DUST COLLECTOR

Original Filed April 21, 1961

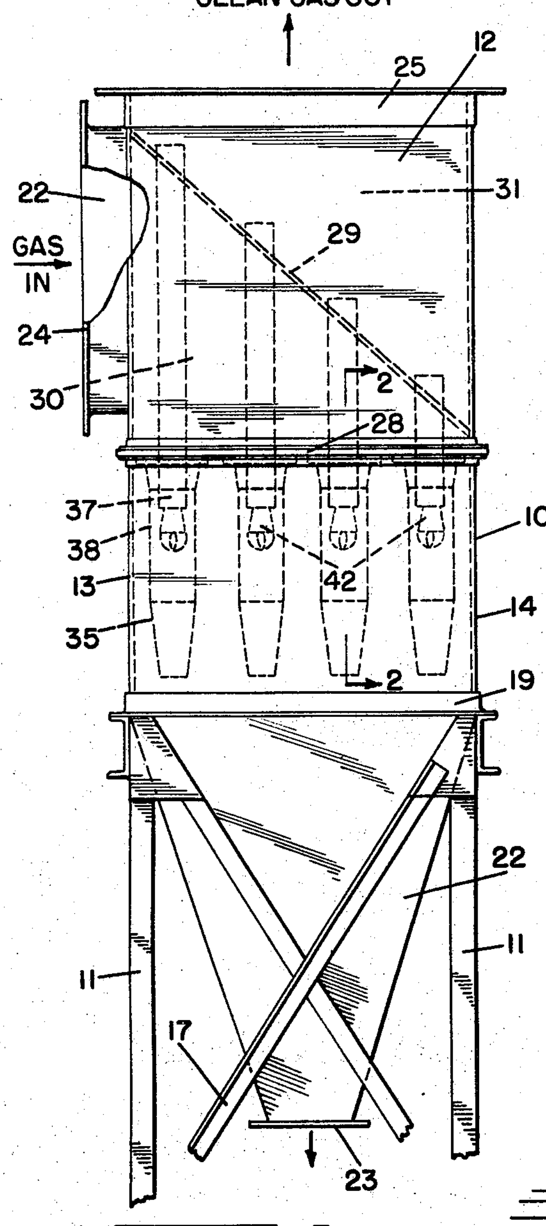

Fig. 1

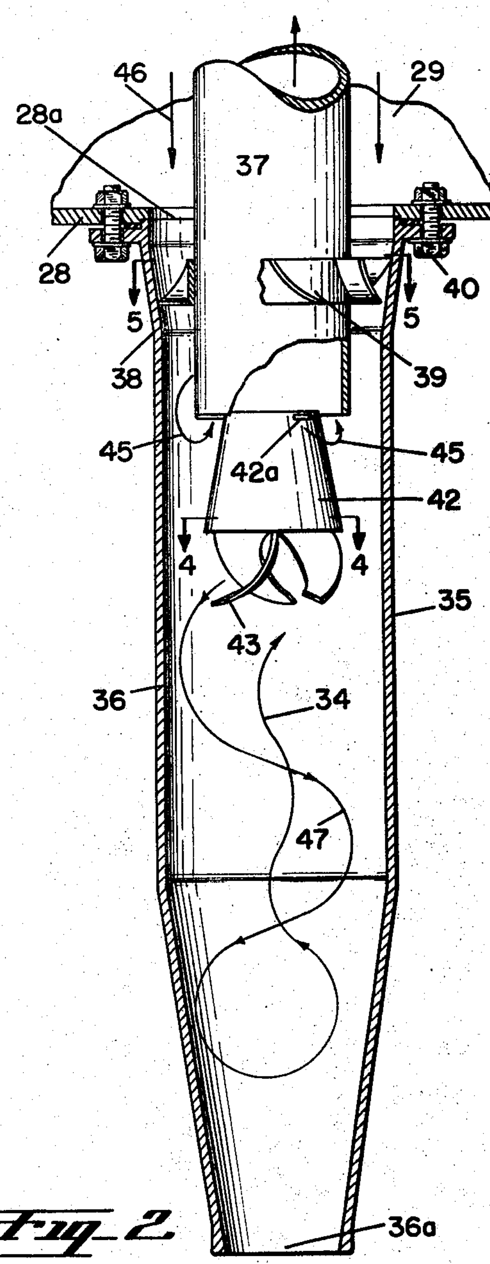

Fig. 2

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Fig. 3

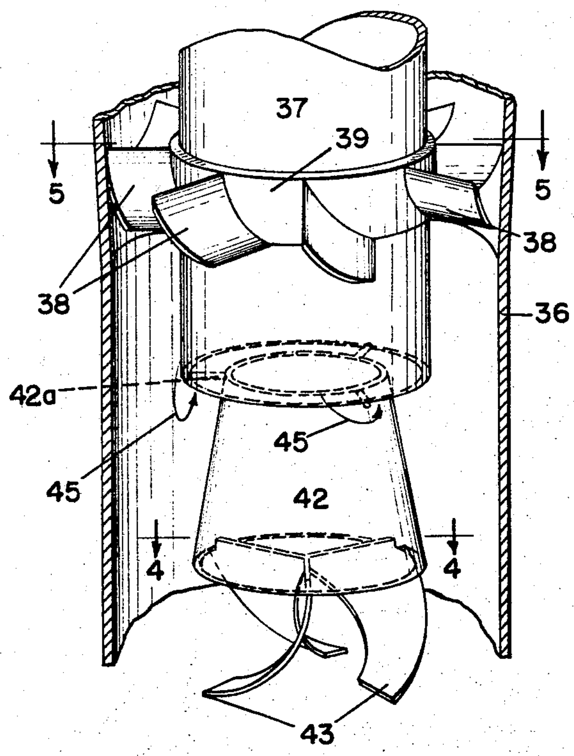
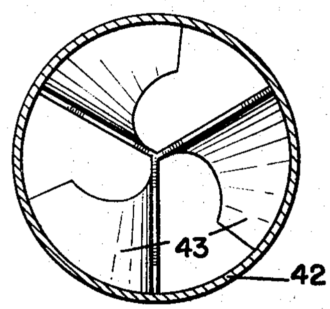


Fig. 4



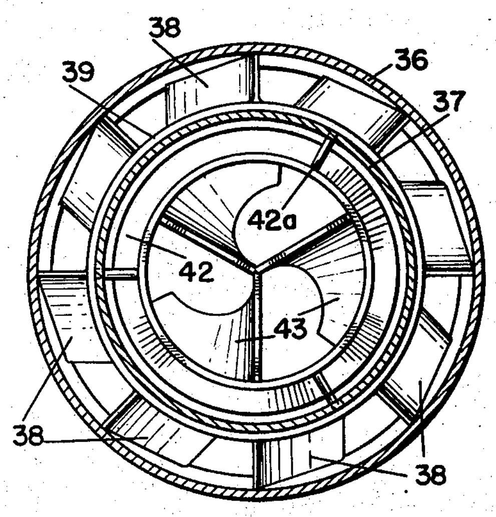


Fig. 5

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Fig. 6

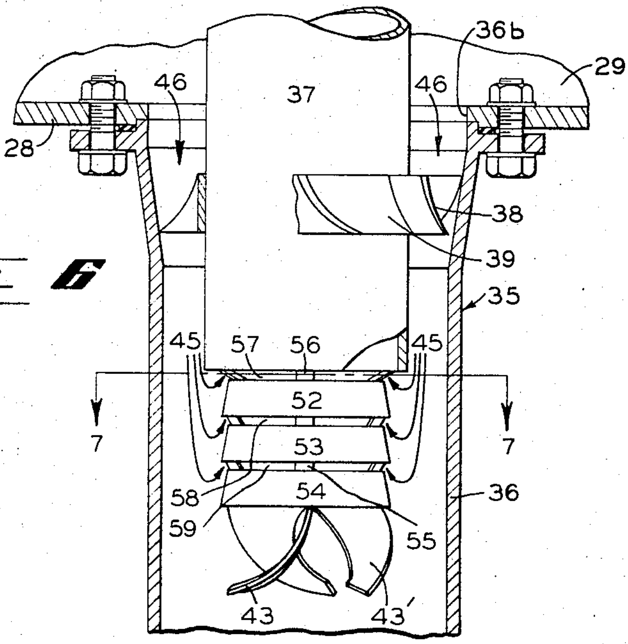
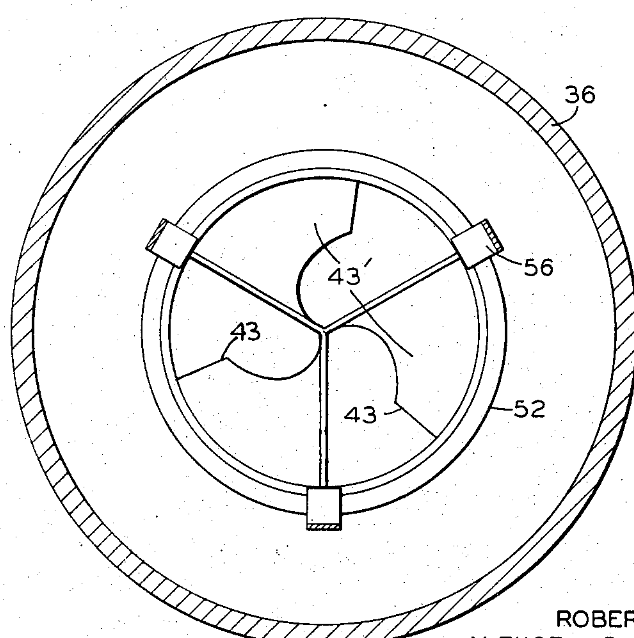


Fig. 7



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3,420,040
DUST COLLECTOR

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Continuation of application Ser. No. 112,147, Apr. 21, 1961. This application June 22, 1965, Ser. No. 468,672
U.S. Cl. 55—346 14 Claims
Int. Cl. B01d *45/12*

This application is a continuation of application Ser. No. 112,147 (now abandoned) filed Apr. 21, 1961, which was a continuation-in-part of application Ser. No. 762,836 filed Sept. 23, 1958, now abandoned.

The present invention relates generally to apparatus for the separation of suspended particles by centrifugal action from a stream of gas in which the particles are carried, and more particularly to improvements in the design of the individual cyclonic units in multiple unit devices of this character.

It is well known that a cyclonic unit of relatively small diameter is more efficient in separating suspended particles than is one of relatively large diameter, because for a given gas velocity within the separating tube, the forces acting on dust particles are inversely proportional to the diameter of the tube. Since the purpose of these units is to remove the maximum possible amount of the material suspended in the gas stream, much effort has been directed toward the improvement of the collecting efficiency of the units. Some prior designs achieve a relatively high collection efficiency with a reduction in the maximum gas flow rate which is attained through the particular cyclonic unit for a given pressure drop across the unit. Such decrease in the maximum attainable gas flow rate through a unit of given diameter is not always acceptable, even at the higher collection efficiency, because the number of such units must be increased, to process a given volume of gas at a specified rate of flow, with a consequent increase in the cost of the complete dust collector.

Accordingly, a general object of this invention is to provide a cyclonic unit of the character described which, under given conditions, obtians both maximum collection efficiency and maximum rate of gas flow through the unit.

The general object of this invention, differently stated, is to increase the rate of gas flow through a cyclonic unit of high efficiency and/or improve the efficiency without any significant increase in the pressure drop between the inlet and the outlet of the unit.

These and other objects of this invention have been achieved in a cyclone type dust collector having cyclonic units each of which includes a separating tube provided with gas inlet in one end and with spin-producing means inwardly adjacent said inlet which impart a whirling motion to the entering gas stream. The cyclonic unit also has a clean gas outlet tube which extends into the separating tube at the inlet end and is positioned coaxially with the separating tube, the cleaned gas leaving the unit through this outlet tube. In one embodiment of this invention a formed generally tubular sleeve, open at both ends, is mounted on the clean gas outlet tube, and is located coaxial with the inner end of the outlet tube so that it forms an extension thereof. This tubular extension sleeve is of lesser diameter than the outlet tube and may be frusto-conical, or of any suitable airfoil shape to insure a directed flow of gas. Being of smaller diameter than the outlet tube, the extension sleeve defines with the outlet tube a first outlet opening for cleansed gas, which opening is of annular shape and located at the inner end of the outlet tube. The sleeve also defines a second outlet opening for clean gas at the innermost end of the extension more remote from the outlet tube. A plurality of straightening vanes of spiral configuration are mounted upon, and extend axially from, the innermost end of the tubular sleeve to engage the swirling gas stream as it approaches the innermost open end of the sleeve forming the second gas outlet opening.

The objects of this invention have also been achieved in another embodiment wherein a similar purpose cyclonic unit differs from the above described embodiment in that a plurality of axially spaced frusto-conical tubular sleeve extensions are provided at the inner end of each clean gas outlet tube. The sleeves are positioned coaxial with the outlet tube and each sleeve has the smaller diameter end thereof, nearest the outlet tube. With such structure a plurality of outlet openings are provided for the cleansed gas. In the embodiment described hereinafter, three such tubular sleeves define a first, a second and a third cleansed gas opening and the innermost larger diameter end of the sleeve most remote from the outlet tube defines a fourth clean gas outlet.

How the above objects and advantages of our invention, as well as others not specifically mentioned herein, are attained will be more readily apparent from the following description and the annexed drawings in which:

FIG. 1 is a side elevation of a complete dust collector comprising a plurality of cyclonic units designed to operate in parallel.

FIG. 2 is an enlarged vertical median section through one of the cyclonic units, as on line 2—2 of FIG. 1.

FIG. 3 is a fragmentary perspective view at a further enlarged scale of an upper portion of the cyclonic unit shown in FIG. 2.

FIG. 4 is a horizontal sectional view taken substantially on line 4—4 of FIG. 3.

FIG. 5 is a horizontal sectional view taken substantially on line 5—5 of FIG. 3.

FIG. 6 is a fragmentary view, similar to FIG. 3 of an enlarged vertical median section through a cyclonic unit with another embodiment of this invention therein.

FIG. 7 is an enlarged horizontal section taken substantially on line 7—7 of FIG. 6.

A complete dust collector is shown in FIG. 1 which is but one of the many possible different designs. The collector comprises a suitable rectangular housing **10** mounted on a suitable angle iron framework that includes four supporting legs **11**. The housing **10** may be made of metal sheets forming two spaced side walls **12** connected at their vertical edges by front and rear walls **13** and **14** respectively. The sheets forming these walls of the housing may be interconnected and reinforced in any suitable manner, as by braces **17**, and angles **19** and other members which are not shown since they are not necessary to an understanding of the present invention.

Housing **10** has a rectangular gas inlet **26** in front wall **13**, the opening being surrounded by an angle iron frame **24** providing a flange to which suitable duct work (not shown) may be connected. A similar flange **25** is provided at the top of the housing to define an outlet opening to which other duct work may be connected to convey away cleansed gas. Alternately, the outlet defined by flange **25** can be in the vertical side wall **14**. In either case, the outlet opening from the housing **10** can vent directly to the atmosphere.

Inside housing **10**, a horizontally disposed plate **28**, commonly referred to as a tube sheet, divides the space within the housing. The space below plate **28** is the hopper space within which the dust is collected, this space extending downwardly and into the pyramidal hopper **22**. Dust is discharged from the bottom of the hopper through outlet **23** by any suitable valve, not shown. Above tube sheet **28** the space within the housing **10** is divided by inclined plate **29** extending between side walls **12**, and between walls **13** and **14**, into a gas inlet chamber **30** communicating with inlet **26** and a gas outlet chamber **31** communicating with the gas outlet at flange **25**.

A plurality of cyclonic dust separating units are located within the housing **10**, individual units being identified by the numeral **35**. As may be seen from FIG. 2, each of these cyclonic units **35** consists of an assembly of several parts including a separating tube **36**, an outlet tube **37**, and a purality of circumferentially spaced formed vanes **38** extending radially therebetween which vanes **38** impart a spinning motion to the gas as it enters each of the separating tubes **36**. Separating tubes **36** are normally arranged with their longitudinal axes parallel and in a substantially vertical position and for this reason they are shown and described in this position. It will be understood that the invention is not necessarily limited thereby as the tubes **36** in horizontal or inclined positions would be within the scope of this invention. Each tube **36** is open at its upper end to receive from the gas inlet chamber **30** a stream of gas, carrying particles suspended therein which are to be separated from the gas. The opening in the upper end of each tube **36** is aligned with a similar opening **36*b*** in tube sheet **28**. Each separating tube **36** is suitably secured to the tube sheet **28** such as by a plurality of bolts **40**.

Each separating tube **36** is also open at the lower end at **26*a*** to discharge dust particles, separated from the gas stream, which fall into hopper **22**. Tubes **36** can be cylindrical for their full lengths, or preferably, taper downwardly from the intermediate portions to the lower ends thereof, as shown.

The vanes **38** are located inwardly adjacent the inlet end of each tube **36**, and are formed integrally with a tubular collar **39**, circumferentially secured on the outlet tube **37**, by which the vane assembly is mounted in place. The entering gas stream impinges against vanes **38** which give to the gas stream a whirling motion which separates the suspended particles from the gas. Alternatively the gas may be introduced tangentially by an involute type of inlet, such as those shown by Patents Nos. 1,930,806 and 1,990,943 issued to G. H. Horne et al., which gives a whirling motion to the gas stream.

Clean gas is exhausted from each separating tube **36** through the cylindrical outlet tube **37** which extends into the separating tube **36** at the inlet end and is positioned coaxially with the separating tube **36**. Clean gas outlet tube **37** is open at both ends. The upper ends of all of the outlet tubes open into the gas outlet chamber **31** from which the clean gas is discharged from the housing through the gas outlet defined by the flange **25**.

The structure of the cyclonic units so far described is old and well known in the art. This invention has improved their operation by the addition thereto of a formed tubular sleeve **42** which, as shown, is mounted on the lower or inner end of the clean gas outlet tube **37** coaxially thereof, by means of a plurality of suitable radial circumferentially spaced arms **42*a***. Mounted on the lower end of sleeve **42**, which is the end remote from the inner or lower end of the outlet tube **37**, is a plurality of circumferentially spaced spiral vanes **43** which extend below the open end of sleeve **42**. In the embodiment shown in FIGS. 1 to 5 the tubular sleeve **42** is of a frustoconical shape, with its maximum diameter smaller than but substantially equal to the diameter of the outlet tube **37**. The smaller end of the sleeve **42** is uppermost or adjacent to the inner end of the outlet tube **37** and is preferably near or substantially in the same plane as the opening at the inner or lower end of tube **37**. The annular space between the sleeve **42** and the outlet tube **37** permits a portion of the cleansed gas to enter directly the open portion of the inner end of the outlet tube **37** as indicated by arrows **45**.

Sleeve **42** is open at both ends. Clean gas can also enter the lower end, flow upwardly through the sleeve **42** and thus enter interiorly of the outlet tube **37**. Vanes **43** are designed to reduce the spinning movement of the gas stream and cause the cleansed gas stream to enter the sleeve **42** with its motion primarily in a direction parallel to the axis of the separating tube **36**. Vanes **43** convert a portion of the rotational energy into translational energy, reducing the total energy required to move gas through the unit. For this purpose vanes **43** are more efficient when they have a spiral configuration and are inclined in a direction opposite to vanes **38**. The number of flow straightening vanes is not critical but three or four are preferred in constructions wherein straightening vanes are preferred.

As may be seen by reference to FIG. 4, the outer curved edge of each vane **43** has a constant radius about the axis of the separating tube **36** so that the axial projection of the outer edge is a circular arc. The inner edge of each vane **43** starts at this axis and recedes farther away from the central axis as a point on this edge moves from the upper edge of the vane **43** to the lower edge. The shape of the curve of the inner edge is not critical. Thus each vane **43** may be defined generally as being of progressively decreasing radial width toward the lower end. At the upper end, each vane **43** has a width equal to the internal radius of the adjoining end of outlet sleeve **42** so that the vanes **43** meet each other substantially on the axis of the separating tube **36** and extend radially outwardly to sleeve **42**. The vanes **43** are welded together where they meet and are welded to the sleeve **42** in a preferred construction, but other suitable fastening means may be used.

The incoming gas stream flows through inlet chamber **30** with portions thereof flowing into the upper end of each of the cyclonic units **35**, as is well known and as indicated by arrows **46**. Upon entering a separating tube **36**, the gas stream strikes against vanes **38** which give the gas stream a spinning motion about the axis of tube **36**. As a consequence each portion of the entire gas stream moves in a spiralling downwardly path (counterclockwise with reference to FIG. 5) within a separating tube **36**. Such spinning motion causes a centrifugal force to be exerted upon the suspended particles in the gas stream that moves the particles radially outwardly in the gas stream to the outer periphery of the stream so that the particles are concentrated in a layer of gas immediately adjacent the inner surface of the tube **36**.

After each portion of the gas stream flows downwardly from a set of vanes **38** such portion is confined between a separating tube **36** and an outlet tube **37** until it passes the inner end of the outlet tube **37**. After such flow an initial portion of such flow immediately adjacent the outer surface of the outlet tube **37** has been cleaned due to the centrifugal forces acting on the entrained particles, which cleansed portion is of increasing radial thickness outwardly from the outer surface of the tube **37** as the gas stream progresses downwardly from the vanes **38** to the inner end of the tube **37**. When the gas stream passes downwardly beyond the inner open end of the tube **37** the lateral cross sectional area of the gas flow path increases so that the velocity of the gas stream decreases and the static pressure of the gas stream increases. In view however, of the downstream divergence of the outer surface of the sleeve **42**, the lateral cross sectional area of the gas flow path below the inner end of the tube **37** gradually decreases whereby the velocity of the gas stream gradually increases as it flows downwardly beside the sleeve **42** and the static pressure gradually decreases. Due to such decrease in velocity and increase in static pressure at the inner end of the tube **37** such initially cleansed portion, or the greater portion thereof, of the gas stream enters the tube **37** at the inner end. It will be appreciated that a minimum of turbulence in the portion of the gas stream entering the inner end of the tube **37** is desired in order to reduce the pressure drop in the system, accordingly, the sleeve **42** is provided with an outer surface which directs the initially cleansed portion of the gas stream to provide as smooth flow as possible. For such purposes the truncated conical sleeve **42** as described has been found to be satisfactory; however, it is to be realized that the outer surface of the sleeve **42** can be of various configurations, such as an airfoil section, to so direct the initially cleansed portion of the gas stream entering the inner end of the tube **37**. The portion of the total gas stream entering the inner end of the outlet tube **37** is also controlled in part by the size of the annular opening between the outlet tube **37** and the sleeve **42**, most favorable operation has been found to occur when the diameter of the sleeve **42** at the end adjoining the outlet tube **37** is within the range of one-half to three-fourths of the diameter of the outlet tube **37**. Thus the radial width of the annular opening around the sleeve **42** is preferably within the range of one-fourth to one-eighth of the diameter of the outlet tube **37**.

The remaining or uncleansed portion of the gas stream, its velocity gradually being increased, continues to spiral downwardly within the separating tube **36** until it reaches some position upwardly adjacent the open lower end **36a** of the tube. After having so traversed downwardly of the tube **36** the static pressure of the gas stream decreases with the decrease in elevation and although rotating in the aforementioned counterclockwise direction, its direction of axial movement is reversed so that the gas stream spirals upwardly in the tube **36**. The general movement of the gas stream in the tube **36** is indicated by the arrows **47** and **34** which illustrate an outer downward spiral and an inner upward spiral, respectively. It is to be realized that such reversal of the gas stream is accomplished in any well known manner such as by means of an exhaust fan or blower in the gas outlet defined by the flange **25**.

Such spiralling downward of the gas stream causes the particles in the gas stream to be forced radially outwardly of the gas stream so that upon reversal of the axial movement of the gas stream the suspended particles in the lower portion of the separating tube **36** are carried into the hopper **22** peripherally through the opening **36a** via small quantities of gas which in turn re-enter the tube **36** centrally through the opening **36a** and mingle with the aforementioned upwardly spiralling gases. The upwardly spiralling portion of the gas stream impinges on the inner concave surface **43'** of the vanes **43**. The surface **43'** has a reducing curvature from its lower edge upwardly, having the lower portion obliquely inclined downwardly in a clockwise direction (with reference to FIG. 5) so that the remaining spinning motion of the upwardly spiralling gas is transformed into axial motion as the gas enters the lower end of the sleeve **42**. This lower end of the sleeve **42** forms an outlet from the separating tube **36** for the upwardly spiralling portion of the gas stream. The sleeve **42**, being of frusto-conical configuration with decreasing cross sectional area in the direction of gas flow, directs the upward flow of gas with increasing velocity into the lower end of the outlet tube **37** where it joins the flow of the first or initially cleaned portion of the gas stream and all the cleansed gas is then discharged from the cyclonic unit through the upper end of the outlet tube **37**. The inner surface of the sleeve **42** has been described as being of frusto-conical configuration in a preferred construction but it is to be realized that the inner surface of the sleeve **42** can be of various configurations such as an airfoil section to impart a smooth flow to the portion of the gas stream affected by it.

Sleeve **42** provides two separate outlets for cleansed gas from the separating tube **36**, the upper annular one of which allows the initially cleansed portion of the gas to be discharged from the separating tube **36** as soon as practical, and before the remaining portion of the gas is cleansed. Mounting the straightening vanes **43** to extend below the sleeve **42** is preferred to mounting the vanes **43** upwardly in the sleeve **42** as at such position the vanes **43** reduce the spinning movement of the gas as soon as possible after the dust particles have been removed and transform such spinning movement into axial motion before the rotational energy of the gas has been dissipated by frictional contact with the inner surface of the sleeve **42**, with a concurrent reduction in turbulence when this upward flowing portion of the gas stream joins with the first cleaned portion at the inner end of outlet tube **37**. Thus the vanes **43** make more efficient use of the energy in the gas. The vanes **43** have been shown and described in a preferred construction, however, it will be appreciated that the vanes **43** can be omitted without departing from the scope and spirit of this invention. Thus, for example, some combinations of pressure drop and gas flow through the unit reduce the usefulness of the vanes **43** because, under such conditions there is little or no spinning movement remaining in the upwardly moving portion of the gas when it reaches the lower end of sleeve **42**.

A comparison of the operation of a cyclonic unit of the prior art with one constructed according to the principles of this invention will reveal the following differences: the presence of the sleeve **42** on the lower end of the outlet tube **37** provides a means of separating the incoming downwardly spiralling stream of gas from the upwardly moving outgoing stream, to prevent mingling of the gaseous countercurrents whereby a much smoother flow of the gas stream is achieved than is achievable without such separation. Such separation of the gaseous streams increases the efficiency of the unit as compared to similar proposed units in which the gas streams are not so separated. The action of the straightening vanes **43**, which transform rotational motion of the gas into axial motion in the desired direction outwardly through the sleeve **42** and the tube **37**, reduces the presure drop through the unit by reducing the energy lost in the unit. Consequently the total gas gow which can be efficiently handled by a cyclonic unit of given dimensions constructed in accordance with the principles of this invention, and having a given pressure drop across it, is increased beyond that of a cyclonic unit of the prior art. The aforementioned increased gas flow with no increase in pressure drop across the unit will cause the downward spiralling steam of gas to penetrate more deeply into the separating tube **36** thus increasing the cleaning action by increasing the length of spiral path along which centrifugal forces can continue to act. In this way the sleeve and straightening vanes combine to achieve maximum collection efficiency with maximum gas flow.

FIGS. 6 and 7 show another embodiment of this invention in which the same numbers have been used to designate parts which are identical with those used in the hereinabove described embodiment. This embodiment differs from that first described in the following respects. The sleeve **42**, mounted on the inner or lower end of the outlet tube **37**, and the straightening vanes **43** (see FIG. 2) have been omitted and replaced by three identical axially alined frusto-conical tubular sleeve members **52**, **53**, and **54**, being upper, middle and lower sleeve respectively, having their common axis coinciding with the axis of outlet tube **37**. The frusto-conical sleeves **52**, **53**, and **54** are all similarly oriented having their smaller ends upward or nearest to the inner end of the outlet tube **37** and are axially spaced from each other and from the inner end of the outlet tube **37** by a distance shown as approximately equal to one-sixth, which fraction can vary from one-eighth to one-quarter, of the axial height of each frusto-conical sleeve for a purpose hereinafter to be described. The maximum diameter of each sleeve is smaller than, but substantially equal to, the inner diameter of the outlet tube **37**. The upper sleeve **52** is rigidly secured, in axially spaced relationship to the innermost end of tube **37**, by three mounting strips **56** rigidly engaged upon the outer surface of the sleeve **52** and the inner periphery of the outlet tube **37** as by welding. The two lower sleeves **53** and **54** are secured in axially spaced relationship to each other and to the upper sleeve **52** in a similar manner by mounting strips **55**. The innermost end of the outlet tube **37** and the smaller end of the sleeve **52**, adjacent thereto, define and inverted frusto-conical space **57**, therebetween coaxial with the the outlet tube **37**, having its upper base concentric with the innermost end of the outlet tube **37** and its lower base defined by the outer periphery of the smaller end of sleeve **52**. This space **57** provides a first outlet for cleansed gas from the collector tube **35** by way of the outlet tube **37**, space **57** being of appropriate size to properly control the amount of gas desirably flowing through this outlet. Similar spaces **58**, **59** defined between the sleeves **52** and **53** and between the sleeves **53** and **54**, respectively, provide a second outlet **58** and a third outlet **59** for cleansed gas from the separating unit **35** by way of the outlet tube **37**. The larger end of the lower sleeve **54** is entirely open and provides a fourth outlet for the cleansed gas. Straightening vanes **43** are mounted on the lower end of sleeve **54** in the same manner as they are on the lower end of sleeve **42** in FIG. 2. If desired, straightening vanes **43** may be omitted in order to increase the cleaning efficiency of the apparatus.

The operation of the embodiment illustrated in FIGS. 6 and 7 is the same as that of the embodiments of FIGS. 1–5 excepting only that three successive small portions of the gas nearest the outlet tube **37** which is a first cleaned portion, are removed seriatim in the same manner as the single portion of the first cleaned gas was removed by the sleeve **42** of the above embodiment, from the main stream of gas. The remaining portion of the gas continues in spiral motion, in a manner hereinbefore described, into the lower portion of the collector tube **36** whence, freed of its suspended dust particles, it returns by the inner path **34** in an upward direction. The gas next passes upwardly through the open end of the lower sleeve **54**, where the inner conical surface configuration of the sleeves controls the joining of the various stream of gas, in the manner hereinbefore described, to achieve the desired flow, out through the outlet tube **37**. The sleeves **52**, **53**, **54** have been described as having a frusto-concial configuration both outwardly and inwardly, however, it is to be realized that various configurations such as air foil sections can be employed to impart a smooth flow to the portions of the gas affected by the sleeves **52**, **53**, **54**.

The provision of three sleeves in this embodiment, compared to the single sleeve of the embodiment illustrated in FIGS. 1–5, adds to the cleaning efficiency of the unit by allowing a larger but closely controlled portion of the first cleaned gas, nearest the outlet tube, to be removed from the main stream and kept separate from the upwardly spiralling portion. When straightening vanes **43** are employed, rotational energy is largely transformed into translational energy and reduces the pressure drop through the unit or alternatively increases the amount of gas which can be efficiently cleaned by a cyclonic unit of given dimensions with a given pressure drop across it. A larger portion of the gas having been removed from the main stream of gas entering the separating tube **36**, its velocity, directed downwardly into the lower portion of the separating tube **36**, is reduced and reversal of its axial direction of motion takes place at a point of lesser penetration into the separating tube **36** with a consequent additional reduction of pressure drop through the unit. Or alternatively a greater volume of gas may be processed at the original value of the pressure drop with a concurrently greater penetration of the downwardly spiralling portion of the gas stream into the lower portion of the separating tube **36** with a consequent increase in cleaning action as hereinbefore described.

It is to be noted that the addition of one or more conical sleeves **42** or **52**, **53**, **54** results mainly in increased cleaning efficiency, while the addition of straightening vanes **43** reduces the pressure drop through the unit with some decrease in efficiency. It follows that a judicious use of a combination of these features will result in a device having both high cleaning efficiency and relatively low pressure drop.

It will be realized that various changes may be made in the exact shape and arrangement of the several parts of the assembly without departing from the spirit and scope of this invention and all such changes are considered to be within the scope of the appended claims.

What I claim is:

1. In a cyclone type dust collector having an elongated separating tube axially disposed about an elongated outlet tube with one end of said outlet tube terminating intermediate the length of said separating tube the improvement comprising, a first open ended tapered sleeve mounted at and concentrically of said one end, said first sleeve having its smaller end spaced radially inwardly from said one end of said outlet tube in a plane to define therewith an opening of annular shape substantially in a plane transverse to the axis of said outlet tube at said one end and having its larger end remote from said outlet tube, a second open ended tapered sleeve mounted at and concentrically of said larger end of said first sleeve, said second sleeve having its smaller end spaced radially inwardly from said larger end in a plane to define therewith an opening of annular shape substantially in a plane transverse to the axis of said outlet tube at said larger end and having its own larger end more remote from said outlet tube, and said separating tube having a substantially constant internal cross sectional area extending at least from a transverse plane containing said one end to a transverse plane spaced axially from said larger end of said second sleeve in the same direction said larger ends are spaced from said one end.

2. A cyclone type dust collector as specified in claim **1** wherein the larger ends of said first and said second open ended tapered sleeves have respective outside diameters substantially equal to the outside diameters of said one end of said outlet tube.

3. In a cyclone type dust collector having an elongated separating tube axially disposed about an elongated outlet tube with one end of said outlet tube terminating intermediate the length of said separating tube and with spin producing means located between said tubes the improvement comprising, a first frusto-conical sleeve open at both ends mounted at and concentrically of said one end, said first sleeve having its smaller end spaced radially inwardly from said one end of said outlet tube in a plane to define therewith an opening of annular shape substantially in a plane transverse to the axis of said outlet tube at said one end and having its larger end remote from said outlet tube; a second frusto-conical sleeve open at both ends mounted at and concentrically of said larger end of said first sleeve, said second sleeve having its smaller end spaced radially inwardly from said larger end in a plane to define therewith an opening of annular shape substantially in a plane transverse to the axis of said outlet tube at said larger end and having its own larger end more remote from said outlet tube, and said separating tube having a substantially constant internal cross sectional area extending at least from a transverse plane containing said one end to a transverse plane spaced axially from said larger end of said second sleeve in the same direction said larger ends are spaced from said one end.

4. In a cyclone type dust collector having an elongated separating tube axially disposed about an elongated outlet tube with one end of said outlet tube terminating intermediate the length of said separating tube and with spin producing means located between said tubes the improvement comprising, a first frusto-conical sleeve open at both ends mounted at and concentrically of said one end, said first sleeve having its smaller end spaced radially inwardly from said one end of said outlet tube in a plane to define therewith an opening of annular shape substantially in a plane transverse to the axis of said outlet tube at said one end and having its larger end remote from said outlet tube; a second frusto-conical sleeve open at both ends mounted at and concentrically of said larger end of said first sleeve, said second sleeve having its smaller end spaced radially inwardly from said larger end of said first sleeve in a plane to define therewith an opening of annular shape substantially in a plane transverse to the axis of said outlet tube at said larger end of said first sleeve and having the larger end of said sleeve remote from said outlet tube, a third frusto-conical sleeve open at both ends mounted at and concentrically of said larger end of said second sleeve, said third sleeve having its smaller end spaced radially inwardly from said larger end of said second sleeve in a plane to define therewith an opening of annular shape substantially in a plane transverse to the axis of said outlet tube at said larger end of said second sleeve and having the larger end of said third sleeve more remote from said outlet tube, and said separating tube having a substantially constant internal cross sectional area extending at least from a transverse plane spaced axially from said larger end of said third sleeve in the same direction said larger ends are spaced from said one end.

5. A cyclone type dust collector as specified in claim **4** wherein the larger ends of said first, second and third frusto-conical sleeves have respective outside diameters substantially equal to the outside diameter of said one end of said outlet tube.

6. In a multiple outlet tube, cyclone type dust collector having a plurality of cyclonic units wherein each unit comprises an elongated separating tube axially disposed about an elongated cylindrical outlet tube with one end of said outlet tube terminating intermediate the length of said separating tube the improvement consisting of, a single open ended tapered sleeve mounted at and concentrically of said one end, said sleeve having its smaller end spaced radially inwardly from said one end of said outlet tube in a plane to define therewith an opening of annular shape substantially in a plane transverse to the axis of said outlet tube at said one end and having its larger end remote from said outlet tube, and said separating tube having a substantially constant internal cross sectional area extending at least from a transverse plane containing said one end to a transverse plane spaced axially from said larger end of said sleeve in the same direction said larger end is spaced from said one end.

7. A cyclone type dust collector as specified in claim **6** wherein the larger end of said tapered sleeve has an outside diameter substantially equal to the outside diameter of said one end of said outlet tube.

8. A cyclone type dust collector as specified in claim **6** wherein the larger end of said tapered sleeve has an outside diameter and an inside diameter substantially equal to the outside diameter and the inside diameter of said one end of said outlet tube respectively.

9. In a multiple outlet tube, cyclone type dust collector having a plurality of cyclonic units wherein each unit comprises an elongated separating tube axially disposed about an elongated cylindrical outlet tube with one end of said outlet tube terminating intermediate the length of said separating tube and with spin producing means located between said tubes the improvement consisting of a single frusto-conical sleeve open at both ends mounted at and concentrically of said one end, said sleeve having its smaller end spaced radially inwardly from said one end of said outlet tube in a plane to define therewith an opening of annular shape substantially in a plane transverse to the axis of said outlet tube at said one end and having its larger end remote from said outlet tube, and said separating tube having a substantially constant internal cross sectional area extending at least from a transverse plane containing said one end to a transverse plane spaced axialy from said larger end of said sleeve in the same direction said larger end is spaced from said one end.

10. In a multiple outlet tube, cyclone type dust collector having a plurality of cyclonic units wherein each unit

comprises an elongated separating tube coaxially disposed about an elongated outlet tube with one end of said outlet tube terminating intermediate the length of said separating tube the improvement consisting of; a formed tubular sleeve having a larger end and a smaller end, said smaller end having an outside diameter in the range of ½ to ¾ of the inside diameter of said one end of said outlet tube, said sleeve being coaxial with said outlet tube and having said smaller end substantially coplanar with said one end to define therewith an annular opening and said tubular sleeve having its larger end outwardly more remote from said one end.

11. In a cyclone type dust collector having an elongated separating tube axially disposed about an elongated outlet tube with one end of said outlet tube terminating intermediate the length of said separating tube and with spin producing means located between said tubes the improvement comprising: a pair of similarly formed tubular sleeves each having a larger end and a smaller end, respectively; both of said sleeves being coaxial with said outlet tube with the first of said sleeves mounted at and concentrically of said one end of said outlet tube; said first sleeve having its smaller end spaced radially inwardly from said one end of said outlet tube to define therewith an opening of annular shape substantially in a plane transverse to the axis of said outlet tube at said one end and having its larger end remote from said outlet tube; and with the second of said sleeves mounted at and concentrically of said larger end of said first sleeve; said second sleeve having its smaller end spaced radially inwardly from said larger end of said first sleeve to define therewith an opening of annular shape substantially in a plane transverse to the axis of said outlet tube at said larger end and having its own larger end more remote from said outlet tube; and said separating tube having a substantially constant internal cross sectional area extending at least from a transverse plane containing said one end to a transverse plane spaced axially from said larger end of said second sleeve in the same direction said larger ends are spaced from said one end.

12. In a cyclone type dust collector having an elongated separating tube axially disposed about an elongated outlet tube with one end of said outlet tube terminating intermediate the length of said separating tube and with spin producing means located between said tubes the improvement comprising: first, second and third formed tubular sleeves each having a smaller end and a larger end, respectively; said first, second and third sleeves being coaxial with said outlet tube; said first sleeve being mounted at and concentrically of said one end; said first sleeve having its smaller end spaced radially inwardly from said one end of said outlet tube to define therewith an opening of annular shape substantially in a plane transverse to the axis of said outlet tube at said one end and having its larger end remote from said outlet tube; said second sleeve mounted at and concentrically of said larger end of said first sleeve; said second sleeve having its smaller end spaced radially inwardly from said larger end of said first sleeve to define therewith an opening of annular shape substantially in a plane transverse to the axis of said outlet tube at said larger end of said first sleeve and having the larger end of said second sleeve remote from said outlet tube; said third sleeve mounted at and concentrically of said larger end of said second sleeve; said third sleeve having its smaller end spaced radially inwardly from said larger end of said second sleeve to define therewith an opening of annular shape substantially in a plane transverse to the axis of said outlet tube at said larger end of said second sleeve and having the larger end of said third sleeve more remote from said outlet tube; and said separating tube having a substantially constant internal cross sectional area extending at least from a transverse plane spaced axially from said larger end of said third sleeve in the same direction said larger ends are spaced from said one end.

13. A cyclone type dust collector as specified in claim 12 wherein the said smaller ends of said formed tubular sleeves have respective outside diameters in the range of ½ to ¾ of the inside diameter of said one end of said outlet tube.

14. A cyclone type dust collector as specified in claim 12 wherein said smaller end of said first sleeve is axially spaced outwardly from said one end of said outlet tube and said smaller end of said second sleeve is axially spaced outwardly from said larger end of said first sleeve and said smaller end of said third sleeve is axially spaced outwardly from said larger end of said second sleeve.

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