to the bottom of wall 27 into chamber 35 where it expands and the rate of rotation is correspondingly decreased. The air continues downwardly again along the inner surfaces of walls 34 and 36 at an increasing speed and with a further decrease in diameter. The stream then passes from the bottom of wall 36 into the top of the second expansion chamber 41 where the vortex expands again and turns about and passes upwardly through the center of the downwardly moving vortex. At the top of the collector the vortex expands again and passes upwardly through cylindrical wall 26 and is discharged through header 9 and the tangential outlet conduit 12. During the passage down wall 27 the increased speed causes additional product particles to be thrown from the air stream and at each of the expansion chambers there are additional small particles thrown from the air stream.

The product particles which are discharge onto wall 16 pass downwardly along this wall and are discharged into the top of chamber 6. The air movement at the top of this chamber tends to throw additional product particles from the air and it also tends to direct the product particles from the bottom edge of wall 16 outwardly away from the vortex and they collect on door 48 at the bottom of chamber 6. Similarly the product particles which are removed from the air along wall 27 pass downwardly into chamber 35 where they are joined by particles thrown from the air against wall 34 and they continue together downwardly along wall 36 to chamber 41. These particles together with the particles thrown from the air in this chamber collect in the bottom of chamber 41 on the top of door 46. Periodically the air flow into the collector is stopped and doors 46 and 48 are opened to discharge the collected particles.

With this arrangement the larger product particles are removed from the air in the primary stage, and the smaller particles are removed from the air in the secondary stage. It has been found that with this arrangement the operation is very efficient in that substantially all of the product particles are removed from the air in sizes down to those of a few microns in diameter. Furthermore, the energy lost in this collector is extremely

small if consideration is given to the high efficiency of operation. In one particular installation a two-stage collector was provided in accordance with Figures 1 to 5 of the drawings with its largest cylindrical wall 48 inches in diameter and with the other part of the apparatus constructed and dimensioned correspondingly to scale in accordance with the drawings. Air was delivered to the collector at the rate of 2200 cu. ft. per minute which bore flour in the ratio of one pound of flour per 8 cu. ft. of air. Tests under these conditions indicated that in the neighborhood of 99.995 percent of the flour was removed from the air in this collector.

Under some circumstances the secondary collector may be used alone as a single stage collector or the primary collector may be used alone as a single stage collector. Thus, for example, if there is a relatively small quantity of large particles and no small particles in a stream of air, the primary collector will in all probability remove all of these particles and the secondary collector is not necessary; and, if there is a relatively small quantity of small particles and no large particles in a stream of air, these are removed by use of the secondary collector alone.

In Figure 6 another embodiment of the invention is shown wherein the secondary collector has only one expansion chamber. This collector is formed by the following elements which correspond to similar elements in the embodiment of Figures 1 to 4: the primary collector including the upper section 2 and the lower section 5; a header 9; top wall 20; cylindrical walls 14 and 18; and helical baffle 28. The secondary collector 122 is identical at its top with the secondary collector of the embodiment of Figures 1 to 5. However, in the embodiment of Figure 6 the frusto-conical wall 127 extends downwardly into chamber 6 of the wall section of the primary collector. At the bottom of wall 27 there is an expansion chamber 138 which is similar to chamber 38 and is formed by a central cylindrical wall 142, an upper frusto-conical wall 140 and a lower frusto-conical wall 144. The bottom of wall 144 carries a cylindrical extension 145 which has its lower end concentrically positioned in opening 47 at the bottom of chamber 6. Thus, during operation the material collects in the bottom of chamber 6 and in cylindrical extension 145, and when door 48 is opened the material is discharged from both collectors simultaneously.

The operation of the embodiment of Figure 6 is readily understood by references to the discussion of the embodiment of Figures 1 to 5. However, in Figure 6 there is only one expansion chamber in the secondary collector and the material from the secondary collector accumulates in the cylindrical extension rather than in the bottom of the expansion chamber.

As many possible embodiments may be made of the mechanical features of the above invention and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinabove set forth, or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In a cyclone separator, the combination of: a first cyclone separator section comprising, a pair of concentrically positioned cylindrical members of different diameters forming an annular passageway therebetween, the larger outer cylindrical member having an inlet opening at the upper portion thereof, an inlet conduit con-

nected to said outer cylindrical member at said inlet opening and forming a tangential inlet passageway which directs a stream of air into said annular passageway at the upper edge thereof and along the inner surface of said outer cylindrical member, a frusto-conical member attached to the bottom edge of said outer cylindrical member and presenting a downwardly converging frusto-conical surface directly beneath said annular passageway which is of substantially lesser diameter at its lower end, a first section expansion chamber structure comprising a cylindrical wall construction and a top wall attached to the bottom end of said frusto-conical member and of a diameter which is substantially the same as the diameter of said outer cylindrical member so that an expansion chamber is formed at the bottom of said frusto-conical surface, whereby an incoming stream of air is caused to rotate at a rapid rate in said annular passageway and to move downwardly and form a cyclone with the outlet from the cyclone being upwardly through the smaller of said cylindrical members; and a second cyclone separator section concentrically positioned within said first section and comprising, a pair of concentrically positioned cylindrical members of different diameters forming an annular passageway therebetween, the larger outer cylindrical member having an inlet opening at the upper portion thereof, means to direct a stream of air from the outlet of said first cyclone separator section into the last-named inlet opening tangentially of the inner surface of the last-named outer cylindrical member, a frusto-conical member attached to the bottom edge of the last-named outer cylindrical member and presenting a downwardly converging frusto-conical surface directly beneath the last-named annular passageway, and a second stage expansion chamber structure concentrically positioned within said first section expansion chamber structure and comprising an annular wall construction and a top wall connected to the bottom end of the last-named frusto-conical member and forming an expansion chamber into which the bottom end of the last-named frusto-conical member opens.

2. A cyclone separator as described in claim 1 which includes means closing the bottoms of said expansion chambers.

3. A cyclone separator as described in claim 1 wherein said second cyclone separator section includes wall structure forming a preliminary expansion chamber positioned above said second section expansion chamber structure and serially related thereto.

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