Sept. 20, 1949. S. G:SON SYLVAN 2,482,642

SEPARATOR

Filed Aug. 12, 1946 3 Sheets-Sheet 1

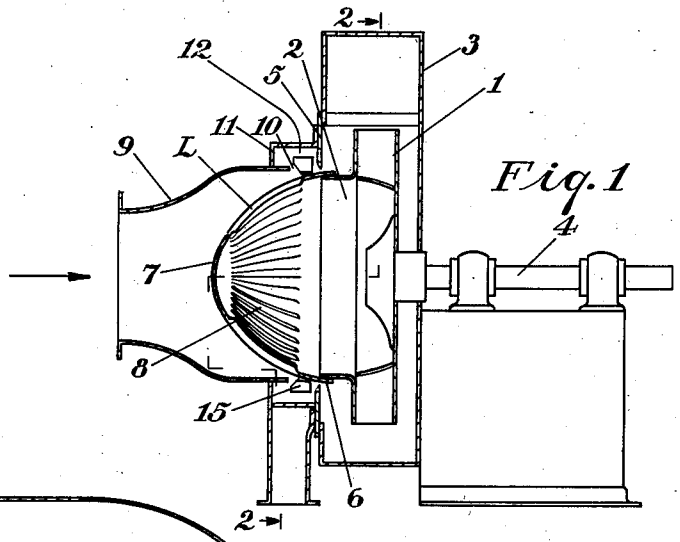


Fig. 1

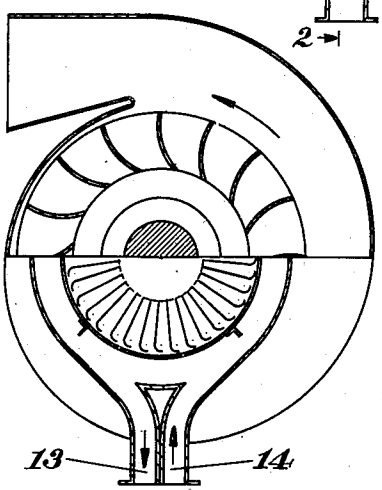


Fig. 2

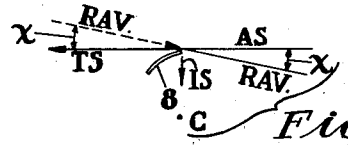


Fig. 4

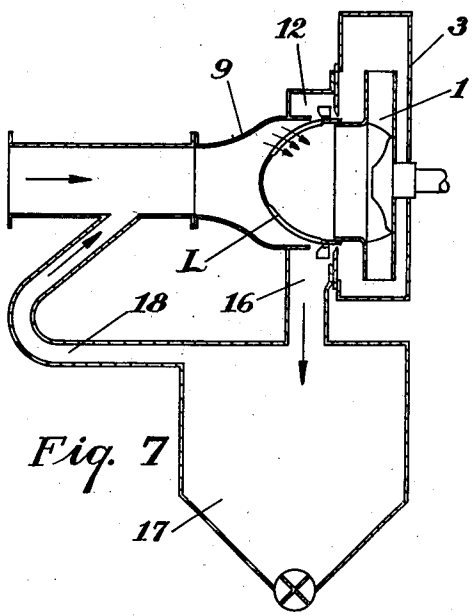


Fig. 7

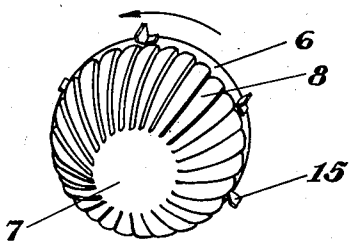


Fig. 3

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Sept. 20, 1949. S. G:SON SYLVAN 2,482,642

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Filed Aug. 12, 1946 3 Sheets-Sheet 2

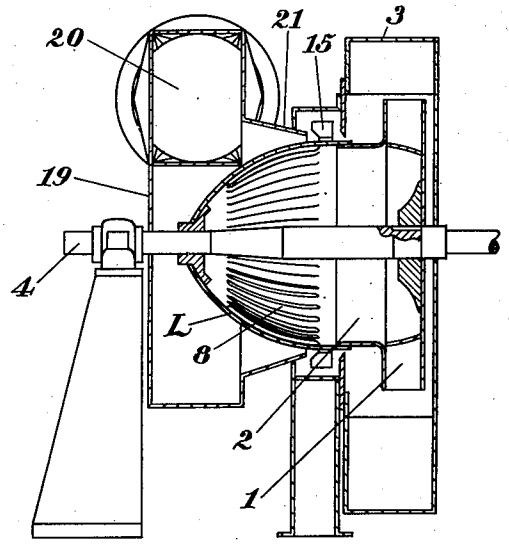


Fig. 8

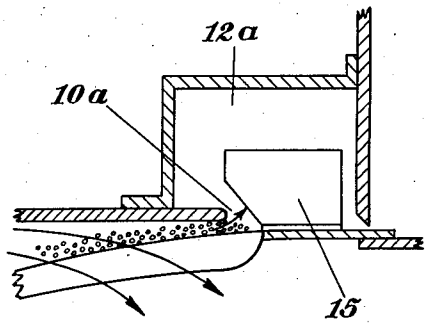


Fig. 5

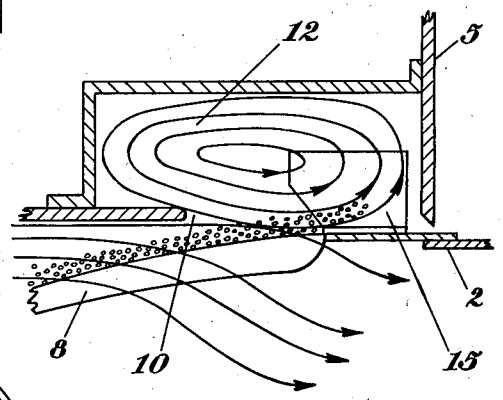


Fig. 6

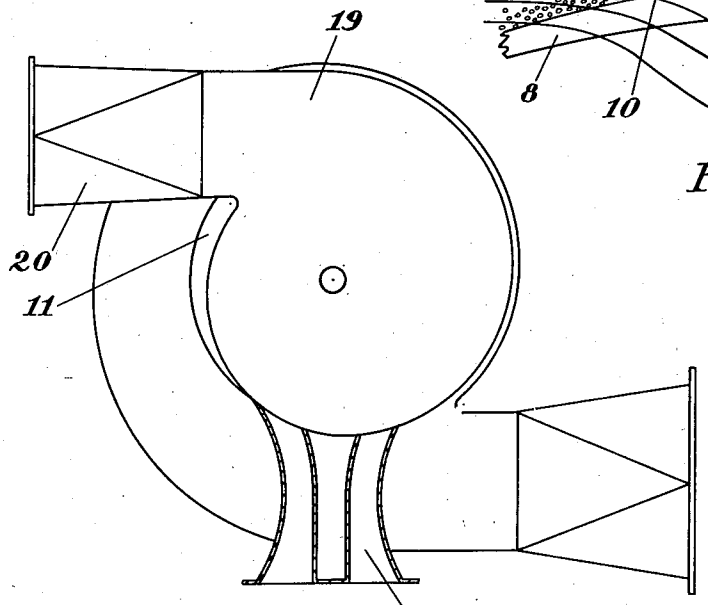


Fig. 9

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Filed Aug. 12, 1946 3 Sheets-Sheet 3

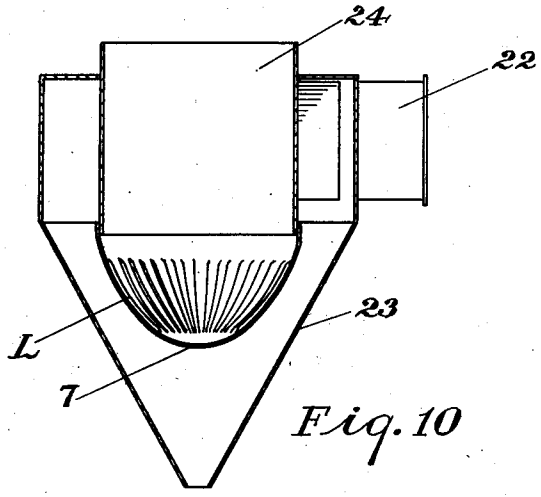


Fig. 10

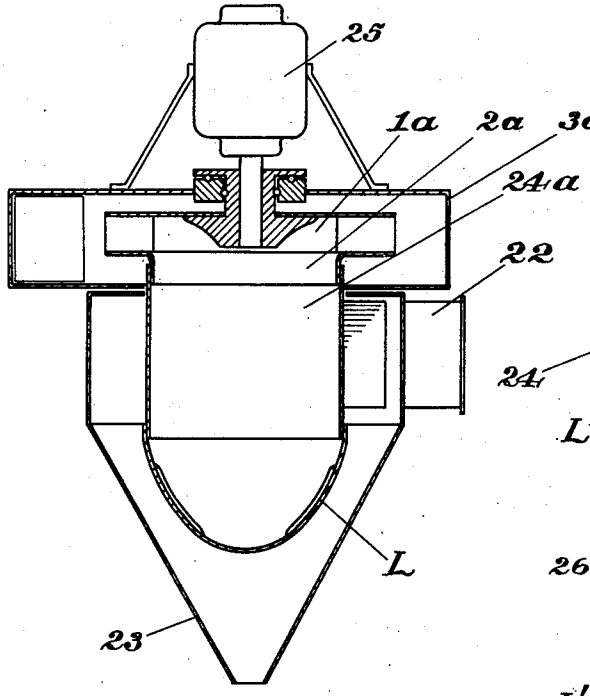


Fig. 12

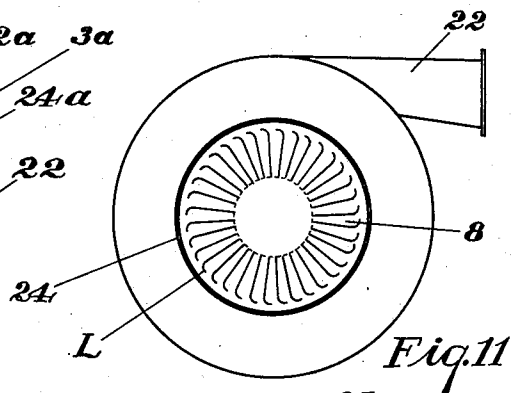


Fig. 11

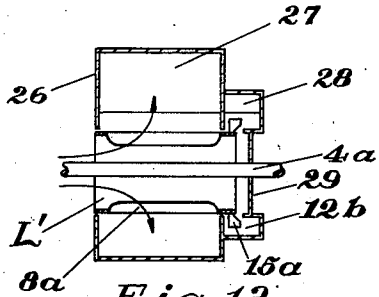


Fig. 13

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UNITED STATES PATENT OFFICE

2,482,642

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Application August 12, 1946, Serial No. 689,885

3 Claims. (Cl. 183—77)

1

It has been proposed in such U. S. Patents as Knickerbocker No. 382,614, Boehning No. 408,285, Goodier No. 645,469, and Haber No. 2,034,467 to clean an air stream by passing it through a louver which effects a sharp deflection of the airflow, the dust particles being retained on the upstream side of the louver and tending to continue in their original direction along that side. The upstream or deflecting edges of the slot-defining louver vanes usually extend at right angles transversely across the air stream while the vanes and the approaching air extend at adjacent acute angles to opposite sides of the upstream face of the louver. This principle of cleaning has been applied to rotary structures in such U. S. patents as Linderoth No. 2,328,220 and possibly Newcombe No. 1,420,665. In rotary structures, the smaller particles (usually one to twenty microns more or less), which are retained on the upstream side of the louver, collect in an area adjacent to but slightly spaced from the upstream face of the louver. They form a cloud which rotates about the louver and which, unless removed, increases in density to a critical value at which it loses dust through the louver at apparently the same rate it receives dust from the incoming air.

While the formation of this cloud is difficult to explain, it is plausible that the particles in the incoming air are made to spin or rotate at increasingly faster rates as they progressively approach the louver and are thus subjected to aerodynamic forces which tend to force the particles away from the louver, these forces being counter-balanced in the cloud area by the force of the air stream which tends to carry the particles through the louver. The possibility that the particles are thus made to rotate is indicated by these facts: first, the incoming air has one velocity component which is parallel to the upstream face of the louver and which, during deflection, initially decreases in one direction between the beginning and reversal points of the deflection from a high maximum value to zero and then increases in the opposite direction between the reversal and end points of the deflection from zero to a high maximum value; and second, as a result of this changing velocity component, the opposite sides of each particle appear to be subjected simultaneously to relatively high and low air velocity components which apparently bring about the aerodynamic forces that cause the particles to move away from the louver.

The problem of removing the cloud-forming

2

dust particles, with sufficient rapidity to prevent the clouds from reaching the critical density, is difficult of solution. If Newcombe's structure produces such a cloud, he makes no attempt to remove it. Linderoth proposes a suction skimmer which is tangentially arranged relatively to the louver surface but this arrangement, if otherwise practical, is objectionable because it involves an independently operated suction system.

The principal object of my invention is to provide a novel, simple, and highly effective means for efficiently removing the cloud particles with sufficient rapidity to prevent the formation of a critically dense cloud.

Another important object is to provide a means which requires little or no auxiliary air flow in effecting the removal and which avoids the necessity of an independently operated dust removal air system.

A further object is to provide a novel form of louver.

The invention is illustrated in the accompanying drawings wherein:

Fig. 1 is an axial section, partly in elevation, of one of my rotary louver separators;

Fig. 2 is a section taken on line 2—2 of Fig. 1;

Fig. 3 is a perspective view of a novel form of louver constructed in accordance with my invention;

Fig. 4 is a vector diagram showing the relative angle between the approaching air and the louver;

Fig. 5 is a cross-sectional detail showing the relationship of the dust removing louver in a separator of the general type described herein;

Fig. 6 is a similar view of the relationship used in the separator of Fig. 1;

Fig. 7 is an axial section, partly in elevation, showing one of my rotary louver separators with one form of secondary dust removing system;

Fig. 8 is an axial section of a separator of the character shown in Figs. 1 and 2 with a modified form of air inlet;

Fig. 9 is an end elevation of the Fig. 8 separator;

Fig. 10 is an axial section of another embodiment in which my louver is stationarily mounted in a cyclone type of housing;

Fig. 11 is a top plan view of the separator of Fig. 10;

Fig. 12 shows an embodiment like that of Fig. 10 but with a rotary louver; and

Fig. 13 is a diagrammatic section of a modified louver separator.

In general terms, a louver separator con-

structed in accordance with my invention for cleaning a primary flow of air may be described as comprising: a dust separator louver having a series of slot-defining spaced vanes extending around an axis of rotation and across the path of the primary air flow, the louver vane being of a type which is adapted, upon the establishment of rotation relatively between said main air flow and the louver, to retain the dust on the upstream side of the louver; means for establishing relative rotation between the primary air and louver; means constraining the primary air to approach the upstream side of the louver in a manner such as to exert a force on retained dust particles causing those particles to move to one side of the air flow; and means on the same side of the primary flow to remove said particles from said flow.

The separator shown in Figs. 1–3 includes a blower impeller 1 having an axial inlet 2 mounted within a conventional blower housing 3 and arranged to be driven through a shaft 4 by some suitable source of power not shown. The inlet face of the blower housing has an axial opening large enough to permit the impeller to be inserted into or removed from the housing. This opening is reduced to air inlet proportions, by a centrally perforated disc plate 5. A louver separator L is mounted in impeller inlet 2 and arranged to project upstream therefrom, through the opening in disc plate 5.

Louver separator L preferably is of the semi-spherical or dome shape shown in the drawings It has: an annular base portion 6 forming its downstream opening and providing a means of securing it to axial inlet 2 of the impeller 1; an apex portion 7 at its opposite end; and a curved side wall portion extending from the base end to the apex end and containing a series of louver-forming slot-defining spaced vanes 8. Vanes 8 may be cut or stamped from an integral sheet forming the curved side walls or louver portions of the separator or they may be formed individually and then secured to the apex and base portions of the louver separator. While the vanes, as shown, are longitudinally curved from the base end inwardly toward the apex end, they may be made longitudinally straight and arranged to extend from the base end portion either parallel with the axis of rotation or at an inwardly inclined angle to the axis of rotation so that they form in one case a cylinder and in the other case a cone.

To obtain good air cleaning results, I have found that it is necessary; first, to establish relative rotation between the incoming air and the louver separator; second, to constrain the incoming air to approach the upstream face of the louver in such a manner as to provide an air velocity component directed along the face of the louver axially toward one end or the other of the louver and thus toward one side or the other of the primary air flow; third, to obtain a sharp deflection of the air; and fourth, to obtain a somewhat uniform blower effect in the louver.

Relative rotation between the air and the louver may be obtained by rotating the louver or by rotating the air about the louver or by a combination of both. In Figs. 1–4 such rotation is obtained solely by rotating louver separator L.

In Figures 1–2, the incoming air is constrained to flow axially toward louver separator L by an inlet piece 9. The shape of this piece is co-ordinated to the shape of the upstream face of the louver separator to accommodate the inlet flow of the air in a well known manner such as to provide a uniform flow of air toward, or a uniform distribution of air over, the upstream face of the louver separator. Preferably also vanes 8 of the louver are spaced so that the total free area of the louver slots is approximately 10% greater than the cross-sectional area of the inlet piece 9 at its upstream end. With this arrangement, as the air axially approaches louver separator L, and while it turns to pass inwardly through the slots between vanes 8, it has a velocity component which extends along the upstream face of the louver and in the direction of the base of the louver. This axial velocity component exerts on the cloud forming dust particles, which are retained on the upstream side of the louver, a force causing those particles to move, as a whole, axially through the cloud forming area toward the base of the louver separator. In other words, this axial velocity component of the incoming air is utilized to move the cloud forming particles to one side of the primary air flow, such side corresponding, in the structures of Figs. 1–2, to the base end of the louver separator.

To secure sharp deflection of the air by the louver, the incoming air must have a small or acute angle of relative approach on one side of the upstream face of the louver, louver vanes 8 should form an adjacent acute angle on the opposite side of the same upstream face, and these angles must point in a direction opposite the direction of louver rotation. With a rotating louver, the relative approach angle is, of course, determined, at any one point, by the tip speed of the rotating louver at that point and that velocity component of the incoming air which is directed radially inward. For example, in Fig. 4, a vane 8 is shown rotating counterclockwise about center C with a tip speed TS, the corresponding relative velocity of the air being shown by the opposite air speed vector AS. With the inward air speed shown by the vector IS, the resultant air velocity will correspond to the vector RAV, this being the relative velocity of the approach air while the angle X represents the angle of approach.

With relative rotation between the louver and the incoming air, it will thus be seen that the relative approach angle is determined by that velocity component of the air which corresponds to the tip speed of the louver and the radially inward velocity component of the air. This angle should be about 10° to 15° although it may vary over a somewhat wider range. The average inclination angle of the vanes will normally reach between 10° and 30°, it being understood that the inclination of the upstream portion of the width of the vanes will normally be different from the downstream portion of the width and also that the inclination will vary with the radius of rotation to compensate for the lower tip speed.

To secure a somewhat uniform "blower effect," the angle of relative approach of the incoming air and the width, cross-sectional shape, and inclination of the vanes must all be co-ordinated in a manner such that the air at the base end portion of the vanes discharges at one velocity and in one direction to produce a certain static pressure with a certain total pressure while the air, at other vane portions of progressively smaller radii, must discharge at progressively higher velocities in appropriate directions to produce progressively lower static pressures with the same total pressure. This, apparently, has not heretofore been appreciated in the air cleaning art but once the necessity of co-ordinating such factors, to produce

a more or less uniform blower effect, is realized, then it becomes obvious that the mode of effecting such co-ordination is a matter of routine blower design; hence it should suffice to say that, in the present case, the vanes, in accordance with well known design principles, are made to decrease, from the large base end to the small apex end, in width, camber and inclination. If the vanes were individually formed of constant or even increasing width from the large base end to the small apex end, the camber and inclination should be changed accordingly to provide a uniform blower effect with the same approach angle.

When an air flow is set up through the rotating louver above described, dust particles will be retained on the upstream side of the louver and these particles will form a cloud. Since the incoming air, passing axially through inlet piece 9, approaches the louver axially and then turns inwardly to pass through the louver, it will be appreciated that an axial component of this flow is directed toward the base end of the louver. This axial component acts on the cloud, forcing its particles axially toward the base end of the louver and thus increasing the relative concentration of particles at that end. If nothing more were done, this concentration would ultimately increase to the critical value at which the cloud would begin to lose particles through the louver at a rate approximating the rate at which it receives particles from the incoming air.

In accordance with my invention, however, means are provided to remove the particles from the base end of the louver. Accordingly inlet piece 9 is spaced axially from disc plate 5 of the blower housing to provide an annular dust discharge opening 10 leading radially outward from the inlet chamber at a point corresponding to the base end portion of the separator which is at one side of the flow of primary air through the inlet chamber. Preferably an annular sheet 11 is arranged to extend around dust discharge opening 10 and between the blower housing and the inlet piece, to both of which it is connected, to form an annular chamber or dust ring 12 communicating through the dust opening 10 with the inlet chamber. The rotation of the louver will induce the air in dust ring 12 to rotate and the air forces causing that induced flow also cause particles of dust adjacent the base end of the louver to pass outwardly into the dust chamber.

In Figs. 1–2, the dust ring is provided with outlet and inlet passages 13 and 14 through which it may be connected to a hopper, not shown. With this arrangement the air in the dust ring not only rotates through the dust ring but a portion of that air passes through outlet passage 13 into the dust hopper where the velocity of the air is reduced so that some of the particles settle out of the air, the relative cleaner air flowing back into the dust ring through inlet passage 14. With induced circulation of this character, none of the primary air is diverted into the dust removal system.

The outward passage of the dust particles into the dust ring may be facilitated by providing the base end of the louver separator with a series of blades 15 projecting radially from the separator through dust opening 10 into dust ring 12. Such blades will also effect a positive circulation of air in the dust ring and hopper.

The Figs. 1–2 arrangement of dust opening 10, dust ring 12, and blades 15 is shown on an enlarged scale in Fig. 6. Referring first however to

Fig. 5 which shows a similarly enlarged detail, it will be noted that the axial dimensions of dust opening 10a and dust ring 12a are barely sufficient to accommodate the blades 15. With this Fig. 5 arrangement, I have secured 94% efficiency of separation of particles in a certain size range. In Fig. 6, however, the corresponding axial dimensions of dust opening 10 and dust ring 12 are greatly increased so that dust opening 10 overlies not only the base end of the separator but also a substantial part of the base end portion of the vanes. With this arrangement, blades 15 cause the air in the dust ring to circulate axially or sidewise as it rotates about the axis of rotation and, in circulating axially, the dust ring air approaching the blades mingles with that portion of the main air flow approaching the base end portion of the vanes. As a result, a better flow of cloud particles into the dust ring is obtained without the diversion of any primary air flow. With the Fig. 6 arrangement, I obtain a 67% increase in efficiency over the efficiency obtained with the Fig. 5 arrangement, bringing the total efficiency to 98% with all other factors remaining the same.

Fig. 7 shows an arrangement which is substantially the same as that shown in Figs. 1–2 and 6, except that a part of the primary air is diverted to the dust removing system for the purpose of creating a positive flow of air for sweeping particles from the base end portion of the separator into the dust removal system. In this case, dust ring 12 is connected by an outlet passage 16 to a hopper 17 where the air gives up at least part of its dust load, the relatively clean air passing through conduit 18 back into the inlet of the separator where it again mingles with the incoming air.

Figs. 8 and 9 show an arrangement which is substantially the same as that shown in Figs. 1–2 and 6, except that the inlet piece of the earlier figures is replaced here by a scroll type of inlet housing which constrains the entering air to flow tangentially so as to create a rotating stream of air which moves axially over the louver. Accordingly a scroll housing 19 is provided having a tangentially directed inlet 20 and an axially directed outlet 21 of frustro conical shape. The conical shape of outlet 21 has been found to increase the separating efficiency somewhat. This arrangement operates in substantially the same way as the arrangements of the earlier figures. The rotating body of air is made to rotate preferably in the direction opposite to the direction of rotation of the louver, although it will be understood that louver rotation is not essential in this case. The manner of particle separation and removal is the same as before.

In Figs. 10 and 11, a louver constructed in accordance with my invention is embodied in a housing of the cyclone type. This housing is conventionally provided with a tangential inlet 22 leading into a cyclone chamber having a conical bottom 23 and an axial outlet 24 to discharge clean air from the top of the housing. Louver separator L is placed over the axial inlet of the discharge passage. It will be well appreciated that the entering air rotates about the axis of the cyclone housing and as it rotates, it moves axially toward and over the louver separator L to pass through that separator and out of discharge passage 24. Louver separator L functions in the same manner as previously described to form a cloud of particles around its upstream face. The axial component of the incoming air

operates to move dust particles toward apex 7 of the louver separator and as the particles are thus moved axially, they gradually settle out of the primary air flow into the bottom of the conical hopper.

The arrangement shown in Fig. 12 is identical to that of Figs. 10–11, except that louver separator L is mounted for rotation within the cyclone housing. To this end discharge passage 24*a* of the cyclone housing is secured to the axial inlet 2*a* of a blower impeller 1*a* rotationally mounted within blower housing 3*a* and arranged to be rotated by motor 25. When motor 25 is energized, the impeller will be rotated to draw a stream of air through the cyclone discharge passage 24*a* into blower housing 3*a*. The separation of dust particles and their axial movement to the bottom of conical hopper 23 is effected in the same way as described in connection with Figs. 10–11.

Fig. 13 illustrates a modification wherein the air being cleaned passes from the interior of a separator L′ to the exterior thereof as distinguished from the reverse in Fig. 1. Separator L′ is preferably of generally cylindrical shape with vanes 8*a* of much the same general shape and size as those of Fig. 1 in the side walls of the cylinder, the vanes however being designed to intercept the dust particles on the interior of the separator. The separator may be mounted on a shaft 4*a* for rotation. The clean air passes between vanes 8*a* into a surrounding scroll-type housing 26 having a discharge opening 27 connected to suitable air suction means.

The intercepted dust continues travel in an axial direction along the inside of the separator until it passes into a dust ring 12*b* which may also be of the scroll-type having a discharge opening at 28. The right end of the assembly is closed by a wall 29, which prevents the escape of dust particles except through the dust ring. Preferably impeller vanes 15*a* are secured to the right end of the separator to rotate therewith and aid in the removal of dust. Dust ring 12*b* may be formed as the dust ring of Fig. 5 or the dust ring of Fig. 6.

In operation, the dirty air enters the interior of the separator at the left end, the clean air passing out through the separator to housing 26 and the dust to housing 28.

It will be noted that in all the embodiments shown herein, the dust particles are moved to one side of the air flow, i. e., to the outside in Fig. 1 and to the inside in Fig. 13, the particles being relatively concentrated adjacent one end of the louver, and that the means to remove the particles from the vanes is on that same side of the air flow so that it is not necessary for the concentration to enter or pass through any portion of the main air flow before being removed. The dust particles can be said to be gradually concentrated and edged out of the primary air flow to a point where they are taken over by the removal means such as the secondary air flow in the dust ring.

Having described my invention, I claim:

1. A louver dust separator for cleaning a main flow of air upon the establishment of relative rotation between the incoming air and the louver, comprising: a louver separator having a series of slot-defining, spaced blade-like vanes extending around an axis of rotation, with each vane lying transversely across the path of the main air flow, and being inclined in relation to the upstream face of the louver to form an acute angle which points in a direction opposite to the direction of rotation of the vane relatively to the approaching air, said vanes being constructed and arranged to prevent the passage of dust through said slots and thereby cause a cloud of dust particles to form on the upstream side of the vanes; means for constraining the incoming air flow to approach the louver in an axial direction such as to effect an axial movement of cloud particles toward one side of the air flow and thereby relatively concentrate said particles adjacent one end of the louver; a dust ring arranged on the same side of the air flow to extend around said one end of the louver, said ring being outwardly spaced therefrom and having an annular opening communicating with the space therebetween; and a series of blades mounted on the louver to project radially into said annular opening to induce the passage of dust particles through said opening into the ring.

2. The louver separator of claim 1 wherein the axial dimension of the dust ring annular opening is substantially larger than the corresponding dimension of the blades at the point where they enter the opening, a substantial portion of the opening being radially lined with the vane area of the louver adjacent said one end.

3. The louver separator of claim 1 wherein the axial dimension of the dust ring is substantially larger than the corresponding dimension of the blades and the dust ring annular opening, and the blades are arranged to cause particles entering the dust ring to move axially toward one side of the ring.

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